Career & Technical Education

Science, Technology, Engineering, & Mathematics (STEM):

Aviation Curriculum

Appendix

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Appendix

AVIATION PROGRAM OF STUDY

CTE Program of Study (CTEPS) Name: Private Pilot Ground School	**Date:** April 2021
Career Cluster: STEM	**District Name:** Fairbanks North Star Borough School District
Pathway: Engineering	**Developed By:** Joni Simpson
CTEPS Description:	

SECONDARY PROGRAM COMPONENTS (Please designate CTE courses in **bold**; designate middle school courses for HS credit with *italics*) [§3(41)(A-B & D)]:

Middle School		9th Grade		10th Grade		11th Grade		12th Grade	
Career Clusters Interest Inventory, AKCIS Jr. Portfolio		Career Clusters Interest Inventory, AKCIS Portfolio, PLCP		Career Interest Inventory, AKCIS Portfolio, PLCP		PSAT, SAT, ACT, Accuplacer/ALEKS, AKCIS Portfolio, PLCP, WorkKeys		SAT, ACT, WorkKeys, Accuplacer/ ALEKS, AKCIS Portfolio, PLCP, WorkKeys	
Grade	Course Name	Courses		Courses		Courses		Courses	
		Semester 1	Semester 2	Semester 1	Semester 2	Semester 1	Semester 2	Semester 1	Semester 2
		English 9 or English 9 Honors	English 9 or English 9 Honors	English 10 or English 10 Honors	English 10 or English 10 Honors	American Literature	Literature	Writing Intensive Course	English Elective
		Algebra I	Algebra I	Geometry	Geometry	Algebra 2	Algebra 2	Functions & Analysis	Trigonometry
		Earth & Space Science or Honors Biology	Earth & Space Science or Honors Biology	Biology or Chemistry	Biology or Chemistry	Chemistry or AP Biology	Chemistry or AP Biology	Elective, AP Chemistry, or AP Physics	Elective, AP Chemistry, or AP Physics
		Alaska Studies		World History	World History	US History	US History	Government	Economics
		Health	PE	PE	PE				
			Tools of Tech & Trade	**Drafting/CAD**	**Drafting/CAD**	**Small Engines**	**Small Engines**	**Private Pilot Ground School**	**Private Pilot Ground School**
Recognized Postsecondary Credential(s):		Recognized Postsecondary Credential(s):		Recognized Postsecondary Credential(s):		Recognized Postsecondary Credential(s):		Recognized Postsecondary Credential(s): FAA Airman's Knowledge Test	

ALIGNMENT TO INDUSTRY NEED [§3(41)(C)]:

State, Regional, Tribal, or Community Industry	State Priority Workforce Area
Aviation	Aviation

***OPTIONAL PROGRAM COMPONENTS:**

Career and Technical Student Organizations	Work-Based Learning Opportunities
SkillsUSA or TSA	Job Shadows and/or Internships

GENERAL POSTSECONDARY OPTIONS [§3(41)(F)]:

One or Two-Year Postsecondary Programs	Adult Registered Apprenticeships	Four-Year College and University Programs	Occupational Certifications and Licenses	On-The-Job Training, Certificates, etc.
• AAS Professional Piloting Program at University of Alaska Anchorage	▪	▪ BSAT Bachelor of Science in Aviation Technology, University of Alaska Anchorage	▪	▪

SPECIFIC POSTSECONDARY DETAILS:

POSTSECONDARY PROGRAM DETAILS	
NAME OF POSTSECONDARY PARTNER(S):	University of Alaska Anchorage
NAME OF POSTSECONDARY PROGRAM(S):	AAS in Professional Piloting or Bachelor of Science in Aviation Technology

***OPTIONAL ADDITIONAL PROGRAM INFORMATION** (Please designate courses possible to complete at high school level in **bold**):

Year 13		Year 14	
Semester 1	**Semester 2**	**Semester 1**	**Semester 2**
Fundamentals of Oral Communication	College Algebra for Calculus	Instrument Ground school	Instrument Flying
Writing and the Sciences	Writing and the Professions	Commercial Ground School	Commercial Flying I
Introduction to Aviation Technology	Aviation Law & Regulations	Commercial Flying II	Commercial Flying III
Pre-Professional Flying	Elements of Weather	College Physics I	Airplane Multiengine Land Rating
Aviation Safety	**Private Pilot Ground School**	College Physics I Laboratory	Flying Alaska Bush
		Pre-Calculus	**Calculus**
Credits 17	**Credits 15**	**Credits 16.5**	**Credits 14.5**
Outcome (Resulting Certificate, Credential or Degree) [§3(41)(F)]: **AAS Degree in Professional Piloting**			
Total Credits: 60 Possible # of completed credits from high school career program: **12**			

POTENTIAL EMPLOYMENT OUTCOMES [§3(41)(C)]:

POTENTIAL EMPLOYMENT OUTCOMES		
Entry-Level Careers	**Technical Careers**	**Professional Careers**
Private Pilot, Sales Administrator, Aviation Records File Clerk, Aviation Apprentice, Aviation Customer Service Representative, Aircraft Refueler	Commercial Pilot, Electronic Systems Technician, Aviation Safety Inspector,	Commercial Pilot, Airport Manager, Engineer

STRATEGIC ENTRY AND EXIT POINTS [§3(41)(E)]:

STRATEGIC ENTRY & EXIT POINTS	
Entry	**Exit**
Private Pilot Ground School	AAS Degree in Professional Piloting

Alaska Standards for Culturally Responsive Schools (1998)

Adopted by the
Assembly of Alaska Native Educators
Anchorage, Alaska
February 3, 1998.

Published by the Alaska Native Knowledge Network, 1998
Alaska Standards for Culturally-Responsive Schools are endorsed by:

Alaska Federation of Natives Alaska Rural
Systemic Initiative Alaska Rural Challenge
Alaska Native Knowledge Network Ciulistet
Research Association Association of Interior
Native Educators Southeast Native
Educators Association
North Slope Inupiaq Educators Association
Association of Native Educators of the
Lower Kuskokwim

Association of Northwest Native Educators
Alaska Native Education Student
Association Alutiiq Native Educator
Association Unangan Educator Association
Alaska Native Education Council
Alaska Native Teachers for
Excellence/Anchorage Consortium for

Alaska Native Higher Education Alaska
First Nations Research Network
Center For Cross-Cultural Studies Alaska
State Board of Education

Preface

The following standards have been developed by Alaska Native educators to provide a way for schools and communities to examine the extent to which they are attending to the educational and cultural well being of the students in their care. These “cultural standards” are predicated on the belief that a firm grounding in the heritage language and culture indigenous to a particular place is a fundamental prerequisite for the development of culturally-healthy students and communities associated with that place, and thus is an essential ingredient for identify- ing the appropriate qualities and practices associated with culturally- responsive educators, curriculum and schools.

For several years, Alaska has been developing “content standards” to define what students should know and be able to do as they go through school. In addition, “performance standards” are being developed for teachers and administrators, and a set of “quality school standards” have been put forward by the Alaska Department of Education to serve as a basis for accrediting schools in Alaska. To the extent that these state standards are written for general use throughout Alaska, they don’t always address some of the special issues that are of critical importance to schools in rural Alaska, particularly those serving Alaska Native communities and students.

Through a series of regional and statewide meetings associated with the Alaska Rural Systemic Initiative (with funding provided by the National Science Foundation and the Annenberg Rural Challenge, and administrative support from the Alaska Federation of Natives in collabo- ration with the University of Alaska), Alaska Native educators have developed the following “Alaska Standards for Culturally-Responsive Schools” for consideration by educators serving Native students around the state. Though the emphasis is on rural schools serving Native communities, many of the standards are applicable to all students and communities because they focus curricular attention on in-depth study of the surrounding physical and cultural environment in which the school is situated, while recognizing the unique contribution that indigenous people can make to such study as long-term inhabitants who have accumulated extensive specialized knowledge related to that environment.

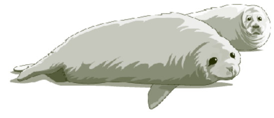
Standards have been drawn up in five areas, including those for students, educators, curriculum, schools, and communities. These “cultural standards” provide guidelines or touchstones against which schools and communities can examine what they are doing to attend to the cultural well-being of the young people they are responsible for nurturing to adulthood. The standards included here serve as a comple- ment to, not as a replacement for, those adopted by the State of Alaska. While the state standards stipulate what students should know and be able to do, the cultural standards are oriented more toward providing guidance on how to get them there in such a way that they become responsible, capable and whole human beings in the process. The emphasis is on fostering a strong connection between what students experience in school and their lives out of school by providing opportu- nities for students to engage in in-depth experiential learning in real- world contexts. By shifting the focus in the curriculum from teaching/ learning about cultural heritage as another subject to teaching/learning through the local culture as a foundation for all education, it is intended that all forms of knowledge, ways of knowing and world views be recognized as equally valid, adaptable and complementary to one another in mutually beneficial ways.

The cultural standards outlined in this document are not intended to be inclusive, exclusive or conclusive, and thus should be reviewed and adapted to fit local needs. Each school, community and related organiza- tion should consider which of these standards are appropriate and which are not, and when necessary, develop additional cultural standards to accommodate local circumstances. Terms should be interpreted to fit local conventions, especially with reference to meanings associated with the definition of Elder, tradition, spirituality, or anything relating to the use of the local language. Where differences of interpretation exist, they should be respected and accommodated to the maximum extent possible. The cultural standards are not intended to produce standard- ization, but rather to encourage schools to nurture and build upon the rich and varied cultural traditions that continue to be practiced in communities throughout Alaska.

Some of the multiple uses to which these cultural standards may be put are as follows:

1. They may be used as a basis for reviewing school or district-level goals, policies and practices with regard to the curriculum and pedagogy being implemented in each community or cultural area.
2. They may be used by a local community to examine the kind of home/family environment and parenting support systems that are provided for the upbringing of its children.
3. They may be used to devise locally appropriate ways to review student and teacher performance as it relates to nurturing and practicing culturally-healthy behavior, including serving as poten- tial graduation requirements for students.
4. They may be used to strengthen the commitment to revitalizing the local language and culture and fostering the involvement of Elders as an educational resource.
5. They may be used to help teachers identify teaching practices that are adaptable to the cultural context in which they are teaching.
6. They may be used to guide the preparation and orientation of teachers in ways that help them attend to the cultural well-being of their students.
7. They may serve as criteria against which to evaluate educational programs intended to address the cultural needs of students.
8. They may be used to guide the formation of state-level policies and regulations and the allocation of resources in support of equal educational opportunities for all children in Alaska.

Curriculum resources and technical support to implement the kind of learning experiences encouraged by the enclosed cultural standards may be found through the Alaska Native Knowledge Network web site located at http://www.ankn.uaf.edu, or call (907) 474-5897.



Cultural Standards for Students

A. Culturally-knowledgeable students are well grounded in the cultural heritage and traditions of their community.

Students who meet this cultural standard are able to:

1. assume responsibility for their role in relation to the well- being of the cultural community and their life-long obligations as a community member;
2. recount their own genealogy and family history;
3. acquire and pass on the traditions of their community through oral and written history;
4. practice their traditional responsibilities to the surrounding environment;
5. reflect through their own actions the critical role that the local heritage language plays in fostering a sense of who they are and how they understand the world around them;
6. live a life in accordance with the cultural values and traditions of the local community and integrate them into their everyday behavior.
7. determine the place of their cultural community in the regional, state, national and international political and economic systems;

B. Culturally-knowledgeable students are able to build on the knowledge and skills of the local cultural community as a foundation from which to achieve personal and academic success throughout life.

Students who meet this cultural standard are able to:

1. acquire insights from other cultures without diminishing the integrity of their own;
2. make effective use of the knowledge, skills and ways of knowing from their own cultural traditions to learn about the larger world in which they live;
3. make appropriate choices regarding the long-term consequences of their actions;
4. identify appropriate forms of technology and anticipate the consequences of their use for improving the quality of life in the community.

C. Culturally-knowledgeable students are able to actively participate in various cultural environments.

Students who meet this cultural standard are able to:

1. perform subsistence activities in ways that are appropri- ate to local cultural traditions;
2. make constructive contributions to the governance of their community and the well-being of their family;
3. attain a healthy lifestyle through which they are able to maintain their own social, emotional, physical, intellec- tual and spiritual well-being;
4. enter into and function effectively in a variety of cultural settings.

D. Culturally-knowledgeable students are able to engage effectively in learning activities that are based on traditional ways of knowing and learning.

Students who meet this cultural standard are able to:

1. acquire in-depth cultural knowledge through active participation and meaningful interaction with Elders;
2. participate in and make constructive contributions to the learning activities associated with a traditional camp environment;
3. interact with Elders in a loving and respectful way that demonstrates an appreciation of their role as culture- bearers and educators in the community;
4. gather oral and written history information from the local community and provide an appropriate interpretation of its cultural meaning and significance;
5. identify and utilize appropriate sources of cultural knowl- edge to find solutions to everyday problems;
6. engage in a realistic self-assessment to identify strengths and needs and make appropriate decisions to enhance life skills.

E. Culturally-knowledgeable students demonstrate an awareness and appreciation of the relationships and processes of interaction of all elements in the world around them.

Students who meet this cultural standard are able to:

1. recognize and build upon the inter-relationships that exist among the spiritual, natural and human realms in the world around them, as reflected in their own cultural traditions and beliefs as well as those of others;
2. understand the ecology and geography of the bioregion they inhabit;
3. demonstrate an understanding of the relationship between world view and the way knowledge is formed and used;
4. determine how ideas and concepts from one knowledge system relate to those derived from other knowledge systems;
5. recognize how and why cultures change over time;
6. anticipate the changes that occur when different cultural systems come in contact with one another;
7. determine how cultural values and beliefs influence the interaction of people from different cultural backgrounds;
8. identify and appreciate who they are and their place in the world.

Cultural Standards for Educators

A. Culturally-responsive educators incorporate local ways of knowing and teaching in their work.

Educators who meet this cultural standard:

1. recognize the validity and integrity of the traditional knowledge system;
2. utilize Elders' expertise in multiple ways in their teaching;
3. provide opportunities and time for students to learn in settings where local cultural knowledge and skills are naturally relevant;
4. provide opportunities for students to learn through observation and hands-on demonstration of cultural knowledge and skills;
5. adhere to the cultural and intellectual property rights that pertain to all aspects of the local knowledge they are addressing;
6. continually involve themselves in learning about the local culture.

B. turally-responsive educators use the local environment and community resources on a regular basis to link what they are teaching to the everyday lives of the students.

Educators who meet this cultural standard:

1. regularly engage students in appropriate projects and experiential learning activities in the surrounding environment;
2. utilize traditional settings such as camps as learning environments for transmitting both cultural and academic knowledge and skills;
3. provide integrated learning activities organized around themes of local significance and across subject areas;
4. are knowledgeable in all the areas of local history and cultural tradition that may have bearing on their work as a teacher, including the appropriate times for certain knowledge to be taught;
5. seek to ground all teaching in a constructive process built on a local cultural foundation.

C. Culturally-responsive educators participate in community events and activities in an appropriate and supportive way.

Educators who meet this cultural standard:

1. become active members of the community in which they teach and make positive and culturally-appropriate contributions to the well being of that community;

2. exercise professional responsibilities in the context of local cultural traditions and expectations;
3. maintain a close working relationship with and make appropriate use of the cultural and professional expertise of their co-workers from the local community.

D. Culturally-responsive educators work closely with parents to achieve a high level of complementary educational expectations between home and school.

Educators who meet this cultural standard:

1. promote extensive community and parental interaction and involvement in their children's education;
2. involve Elders, parents and local leaders in all aspects of instructional planning and implementation;
3. seek to continually learn about and build upon the cultural knowledge that students bring with them from their homes and community;
4. seek to learn the local heritage language and promote its use in their teaching.

E. ulturally-responsive educators recognize the full educational potential of each student and provide the challenges necessary for them to achieve that potential.

Educators who meet this cultural standard:

1. recognize cultural differences as positive attributes around which to build appropriate educational experiences;
2. provide learning opportunities that help students recog- nize the integrity of the knowledge they bring with them and use that knowledge as a springboard to new under-standings;
3. reinforce the student's sense of cultural identity and place in the world;
4. acquaint students with the world beyond their home community in ways that expand their horizons while strengthening their own identities;
5. recognize the need for all people to understand the importance of learning about other cultures and appreciating what each has to offer.

Cultural Standards for Curriculum

A. A culturally-responsive curriculum reinforces the integrity of the cultural knowledge that students bring with them.

A curriculum that meets this cultural standard:

1. recognizes that all knowledge is imbedded in a larger system of cultural beliefs, values and practices, each with its own integrity and interconnectedness;
2. insures that students acquire not only the surface knowl- edge of their culture, but are also well grounded in the deeper aspects of the associated beliefs and practices;
3. incorporates contemporary adaptations along with the historical and traditional aspects of the local culture;
4. respects and validates knowledge that has been derived from a variety of cultural traditions;
5. provides opportunities for students to study all subjects starting from a base in the local knowledge system.

B. culturally-responsive curriculum recognizes cultural knowledge as part of a living and constantly adapting system that is grounded in the past, but continues to grow through the present and into the future.

A curriculum that meets this cultural standard:

1. recognizes the contemporary validity of much of the traditional cultural knowledge, values and beliefs, and grounds students learning in the principles and practices associated with that knowledge;
2. provides students with an understanding of the dynamics of cultural systems as they change over time, and as they are impacted by external forces;
3. incorporates the in-depth study of unique elements of contemporary life in Native communities in Alaska, such as the Alaska Native Claims Settlement Act, subsistence, sovereignty and self-determination.

C. A culturally-responsive curriculum uses the local language and cultural knowledge as a foundation for the rest of the curriculum.

A curriculum that meets this cultural standard:

1. utilizes the local language as a base from which to learn the deeper meanings of the local cultural knowledge, values, beliefs and practices;

2. recognizes the depth of knowledge that is associated with the long inhabitation of a particular place and utilizes the study of “place” as a basis for the comparative analysis of contemporary social, political and economic systems;
3. incorporates language and cultural immersion experiences wherever in-depth cultural understanding is necessary;
4. views all community members as potential teachers and all events in the community as potential learning opportunities;
5. treats local cultural knowledge as a means to acquire the conventional curriculum content as outlined in state standards, as well as an end in itself;
6. makes appropriate use of modern tools and technology to help document and transmit traditional cultural knowledge;
7. is sensitive to traditional cultural protocol, including role of spirituality, as it relates to appropriate uses of local knowledge.

D. A culturally-responsive curriculum fosters a complementary relationship across knowledge derived from diverse knowledge systems.

A curriculum that meets this cultural standard:

1. draws parallels between knowledge derived from oral tradition and that derived from books;
2. engages students in the construction of new knowledge and understandings that contribute to an ever-expanding view of the world.

E. A culturally-responsive curriculum situates local knowledge and actions in a global context.

A curriculum that meets this cultural standard:

1. encourages students to consider the inter-relationship between their local circumstances and the global community;
2. conveys to students that every culture and community contributes to, at the same time that it receives from the global knowledge base;
3. prepares students to “think globally, act locally.”

Cultural Standards for Schools

A. A culturally-responsive school fosters the on-going participation of Elders in all aspects of the schooling process.

A school that meets this cultural standard:

1. maintains multiple avenues for Elders to interact formally and informally with students at all times;
2. provides opportunities for students to regularly engage in the documenting of Elders' cultural knowledge and produce appropriate print and multimedia materials that share this knowledge with others;
3. includes explicit statements regarding the cultural values that are fostered in the community and integrates those values in all aspects of the school program and operation;
4. utilizes educational models that are grounded in the traditional world view and ways of knowing associated with the cultural knowledge system reflected in the community.

B. A culturally-responsive school provides multiple avenues for students to access the learning that is offered, as well as multiple forms of assessment for students to demonstrate what they have learned.

A school that meets this cultural standard:

1. utilizes a broad range of culturally-appropriate perfor- mance standards to assess student knowledge and skills;
2. encourages and supports experientially oriented ap- proaches to education that makes extensive use of community-based resources and expertise;
3. provides cultural and language immersion programs in which student acquire in-depth understanding of the culture of which they are members;
4. helps students develop the capacity to assess their own strengths and weaknesses and make appropriate decisions based on such a self-assessment.

C. A culturally-responsive school provides opportunities for students to learn in and/or about their heritage language.

A school that meets this cultural standard:

1. provides language immersion opportunities for students who wish to learn in their heritage language;
2. offers courses that acquaint all students with the heritage language of the local community;
3. makes available reading materials and courses through which students can acquire literacy in the heritage language;
4. provides opportunities for teachers to gain familiarity with the heritage language of the students they teach through summer immersion experiences.

D. A culturally-responsive school has a high level of involvement of professional staff who are of the same cultural background as the students with whom they are working.

A school that meets this cultural standard:

1. encourages and supports the professional development of local personnel to assume teaching and administrative roles in the school;
2. recruits and hires teachers whose background is similar to that of the students they will be teaching;
3. provides a cultural orientation camp and mentoring program for new teachers to learn about and adjust to the cultural expectations and practices of the community and school;
4. fosters and supports opportunities for teachers to partici- pate in professional activities and associations that help them expand their repertoire of cultural knowledge and pedagogical skills.

E. A culturally-responsive school consists of facilities that are compatible with the community environment in which they are situated.

A school that meets this cultural standard:

1. provides a physical environment that is inviting and readily accessible for local people to enter and utilize;
2. makes use of facilities throughout the community to demonstrate that education is a community-wide process involving everyone as teachers;
3. utilizes local expertise, including students, to provide culturally-appropriate displays of arts, crafts and other forms of decoration and space design.

F. culturally-responsive school fosters extensive on-going participation, communication and interaction between school and community personnel.

A school that meets this cultural standard:

1. holds regular formal and informal events bringing together students, parents, teachers and other school and commu- nity personnel to review, evaluate and plan the educational program that is being offered;
2. provides regular opportunities for local and regional board deliberations and decision-making on policy, program and personnel issues related to the school;
3. sponsors on-going activities and events in the school and community that celebrate and provide opportunities for students to put into practice and display their knowledge of local cultural traditions.

Cultural Standards for Communities

A. A culturally-supportive community incorporates the practice of local cultural traditions in its everyday affairs.

A community that meets this cultural standard:

1. provides respected Elders with a place of honor in community functions;
2. models culturally-appropriate behavior in the day-to-day life of the community;
3. utilizes traditional child-rearing and parenting practices that reinforce a sense of identity and belonging;
4. organizes and encourages participation of members from all ages in regular community-wide, family-oriented events;
5. incorporates and reinforces traditional cultural values and beliefs in all formal and informal community functions.

B. A culturally-supportive community nurtures the use of the local heritage language.

A community that meets this cultural standard:

1. recognizes the role that language plays in conveying the deeper aspects of cultural knowledge and traditions;
2. sponsors local heritage language immersion opportunities for young children when they are at the critical age for language learning;
3. encourages the use of the local heritage language when- ever possible in the everyday affairs of the community, including meetings, cultural events, print materials and broadcast media;
4. assists in the preparation of curriculum resource material in the local heritage language for use in the school;

5. provides simultaneous translation services for public meetings where persons unfamiliar with the local heritage language are participants.

C. A culturally-supportive community takes an active role in the education of all its members.

A community that meets this cultural standard:

1. encourages broad-based participation of parents in all aspects of their children's education, both in and out of school;
2. insures active participation by community members in reviewing all local, regional and state initiatives that have bearing on the education of their children;
3. encourages and supports members of the local community who wish to pursue further education to assume teaching and administrative roles in the school;
4. engages in subsistence activities, sponsors cultural camps and hosts community events that provide an opportunity for children to actively participate in and learn appropriate cultural values and behavior;
5. provides opportunities for all community members to acquire and practice the appropriate knowledge and skills associated with local cultural traditions.

D. A culturally-supportive community nurtures family responsibility, sense of belonging and cultural identity.

A community that meets this cultural standard:

1. fosters cross-generational sharing of parenting and child- rearing practices;
2. creates a supportive environment for youth to participate in local affairs and acquire the skills to be contributing members of the community;
3. adopts the adage, "It takes the whole village to raise a child."

E. culturally-supportive community assists teachers in learning and utilizing local cultural traditions and practices.

A community that meets this cultural standard:

1. sponsors a cultural orientation camp and community mentoring program for new teachers to learn about and adjust to the cultural expectations and practices of the community;

2. encourages teachers to make use of facilities and expertise in the community to demonstrate that education is a community-wide process involving everyone as teachers;
3. sponsors regular community/school potlucks to celebrate the work of students and teachers and to promote on- going interaction and communication between teachers and parents;
4. attempts to articulate the cultural knowledge, values and beliefs that it wishes teachers to incorporate into the school curriculum;
5. establishes a program to insure the availability of Elders' expertise in all aspects of the educational program in the school.

F. A culturally-supportive community contributes to all aspects of curriculum design and implementation in the local school.

A community that meets this cultural standard:

1. takes an active part in the development of the mission, goals and content of the local educational program;
2. promotes the active involvement of students with Elders in the documentation and preservation of traditional knowledge through a variety of print and multimedia formats;
3. facilitates teacher involvement in community activities and encourages the use of the local environment as a curricular resource;
4. promotes parental involvement in all aspects of their children's educational experience.

Alaska Employability Standards (1998)

Adopted by Alaska State Board of Education
September 29, 1998

Employability Standards are a critical part of student learning. Proficiency in achieving Alaska's content standards is fundamental to creating an employable individual. These employability standards are to be used in conjunction with Alaska's academic content and performance standards to ensure Alaska students have the skills and knowledge necessary to be good citizens, effective parents, productive workers, and most of all, life-long learners. Alaska students are expected to learn how to learn and apply their skills and knowledge in a variety of settings to create a satisfying and productive life. These standards are designed to promote successful student transition from school to work.

A student should be able to develop and be able to use employability skills in order to effectively make the transition from school to work and life-long learning.

A student who meets this standard should:

1. Develop and maintain a work ethic necessary for success in the workplace that includes honesty, integrity, dependability, punctuality, self discipline, initiative, reliability, accuracy, productivity, respect and perseverance;
2. Understand how to apply skills and academic knowledge in a variety of work settings;
3. Understand the process for seeking employment including resume development, application completion, interview skills and appropriate dress for work settings;
4. Understand the process for developing self-employment opportunities including marketing studies, business plan development, and managing business finances;
5. Understand how an individual job fits into the overall organization and how the organization fits into the overall economy;
6. Understand the need for safe practices in workplaces;
7. Understand employer and employee rights and responsibilities.

B A student should be able to identify career interests and plan for career options.

A student who meets this standard should:

1. Identify and appreciate personal interests, aptitudes, abilities, and priorities;
2. Identify possible career options, considering both employment and self employment and understand how changes in the workplace affect career choice;
3. Use labor market information to identify occupational and economic trends and opportunities, and evaluate possible career options;
4. Identify education and/or training needed for career options and advancement, and develop a career plan;
5. Identify resources available to support education and training related to career possibilities.

Department of Education
& Early Development

ALASKA ENGLISH/LANGUAGE ARTS STANDARDS

Including Standards for Literacy in History/Social Studies, Science, and Technical Subjects

Adopted June 2012

Alaska Board of Education & Early Development

For additional information on Alaska's standards, write:
Standards, Department of Education & Early Development
PO Box 110500 Juneau, Alaska 99811-0500
Or call, (907) 465-2900; or visit our website: http://education.alaska.gov

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Alaska English/Language Arts and Mathematics Content Standards

High academic standards are an important first step in ensuring that all Alaska's students have the tools they need for success. These standards reflect the collaborative work of Alaskan educators and national experts from the nonprofit National Center for the Improvement of Educational Assessment. Further, they are informed by public comments. Alaskan teachers have played a key role in this effort, ensuring that the standards reflect the realities of the classroom. Since work began in spring 2010, the standards have undergone a thoughtful and rigorous drafting and refining process.

A nationwide movement among the states and employers has called for America's schools to prepare students to be ready for postsecondary education and careers. Standards in English/language arts and mathematics build a foundation for college and career readiness. Students proficient in the standards read widely and deeply in a range of subjects, communicate clearly in written and spoken English, have the capacity to build knowledge on a subject, and understand and use mathematics.

Industry leaders were part of Alaska's standards review. Repeatedly these leaders placed the greatest weight on critical thinking and adaptability as essential skills in the workplace. Industry leaders believe that strengthening our K-12 system will help ensure that Alaskans are prepared for high-demand, good-wage jobs. Instructional expectations that include employability standards will help students prepare for a career.

Additionally, institutions of higher education were engaged in refining Alaska's standards. These educators focused on whether the standards would culminate in student preparedness. Students proficient in Alaska's standards will be prepared for credit-bearing courses in their first year of postsecondary education. It is critical that students can enter institutions of higher education ready to apply their knowledge, extend their learning, and gain technical and job-related skills.

These standards do not tell teachers how to teach, nor do they attempt to override the unique qualities of each student and classroom. They simply establish a strong foundation of knowledge and skills all students need for success after graduation. It is up to schools and teachers to decide how to put the standards into practice and incorporate other state and local standards, including cultural standards. In sum, students must be provided opportunities to gain skills and learn to apply them to real-world life and work situations.

Introduction to English/Language Arts Standards

Reading

The standards establish increasing complexity in what students must be able to read so all students are ready for the demands of college-level and career-level reading no later than the end of high school. The standards also require the progressive development of reading comprehension; students advancing through the grades are able to gain more from whatever they read.

Through reading a diverse array of classic, contemporary, and Alaskan-based literature as well as challenging informational texts, students are expected to build knowledge, gain insights, explore possibilities, and broaden their perspective. This may require a review of texts provided at various grades, and within courses, to determine if the full breadth of reading is available.

The reading standards in K-5 include Foundational Skills. The Foundational Skills are focused on developing students' understanding and working-knowledge of print concepts, phonological awareness, phonics and word recognition, and fluency. A key design feature is that at the same time students are developing strong Foundational Skills (learning to read well) they are also developing strong comprehension and vocabulary skills by listening to and reading stories and informational texts about animals, space, or the history of where they live.

The reading standards place equal emphasis on the sophistication of what students read and the skill with which they read. Standard 10 defines a grade-by-grade “staircase” of increasing text complexity that rises from beginning reading to the college- and career-readiness level. Teachers are to engage students in a range of text at multiple grade levels; an extension into upper grade levels may require scaffolding. Whatever they are reading, students must also show a steadily growing ability to discern more from and make fuller use of the text, including making an increased number of connections among ideas and between texts, considering a wider range of textual evidence, and becoming more sensitive to inconsistencies, ambiguities, and poor reasoning in texts.

Writing

The ability to write logical arguments based on substantive claims, sound reasoning, and relevant evidence is a cornerstone of the writing standards, with opinion writing—a basic form of argument—extending down into the earliest grades.

Student research includes both short, focused projects and longer-term, in-depth projects. This is emphasized throughout the standards. Research skills are predominantly in the writing strand since a written analysis and presentation of findings are so often critical to communicate information.

Speaking and Listening

The standards require that students gain, evaluate, and present increasingly complex information, ideas, and evidence through listening and speaking as well as through media.

An important focus of the speaking and listening standards is academic discussion in one-on-one, small-group, and whole-class settings. Formal presentations are important, but so is the more informal discussion that takes place as students collaborate to answer questions, build understanding, and solve problems.

Language

The standards provide opportunities for students to develop their vocabularies through a mix of conversations, direct instruction, and reading. The standards emphasize word meanings and nuances of words, and steadily expand the repertoire of words and phrases.

The language standards prepare students for real life experience at college and in twenty-first century careers. Students must be able to use formal English in their writing and speaking and be able to make informed, skillful choices among the many ways to express themselves through language.

A Language Progressive Skills table accompanies the language standards. The table shows language standards introduced in each grade that are particularly likely to require continued attention in higher grades as they are applied to increasingly sophisticated writing and speaking. In other words, even though the standards noted in the Language Progressive Skills table are not repeated in higher grades, they must be incorporated into instruction.

Literacy development across the curriculum

The literacy standards establish that interaction in reading, writing, speaking, listening, and language be shared responsibly within the school. The K-5 standards include expectations for reading, writing, speaking, listening, and language applicable to a range of subjects, including but not limited to English/language arts. The grades 6-12 standards are divided into two sections, one for English/language arts and the other for history/social studies, science, and technical subjects. This division recognizes that teachers in other content areas must have a role in the development of students’ literacy skills.

Students Who are College and Career Ready in Reading, Writing, Speaking, Listening, and Language

The descriptions that follow are not standards themselves but instead offer a portrait of students who meet the standards set out in this document. As students advance through the grades and master the standards in reading, writing, speaking, listening, and language, they are able to exhibit with increasing fullness and regularity these capacities of the literate individual.

They demonstrate independence.

Students can, without significant scaffolding, comprehend and evaluate complex texts across a range of types and disciplines, and they can construct effective arguments and convey intricate or multifaceted information. Likewise, students are able independently to discern a speaker's key points, request clarification, and ask relevant questions. They build on others' ideas, articulate their own ideas, and confirm they have been understood. Without prompting, they demonstrate command of Standard English and acquire and use a wide-ranging vocabulary. More broadly, they become self-directed learners, effectively seeking out and using resources to assist them, including teachers, peers, and print and digital reference materials.

They build strong content knowledge.

Students establish a base of knowledge across a wide range of subject matter by engaging with works of quality and substance. They become proficient in new areas through research and study. They read purposefully and listen attentively to gain both general knowledge and discipline-specific expertise. They refine and share their knowledge through writing and speaking.

They respond to the varying demands of audience, task, purpose, and discipline.

Students adapt their communication in relation to audience, task, purpose, and discipline. They set and adjust purpose for reading, writing, speaking, listening, and language use as warranted by the task. They appreciate nuances, such as how the composition of an audience should affect tone when speaking and how the connotations of words affect meaning. They also know that different disciplines call for different types of evidence (e.g., documentary evidence in history, experimental evidence in science).

They comprehend as well as critique.

Students are engaged and open-minded—but discerning—readers and listeners. They work diligently to understand precisely what an author or speaker is saying, but they also question an author's or speaker's assumptions and premises and assess the veracity of claims and the soundness of reasoning.

They value evidence.

Students cite specific evidence when offering an oral or written interpretation of a text. They use relevant evidence when supporting their own points in writing and speaking, making their reasoning clear to the reader or listener, and they constructively evaluate others' use of evidence.

They use technology and digital media strategically and capably.

Students employ technology thoughtfully to enhance their reading, writing, speaking, listening, and language use. They tailor their searches online to acquire useful information efficiently, and they integrate what they learn using technology with what they learn offline. They are familiar with the strengths and limitations of various technological tools and media and can select and use those best suited to their communication goals.

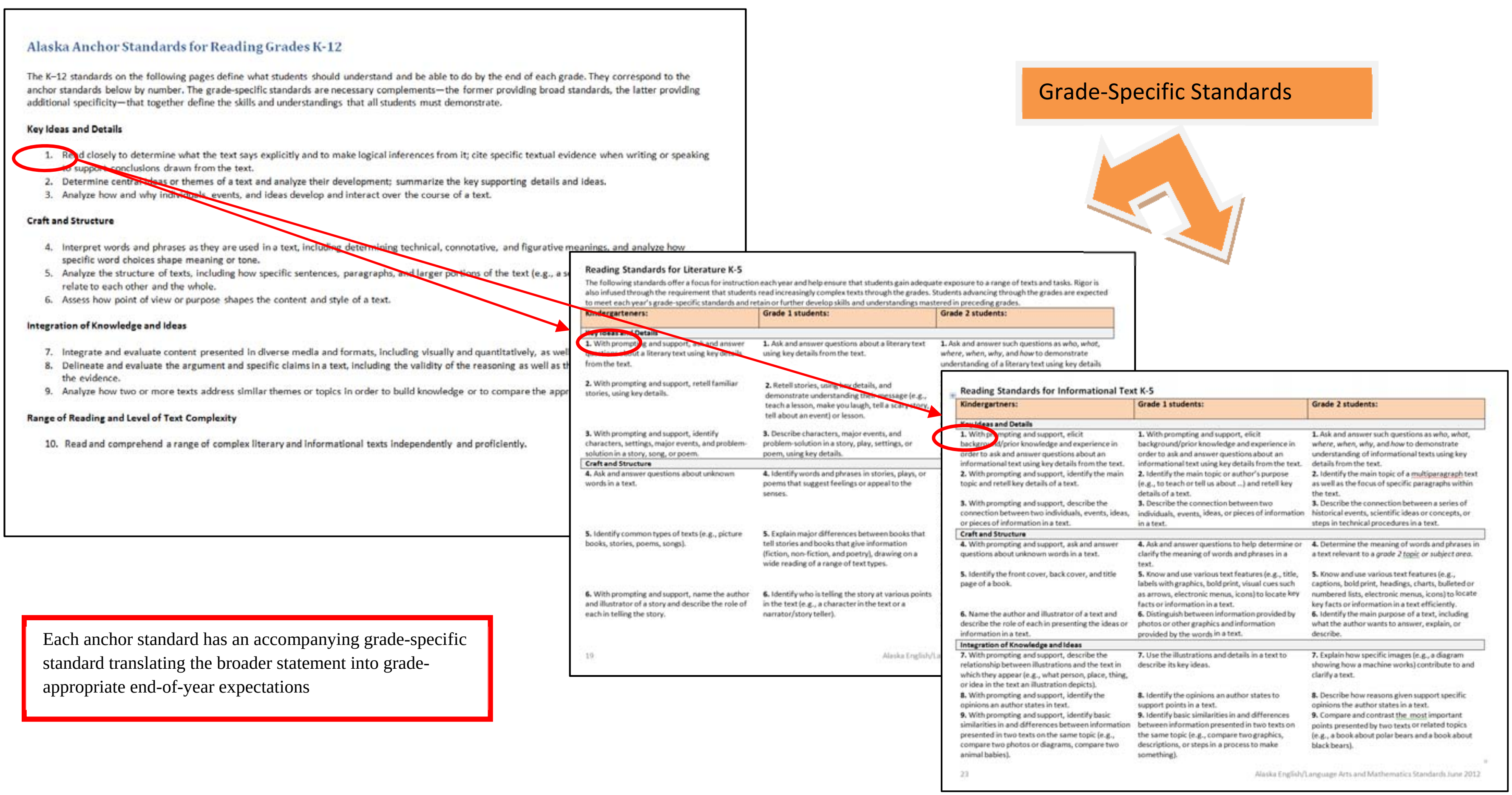
They come to understand other perspectives and cultures.

Students appreciate that the twenty-first-century classroom and workplace are settings in which people from often widely divergent cultures and who represent diverse experiences and perspectives must learn and work together. Students actively seek to understand other perspectives and cultures through reading and listening, and they are able to communicate effectively with people of varied backgrounds. They evaluate other points of view critically and constructively. Through reading great classic and contemporary works of literature representative of a variety of periods, cultures, and worldviews, students can vicariously inhabit worlds and have experiences much different than their own.

Organization of English/Language Arts Standards

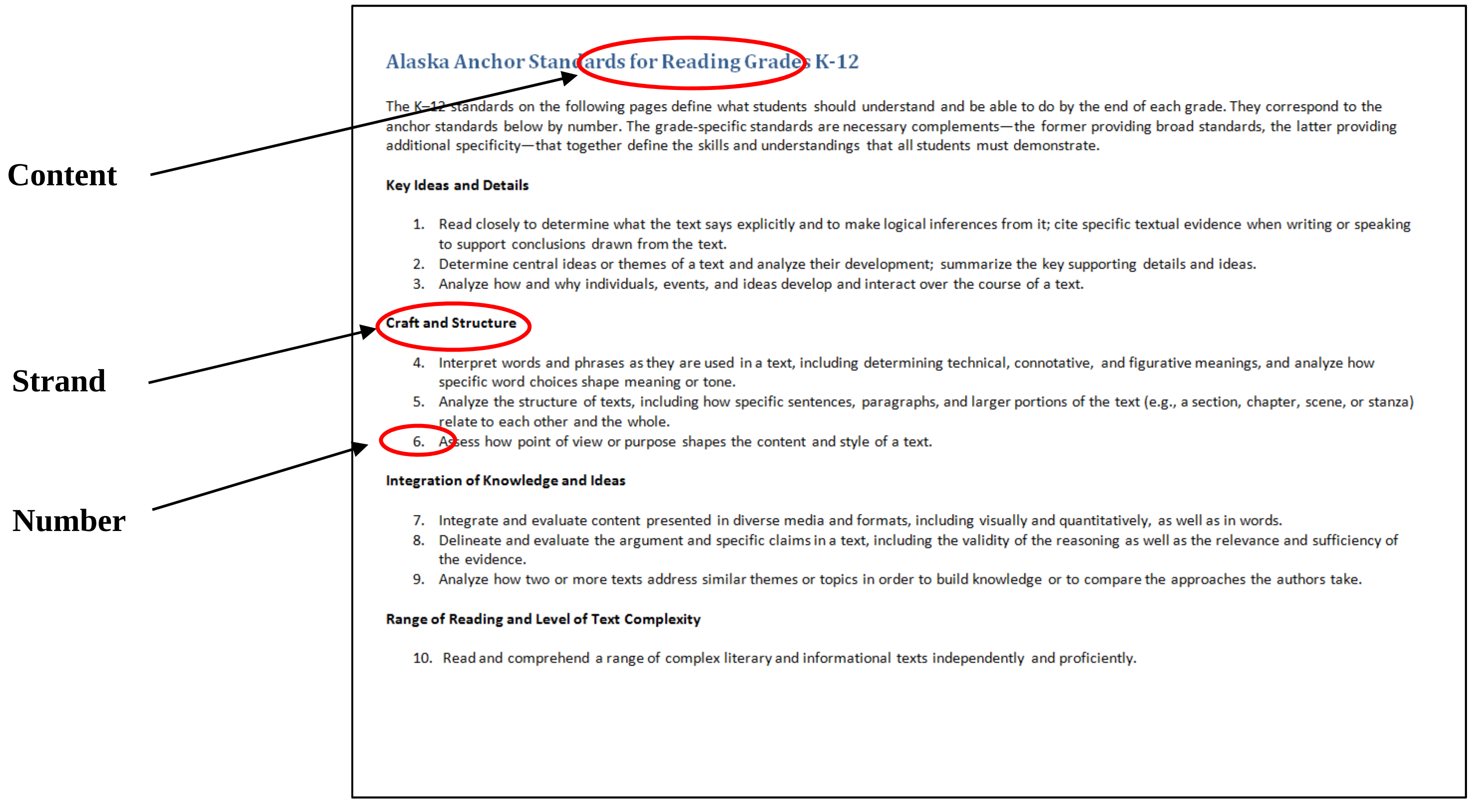
The Standards comprise two main sections: a comprehensive K-5 section and content area-specific section for grades 6-12. Appendices and instructional tools accompany the main document and can be found on the state's website http://www.eed.alaska.gov.

Standards for each grade within K-8 and for grade spans 9-10 and 11-12 follow the same anchor standards for each content area: reading, writing, listening and speaking, and language. Each grade-specific standard corresponds to the same-numbered anchor standard. Put another way, each anchor standard has an accompanying grade-specific standard translating the broader statement into grade-appropriate end-of-year expectations. Anchor standards "anchor" the document and define general, cross-disciplinary literacy expectations.



The K-12 grade-specific standards define end-of-year expectations and a cumulative progression designed to enable students to meet college and career readiness. Individual grade-specific standards can be identified by their content/focus, grade, strand, and number (or number and letter, where applicable), so that RI.4.3, for example, stands for Reading, Informational Text, grade 4, standard 3, and W.5.1a stands for Writing, grade 5, standard 1a.

Anchor standards are coded similarly. For example, R.CS.6 stands for Reading, Craft and Structure, standard 6.



Alaska Anchor Standards for Reading Grades K-12

The K–12 standards on the following pages define what students should understand and be able to do by the end of each grade. They correspond to the anchor standards below by number. The grade-specific standards are necessary complements—the former providing broad standards, the latter providing additional specificity—that together define the skills and understandings that all students must demonstrate.

Key Ideas and Details

1. Read closely to determine what the text says explicitly and to make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.
2. Determine central ideas or themes of a text and analyze their development; summarize the key supporting details and ideas.
3. Analyze how and why individuals, events, and ideas develop and interact over the course of a text.

Craft and Structure

4. Interpret words and phrases as they are used in a text, including determining technical, connotative, and figurative meanings, and analyze how specific word choices shape meaning or tone.
5. Analyze the structure of texts, including how specific sentences, paragraphs, and larger portions of the text (e.g., a section, chapter, scene, or stanza) relate to each other and the whole.
6. Assess how point of view or purpose shapes the content and style of a text.

Integration of Knowledge and Ideas

7. Integrate and evaluate content presented in diverse media and formats, including visually and quantitatively, as well as in words.
8. Delineate and evaluate the argument and specific claims in a text, including the validity of the reasoning as well as the relevance and sufficiency of the evidence.
9. Analyze how two or more texts address similar themes or topics in order to build knowledge or to compare the approaches the authors take.

Range of Reading and Level of Text Complexity

10. Read and comprehend a range of complex literary and informational texts independently and proficiently.

Strand Key:

KI - Key Ideas and Details
CS - Craft and Structure
IK - Integration of Knowledge and Ideas
RR - Range of Reading and Level of Text Complexity

Alaska English/Language Arts Anchor Standards

Alaska Anchor Standards Reading Grades K-12

The K-12 grade-specific standards on the following pages define what students should understand and be able to do by the end of each grade. They correspond to the anchor standards below by number. The grade-specific standards are necessary complements—the former providing broad standards, the latter providing additional specificity—that together define the skills and understandings that all students must demonstrate.

Key Ideas and Details

1. Read closely to determine what the text says explicitly and to make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.
2. Determine central ideas or themes of a text and analyze their development; summarize the key supporting details and ideas.
3. Analyze how and why individuals, events, and ideas develop and interact over the course of a text.

Craft and Structure

4. Interpret words and phrases as they are used in a text, including determining technical, connotative, and figurative meanings, and analyze how specific word choices shape meaning or tone.
5. Analyze the structure of texts, including how specific sentences, paragraphs, and larger portions of the text (e.g., a section, chapter, scene, or stanza) relate to each other and the whole.
6. Assess how point of view or purpose shapes the content and style of a text.

Integration of Knowledge and Ideas

7. Integrate and evaluate content presented in diverse media and formats, including visually and quantitatively, as well as in words.
8. Delineate and evaluate the argument and specific claims in a text, including the validity of the reasoning as well as the relevance and sufficiency of the evidence.
9. Analyze how two or more texts address similar themes or topics in order to build knowledge or to compare the approaches the authors take.

Range of Reading and Level of Text Complexity

10. Read and comprehend a range of complex literary and informational texts independently and proficiently.

Alaska Anchor Standards for Writing Grades K-12

The K-12 grade-specific standards on the following pages define what students should understand and be able to do by the end of each grade. They correspond to the anchor standards below by number. The grade-specific standards are necessary complements—the former providing broad standards, the latter providing additional specificity—that together define the skills and understandings that all students must demonstrate.

Text Types and Purposes

1. Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence.
2. Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content.
3. Use narrative writing to develop real or imagined experiences or events using effective technique, well-chosen details, and well-structured event sequences.

Production and Distribution of Writing

4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
5. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach.
6. Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others.

Research to Build and Present Knowledge

7. Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation.
8. Gather relevant information from multiple print and digital sources, assess the credibility and accuracy of each source, and integrate the information while avoiding plagiarism.
9. Draw evidence from literary or informational texts to support analysis, reflection, and research.

Range of Writing

10. Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes, and audiences.

Alaska Anchor Standards for Speaking and Listening Grades K-12

The K-12 grade-specific standards on the following pages define what students should understand and be able to do by the end of each grade. They correspond to the anchor standards below by number. The grade-specific standards are necessary complements—the former providing broad standards, the latter providing additional specificity—that together define the skills and understandings that all students must demonstrate.

Comprehension and Collaboration

1. Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others' ideas and expressing their own clearly and persuasively.
2. Integrate and evaluate information presented in diverse media and formats, including visually, quantitatively, and orally.
3. Evaluate a speaker's point of view, reasoning, and use of evidence and rhetoric.

Presentation of Knowledge and Ideas

4. Present information, findings, and supporting evidence such that listeners can follow the line of reasoning and that the organization, development, and style are appropriate to task, purpose, and audience.
5. Make strategic use of digital media and visual displays of data to express information and enhance understanding of presentations.
6. Adapt speech to a variety of contexts and communicative tasks, demonstrating command of formal English when indicated or appropriate.

Alaska Anchor Standards for Language Grades K-12

The K-12 grade-specific standards on the following pages define what students should understand and be able to do by the end of each grade. They correspond to the anchor standards below by number. The grade-specific standards are necessary complements—the former providing broad standards, the latter providing additional specificity—that together define the skills and understandings that all students must demonstrate.

Conventions of Standard English

1. Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.
2. Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing.

Knowledge of Language

3. Apply knowledge of language to understand how language functions in different contexts, to make effective choices for meaning or style, and to comprehend more fully when reading or listening.

Vocabulary Acquisition and Use

4. Determine or clarify the meaning of unknown and multiple-meaning words and phrases by using context clues, analyzing meaningful word parts, and consulting general and specialized reference materials, as appropriate.
5. Demonstrate understanding of figurative language, word relationships, and nuances in word meanings.
6. Acquire and use accurately a range of general academic and domain-specific words and phrases sufficient for reading, writing, speaking, and listening at the college- and career-readiness level; demonstrate independence in gathering vocabulary knowledge when encountering an unknown term important to comprehension or expression.

Language Progressive Skills, by Grade

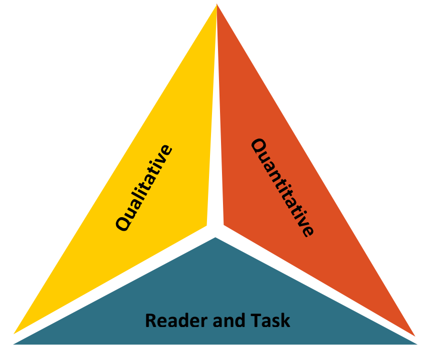
The following skills, marked with an asterisk (*) in Language standards 1–3, are particularly likely to require continued attention in higher grades as they are applied to increasingly sophisticated writing and speaking.

Standard	Grade(s)							
	3	4	5	6	7	8	9-10	11-12
L.3.1f. Ensure subject-verb and pronoun-antecedent agreement.								
L.3.3a. Choose words and phrases for effect.								
L.4.1f. Produce complete sentences, recognizing and correcting inappropriate fragments and run-ons.								
L.4.1g. Correctly use frequently confused words (e.g., *to/too/two; there/their*).								
L.4.3a. Choose words and phrases to convey ideas precisely.*								
L.4.3b. Choose punctuation for effect.								
L.5.1d. Recognize and correct inappropriate shifts in verb tense.								
L.5.2a. Use punctuation to separate items in a series.†								
L.6.1c. Recognize and correct inappropriate shifts in pronoun number and person.								
L.6.1d. Recognize and correct vague pronouns (i.e., ones with unclear or ambiguous antecedents).								
L.6.1e. Recognize variations from standard English in their own and others' writing and speaking, and identify and use strategies to improve expression in conventional language.								
L.6.2a. Use punctuation (commas, parentheses, dashes) to set off nonrestrictive/parenthetical elements.								
L.6.3a. Vary sentence patterns for meaning, reader/listener interest, and style.‡								
L.6.3b. Maintain consistency in style and tone.								
L.7.1c. Place phrases and clauses within a sentence, recognizing and correcting misplaced and dangling modifiers.								
L.7.3a. Choose language that expresses ideas precisely and concisely, recognizing and eliminating wordiness and redundancy.								
L.8.1d. Recognize and correct inappropriate shifts in verb voice and mood.								
L.9–10.1a. Use parallel structure.								

*Subsumed by L.7.3a
†Subsumed by L.9–10.1a
‡Subsumed by L.11–12.3a

Measuring Text Complexity: Three Factors

1. Quantitative measures – readability and other scores of text complexity, often best measured by computer software.
2. Qualitative measures – levels of meaning, structure, language conventionality and clarity, and knowledge demands, often best measured by an attentive human reader.
3. Reader and Task considerations – background knowledge of reader, motivation, interests, and complexity generated by tasks assigned, often best made by educators employing their professional judgment.



Text complexity described in Standard 10 is not limited to the quantitative measure, which deals exclusively with length and number of words. The more rigorous standard considers a qualitative measure, which addresses the levels of meaning, structure, language conventionality and clarity. Reader and task considerations look at the background knowledge of reader, motivation and interest. For instance, Steinbeck's *Grapes of Wrath* may be considered at the second-grade level when looking only at the quantitative measure, but when the language conventions and background knowledge of the reader are considered, it is a ninth grade level.

Range of Text Types for K-5

Students in K-5 apply the Reading standards to the following range of text types, with texts selected from a broad range of cultures and periods.

Literature			**Informational Text**
Stories	**Dramas**	**Poetry**	**Literary Nonfiction and Historical, Scientific, and Technical Texts**
Includes children's adventure stories, folktales, legends, fables, fantasy, realistic fiction, and myth	Includes staged dialogue and brief familiar scenes	Includes nursery rhymes and the subgenres of the narrative poem, limerick, and free verse poem	Includes biographies and autobiographies; books about history, social studies, science, and the arts; technical texts, including directions, forms, and information displayed in graphs, charts, or maps; and digital sources on a range of topics

Range of Text Types for 6-12

Students in 6-12 apply the Reading standards to the following range of text types, with texts selected from a broad range of cultures and periods.

Literature			**Informational Text**
Stories	**Dramas**	**Poetry**	**Literary Nonfiction and Historical, Scientific, and Technical Texts**
Includes the subgenres of adventure stories, historical fiction, mysteries, myths, science fiction, realistic fiction, allegories, parodies, satire, and graphic novels	Includes one-act and multi-act plays, both in written form and on film	Includes the subgenres of narrative poems, lyrical poems, free verse poems, sonnets, odes, ballads, and epics	Includes the subgenres of exposition, argument, and functional text in the form of personal essays, speeches, opinion pieces, essays about art or literature, biographies, memoirs, journalism, and historical, scientific, technical, or economic accounts (including digital sources) written for a broad audience

K-5 English/Language Arts Standards

Reading Standards for Literature K-5

The following standards offer a focus for instruction each year and help ensure that students gain adequate exposure to a range of texts and tasks. Rigor is also infused through the requirement that students read increasingly complex texts through the grades. Students advancing through the grades are expected to meet each year's grade-specific standards and retain or further develop skills and understandings mastered in preceding grades.

Kindergartners:	**Grade 1 students:**	**Grade 2 students:**
Key Ideas and Details		
1. With prompting and support, ask and answer questions about a literary text using key details from the text.	**1.** Ask and answer questions about a literary text using key details from the text.	**1.** Ask and answer such questions as *who*, *what*, *where*, *when*, *why*, and *how* to demonstrate understanding of a literary text using key details from the text.
2. With prompting and support, retell familiar stories, using key details.	**2.** Retell stories, using key details, and demonstrate understanding their message (e.g., teach a lesson, make you laugh, tell a scary story, tell about an event) or lesson.	**2.** Retell stories, including fables and folktales from diverse cultures, and determine the author's purpose (e.g., teach a lesson, make you laugh, tell a scary story, describe an imaginary place), lesson or moral.
3. With prompting and support, identify characters, settings, major events, and problem-solution in a story, song, or poem.	**3.** Describe characters, settings, major events, and problem-solution in a story, play, or poem, using key details.	**3.** Describe how characters in a story, play or poem respond to major events, problems, and challenges.
Craft and Structure		
4. Ask and answer questions about unknown words in a text.	**4.** Identify words and phrases in stories, plays, or poems that suggest feelings or appeal to the senses.	**4.** Identify words and phrases that supply rhythm or sensory images and meaning in a story, poem, or song (e.g., regular beats, alliteration, rhymes, repeated lines) and describe how they make a reader feel or what a reader might see in his or her mind.
5. Identify common types of texts (e.g., picture books, stories, poems, songs).	**5.** Explain major differences between books that tell stories and books that give information (fiction, non-fiction, and poetry), drawing on a wide reading of a range of text types.	**5.** Describe the overall structure of a story, including describing how the beginning introduces the story (who, what, why, where), the middle describes the problem (how characters react or feel and what they do), and the ending concludes the action or tells how the problem was solved.
6. With prompting and support, name the author and illustrator of a story and describe the role of each in telling the story.	**6.** Identify who is telling the story at various points in the text (e.g., a character in the text or a narrator/story teller).	**6.** Acknowledge differences in the points of view of characters, including by speaking in a different voice for each character when reading dialogue aloud.

Reading Standards for Literature K-5

Kindergartners:	Grade 1 students:	Grade 2 students:
Integration of Knowledge and Ideas		
7. With prompting and support, describe the relationship between illustrations and the story in which they appear (e.g., what moment in a story an illustration depicts) or use illustrations to tell or retell a story.	**7.** Use illustrations and details in a story read or read aloud to describe its characters, events, setting, or problem-solution.	**7.** Use information gained from the illustrations and words in a print or digital text to demonstrate understanding of its characters, setting, or plot (e.g., problem-solution; chronology).
8. (Not applicable to literature)	**8.** (Not applicable to literature)	**8.** (Not applicable to literature)
9. With prompting and support, compare and contrast the adventures and experiences of characters in familiar stories.	**9.** With prompting and support, compare and contrast the adventures and experiences of characters in stories.	**9.** Compare and contrast two or more versions of the same story/text (e.g., Cinderella stories) by different authors or from different cultures.
Range of Reading and Level of Complexity		
10. Actively engage in shared reading activities using literature from a variety of cultures with purpose and understanding, and scaffolding as needed.	**10.** With prompting and support, read prose and poetry from a variety of cultures of appropriate complexity for grade 1.	**10.** By the end of the year, read and comprehend a range of literature from a variety of cultures, within a complexity band appropriate to grade 2 (from upper grade 1 to grade 3), with scaffolding as needed at the high end of the range.

Reading Standards for Literature K-5

Grade 3 students:	Grade 4 students:	Grade 5 students:
Key Ideas and Details		
1. Ask and answer questions to demonstrate understanding of a text (e.g., making basic inferences and predictions), referring explicitly to details from the text as the basis for the answers.	**1.** Refer to details and examples in a text when explaining what the text says explicitly and when drawing inferences from the text.	**1.** Locate explicit information in the text to support inferences drawn from the text. Quote accurately from a text when explaining what the text says explicitly and when drawing inferences from the text.
2. Determine the author's purpose, message, lesson, or moral and explain how it is conveyed through key details in the text; summarize stories in correct sequence, including fables and folktales from diverse cultures.	**2.** Determine a theme or author's message or purpose of a story, drama, or poem using details and evidence from the text as support; summarize main ideas or events, in correct sequence, including how conflicts are resolved.	**2.** Determine a theme or author's message or purpose of a story, drama, or poem using details and evidence from the text as support, including how characters in a story or drama respond to challenges or how the speaker in a poem reflects upon a topic; summarize main ideas or events, in correct sequence.
3. Describe characters in a story (e.g., their traits, motivations, or feelings) and explain how their actions contribute to the sequence of events (e.g., creating or solving a problem).	**3.** Describe in depth a character, setting, or event in a story or drama, drawing on specific details in the text (e.g., a character's thoughts, words, or actions).	**3.** Compare and contrast two or more characters, settings, or events in a story or drama, drawing on specific details in the text (e.g., how characters interact, how conflicts are resolved).
Craft and Structure		
4. Determine the meaning of words and phrases as they are used in a text, distinguishing literal meanings from use of figurative language (e.g., exaggeration in tall tales).	**4.** Determine the meaning of words and phrases as they are used in a text, including use of figurative language and literary devices (e.g., imagery, metaphors, similes).	**4.** Determine the meaning of words and phrases as they are used in a text, including use of figurative language and literary devices (e.g., imagery, metaphors, analogies, hyperbole).
5. Refer to parts of stories, dramas, and poems when writing or speaking about a text, using terms such as chapter, scene, and stanza; describe how each successive part builds on earlier sections.	**5.** Explain major differences between poems, drama, and prose, and refer to the structural elements of poems (e.g., verse and rhythm) and drama (e.g., casts of characters, settings, descriptions, dialogue, stage directions) when writing or speaking about a text.	**5.** Explain how a series of chapters, scenes, or stanzas fits together to provide the overall structure of a particular story, drama, or poem.
6. Distinguish their own point of view from that of the narrator or those of the characters.	**6.** Compare and contrast the point of view from which different stories are narrated, including how the use of first or third person can change the way a reader might see characters or events described.	**6.** Describe how a narrator's or speaker's point of view (e.g., first person, third person) influences how events are described or how characters are developed and portrayed.

Reading Standards for Literature K-5

Grade 3 students:	Grade 4 students:	Grade 5 students:
Integration of Knowledge and Ideas		
7. Explain how specific aspects of text's illustrations contribute to what is conveyed by the words in a story (e.g., create mood, emphasize aspects of a character or setting). **8.** (Not applicable to literature) **9.** Compare and contrast the themes, settings, and plots of stories written by the same author about the same or similar characters (e.g., in books from a series).	**7.** Make connections between the text of a story or drama and a visual or oral presentation of the text, identifying where each version reflects specific descriptions and directions in the text. **8.** (Not applicable to literature) **9.** Compare and contrast the treatment of similar themes and plots (e.g., opposition of good and evil) and patterns of events (e.g., the quest) in literature.	**7.** Analyze how visual and multimedia elements contribute to the meaning, tone, or personal appeal of a text (e.g., graphic novel, multimedia presentation of fiction, folktale, myth, poem). **8.** (Not applicable to literature) **9.** Compare and contrast stories in the same genre (e.g., mysteries and adventure stories) on their approaches to similar themes and plot development.
Range of Reading and Level of Text Complexity		
10. By the end of the year, read and comprehend a range of literature from a variety of cultures, within a complexity band appropriate to grade 3 (from upper grade 2 to grade 4), with scaffolding as needed at the high end of the range.	**10.** By the end of the year, read and comprehend a range of literature from a variety of cultures, within a complexity band appropriate to grade 4 (from upper grade 3 to grade 5), with scaffolding as needed at the high end of the range.	**10.** By the end of the year, read and comprehend a range of literature from a variety of cultures, within a complexity band appropriate to grade 5 (from upper grade 4 to grade 6), with scaffolding as needed at the high end of the range.

Reading Standards for Informational Text K-5

Kindergartners:	Grade 1 students:	Grade 2 students:
Key Ideas and Details		
1. With prompting and support, elicit background/prior knowledge and experience in order to ask and answer questions about an informational text using key details from the text.	**1.** With prompting and support, elicit background/prior knowledge and experience in order to ask and answer questions about an informational text using key details from the text.	**1.** Ask and answer such questions as *who*, *what*, *where*, *when*, *why*, and *how* to demonstrate understanding of informational texts using key details from the text.
2. With prompting and support, identify the main topic and retell key details of a text.	**2.** Identify the main topic or author's purpose (e.g., to teach or tell us about …) and retell key details of a text.	**2.** Identify the main topic of a multiparagraph text as well as the focus of specific paragraphs within the text.
3. With prompting and support, describe the connection between two individuals, events, ideas, or pieces of information in a text.	**3.** Describe the connection between two individuals, events, ideas, or pieces of information in a text.	**3.** Describe the connection between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text.
Craft and Structure		
4. With prompting and support, ask and answer questions about unknown words in a text.	**4.** Ask and answer questions to help determine or clarify the meaning of words and phrases in a text.	**4.** Determine the meaning of words and phrases in a text relevant to a grade 2 topic or subject area.
5. Identify the front cover, back cover, and title page of a book.	**5.** Know and use various text features (e.g., title, labels with graphics, bold print, visual cues such as arrows, electronic menus, icons) to locate key facts or information in a text.	**5.** Know and use various text features (e.g., captions, bold print, headings, charts, bulleted or numbered lists, electronic menus, icons) to locate key facts or information in a text efficiently.
6. Name the author and illustrator of a text and describe the role of each in presenting the ideas or information in a text.	**6.** Distinguish between information provided by photos or other graphics and information provided by the words in a text.	**6.** Identify the main purpose of a text, including what the author wants to answer, explain, or describe.
Integration of Knowledge and Ideas		
7. With prompting and support, describe the relationship between illustrations and the text in which they appear (e.g., what person, place, thing, or idea in the text an illustration depicts).	**7.** Use the illustrations and details in a text to describe its key ideas.	**7.** Explain how specific images (e.g., a diagram showing how a machine works) contribute to and clarify a text.
8. With prompting and support, identify the opinions an author states in a text.	**8.** Identify the opinions an author states to support points in a text.	**8.** Describe how reasons given support specific opinions the author states in a text.
9. With prompting and support, identify basic similarities in and differences between information presented in two texts on the same topic (e.g., compare two photos or diagrams, compare two animal babies).	**9.** Identify basic similarities in and differences between information presented in two texts on the same topic (e.g., compare two graphics, descriptions, or steps in a process to make something).	**9.** Compare and contrast the most important points presented by two texts or related topics (e.g., a book about polar bears and a book about black bears).

Reading Standards for Informational Text K-5

Kindergartners:	Grade 1 students:	Grade 2 students:
Range of Reading and Level of Text Complexity		
10. Actively engage in shared reading activities using a range of topics and texts with purpose and understanding, with scaffolding as needed.	**10.** With prompting and support, read informational texts on a range of topics appropriately complex for grade 1, with scaffolding as needed.	**10.** By the end of the year, read and comprehend a range of informational texts, including history/social studies, science, and technical texts within a complexity band appropriate to grade 2 (from upper grade 1 to grade 3), with scaffolding as needed at the high end of the range.

Reading Standards for Informational Text K-5

Grade 3 students:	Grade 4 students:	Grade 5 students:
Key Ideas and Details		
1. Ask and answer questions to demonstrate understanding of a text, (e.g., explaining what the texts says explicitly, making basic inferences and predictions), referring explicitly to the text as the basis for the answers.	**1.** Locate explicit information in the text to explain what the text says explicitly and to support inferences drawn from the text.	**1.** Locate explicit information in the text to explain what the text says explicitly and to support inferences drawn from the text.
2. Determine the main idea of a text and locate details that support the main idea; paraphrase or summarize main ideas or events in a multi-paragraph text, including correct sequence and details that support the main idea.	**2.** Determine the main idea of a text and explain how it is supported by key details; paraphrase or summarize key ideas, events, or procedures including correct sequence when appropriate.	**2.** Determine the main idea and subtopics of a text and explain how they are supported by key details; paraphrase or summarize key ideas, events, or procedures including correct sequence when appropriate.
3. Describe the relationship or connection among a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text, using language that pertains to time, sequence, and cause/effect.	**3.** Explain relationships (e.g., cause-effect) among events, procedures, ideas, or concepts in a historical, scientific, or technical text, including what happened and why, based on specific information in the text.	**3.** Explain the relationships (e.g., cause-effect) or interactions among two or more individuals, events, ideas, or concepts in a historical, scientific, or technical text based on specific information in the text.
Craft and Structure		
4. Determine the meaning of general academic and domain-specific words and phrases in a text relevant to a grade 3 topic or subject area.	**4.** Determine the meaning of general academic and domain-specific words or phrases in a text relevant to a grade 4 topic or subject area.	**4.** Determine the meaning of general academic and domain-specific words and phrases in a text relevant to a grade 5 topic or subject area.
5. Use text features and search tools (e.g., table of contents, index, key words, sidebars, hyperlinks) to locate information relevant to a given topic efficiently.	**5.** Describe the overall structure (e.g., sequence, comparison, cause/effect, problem/solution) of events, ideas, concepts, or information in a text or part of a text.	**5.** Compare and contrast the overall structure (e.g., sequence, comparison, cause/effect, problem/solution) of events, ideas, concepts, or information in two or more texts.
6. Determine author's purpose; distinguish own point of view from that of the author of a text.	**6.** Determine author's purpose; compare and contrast a firsthand and secondhand account of the same event or topic; describe the differences in focus and the information provided.	**6.** Determine author's purpose; analyze multiple accounts of the same event or topic, noting important similarities and differences in the points of view they represent. (e.g., social studies topics, media messages about current events).

Reading Standards for Informational Text K-5

Grade 3 students:	Grade 4 students:	Grade 5 students:
Integration of Knowledge and Ideas		
7. Use information gained from illustrations (e.g., maps, photographs), and the words in a text to demonstrate understanding of the text (e.g., where, when, why, and how key events occur).	**7.** Interpret information presented visually, orally, or quantitatively (e.g., in charts, graphs, diagrams, time lines, animations, or interactive elements on Web pages) and explain how the information contributes to an understanding of the text in which it appears.	**7.** Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently.
8. Describe the logical connection between particular sentences and paragraphs in a text (e.g., comparison, cause/effect, first/second/third in a sequence).	**8.** Explain how an author uses reasons and evidence to support particular points in a text.	**8.** Explain how an author uses reasons and evidence to support particular points in a text, identifying which reasons and evidence supports which point(s).
9. Compare and contrast the most important points and key details presented in two texts on the same topic or related topics.	**9.** Integrate information from two texts on the same topic or related topics in order to write or speak about the subject knowledgeably.	**9.** Integrate information from several texts on the same topic or related topics in order to write or speak about the subject knowledgeably.
Range of Reading and Level of Text Complexity		
10. By the end of the year, read and comprehend a range of informational texts, including history/social studies, science, and technical texts within a complexity band appropriate to grade 3 (from upper grade 2 to grade 4), with scaffolding as needed at the high end of the range.	**10.** By the end of the year, read and comprehend a range of informational texts, including history/social studies, science, and technical texts within a complexity band appropriate to grade 4 (from upper grade 3 to grade 5), with scaffolding as needed at the high end of the range.	**10.** By the end of the year, read and comprehend a range of informational texts, including history/social studies, science, and technical texts within a complexity band appropriate to grade 5 (from upper grade 4 to grade 6), with scaffolding as needed at the high end of the range.

Reading Standards: Foundational Skills K-5

These standards are directed toward fostering students' understanding and working knowledge of concepts of print, the alphabetic principle, and other basic conventions of the English writing system. These foundational skills are not an end in and of themselves; rather, they are necessary and important components of an effective, comprehensive reading program designed to develop proficient readers with the capacity to comprehend texts across a range of types and disciplines. Instruction should be differentiated: good readers will need much less practice with these concepts than struggling readers will. The point is to teach students what they need to learn and not what they already know—to discern when particular children or activities warrant more or less attention.

Note: In kindergarten, children are expected to demonstrate increasing awareness and competence in the areas that follow.

Kindergartners:	**Grade 1 students:**
Print Concepts	
1. Demonstrate understanding of the organization and basic features of print. a. Follow words from left to right, top to bottom, and page-by-page. b. Recognize that spoken words are represented in written language by specific sequences of letters. c. Understand that words are separated by spaces in print. d. Recognize and name all upper- and lowercase letters of the alphabet.	**1.** Demonstrate understanding of the organization and basic features of print. a. Recognize the distinguishing features of a sentence (e.g., first word, capitalization, ending punctuation).
Phonological Awareness	
2. Demonstrate understanding of spoken `words, syllables, and sounds (phonemes). a. Recognize and produce rhyming words. b. Count, pronounce, blend, and segment syllables in spoken words. c. Blend and segment onsets and rimes of single-syllable spoken words. d. Isolate and pronounce the initial, medial vowel, and final sounds (phonemes) in three-phoneme (consonant-vowel-consonant, or CVC) words.* (This does not include CVCs ending with /l/, /r/, or /x/.) e. Add or substitute individual sounds (phonemes) in simple, one-syllable words to make new words. *Words, syllables, or phonemes written in /slashes/refer to their pronunciation or phonology. Thus, /CVC/ is a word with three phonemes regardless of the number of letters in the spelling of the word.	**2.** Demonstrate understanding of spoken words, syllables, and sounds (phonemes). a. Distinguish long from short vowel sounds in spoken single-syllable words. b. Orally produce single-syllable words by blending sounds (phonemes), including consonant blends. c. Isolate and pronounce initial, medial vowel, and final sounds (phonemes) in spoken single-syllable words. d. Segment spoken single-syllable words into their complete sequence of individual sounds (phonemes).

Reading Standards: Foundational Skills K-5

Note: In kindergarten, children are expected to demonstrate increasing awareness and competence in the areas that follow.

Kindergartners:	**Grade 1 students:**	**Grade 2 students:**
Phonics and Word Recognition		
3. Know and apply grade-level phonics and word analysis skills in decoding words. a. Demonstrate basic knowledge of one-to-one letter-sound correspondences by producing the primary sound or many of the most frequent sounds for each consonant. b. Associate the long and short sounds with the common spellings (graphemes) for the five major vowels. c. Read common high-frequency words by sight. (e.g., *the*, *of*, *to*, *you*, *she*, *my*, *is*, *are*, *do*, *does*). d. Distinguish between similarly spelled words by identifying the sounds of the letters that differ.	**3.** Know and apply grade-level phonics and word analysis skills in decoding words. a. Know the spelling-sound correspondences for common consonant digraphs. b. Decode regularly spelled one-syllable words. c. Know final -e and common vowel team conventions for representing long vowel sounds. d. Use knowledge that every syllable must have a vowel sound to determine the number of syllables in a printed word. e. Decode two-syllable words following basic patterns by breaking the words into syllables. f. Read words with inflectional endings. g. Recognize and read grade-appropriate irregularly spelled words.	**3.** Know and apply grade-level phonics and word analysis skills in decoding words. a. Distinguish long and short vowels when reading regularly spelled one-syllable words. b. Know spelling-sound correspondences for additional common vowel teams. c. Decode regularly spelled two-syllable words with long vowels. d. Decode words with common prefixes and suffixes. e. Identify words with inconsistent but common spelling-sound correspondences. f. Recognize and read grade-appropriate irregularly spelled words.
Fluency		
4. Read emergent-reader texts with purpose and understanding.	**4.** Read with sufficient accuracy and fluency to support comprehension. a. Read on-level text with purpose and understanding. b. Read on-level text orally with accuracy, appropriate rate, and expression on successive readings. c. Use context to confirm or self-correct word recognition and understanding, rereading as necessary.	**4.** Read with sufficient accuracy and fluency to support comprehension. a. Read on-level text with purpose and understanding. b. Read on-level text orally with accuracy, appropriate rate, and expression on successive readings. c. Use context to confirm or self-correct word recognition and understanding, rereading as necessary.

Reading Standards: Foundational Skills K-5

Grade 3 students:	Grade 4 students:	Grade 5 students:
Phonics and Word Recognition*		
3. Know and apply grade-level phonics and word analysis skills in decoding words. a. Identify and know the meaning of the most common prefixes and derivational suffixes. b. Decode words with common Latin suffixes. c. Decode multisyllable words. d. Read grade-appropriate irregularly spelled words.	**3.** Know and apply grade-level phonics and word analysis skills in decoding words. a. Use combined knowledge of all letter-sound correspondences, syllabication patterns, and morphology (e.g., roots and affixes) to read accurately unfamiliar multisyllabic words in context and out of context.	**3.** Know and apply grade-level phonics and word analysis skills in decoding words. a. Use combined knowledge of all letter-sound correspondences, syllabication patterns, and morphology (e.g., roots and affixes) to read accurately unfamiliar multisyllabic words in context and out of context.
Fluency		
4. Read with sufficient accuracy and fluency to support comprehension. a. Read on-level text with purpose and understanding. b. Read on-level prose and poetry orally with accuracy, appropriate rate, and expression on successive readings. c. Use context to confirm or self-correct word recognition and understanding, rereading as necessary.	**4.** Read with sufficient accuracy and fluency to support comprehension. a. Read on-level text with purpose and understanding. b. Read on-level prose and poetry orally with accuracy, appropriate rate, and expression on successive readings. c. Use context to confirm or self-correct word recognition and understanding, rereading as necessary.	**4.** Read with sufficient accuracy and fluency to support comprehension. a. Read on-level text with purpose and understanding. b. Read on-level prose and poetry orally with accuracy, appropriate rate, and expression on successive readings. c. Use context to confirm or self-correct word recognition and understanding, rereading as necessary.

***There are no foundational skills 1 and 2 for grades 3-5.**

Writing Standards K-5

The following standards for K - 5 offer a focus for instruction each year to help ensure that students gain adequate mastery of a range of skills and applications. Each year in their writing, students should demonstrate increasing sophistication in all aspects of language use, from vocabulary and syntax to the development and organization of ideas, and they should address increasingly demanding content and sources. Students advancing through the grades are expected to meet each year's grade-specific standards and retain or further develop skills and understandings mastered in preceding grades.

Kindergartners:	Grade 1 students:	Grade 2 students:
Text Types and Purposes		
1. Use a combination of drawing, dictating, and writing to state an opinion or a preference about a topic or part of a book (e.g., I like dogs better than cats because…; My favorite part of the story is when...; I think it was funny when…).	**1.** Write opinion pieces in which they introduce the topic or name the book they are writing about, state an opinion or preference, supply a fact (e.g., because race cars go faster than…) or reason for the opinion, and end with a sentence that restates their opinion related to a feeling or emotion (e.g., it makes me laugh; that was the scariest part).	**1.** Write opinion pieces in which they introduce the topic or book they are writing about, state an opinion, supply reasons that support the opinion, use linking words (e.g., *because*, *and*, *also*) to connect opinion and reasons, and provide one or more concluding sentences that restate or paraphrase their opinion.
2. Use a combination of drawing, dictating, and writing to compose informative/explanatory texts in which they name what they are writing about and supply some information about the topic.	**2.** Write informative/explanatory texts in which they name a topic, supply some facts about the topic, and provide some sense of closure (e.g., restate at the end the most interesting fact or the most important idea shared).	**2.** Write informative/explanatory texts in which they introduce a topic, use facts and definitions to develop points, and provide a concluding statement or one or more concluding sentences that emphasize their most important point or focus.
3. Use a combination of drawing, dictating, and writing to narrate a real or imagined event or several loosely linked events, tell about the events in the order in which they occurred, and provide an ending (how the problem was solved) or a reaction (e.g., a feeling) to what happened.	**3.** Use narrative writing to recount two or more real or imagined sequenced events, include some details regarding what happened, who was there, use linking words to signal event order (e.g., first, next, then), and provide an ending (e.g., how the problem was solved; how someone felt at the end).	**3.** Use narrative writing to retell a well-elaborated event or short sequence of real or imagined events, include details to describe actions, thoughts, and feelings, use linking words to signal event order, and provide one or more concluding sentences that restate or emphasize a feeling or lesson learned.
Production and Distribution of Writing		
4. (Begins in grade 3.)	**4.** (Begins in grade 3)	**4.** (Begins in grade 3)
5. With guidance and support from adults, respond to questions and suggestions from peers and add details to strengthen writing as needed.	**5.** With guidance and support from adults, focus on a topic, respond to questions and suggestions from peers, and add concrete and sensory details to strengthen writing as needed.	**5.** With guidance and support from adults and peers, focus on a topic and strengthen writing as needed (e.g., adding concrete and sensory details; elaborating on how the details chosen support the focus) by revising and editing.

Writing Standards K-5

Kindergartners:	Grade 1 students:	Grade 2 students:
6. With guidance and support from adults, explore a variety of digital tools to produce and publish writing, including in collaboration with peers.	**6.** With guidance and support from adults, use a variety of digital tools to produce and publish writing, including in collaboration with peers.	**6.** With guidance and support from adults, use a variety of digital tools to produce and publish writing, including in collaboration with peers.
Research to Build and Present Knowledge		
7. Participate in shared research and writing projects (e.g., explore a number of books by a favorite author and combine or summarize information/facts learned or express opinions about them).	**7.** Participate in shared research and writing projects (e.g., explore a number of "how-to" books on a given topic and use them to write a sequence of instructions or combine or summarize information/facts learned).	**7.** Participate in shared research and writing projects (e.g., read a number of books on a single topic to produce a report or visual or oral presentation; record data from science observations).
8. With guidance and support from adults, recall information from experiences or gather information from provided sources to answer a question.	**8.** With guidance and support from adults, recall information from experiences or gather information from provided sources to answer a question.	**8.** Recall information from experiences or gather information from provided sources to answer a question.
9. (Begins in grade 4)	**9.** (Begins in grade 4)	**9.** (Begins in grade 4)
Range of Writing		
10. (Begins in grade 3)	**10.** (Begins in grade 3)	**10.** (Begins in grade 3)

Writing Standards K-5

Grade 3 students:	Grade 4 students:	Grade 5 students:
Text Types and Purposes		
1. Write opinion pieces on topics or texts, supporting a point of view with fact- or text-based reasons (e.g., I like large dogs better than small dogs because they can pull a sled and run for a longer time than small dogs can). a. Introduce the topic or text they are writing about, state an opinion, and create an organizational structure that lists fact- or text-based reasons. b. Provide reasons that support the opinion. c. Link opinion and reasons using words and phrases (e.g., *because*, *therefore*, *since*, *for example*). d. Provide a concluding statement or section that reinforces or restates the opinion.	**1.** Write opinion pieces on topics or texts, supporting a point of view with fact- or text-based reasons and information (e.g., The character ___ was brave because she ____). a. Introduce a topic or text clearly, state an opinion, and create an organizational structure in which related ideas are grouped to support the writer's purpose. b. Provide reasons that are supported by facts and details. c. Link opinion and reasons using words and phrases (e.g., *for instance*, *in order to*, *in addition*). d. Provide a concluding statement or section that reinforces or restates the opinion presented.	**1.** Write opinion pieces on topics or texts, supporting a point of view with fact- or text-based reasons and information. a. Introduce a topic or text clearly, state an opinion, and create an organizational structure in which ideas are logically grouped to support the writer's purpose. b. Provide logically ordered reasons that are supported by facts and details. c. Link opinion and reasons using words, phrases, and clauses (e.g., *consequently*, *specifically, most of all*). d. Provide a concluding statement or section that reinforces or restates the opinion presented.
2. Write informative/explanatory texts to examine a topic and convey ideas and information clearly. a. Introduce a topic and group related information together; include labeled or captioned visuals when useful to aiding comprehension. b. Develop the topic with facts, definitions, details, and explanations that support the focus. c. Use linking words and phrases (e.g., *also*, *another*, *and*, *more*, *but*) to connect ideas within categories of information.	**2.** Write informative/explanatory texts to examine a topic and convey ideas and information clearly. a. Introduce a topic clearly and group related information in paragraphs and sections; include formatting (e.g., headings), labeled or captioned visuals/diagrams, and multimedia when useful to aiding comprehension. b. Develop the topic with facts, definitions, concrete details, quotations, or other information/explanations and examples that support the focus. c. Link ideas within categories of information using words and phrases (e.g., *another*, *for example*, *also*, *because*).	**2.** Write informative/explanatory texts to examine a topic and convey ideas and information clearly. a. Introduce a topic clearly, provide a general observation and focus, and group related information logically; include formatting (e.g., headings), labeled or captioned visuals/graphics, and multimedia when useful to aiding comprehension. b. Develop the topic with facts, definitions, concrete details, quotations, or other information and examples that support the topic. c. Link ideas within and across categories of information using words, phrases, and clauses (e.g., *in contrast*, *especially*).

Writing Standards K-5

Grade 3 students:	Grade 4 students:	Grade 5 students:
d. Provide a concluding statement or section that paraphrases the focus of the text.	d. Use precise language and domain-specific vocabulary to inform about or explain the topic. e. Provide a concluding statement or section that paraphrases the focus of the text or explanation presented.	d. Use precise language and domain-specific vocabulary to inform about or explain the topic. e. Provide a concluding statement or section that paraphrases the focus of the text or explanation presented.
3. Use narrative writing to develop real or imagined characters, experiences, or events using effective narrative techniques (dialogue, description, elaboration, problem-solution, figurative language), and clear event sequences (chronology). a. Establish a context or situation and introduce a narrator and/or characters; organize an event sequence that unfolds naturally. b. Use narrative techniques, such as dialogue, description and elaboration, and concrete and sensory details to describe actions, thoughts, and feelings and to develop experiences and events showing the response of characters to situations or problems. c. Use transitional words and phrases to signal event sequences (e.g., *later, soon after*). d. Provide a sense of closure (e.g., how a problem was solved or how the event ended).	**3.** Use narrative writing to develop real or imagined characters, experiences, or events using effective narrative techniques (dialogue, description, elaboration, problem-solution, figurative language) and clear event sequences (chronology). a. Orient the reader by establishing a context or situation and introducing a narrator and/or characters; organize an event sequence that unfolds naturally. b. Use narrative techniques, such as dialogue, description and elaboration, and concrete and sensory details to describe actions, thoughts, and motivations and to develop experiences and events showing the responses of characters to situations, problems, or conflicts. c. Use a variety of transitional words and phrases to develop the sequence of events. d. Use concrete words and phrases and sensory details, and elaboration to convey experiences and events precisely. e. Provide a conclusion that follows from the narrated experiences or events.	**3.** Use narrative writing to develop real or imagined characters, experiences, or events using effective narrative techniques (dialogue, description, elaboration, problem-solution, figurative language) and clear event sequences (chronology). a. Orient the reader by establishing a context or situation and introducing a narrator and/or characters; organize an event sequence that unfolds naturally. b. Use narrative techniques, such as dialogue, description and elaboration, concrete and sensory details, literary devices, and pacing to describe actions, thoughts, and motivations and to develop experiences and events showing the responses of characters to situations, problems, or conflicts. c. Use a variety of transitional words, phrases, and devices (e.g., foreshadowing) to develop the pacing and sequence of events. d. Use concrete words and phrases, sensory details, and elaboration to convey experiences and events precisely. e. Provide a conclusion that follows from the narrated experiences or events.

Writing Standards K-5

Grade 3 students:	Grade 4 students:	Grade 5 students:
Production and Distribution of Writing		
4. With guidance and support from adults, produce writing in which the development and organization are appropriate to task and purpose. (Grade-specific expectations for writing types are defined in standards 1–3 above.)	**4.** Produce clear and coherent writing in which the development and organization are appropriate to task, purpose, and audience. (Grade-specific expectations for writing types are defined in standards 1–3 above.)	**4.** Produce clear and coherent writing in which the development and organization are appropriate to task, purpose, and audience. (Grade-specific expectations for writing types are defined in standards 1–3 above.)
5. With guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, and editing. (Editing for conventions should demonstrate command of Language standards 1–3 up to and including grade 3.)	**5.** With guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, and editing. (Editing for conventions should demonstrate command of Language standards 1–3 up to and including grade 4.)	**5.** With guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach. (Editing for conventions should demonstrate command of Language standards 1–3 up to and including grade 5.)
6. With guidance and support from adults, use technology to produce and publish writing (using keyboarding skills) as well as to interact and collaborate with others and to locate information about topics.	**6.** With some guidance and support from adults, use technology, including the Internet, to produce, edit, and publish writing as well as to interact and collaborate with others and to locate information about topics; demonstrate sufficient command of keyboarding skills to type a minimum of one page in a single sitting.	**6.** With some guidance and support from adults, use technology, including the Internet, to produce, edit, and publish writing as well as to interact and collaborate with others; demonstrate sufficient command of keyboarding skills to type a minimum of two pages in a single sitting.
Research to Build and Present Knowledge		
7. Conduct short research projects that build knowledge about a topic.	**7.** Conduct short research projects that build knowledge through investigation of different aspects of a topic.	**7.** Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic.
8. Recall information from experiences or gather information from print and digital sources; take brief notes on sources and sort evidence into provided categories.	**8.** Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources.	**8.** Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources.

Writing Standards K-5

Grade 3 students:	Grade 4 students:	Grade 5 students:
9. (Begins in grade 4)	**9.** Draw evidence from literary or informational texts to support analysis, reflection, and research. a. Apply grade 4 Reading standards to literature (e.g., "Describe in depth a character, setting, or event in a story or drama, drawing on specific details in the text [e.g., a character's thoughts, words, or actions]."). b. Apply grade 4 Reading standards to informational texts (e.g., "Explain how an author uses reasons and evidence to support particular points in a text.").	**9.** Draw evidence from literary or informational texts to support analysis, reflection, and research. a. Apply grade 5 Reading standards to literature (e.g., "Compare and contrast two or more characters, settings, or events in a story or drama, drawing on specific details in the text [e.g., how characters interact, how conflicts are resolved]."). b. Apply grade 5 Reading standards to informational texts (e.g., "Explain how an author uses reasons and evidence to support particular points in a text, identifying which reasons and evidence supports which point[s].").
Range of Writing		
10. Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.	**10.** Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.	**10.** Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Speaking and Listening Standards K-5

The following standards for K-5 offer a focus for instruction each year to help ensure that students gain adequate mastery of a range of skills and applications. Students advancing through the grades are expected to meet each year's grade-specific standards and retain or further develop skills and understandings mastered in preceding grades.

Kindergartners:	Grade 1 students:	Grade 2 students:
Comprehension and Collaboration		
1. Participate in collaborative conversations with diverse partners about kindergarten topics and texts with peers and adults in small and larger groups. a. Follow agreed-upon rules for discussions (e.g., listening to others and taking turns speaking about the topics and texts under discussion). b. Continue a conversation through multiple exchanges.	**1.** Participate in collaborative conversations with diverse partners about grade 1 topics and texts with peers and adults in small and larger groups. a. Follow agreed-upon rules for discussions (e.g., listening to others with care, speaking one at a time about the topics and texts under discussion). b. Build on others' talk in conversations by responding to the comments of others through multiple exchanges. c. Ask questions to clear up any confusion about the topics and texts under discussion.	**1.** Participate in collaborative conversations with diverse partners about grade 2 topics and texts with peers and adults in small and larger groups. a. Follow agreed-upon rules for discussions (e.g., gaining the floor in respectful ways, listening to others with care, speaking one at a time about the topics and texts under discussion). b. Build on others' talk in conversations by linking their comments to the remarks of others. c. Ask for clarification and further explanation as needed about the topics and texts under discussions.
2. Confirm understanding of a text read aloud or information presented orally or through other media by asking and answering questions about key details and requesting clarification if something is not understood.	**2.** Ask and answer questions about key details in a text read aloud or information presented orally or through other media.	**2.** Retell or describe key ideas or details from a text read aloud or information presented orally or through other media.
3. Ask and answer questions in order to seek help, get information, or clarify something that is not understood.	**3.** Ask and answer questions about what a speaker says in order to gather additional information or clarify something that is not understood.	**3.** Ask and answer questions about what a speaker says in order to clarify comprehension, gather additional information, or deepen understanding of a topic or issue.
Presentation of Knowledge and Ideas		
4. Describe familiar people, places, things, and events, and with prompting and support, provide additional related details.	**4.** Describe people, places, things, and events with relevant details, expressing ideas and feelings clearly.	**4.** Tell a story or retell an experience with relevant facts and relevant, descriptive details, speaking audibly in coherent sentences.

Speaking and Listening Standards K-5

Kindergartners:	**Grade 1 students:**	**Grade 2 students:**
5. Add drawings or other visual displays to descriptions as desired to provide additional details.	**5.** Add drawings or other visual displays to descriptions when appropriate to clarify ideas, thoughts, and feelings.	**5.** Create audio recordings of stories or poems; add drawings or other visual displays to stories or recounts of experiences when appropriate to clarify ideas, thoughts, and feelings.
6. Speak audibly and express thoughts, feelings, and ideas clearly in complete sentences when appropriate to task and situation.	**6.** Produce complete sentences when appropriate to task and situation. (See grade 1 Language standards 1 and 3 for specific expectations.)	**6.** Produce complete sentences when appropriate to task and situation in order to provide requested detail or clarification. (See grade 2 Language standards 1 and 3 for specific expectations.)

Speaking and Listening Standards K-5

Grade 3 students:	Grade 4 students:	Grade 5 students:
Comprehension and Collaboration		
1. Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 3 topics and texts, building on others' ideas and expressing their own clearly. a. After learning a protocol (e.g., Socratic method), come to discussions prepared, having read or studied required material; explicitly draw on that preparation and other information known about the topic to explore ideas under discussion. b. Follow agreed-upon rules for discussions (e.g., gaining the floor in respectful ways, listening to others with care, speaking one at a time about the topics and texts under discussion). c. Ask questions to check understanding of information presented, stay on topic, and link their comments to the remarks of others. d. Explain their own ideas and understanding in light of the discussion.	**1.** Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 4 topics and texts, building on others' ideas and expressing their own clearly. a. Come to discussions prepared, having read or studied required material; explicitly draw on that preparation and other information known about the topic to explore ideas under discussion. b. Follow agreed-upon rules for discussions and carry out assigned roles. c. Pose and respond to specific questions to clarify or follow up on information, and make comments that contribute to the discussion and link to the remarks of others. d. Review the key ideas expressed and explain their own ideas and understanding in light of the discussion.	**1.** Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 5 topics and texts, building on others' ideas and expressing their own clearly. a. Come to discussions prepared, having read or studied required material; explicitly draw on that preparation and other information known about the topic to explore ideas under discussion. b. Follow agreed-upon rules for discussions and carry out assigned roles. c. Pose and respond to specific questions by making comments that contribute to the discussion and elaborate on the remarks of others. d. Review the key ideas expressed and draw conclusions in light of information and knowledge gained from the discussions.
2. Determine the main ideas and supporting details of a text read aloud or information presented in diverse media and formats, including visually, quantitatively, and orally.	**2.** Paraphrase portions of a text read aloud or information presented in diverse media and formats, including visually, quantitatively, and orally.	**2.** Summarize a written text read aloud or information presented in diverse media and formats, including visually, quantitatively, and orally.
3. Ask and answer questions about information from a speaker, offering appropriate elaboration or explanations and detail.	**3.** Identify the reasons and evidence a speaker provides to support particular points (e.g., using a graphic organizer to show connections between reasons given and support provided).	**3.** Summarize the points a speaker makes and explain how each claim is supported by reasons and evidence (e.g., use a graphic organizer or note cards completed while listening to summarize or paraphrase key ideas presented by a speaker).

Speaking and Listening Standards K-5

Grade 3 students:	Grade 4 students:	Grade 5 students:
Presentation of Knowledge and Ideas		
4. Report on a topic or text, tell a story, or recount an experience with appropriate facts and relevant, descriptive details, speaking clearly at an understandable pace.	**4.** Report on a topic or text, tell a story, or recount an experience in an organized manner, using appropriate facts and relevant, descriptive details to support main ideas or themes; speak clearly at an understandable pace.	**4.** Report on a topic or text or present an opinion, sequencing ideas logically and using appropriate facts and relevant, descriptive details to support main ideas or themes; speak clearly at an understandable pace.
5. Create audio recordings of stories or poems that demonstrate fluid reading at an understandable pace; use techniques that engage the listener (e.g., inflection, different voices); and add visual displays when appropriate to emphasize or enhance certain facts or details.	**5.** Add audio recordings and visual displays to presentations when appropriate to enhance the development of main ideas or themes and to engage listeners more fully.	**5.** Include multimedia components (e.g., graphics, sound) and visual displays in presentations when appropriate to enhance the development of main ideas or themes and to engage listeners more fully.
6. Speak in complete sentences when appropriate to task and situation in order to provide requested detail or clarification. (See grade 3 Language standards 1 and 3 for specific expectations.)	**6.** Differentiate between contexts that call for formal English (e.g., presenting ideas) and situations where informal discourse is appropriate (e.g., small-group discussion); use formal English when appropriate to task and situation. (See grade 4 Language standards 1 and 3 for specific expectations.)	**6.** Adapt speech to a variety of contexts and tasks, using formal English when appropriate to task and situation. (See grade 5 Language standards 1 and 3 for specific expectations.)

Language Standards K-5

The following standards for grades K-5 offer a focus for instruction each year to help ensure that students gain adequate mastery of a range of skills and applications. Students advancing through the grades are expected to meet each year's grade-specific standards and retain or further develop skills and understandings mastered in preceding grades. Beginning in grade 3, skills and understandings that are particularly likely to require continued attention in higher grades as they are applied to increasingly sophisticated writing and speaking are marked with an asterisk (*).For a complete list see the Literacy Progressive Skills table in the Introduction.

Kindergartners:	Grade 1 students:	Grade 2 students:
Conventions of Standard English		
1. Demonstrate command of the conventions of standard English grammar and usage when writing or speaking. a. Print many upper- and lowercase letters. b. Use frequently occurring nouns and verbs. c. Form regular plural nouns orally by adding /s/ or /es/ (e.g., *dog*, *dogs*; *wish*, *wishes*). d. Understand and use question words (interrogatives) (e.g., *who*, *what*, *where*, *when*, *why*, *how*). e. Use the most frequently occurring prepositions (e.g., *to, from, in, out, on, off, for, of, by, with*). f. Produce and expand complete sentences in shared language activities.	**1.** Demonstrate command of the conventions of standard English grammar and usage when writing or speaking. a. Print all upper- and lowercase letters. b. Use common, proper, and possessive nouns. c. Use singular and plural nouns with matching verbs in basic sentences (e.g., *He hops; We hop).* d. Use personal, possessive, and indefinite pronouns (e.g., *I me, my; they, them, their, anyone, everything*). e. Use verbs to convey a sense of past, present, and future (e.g., Yesterday I walked home; Today I walk home; Tomorrow I will walk home). f. Use frequently occurring adjectives. g. Use frequently occurring conjunctions (e.g., *and, but, or, so, because*). h. Use determiners (e.g., articles, demonstratives). i. Use frequently occurring prepositions (e.g., *during, beyond, toward*). j. Produce and expand complete simple and compound declarative, interrogative, imperative, and exclamatory sentences in response to prompts.	**1.** Demonstrate command of the conventions of standard English grammar and usage when writing or speaking. a. Use collective nouns (e.g., *group*). b. Form and use frequently occurring irregular plural nouns (e.g., *feet, children, teeth, mice, fish*). c. Use reflexive pronouns (e.g., *myself, ourselves*). d. Form and use the past tense of frequently occurring irregular verbs (e.g., sat, hid, told). e. Use adjectives and adverbs, and choose between them depending on what is to be modified. f. Produce, expand, and rearrange complete simple and compound sentences (e.g., The boy watched the movie; The little boy watched the movie; The action movie was watched by the little boy).

Language Standards K-5

Kindergartners:	Grade 1 students:	Grade 2 students:
2. Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing. a. Capitalize the first word in a sentence, the first letter of the student's name, and the pronoun *I*. b. Recognize and name end punctuation. c. Write a letter or letters for most consonant and short-vowel sounds (phonemes). d. Spell simple words phonetically, drawing on knowledge of sound-letter relationships.	**2.** Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing. a. Capitalize dates and names of people. b. Use end punctuation for sentences. c. Use commas in dates and to separate single words in a series. d. Use conventional spelling for words with common spelling patterns and for frequently occurring irregular words. e. Spell untaught words phonetically, drawing on phonemic awareness and spelling conventions.	**2.** Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing. a. Capitalize holidays, product names, and geographic names. b. Use commas in greetings and closing of letters. c. Use an apostrophe to form contractions and frequently occurring possessives. d. Generalize learned spelling patterns when writing words (e.g., *cage* → *badge*; *boy* → *boil*). e. Consult reference materials, including beginning dictionaries, as needed to check and correct spellings.
Knowledge of Language		
3. (Begins in grade 2)	**3.** (Begins in grade 2)	**3.** Use knowledge of language and its conventions when writing, speaking, reading, or listening. a. Compare formal and informal uses of English.
Vocabulary Acquisition and Use		
4. Determine or clarify the meaning of unknown and multiple-meaning words and phrases based on kindergarten reading and content. a. Identify new meanings for familiar words and apply them accurately (e.g., knowing *duck* is a bird and learning the verb *to duck*). b. Use the most frequently occurring inflections and affixes (e.g., *-ed*, *-s*, *re-*, *un-*, *pre-*, *-ful*, *-less*) as a clue to the meaning of an unknown word.	**4.** Determine or clarify the meaning of unknown and multiple-meaning words and phrases based on grade 1 reading and content, choosing flexibly from an array of strategies. a. Use sentence-level context as a clue to the meaning of a word or phrase. b. Use frequently occurring affixes as a clue to the meaning of a word. c. Identify frequently occurring root words (e.g., *look*) and their inflectional forms (e.g., *looks*, *looked*, *looking*).	**4.** Determine or clarify the meaning of unknown and multiple-meaning words and phrases based on grade 2 reading and content, choosing flexibly from an array of strategies. a. Use sentence-level context as a clue to the meaning of a word or phrase. b. Determine the meaning of the new word formed when a known prefix is added to a known word (e.g., *happy/unhappy*, *tell/retell*). c. Use a known root word as a clue to the meaning of an unknown word with the same root (e.g., *addition*, *additional*).

Language Standards K-5

Kindergartners:	Grade 1 students:	Grade 2 students:
		d. Use knowledge of the meaning of individual words to predict the meaning of compound words (e.g., *birdhouse*, *lighthouse*, *housefly*; *bookshelf*, *notebook*, *bookmark*). e. Use glossaries and beginning picture dictionaries, both print and digital, to determine or clarify the meaning of words and phrases.
5. With guidance and support from adults, explore word relationships and nuances in word meanings. a. Sort common objects into categories (e.g., shapes, foods) to gain a sense of the concepts the categories represent. b. Demonstrate understanding of frequently occurring verbs and adjectives by relating them to their opposites (antonyms). c. Identify real-life connections between words and their use (e.g., note places at school that are *colorful*). d. Distinguish shades of meaning among verbs describing the same general action (e.g., *walk*, *march*, *strut*, *prance*) by acting out the meanings.	**5.** With guidance and support from adults, demonstrate understanding of word relationships and nuances in word meanings. a. Sort words into categories (e.g., colors, clothing) to gain a sense of the concepts the categories represent. b. Define words by category and by one or more key attributes (e.g., a *duck* is a bird that swims; a *tiger* is a large cat with stripes). c. Identify real-life connections between words and their use (e.g., note places at home that are *cozy*). d. Distinguish shades of meaning among verbs differing in manner (e.g., *look*, *peek*, *glance*, *stare*, *glare*, *scowl*) and adjectives differing in intensity (e.g., *large*, *gigantic*) by defining or choosing them or by acting out the meanings.	**5.** Demonstrate understanding of word relationships and nuances in word meanings. a. Identify real-life connections between words and their use (e.g., describe foods that are *spicy* or *juicy*). b. Distinguish shades of meaning among closely related verbs (e.g., *toss*, *throw*, *hurl*) and closely related adjectives (e.g., *thin*, *slender*, *skinny*, *scrawny*).
6. Use words and phrases acquired through conversations, reading and being read to, and responding to texts.	**6.** Use words and phrases acquired through conversations, reading and being read to, and responding to texts, including using frequently occurring conjunctions to signal simple relationships (e.g., *because*).	**6.** Use words and phrases acquired through conversations, reading and being read to, and responding to texts, including using adjectives and adverbs to describe (e.g., When other kids are happy that makes me happy).

Language Standards K-5

Grade 3 students:	Grade 4 students:	Grade 5 students:
Conventions of Standard English		
1. Demonstrate command of the conventions of standard English grammar and usage when writing or speaking. a. Use nouns, pronouns, verbs, adjectives, and adverbs appropriate to function and purpose in order to apply the conventions of English. b. Form and use regular and irregular plural nouns. c. Use abstract nouns (e.g., *childhood*). d. Form and use regular and irregular verbs. e. Form and use the simple (e.g., *I walked*; *I walk*; *I will walk*) verb tenses. f. Ensure subject-verb and pronoun-antecedent agreement.* g. Form and use comparative and superlative adjectives and adverbs, and choose between them depending on what is to be modified. h. Use coordinating and subordinating conjunctions. i. Produce simple, compound, and complex sentences.	**1.** Demonstrate command of the conventions of standard English grammar and usage when writing or speaking. a. Use nouns, pronouns, verbs, adjectives, adverbs, relative pronouns (*who*, *whose*, *whom*, *which*, *that*), and relative adverbs (*where, when, why*) appropriate to function and purpose in order to apply the conventions of English. b. Form and use the progressive (e.g., *I was walking*; *I am walking*; *I will be walking*) verb tenses. c. Use modal auxiliaries (e.g., *can*, *may*, *must*) to convey various conditions. d. Order adjectives within sentences according to conventional patterns (e.g., *a small red bag* rather than *a red small bag*). e. Form and use prepositional phrases. f. Produce complete sentences, recognizing and correcting inappropriate fragments and run-ons.* g. Correctly use frequently confused words (e.g., *to*, *too, two, there, their).**	**1.** Demonstrate command of the conventions of standard English grammar and usage when writing or speaking. a. Use nouns, pronouns, verbs, adjectives, adverbs, relative pronouns, relative adverbs, conjunctions, prepositions, and interjections appropriate to function and purpose in order to apply the conventions of English. b. Form and use the perfect (e.g., *I had walked*; *I have walked*; *I will have walked*) verb tenses. c. Use verb tense to convey various times, sequences, states, and conditions. d. Recognize and correct inappropriate shifts in verb tense.* e. Use correlative conjunctions (e.g., *either/or, neither/nor*).

Language Standards K-5

Grade 3 students:	Grade 4 students:	Grade 5 students:
2. Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing. a. Capitalize appropriate words in titles. b. Use commas in addresses. c. Use commas and quotation marks in dialogue. d. Form and use possessives. e. Use conventional spelling for high-frequency and other studied words and for adding suffixes to base words (e.g., sitting, smiled, cries, happiness). f. Use spelling patterns and generalizations (e.g., word families, position-based spellings, syllable patterns, ending rules, meaningful word parts) in writing words. g. Consult reference materials, including beginning dictionaries, as needed to check and correct spelling.	**2.** Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing. a. Use correct capitalization. b. Use commas and quotation marks to mark direct speech and quotations from a text. c. Use a comma before a coordinating conjunction in a compound sentence. d. Spell grade-appropriate words correctly, consulting references as needed.	**2.** Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing. a. Use punctuation to separate items in a series.* b. Use a comma to separate an introductory element from the rest of the sentence. c. Use a comma to set off the words yes and no (e.g., Yes, thank you), to set off a tag question from the rest of the sentence (e.g., It's true, isn't it?), and to indicate direct address (e.g., Is that you, Steve?). d. Use underlining, quotation marks, or italics to indicate titles of works. e. Spell grade-appropriate words correctly, consulting references as needed.
Knowledge of Language		
3. Use knowledge of language and its conventions when writing, speaking, reading, or listening. a. Choose words and phrases for effect.* b. Recognize and observe differences between the conventions of spoken and written standard English.	**3.** Use knowledge of language and its conventions when writing, speaking, reading, or listening. a. Choose words and phrases to convey ideas precisely.* b. Choose punctuation for effect.* c. Differentiate between contexts that call for formal English (e.g., presenting ideas) and situations where informal discourse is appropriate (e.g., small-group discussion).	**3.** Use knowledge of language and its conventions when writing, speaking, reading, or listening. a. Expand, combine, and reduce sentences for meaning, reader/listener interest, and style. b. Compare and contrast the varieties of English (e.g., dialects, registers) used in stories, dramas, or poems.

Language Standards K-5

Grade 3 students:	Grade 4 students:	Grade 5 students:
Vocabulary Acquisition and Use		
4. Determine or clarify the meaning of unknown and multiple-meaning word and phrases based on *grade 3 reading and content*, choosing flexibly from a range of strategies. a. Use a sentence-level context as a clue to the meaning of a word or phrase. b. Determine the meaning of a new word formed when a known affix is added to a known word (e.g., *agreeable/disagreeable, comfortable/uncomfortable, care/careless, heat/preheat*). c. Use a known root word as a clue to the meaning of an unknown word with the same root (e.g., *company*, *companion*). d. Use glossaries or beginning dictionaries, both print and digital, to determine or clarify the precise meaning of key words and phrases.	**4.** Determine or clarify the meaning of unknown and multiple-meaning words and phrases based on grade 4 reading and content, choosing flexibly from a range of strategies. a. Determine meaning of unfamiliar words by using knowledge of phonetics, word structure, and language structure through reading words in text (word order, grammar, syntax), use context (e.g., definitions, examples, or restatements in text) as a clue to the meaning of a word or phrase. b. Use common, grade-appropriate Greek and Latin affixes and roots as clues to the meaning of a word (e.g., *telegraph, photograph, autograph*). c. Consult reference materials (e.g., dictionaries, glossaries, thesauruses), both print and digital, to find the pronunciation and determine or clarify the precise meaning of key words and phrases.	**4.** Determine or clarify the meaning of unknown and multiple-meaning words and phrases based on grade 5 reading and content, choosing flexibly from a range of strategies. a. Determine meaning of unfamiliar words by using knowledge of word structure (root words, prefixes, suffixes, abbreviations) and language structure through reading words in text (word order, grammar, syntax), use context (e.g., cause/effect relationships and comparisons in text) as a clue to the meaning of a word or phrase. b. Use common, grade-appropriate Greek and Latin affixes and roots as clues to the meaning of a word (e.g., *photograph, photosynthesis*). c. Consult reference materials (e.g., dictionaries, glossaries, thesauruses), both printing and digital, to find the pronunciation and determine or clarify the precise meaning of key words and phrases.

Language Standards K-5

Grade 3 students:	Grade 4 students:	Grade 5 students:
5. Demonstrate understanding of word relationships and nuances in word meanings. a. Distinguish the literal and nonliteral meanings of words and phrases in context (e.g., *take steps*). b. Identify real-life connections between words and their use (e.g., describe people who are *friendly* or *helpful*). c. Distinguish shades of meaning among related words (e.g., words that describe states of mind or degrees of certainty, such as *knew*, *believed*).	**5.** Demonstrate understanding of figurative language, word relationships, and nuances in word meanings. a. Explain the meaning of simple similes and metaphors (e.g., as pretty as a picture) in context. b. Recognize and explain the meaning of common idioms, adages, and proverbs. c. Demonstrate understanding of words by relating them to their opposites (antonyms) and to words with similar but not identical meanings (synonyms).	**5.** Demonstrate understanding of figurative language, word relationships, and nuances in word meanings. a. Interpret figurative language, including similes and metaphors, in context. b. Recognize and explain the meaning of common idioms, adages, and proverbs. c. Use the relationship between particular words (e.g., synonyms, antonyms, homographs) to better understand each of the words.
6. Acquire and accurately use grade-appropriate conversational, general academic, and domain-specific words and phrases, including those that signal spatial and temporal relationships (e.g., After dinner that night we went looking for them).	**6.** Acquire and accurately use grade-appropriate general academic and domain-specific words and phrases, including those that signal precise actions, emotions, or states of being (e.g., *quizzed*, *whined*, *stammered*) and that are basic to a particular topic (e.g., *wildlife*, *conservation*, and *endangered* when discussing animal preservation).	**6.** Acquire and accurately use grade-appropriate general academic and domain-specific words and phrases, including those that signal contrast, addition, and other logical relationships (e.g., *however*, *although*, *nevertheless*, *similarly*, *moreover*, *in addition*).

6-12 English/Language Arts Standards

Reading Standards for Literature 6-12

The following standards offer a focus for instruction each year and help ensure that students gain adequate exposure to a range of texts and tasks. Rigor is also infused through the requirement that students read increasingly complex texts through the grades. Students advancing through the grades are expected to meet each year's grade-specific standards and retain or further develop skills and understandings mastered in preceding grades.

Grade 6 students:	**Grade 7 students:**	**Grade 8 students:**
Key Ideas and Details		
1. Cite textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text. **2.** Determine a theme or central idea of a text and how it is conveyed through particular details; restate and summarize main ideas or events, in correct sequence, after reading a text.	**1.** Cite several pieces of textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text. **2.** Determine a theme or central idea of a text and analyze its development over the course of the text; restate and summarize main ideas or events, in correct sequence, after reading a text.	**1.** Cite the textual evidence that most strongly supports an analysis of what the text says explicitly as well as inferences drawn from the text. **2.** Determine a theme or central idea of a text and analyze its development over the course of the text, including its relationship to the characters, setting, and plot; restate and summarize main ideas or events, in correct sequence, after reading a text.
3. Describe how a particular story's or drama's plot unfolds in a series of episodes as well as how the characters respond or change as the plot moves toward a resolution or as the narrative advances.	**3.** Analyze how particular elements of a story or drama interact (e.g., how setting shapes the characters or plot).	**3.** Analyze how particular lines of dialogue or incidents in a story or drama propel the action, reveal aspects of a character, or provoke a decision.
Craft and Structure		
4. Determine the meaning of words and phrases as they are used in a text, including figurative and connotative meanings. Analyze the impact of a specific word choice on meaning and tone.	**4.** Determine the meaning of words and phrases as they are used in a text, including figurative and connotative meanings; analyze the impact of a specific word choice on meaning and tone.	**4.** Determine the meaning of words and phrases as they are used in a text, including figurative and connotative meanings; analyze the impact of specific word choices on meaning and tone, including analogies or allusions to other texts.
5. Analyze the overall structure of a text: how a particular sentence, chapter, scene, or stanza fits into the overall work and analyzing how it contributes to the development of the characters, theme, setting, or plot.	**5.** Analyze the overall structure of a text: how a drama's or poem's form or structure (e.g. sonnet, soliloquy) contributes to its meaning, including analyzing the impact of rhymes and other repetitions of sounds (e.g., alliteration) on a specific verse or stanza of a poem or section of a story or drama.	**5.** Analyze the overall structure of a text: compare and contrast the structure of two or more texts and analyze how the differing structure of each text contributes to its meaning and style.

Reading Standards for Literature 6-12

Grade 6 students:	Grade 7 students:	Grade 8 students:
6. Determine author's purpose and explain how an author develops the point of view of the narrator or speaker in a text.	**6.** Analyze author's purpose and how an author establishes and contrasts the points of view of different characters or narrators in a text.	**6.** Analyze author's purpose and how differences in the points of view of the characters and the audience or reader (e.g., created through the use of dramatic irony) create such effects as suspense or humor.
Integration of Knowledge and Ideas		
7. Compare and contrast the experience of reading a story, drama, or poem to listening to or viewing an audio, video, or live version of the text, including contrasting what they "see" and "hear" when reading the text to what they perceive when they listen or watch (e.g., *Shiloh*).	**7.** Compare and contrast a written story, drama, or poem to its audio, filmed, staged, or multimedia version, analyzing the effects of techniques unique to each medium (e.g., lighting, sound, color, or camera focus and angles in a film) (e.g., *The Incredible Journey, Call of the Wild*).	**7.** Analyze the extent to which a filmed or live production of a story or drama stays faithful to or departs from the text or script, evaluating the choices made by the director or actors (e.g., *Old Yeller, Brian's Song, The Miracle Worker*).
8. (Not applicable to literature)	**8.** (Not applicable to literature)	**8.** (Not applicable to literature)
9. Compare and contrast texts in different forms or genres (e.g., stories and poems; historical novels and fantasy stories) in terms of their approaches to similar themes and topics.	**9.** Compare and contrast a fictional portrayal of a time, place, or character and a historical or cultural account of the same period as a means of understanding how authors of fiction use or alter history.	**9.** Analyze how a modern work of fiction draws on themes, patterns of events, or character types from myths, traditional stories, or religious works such as the Bible, including describing how the material is rendered new.
Range of Reading and Level of Text Complexity		
10. By the end of the year, read and comprehend a range of literature from a variety of cultures, within a complexity band appropriate to grade 6 (from upper grade 5 to grade 7), with scaffolding as needed at the high end of the range.	**10.** By the end of the year, read and comprehend a range of literature from a variety of cultures, within a complexity band appropriate to grade 7 (from upper grade 6 to grade 8), with scaffolding as needed at the high end of the range.	**10.** By the end of the year, read and comprehend a range of literature from a variety of cultures, within a complexity band appropriate to grade 8 (from upper grade 7 to grade 9), with scaffolding as needed at the high end of the range.

Reading Standards for Literature 6-12

The anchor standards and high school grade-specific standards work in tandem to define expectations—the former providing broad standards, the latter providing additional specificity.

Grades 9-10 students:	**Grades 11-12 students:**
Key Ideas and Details	
1. Cite strong and thorough textual evidence to support analysis of what the text says explicitly as well as implicit inferences drawn from the text.	**1.** Cite strong and thorough textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text, including determining where the text leaves matters uncertain (ambiguity).
2. Determine a theme or central idea of a text and analyze in detail its development over the course of the text, including how it emerges and is shaped and refined by specific details; restate and summarize main ideas or events, in correct sequence, after reading a text.	**2.** Determine two or more themes or central ideas of a text and analyze their development over the course of the text, including how they interact and build on one another to produce a complex account; restate and summarize main ideas or events, in correct sequence, after reading a text.
3. Analyze how complex characters (e.g., those with multiple or conflicting motivations) develop over the course of a text, interact with other characters, and advance the plot or develop the theme.	**3.** Analyze the impact of the author's choices regarding how to develop and relate elements of a story or drama (e.g., where a story is set, how the action is ordered, how the characters are introduced and developed).
Craft and Structure	
4. Determine the meaning of words and phrases as they are used in the text, including figurative and connotative meanings; analyze the cumulative impact of specific word choices on meaning and tone (e.g., how the language evokes a sense of time and place; how it sets a formal or informal tone).	**4.** Determine the meaning of words and phrases as they are used in the text, including figurative and connotative meanings; analyze the impact of specific word choices on meaning and tone, including words with multiple meanings or language that is particularly fresh, engaging, or beautiful. (Include Shakespeare as well as other authors.)
5. Analyze how an author's choices concerning how to structure a text, use literary devices appropriate to genre (e.g., foreshadowing, imagery, allusion or symbolism), order events within it (e.g., parallel plots), and manipulate time (e.g., pacing, flashbacks) create such effects as mystery, tension, or surprise.	**5.** Analyze how an author's choices concerning how to structure specific parts of a text (e.g., the choice of where to begin or end a story, the choice to provide a comedic or tragic resolution) contribute to its overall structure and meaning as well as its aesthetic impact.
6. Analyze a particular point of view or cultural experience reflected in a work of literature (e.g., mythology, colonialism, local culture), drawing on a wide reading of world literature.	**6.** Analyze a case in which grasping point of view requires distinguishing what is directly stated in a text from what is really meant (e.g., satire, sarcasm, irony, understatement, or attitude).
Integration of Knowledge and Ideas	
7. Analyze the representation of a subject or a key scene in two different artistic media, including what is emphasized or absent in each treatment (e.g., Auden's "Musée des Beaux Arts" and Breughel's *Landscape with the Fall of Icarus*).	**7.** Analyze multiple interpretations of a story, drama, or poem (e.g., recorded or live production of a play or recorded novel or poetry), evaluating how each version interprets the source text. (Include at least one play by Shakespeare and one play by an American dramatist.)
8. (Not applicable to literature)	**8.** (Not applicable to literature)

Reading Standards for Literature 6-12

Grades 9-10 students:	Grades 11-12 students:
9. Analyze how an author draws on and transforms source material in a specific work (e.g., how Shakespeare treats a theme or topic from Ovid or how a later author draws on a play by Shakespeare).	**9.** Demonstrate knowledge of eighteenth-, nineteenth- and early-twentieth-century foundational works of American literature, including how two or more texts from the same period treat similar themes or topics.
Range of Reading and Level of Text Complexity	
10. By the end of grade 9, read and comprehend a range of literature from a variety of cultures, within a complexity band appropriate to grade 9 (from upper grade 8 to grade 10), with scaffolding as needed at the high end of the range. By the end of grade 10, read and comprehend a range of literature from a variety of cultures, within a complexity band appropriate to grade 10 (from upper grade 9 to grade 11), with scaffolding as needed at the high end of the range.	**10.** By the end of grade 11, read and comprehend a range of literature from a variety of cultures, within a complexity band appropriate to grade 11 (from upper grade 10 to grade 12), with scaffolding as needed at the high end of the range. By the end of grade 12, read and comprehend a range of literature from a variety of cultures, at the high end of the grades 11–12 text complexity band independently and proficiently.

Reading Standards for Informational Text 6-12

Grade 6 students:	Grade 7 students:	Grade 8 students:
Key Ideas and Details		
1. Cite textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text.	**1.** Cite several pieces of textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text.	**1.** Cite the textual evidence that most strongly supports an analysis of what the text says explicitly as well as inferences drawn from the text.
2. Determine a central idea and subtopics of a text and how they are conveyed through particular details; restate and summarize the central idea or events, in correct sequence when necessary, after reading a text.	**2.** Determine the central idea and subtopics in a text and analyze their development over the course of the text; restate and summarize the central idea or events, in correct sequence when necessary, after reading a text.	**2.** Determine a central idea and subtopics of a text and analyze their development over the course of the text, including their relationship to supporting ideas; restate and summarize the central idea or events, in correct sequence when necessary, after reading a text.
3. Analyze in detail how a key individual, event, or idea is introduced, illustrated, and elaborated on in a text (e.g., through examples or anecdotes).	**3.** Analyze the interactions between individuals, events, and ideas presented in a text (e.g., how ideas influence individuals or events, or how individuals influence ideas or events).	**3.** Analyze how a text makes connections among and distinctions between individuals, ideas, or events (e.g., through comparisons, analogies, or categories).
Craft and Structure		
4. Determine the meaning of words and phrases as they are used in a text, including figurative, connotative, and technical meanings.	**4.** Determine the meaning of words and phrases as they are used in a text, including figurative, connotative, and technical meanings; analyze the impact of a specific word choice on meaning and tone.	**4.** Determine the meaning of words and phrases as they are used in a text, including figurative, connotative, and technical meanings; analyze the impact of specific word choices on meaning and tone, including analogies or allusions to other texts.
5. Analyze how a particular sentence, paragraph, chapter, or section fits into the overall structure of a text and contributes to the development of the ideas.	**5.** Analyze the structure an author uses to organize a text, including how the major sections contribute to the whole and to the development of the ideas.	**5.** Analyze in detail the structure of a specific paragraph in a text, including the role of particular sentences in developing and refining a key concept.
6. Determine an author's purpose (to inform, persuade, entertain, critique, etc.) and point of view in a text and explain how it is conveyed in the text.	**6.** Determine an author's purpose (to inform, persuade, entertain, critique, etc.) and point of view in a text and analyze how the author distinguishes his or her point of view from that of others.	**6.** Determine an author's purpose (to inform, persuade, entertain, critique, etc.) and point of view in a text and analyze how the author acknowledges and responds to conflicting evidence or viewpoints.

Reading Standards for Informational Text 6-12

Grade 6 students:	Grade 7 students:	Grade 8 students:
Integration of Knowledge and Ideas		
7. Integrate information presented in different media (e.g., may include, but not limited to podcasts) or formats (e.g., visually, quantitatively/ data-related) as well as in words to develop a coherent understanding of a topic or issue.	**7.** Compare and contrast a text to an audio, video, or multimedia version of the text, analyzing each medium's portrayal of the subject (e.g., how the method of the delivery of a speech affects the impact of the overall message).	**7.** Evaluate the advantages and disadvantages of using different media (e.g., print or digital text, video, multimedia) to present a particular topic or idea.
8. Trace and evaluate the argument and specific claims in a text, distinguishing claims that are supported by reasons and evidence from claims that are not.	**8.** Trace and evaluate the argument and specific claims in a text, assessing whether the reasoning is sound and the evidence is relevant and sufficient to support the claims.	**8.** Delineate and evaluate the argument and specific claims in a text (e.g., identify bias and propaganda techniques, well-supported logical arguments), assessing whether the reasoning is sound and the evidence is relevant and sufficient; recognize when irrelevant evidence is introduced.
9. Compare and contrast one author's presentation of events with that of another (e.g., a memoir written by and a biography on the same person).	**9.** Analyze how two or more authors writing about the same topic shape their presentations of key information by emphasizing different evidence or advancing different interpretations of facts.	**9.** Analyze a case in which two or more texts provide conflicting information on the same topic and identify where the texts disagree on matters of fact or interpretation.
Range of Reading and Level of Text Complexity		
10. By the end of the year, read and comprehend literary nonfiction, within a complexity band appropriate to grade 6 (from upper grade 5 to grade 7), with scaffolding as needed at the high end of the range.	**10.** By the end of the year, read and comprehend literary nonfiction, within a complexity band appropriate to grade 7 (from upper grade 6 to grade 8), with scaffolding as needed at the high end of the range.	**10.** By the end of the year, read and comprehend literary nonfiction, within a complexity band appropriate to grade 8 (from upper grade 7 to grade 9), with scaffolding as needed at the high end of the range.

Reading Standards for Informational Text 6-12

The anchor standards and high school grade-specific standards work in tandem to define expectations—the former providing broad standards, the latter providing additional specificity.

Grades 9-10 students:	Grades 11-12 students:
Key Ideas and Details	
1. Cite strong and thorough textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text.	**1.** Cite strong and thorough textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text, including determining where the text leaves matters uncertain.
2. Determine a central idea of a text and analyze its development over the course of the text, including how it emerges and is shaped and refined by specific details; restate and summarize main ideas or events, in correct sequence when necessary, after reading a text.	**2.** Determine two or more central ideas of a text and analyze their development over the course of the text, including how they interact and build on one another to provide a complex analysis; restate and summarize main ideas or events, in correct sequence when necessary, after reading a text.
3. Analyze how the author unfolds an analysis or series of ideas or events, including the order in which the points are made, how they are introduced and developed, and the connections that are drawn between them.	**3.** Analyze a complex set of ideas or sequence of events and explain how specific individuals, ideas, or events interact and develop over the course of the text.
Craft and Structure	
4. Determine the meaning of words and phrases as they are used in various genres, including figurative, connotative, and technical meanings; analyze the cumulative impact of specific word choices on meaning and tone (e.g., how the language of a court opinion differs from that of a newspaper).	**4.** Determine the meaning of words and phrases as they are used in various genres, including figurative, connotative, and technical meanings; analyze how an author uses and refines the meaning of a key term or terms over the course of a text.
5. Analyze in detail how an author's ideas or claims are developed and refined by particular sentences, paragraphs, or larger portions of a text (e.g., a section or chapter).	**5.** Analyze and evaluate the effectiveness of the structure an author uses in his or her exposition or argument, including whether the structure makes points clear, convincing, and engaging.
6. Determine an author's point of view or purpose in a text and analyze how an author uses rhetoric to advance that point of view or purpose.	**6.** Discern an author's point of view or purpose in a text in which the rhetoric is particularly effective, analyzing how style and content contribute to the power, persuasiveness, or aesthetic impact of the text.
Integration of Knowledge and Ideas	
7. Analyze various accounts of a subject told in different media (e.g., a person's life story in both print and multimedia), determining which details are emphasized in each account.	**7.** Integrate and evaluate multiple sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a question or solve a problem.

Reading Standards for Informational Text 6-12

Grades 9-10 students:	Grades 11-12 students:
8. Delineate and evaluate the argument and specific claims in a text (e.g., bias and propaganda techniques, emotional effect of specific word choices and sentence structures, well-supported logical arguments), assessing whether the reasoning is valid and the evidence is relevant and sufficient; identify false statements and fallacious reasoning. **9.** Analyze seminal U.S. and world documents of historical and literary significance (e.g., Washington's Farewell Address, the Gettysburg Address, Roosevelt's Four Freedoms speech, King's "Letter from Birmingham Jail"), including how they address related themes and concepts.	**8.** Delineate and evaluate the reasoning in seminal U.S. texts, including the application of constitutional principles and use of legal reasoning (e.g., in U.S. Supreme Court majority opinions and dissents) and the premises, purposes, and arguments in works of public advocacy (e.g., *The Federalist*, presidential addresses). **9.** Analyze seventeenth-, eighteenth-, and nineteenth-century foundational U.S. and world documents of historical and literary significance (including The Declaration of Independence, the Preamble to the Constitution, the Bill of Rights, and Lincoln's Second Inaugural Address) for their themes, purposes, and rhetorical features.
Range of Reading and Level of Text Complexity	
10. By the end of grade 9, read and comprehend literary nonfiction, within a complexity band appropriate to grade 9 (from upper grade 8 to grade 10), with scaffolding as needed at the high end of the range. By the end of grade 10, read and comprehend literary nonfiction, within a complexity band appropriate to grade 10 (from upper grade 9 to grade 11), with scaffolding as needed at the high end of the range.	**10.** By the end of grade 11, read and comprehend literary nonfiction, within a complexity band appropriate to grade 11 (from upper grade 10 to grade 12), with scaffolding as needed at the high end of the range. By the end of grade 12, read and comprehend literary nonfiction at the high end of the grades 11–12 text complexity band independently and proficiently.

Writing Standards 6-12

The following standards for 6-12 offer a focus for instruction each year to help ensure that students gain adequate mastery of a range of skills and applications. Each year in their writing, students should demonstrate increasing sophistication in all aspects of language use, from vocabulary and syntax to the development and organization of ideas, and they should address increasingly demanding content and sources. Students advancing through the grades are expected to meet each year's grade-specific standards and retain or further develop skills and understandings mastered in preceding grades.

Grade 6 students:	Grade 7 students:	Grade 8 students:
Text Types and Purposes		
1. Write arguments to support claims with clear reasons and relevant evidence. a. Introduce claim(s) and organize the reasons and evidence clearly. b. Support claim(s) with clear reasons and accurate, relevant evidence, using credible sources and demonstrating an understanding of the topic or text. c. Use words, phrases, and clauses to clarify the relationships among claim(s) and reasons. d. Establish and maintain a formal style. e. Provide a concluding statement or section that follows from the argument presented.	**1.** Write arguments to support claims with clear reasons and relevant evidence. a. Introduce claim(s), acknowledge alternate or opposing claims, and organize the reasons and evidence logically. b. Support claim(s) with logical reasoning and accurate, relevant evidence, using credible sources and demonstrating an understanding of the topic or text. c. Use words, phrases, and clauses to create cohesion and clarify the relationships among claim(s), reasons, and evidence. d. Establish and maintain a formal style. e. Provide a concluding statement or section that follows from and supports the argument presented.	**1.** Write arguments to support claims with clear reasons and relevant evidence. a. Introduce claim(s), acknowledge and distinguish the claim(s) from alternate or opposing claims, and organize the reasons and evidence logically. b. Support claim(s) with logical reasoning and accurate, relevant evidence, using credible sources and demonstrating an understanding of the topic or text. c. Use words, phrases, and clauses to create cohesion and clarify the relationships among claim(s), counterclaims, reasons, and evidence. d. Establish and maintain a formal style. e. Provide a concluding statement or section that follows from and supports the argument presented.
2. Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. a. Introduce a topic; organize ideas, concepts, and information, using strategies such as definition, classification, comparison/contrast, and cause/effect; include formatting (e.g., headings), graphics (e.g., charts, tables), and multimedia when useful to aiding comprehension.	**2.** Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. a. Introduce a topic clearly, previewing what is to follow; organize ideas, concepts, and information, using strategies such as definition, classification, comparison/contrast, and cause/effect; include formatting (e.g., headings), graphics (e.g., charts, tables), and multimedia when useful to aiding comprehension.	**2.** Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. a. Introduce a topic clearly, previewing what is to follow; organize ideas, concepts, and information into broader categories; include formatting (e.g., headings), graphics (e.g., charts, tables), and multimedia when useful to aiding comprehension.

Writing Standards 6-12

Grade 6 students:	Grade 7 students:	Grade 8 students:
b. Develop the topic with relevant facts, definitions, concrete details, quotations, or other information and examples. c. Use appropriate transitions to clarify the relationships among ideas and concepts. d. Use precise language and domain-specific vocabulary to inform about or explain the topic. e. Establish and maintain a formal style. f. Provide a concluding statement or section that follows from the information or explanation presented.	b. Develop the topic with relevant facts, definitions, concrete details, quotations, or other information and examples. c. Use appropriate transitions to create cohesion and clarify the relationships among ideas and concepts. d. Use precise language and domain-specific vocabulary to inform about or explain the topic. e. Establish and maintain a formal style. f. Provide a concluding statement or section that follows from and supports the information or explanation presented.	b. Develop the topic with relevant, well-chosen facts, definitions, concrete details, quotations, or other information and examples. c. Use appropriate and varied transitions to create cohesion and clarify the relationships among ideas and concepts. d. Use precise language and domain-specific vocabulary to inform about or explain the topic. e. Establish and maintain a formal style. f. Provide a concluding statement or section that follows from and supports the information or explanation presented.
3. Use narrative writing to develop real or imagined experiences or events using effective technique, relevant descriptive details, and well-structured event sequences. a. Engage and orient the reader by establishing a context and introducing a narrator and/or characters; organize an event sequence that unfolds naturally and logically. b. Use narrative techniques, such as dialogue, pacing, and description, to develop experiences, events, and/or characters. c. Use a variety of transition words, phrases, and clauses to convey sequence and signal shifts from one time frame or setting to another. d. Use precise words and phrases, relevant descriptive details, and sensory language to convey experiences and events. e. Provide a conclusion that follows from the narrated experiences or events.	**3.** Use narrative writing to develop real or imagined experiences or events using effective technique, relevant descriptive details, and well-structured event sequences. a. Engage and orient the reader by establishing a context and point of view and introducing a narrator and/or characters; organize an event sequence that unfolds naturally and logically. b. Use narrative techniques, such as dialogue, pacing, and description, to develop experiences, events, and/or characters. c. Use a variety of transition words, phrases, and clauses to convey sequence and signal shifts from one time frame or setting to another. d. Use precise words and phrases, relevant descriptive details, and sensory language to advance the action and convey experiences and events. e. Provide a conclusion that follows from and reflects on the narrated experiences or events.	**3.** Use narrative writing to develop real or imagined experiences or events using effective technique, relevant descriptive details, and well-structured event sequences. a. Engage and orient the reader by establishing a context and point of view and introducing a narrator and/or characters; organize an event sequence that unfolds naturally and logically. b. Use narrative techniques, such as dialogue, pacing, description, and reflection, to develop experiences, events, and/or characters. c. Use a variety of transition words, phrases, and clauses to convey sequence, signal shifts from one time frame or setting to another, and show the relationships among experiences and events. d. Use precise words and phrases, relevant descriptive details, and sensory language to advance the action and convey experiences and events. e. Provide a conclusion that follows from and reflects on the narrated experiences or events.

Writing Standards 6-12

Grade 6 students:	Grade 7 students:	Grade 8 students:
Production and Distribution of Writing		
4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. (Grade-specific expectations for writing types are defined in standards 1–3 above.)	**4.** Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. (Grade-specific expectations for writing types are defined in standards 1–3 above.)	**4.** Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. (Grade-specific expectations for writing types are defined in standards 1–3 above.)
5. With some guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach. (Editing for conventions should demonstrate command of Language standards 1–3 up to and including grade 6.)	**5.** With some guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on how well purpose and audience have been addressed. (Editing for conventions should demonstrate command of Language standards 1–3 up to and including grade 7.)	**5.** With some guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on how well purpose and audience have been addressed. (Editing for conventions should demonstrate command of Language standards 1–3 up to and including grade 8.)
6. Use technology, including the Internet, to produce and publish writing as well as to interact and collaborate with others; demonstrate sufficient command of keyboarding skills to create a piece of writing.	**6.** Use technology, including the Internet, to produce and publish writing and link to and cite sources as well as to interact and collaborate with others, including linking to and citing sources.	**6.** Use technology, including the Internet, to produce and publish writing and present the relationships between information and ideas efficiently as well as to interact and collaborate with others.
Research to Build and Present Knowledge		
7. Conduct short research projects to answer a question, drawing on several sources and refocusing the inquiry when appropriate.	**7.** Conduct short research projects to answer a question, drawing on several sources and generating additional related, focused questions for further research and investigation.	**7.** Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.
8. Gather relevant information from multiple print and digital sources; assess the credibility of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and providing basic bibliographic information for sources.	**8.** Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation.	**8.** Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation.

Writing Standards 6-12

Grade 6 students:	Grade 7 students:	Grade 8 students:
9. Draw evidence from literary or informational texts to support analysis, reflection, and research. a. Apply grade 6 Reading standards to literature (e.g., “Compare and contrast texts in different forms or genres (e.g., stories and poems; historical novels and fantasy stories) in terms of their approaches to similar themes and topics.”). b. Apply grade 6 Reading standards to literary nonfiction (e.g., “Trace and evaluate the argument and specific claims in a text, distinguishing claims that are supported by reasons and evidence from claims that are not”).	**9.** Draw evidence from literary or informational texts to support analysis, reflection, and research. a. Apply grade 7 Reading standards to literature (e.g., “Compare and contrast a fictional portrayal of a time, place, or character and a historical account of the same period as a means of understanding how authors of fiction use or alter history.”). b. Apply grade 7 Reading standards to literary nonfiction (e.g. “Trace and evaluate the argument and specific claims in a text, assessing whether the reasoning is sound and the evidence is relevant and sufficient to support the claims.”).	**9.** Draw evidence from literary or informational texts to support analysis, reflection, and research. a. Apply grade 8 Reading standards to literature (e.g., “Analyze how a modern work of fiction draws on themes, patterns of events, or character types from myths, traditional stories, or religious works such as the Bible, including describing how the material is rendered new.”). b. Apply grade 8 Reading standards to literary nonfiction (e.g., “Delineate and evaluate the argument and specific claims in a text [e.g., identifies bias and propaganda techniques, well-supported logical arguments], assessing whether the reasoning is sound and the evidence is relevant and sufficient; recognize when irrelevant evidence is introduced.”).
Range of Writing		
10. Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.	**10.** Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.	**10.** Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Writing Standards 6-12

The anchor standards and high school grade-specific standards work in tandem to define expectations—the former providing broad standards, the latter providing additional specificity.

Grades 9-10 students:	Grades 11-12 students:
Text Types and Purposes	
1. Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence. a. Introduce precise claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that establishes clear relationships among claim(s), counterclaims, reasons, and evidence. b. Develop claim(s) and counterclaims fairly, supplying evidence for each while pointing out the strengths and limitations of both in a manner that anticipates the audience's knowledge level and concerns. c. Use words, phrases, and clauses to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims. d. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing. e. Provide a concluding statement or section that follows from and supports the argument presented.	**1.** Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence. a. Introduce precise, knowledgeable claim(s), establish the significance of the claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that logically sequences claim(s), counterclaims, reasons, and evidence. b. Develop claim(s) and counterclaims fairly and thoroughly, supplying the most relevant evidence for each while pointing out the strengths and limitations of both in a manner that anticipates the audience's knowledge level, concerns, values, and possible biases. c. Use words, phrases, and clauses as well as varied syntax to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims. d. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing. e. Provide a concluding statement or section that follows from and supports the argument presented.
2. Write informative/explanatory texts to examine and convey complex ideas, concepts, and information clearly and accurately through the effective selection, organization, and analysis of content. a. Introduce a topic; organize complex ideas, concepts, and information to make important connections and distinctions; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension. b. Develop the topic with well-chosen, relevant, and sufficient facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic.	**2.** Write informative/explanatory texts to examine and convey complex ideas, concepts, and information clearly and accurately through the effective selection, organization, and analysis of content. a. Introduce a topic; organize complex ideas, concepts, and information so that each new element builds on that which precedes it to create a unified whole; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension. b. Develop the topic thoroughly by selecting the most significant and relevant facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic.

Writing Standards 6-12

Grades 9-10 students:	Grades 11-12 students:
c. Use appropriate and varied transitions to link the major sections of the text, create cohesion, and clarify the relationships among complex ideas and concepts. d. Use precise language and domain-specific vocabulary to manage the complexity of the topic. e. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing. f. Provide a concluding statement or section that follows from and supports the information or explanation presented (e.g., articulating implications or the significance of the topic).	c. Use appropriate and varied transitions and syntax to link the major sections of the text, create cohesion, and clarify the relationships among complex ideas and concepts. d. Use precise language, domain-specific vocabulary, and techniques such as metaphor, simile, and analogy to manage the complexity of the topic. e. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing. f. Provide a concluding statement or section that follows from and supports the information or explanation presented (e.g., articulating implications or the significance of the topic).
3. Use narrative writing to develop real or imagined experiences or events using effective technique, well-chosen details, and well-structured event sequences. a. Engage and orient the reader by setting out a problem, situation, or observation, establishing one or multiple point(s) of view, and introducing a narrator and/or characters; create a smooth progression of experiences or events. b. Use narrative techniques, such as dialogue, pacing, description, reflection, and multiple plot lines, to develop experiences, events, and/or characters. c. Use a variety of techniques to sequence events so that they build on one another to create a coherent whole. d. Use precise words and phrases, telling details, and sensory language to convey a vivid picture of the experiences, events, setting, and/or characters. e. Provide a conclusion that follows from and reflects on what is experienced, observed, or resolved over the course of the narrative.	**3.** Use narrative writing to develop real or imagined experiences or events using effective technique, well-chosen details, and well-structured event sequences. a. Engage and orient the reader by setting out a problem, situation, or observation and its significance, establishing one or multiple point(s) of view, and introducing a narrator and/or characters; create a smooth progression of experiences or events. b. Use narrative techniques, such as dialogue, pacing, description, reflection, and multiple plot lines, to develop experiences, events, and/or characters. c. Use a variety of techniques to sequence events so that they build on one another to create a coherent whole and build toward a particular tone and outcome (e.g., a sense of mystery, suspense, growth, or resolution). d. Use precise words and phrases, telling details, and sensory language to convey a vivid picture of the experiences, events, setting, and/or characters. e. Provide a conclusion that follows from and reflects on what is experienced, observed, or resolved over the course of the narrative.
Production and Distribution of Writing	
4. Produce clear and coherent writing in which the development, organization, style, and features are appropriate to task, genre, purpose, and audience. (Grade-specific expectations for writing types are defined in standards 1–3 above.)	**4.** Produce clear and coherent writing in which the development, organization, style, and features are appropriate to task, genre, purpose, and audience. (Grade-specific expectations for writing types are defined in standards 1–3 above.)

Writing Standards 6-12

Grades 9-10 students:	Grades 11-12 students:
5. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (Editing for conventions should demonstrate command of Language standards 1–3 up to and including grades 9–10.) **6.** Use technology, including the Internet, to produce, publish, and update individual or shared writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically.	**5.** Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (Editing for conventions should demonstrate command of Language standards 1–3 up to and including grades 11–12.) **6.** Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.
Research to Build and Present Knowledge	
7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. **8.** Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation. **9.** Draw evidence from literary or informational texts to support analysis, reflection, and research. a. Apply grades 9–10 Reading standards to literature (e.g., "Analyze how an author draws on and transforms source material in a specific work [e.g., how Shakespeare treats a theme or topic from Ovid or how a later author draws on a play by Shakespeare]."). b. Apply grades 9–10 Reading standards to literary nonfiction (e.g., "Delineate and evaluate the argument and specific claims in a text [e.g., bias and propaganda techniques, emotional effect of specific word choices and sentence structures, well-supported logical arguments], assessing whether the reasoning is valid and the evidence is relevant and sufficient; identify false statements and fallacious reasoning.").	**7.** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. **8.** Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. **9.** Draw evidence from literary or informational texts to support analysis, reflection, and research. a. Apply grades 11–12 Reading standards to literature (e.g., "Demonstrate knowledge of eighteenth-, nineteenth- and early twentieth-century foundational works of American literature, including how two or more texts from the same period treat similar themes or topics."). b. Apply grades 11–12 Reading standards to literary nonfiction (e.g., "Delineate and evaluate the reasoning in seminal U.S. texts, including the application of constitutional principles and use of legal reasoning [e.g., in U.S. Supreme Court Case majority opinions and dissents] and the premises, purposes, and arguments in works of public advocacy [e.g., *The Federalist*, presidential addresses].").

Writing Standards 6-12

Grades 9-10 students:	Grades 11-12 students:
Range of Writing	
10. Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes, and audiences.	**10.** Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes, and audiences.

Speaking and Listening Standards 6-12

The following standards for grades 6 - 12 offer a focus for instruction in each year to help ensure that students gain adequate mastery of a range of skills and applications. Students advancing through the grades are expected to meet each year's grade-specific standards and retain or further develop skills and understandings mastered in preceding grades.

Grade 6 students:	Grade 7 students:	Grade 8 students:
Comprehension and Collaboration		
1. Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 6 topics, texts, and issues, building on others' ideas and expressing their own clearly. a. Come to discussions prepared, having read or studied required material; explicitly draw on that preparation by referring to evidence on the topic, text, or issue to probe and reflect on ideas under discussion. b. Follow rules for collegial discussions (e.g., establishing norms: taking turns, paraphrasing, respecting diverse viewpoints), set specific goals and deadlines, and define individual roles as needed. c. Pose and respond to specific questions with elaboration and detail by making comments that contribute to the topic, text, or issue under discussion. d. Review the key ideas expressed and demonstrate understanding of multiple perspectives through reflection and paraphrasing.	**1.** Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 7 topics, texts, and issues, building on others' ideas and expressing their own clearly. a. Come to discussions prepared, having read or researched material under study; explicitly draw on that preparation by referring to evidence on the topic, text, or issue to probe and reflect on ideas under discussion. b. Follow rules for collegial discussions (e.g., establishing norms: taking turns, paraphrasing, respecting diverse viewpoints), track progress toward specific goals and deadlines, and define individual roles as needed. c. Pose questions that elicit elaboration and respond to others' questions and comments with relevant observations and ideas that bring the discussion back on topic as needed. d. Acknowledge new information expressed by others and, when warranted, modify their own views.	**1.** Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 8 topics, texts, and issues, building on others' ideas and expressing their own clearly. a. Come to discussions prepared, having read or researched material under study; explicitly draw on that preparation by referring to evidence on the topic, text, or issue to probe and reflect on ideas under discussion. b. Follow rules for collegial discussions (e.g., establishing norms: taking turns, paraphrasing, respecting diverse viewpoints), and decision-making (e.g., coming to consensus), track progress toward specific goals and deadlines, and define individual roles as needed. c. Pose questions that connect the ideas of several speakers and respond to others' questions and comments with relevant evidence, observations, and ideas. d. Acknowledge new information expressed by others, and, when warranted, qualify or justify their own views in light of the evidence presented.
2. Interpret information presented in diverse media (included but not limited to podcasts) and formats (e.g., visually, quantitatively/ data-related, orally) and explain how it contributes to a topic, text, or issue under study.	**2.** Analyze the main ideas and supporting details presented in diverse media and formats (e.g., visually, quantitatively/data-related, orally) and explain how the ideas clarify a topic, text, or issue under study.	**2.** Analyze the purpose of information presented in diverse media and formats (e.g., visually, quantitatively/data-related, orally) and evaluate the motives (e.g., social, commercial, political) behind its presentation.

Speaking and Listening Standards 6-12

Grade 6 students:	Grade 7 students:	Grade 8 students:
3. Delineate a speaker's argument and specific claims, distinguishing claims that are supported by reasons and evidence from claims that are not.	**3.** Delineate a speaker's argument and specific claims, evaluating the soundness of the reasoning and the relevance and sufficiency of the evidence.	**3.** Delineate a speaker's argument and specific claims, evaluating the soundness of the reasoning and relevance and sufficiency of the evidence and identifying when irrelevant evidence is introduced.
Presentation of Knowledge and Ideas		
4. Present claims and findings, sequencing ideas logically and using pertinent descriptions, facts, and details to accentuate main ideas or themes; use appropriate eye contact, adequate volume, and clear pronunciation. **5.** Include multimedia components (e.g., graphics, images, music, sound) and visual displays in presentations to clarify information. **6.** Adapt speech to a variety of contexts and tasks, demonstrating command of formal English when indicated or appropriate. (See grade 6 Language standards 1 and 3 for specific expectations.)	**4.** Present claims and findings, emphasizing salient points in a focused, coherent manner with pertinent descriptions, facts, details, and examples; use appropriate eye contact, adequate volume, and clear pronunciation. **5.** Include multimedia components and visual displays in presentations to clarify claims and findings and emphasize salient points. **6.** Adapt speech to a variety of contexts and tasks, demonstrating command of formal English when indicated or appropriate. (See grade 7 Language standards 1 and 3 for specific expectations.)	**4.** Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation. **5.** Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. **6.** Adapt speech to a variety of contexts and tasks, demonstrating command of formal English when indicated or appropriate. (See grade 8 Language standards 1 and 3 for specific expectations.)

Speaking and Listening Standards 6-12

The anchor standards and high school grade-specific standards work in tandem to define expectations—the former providing broad standards, the latter providing additional specificity.

Grades 9-10 students:	**Grades 11-12 students:**
Comprehension and Collaboration	
1. Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grades 9–10 topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively. a. Come to discussions prepared, having read and researched material under study; explicitly draw on that preparation by referring to evidence from texts and other research on the topic or issue to stimulate a thoughtful, well-reasoned exchange of ideas. b. Work with peers to set rules for collegial discussions and decision-making (e.g., informal consensus, taking votes on key issues, presentation of alternate views), clear goals and deadlines, and individual roles as needed. c. Propel conversations by posing and responding to questions that relate the current discussion to broader themes or larger ideas; actively incorporate others into the discussion; and clarify, verify, or challenge ideas and conclusions. d. Respond thoughtfully to diverse perspectives, summarize points of agreement and disagreement, and, when warranted, qualify or justify their own views and understanding and make new connections in light of the evidence and reasoning presented.	**1.** Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grades 11–12 topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively. a. Come to discussions prepared, having read and researched material under study; explicitly draw on that preparation by referring to evidence from texts and other research on the topic or issue to stimulate a thoughtful, well-reasoned exchange of ideas. b. Work with peers to promote civil, democratic discussions and decision-making, set clear goals and deadlines, and establish individual roles as needed. c. Propel conversations by posing and responding to questions that probe reasoning and evidence; ensure a hearing for a full range of positions on a topic or issue; clarify, verify, or challenge ideas and conclusions; and promote divergent and creative perspectives. d. Respond thoughtfully to diverse perspectives or arguments; synthesize comments, claims, and evidence made on all sides of an issue; resolve contradictions when possible; and determine what additional information or research is required to deepen the investigation or complete the task.
2. Integrate multiple sources of information presented in diverse media or formats (e.g., visually, quantitatively, orally) evaluating the credibility and accuracy of each source and noting any discrepancies among data or information.	**2.** Integrate multiple sources of information presented in diverse formats and media (e.g., visually, quantitatively, orally) in order to make informed decisions and solve problems, evaluating the credibility and accuracy of each source and noting any discrepancies among the data or information.
3. Identify and evaluate a speaker's point of view, reasoning, and use of evidence and rhetoric, identifying any fallacious reasoning or exaggerated or distorted evidence.	**3.** Identify and evaluate a speaker's point of view, reasoning, and use of evidence and rhetoric, assessing the stance, premises, links among ideas, word choice, points of emphasis, and tone used.

Speaking and Listening Standards 6-12

Grades 9-10 students:	Grades 11-12 students:
Presentation of Knowledge and Ideas	
4. Present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of reasoning and the organization, development, substance, and style are appropriate to purpose, audience, and task.	**4.** Present information, findings, and supporting evidence, conveying a clear and distinct perspective, such that listeners can follow the line of reasoning, alternative or opposing perspectives are addressed, and the organization, development, substance, and style are appropriate to purpose, audience, and a range or formal and informal tasks.
5. Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.	**5.** Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.
6. Adapt speech to a variety of contexts and tasks, demonstrating command of formal English when indicated or appropriate and addressing intended audience needs and knowledge level. (See grades 9–10 Language standards 1 and 3 for specific expectations.)	**6.** Adapt speech to a variety of contexts and tasks, demonstrating a command of formal English when indicated or appropriate and addressing intended audience needs and knowledge level. (See grades 11–12 Language standards 1 and 3 for specific expectations.)

Language Standards 6-12

The following standards for grades 6-12 offer a focus for instruction each year to help ensure that students gain adequate mastery of a range of skills and applications. Students advancing through the grades are expected to meet each year's grade-specific standards and retain or further develop skills and understandings mastered in preceding grades. Beginning in grade 3, skills and understandings that are particularly likely to require continued attention in higher grades as they are applied to increasingly sophisticated writing and speaking are marked with an asterisk (*). For a complete list see the table in the Introduction.

Grade 6 students:	Grade 7 students:	Grade 8 students:
Conventions of Standard English		
1. Demonstrate command of the conventions of standard English grammar and usage when writing or speaking. a. Ensure that pronouns are in the proper case (subjective, objective, possessive). b. Use intensive pronouns (e.g., *myself*, *ourselves*). c. Recognize and correct inappropriate shifts in pronoun number and person.* d. Recognize and correct vague pronouns (i.e., ones with unclear or ambiguous antecedents).* e. Recognize variations from standard English in their own and others' writing and speaking, and identify and use strategies to improve expression in conventional language.*	**1.** Demonstrate command of the conventions of standard English grammar and usage when writing or speaking. a. Explain the function of phrases and clauses in general and their function in specific sentences in order to apply the conventions of English. b. Choose among simple, compound, complex, and compound-complex sentences to signal differing relationships among ideas. c. Place phrases and clauses within a sentence, recognizing and correcting misplaced and dangling modifiers.*	**1.** Demonstrate command of the conventions of standard English grammar and usage when writing or speaking. a. Explain the function of verbals (gerunds, participles, infinitives) in general and their function in particular sentences in order to apply the conventions of English. b. Form and use verbs in the active and passive voice. c. Form and use verbs in the indicative, imperative, interrogative, conditional, and subjunctive mood. d. Recognize and correct inappropriate shifts in verb voice and mood.*
2. Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing. a. Use punctuation (commas, parentheses, dashes) to set off nonrestrictive/parenthetical elements.* b. Spell correctly.	**2.** Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing. a. Use a comma to separate coordinate adjectives (e.g., It was a fascinating, enjoyable movie.). b. Spell correctly.	**2.** Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing. a. Use punctuation (comma, ellipsis, dash) to indicate a pause or break. b. Use an ellipsis to indicate an omission. c. Spell correctly.

Language Standards 6-12

Grade 6 students:	Grade 7 students:	Grade 8 students:
Knowledge of Language		
3. Use knowledge of language and its conventions when writing, speaking, reading, or listening. a. Vary sentence patterns for meaning, reader/listener interest, and style.* b. Maintain consistency in style and tone.*	**3.** Use knowledge of language and its conventions when writing, speaking, reading, or listening. a. Choose language that expresses ideas precisely and concisely, recognizing and eliminating wordiness and redundancy.*	**3.** Use knowledge of language and its conventions when writing, speaking, reading, or listening. a. Use verbs in the active and passive voice and in the conditional and subjunctive mood to achieve particular effects (e.g., emphasizing the actor or the action; expressing uncertainty or describing a state contrary to fact).
Vocabulary Acquisition and Use		
4. Determine or clarify the meaning of unknown and multiple-meaning words and phrases based on grade 6 reading and content, choosing flexibly from a range of strategies. a. Determine meaning of unfamiliar words by using knowledge of word structure (root words, prefixes, suffixes, abbreviations) and language structure through reading words in text (word order, grammar), context (e.g., the overall meaning of a sentence or paragraph; a word's position or function in a sentence) as a clue to the meaning of a word or phrase. b. Use common, grade-appropriate Greek or Latin affixes and roots as clues to the meaning of a word (e.g., *audience*, *auditory*, *audible*). c. Consult reference materials (e.g., dictionaries, glossaries, thesauruses and specialized reference materials), both print and digital, to find the pronunciation of a word or determine or clarify its precise meaning or its part of speech. d. Verify the preliminary determination of the meaning of a word or phrase (e.g., by checking the inferred meaning in context or in a dictionary).	**4.** Determine or clarify the meaning of unknown and multiple-meaning words and phrases based on grade 7 reading and content, choosing flexibly from a range of strategies. a. Determine meaning of unfamiliar words by using knowledge of word structure, (prefixes/suffixes, base words, common roots, or word origins), context (e.g., the overall meaning of a sentence or paragraph; a word's position or function in a sentence) as a clue to the meaning of a word or phrase. b. Use common, grade-appropriate Greek or Latin affixes and roots as clues to the meaning of a word (e.g., *belligerent*, *bellicose*, *rebel*). c. Consult general and specialized reference materials (e.g., dictionaries, glossaries, and thesauruses), both print and digital, to find the pronunciation of a word or determine or clarify its precise meaning or its part of speech. d. Verify the preliminary determination of the meaning of a word or phrase (e.g., by checking the inferred meaning in context or in a dictionary).	**4.** Determine or clarify the meaning of unknown and multiple-meaning words or phrases based on grade 8 reading and content, choosing flexibly from a range of strategies. a. Determine meanings of unfamiliar words by using knowledge of word structure, (prefixes/suffixes, base words, common roots, or word origins), context (e.g., the overall meaning of a sentence or paragraph; a word's position or function in a sentence), knowledge of language structure including using context clues and prior knowledge. b. Use common, grade-appropriate Greek or Latin affixes and roots as clues to the meaning of a word (e.g., *precede*, *recede*, *secede*). c. Consult general and specialized reference materials (e.g., dictionaries, glossaries, and thesauruses), both print and digital, to find the pronunciation of a word or determine or clarify its precise meaning or its part of speech. d. Verify the preliminary determination of the meaning of a word or phrase (e.g., by checking the inferred meaning in context or in a dictionary).

Language Standards 6-12

Grade 6 students:	Grade 7 students:	Grade 8 students:
5. Demonstrate understanding of figurative language, word relationships, and nuances in word meanings. a. Interpret the intent or meaning of figures of speech (e.g., personification, metaphors, alliteration) as used in context. b. Use the relationship between particular words (e.g., cause/effect, part/whole, item/category) to better understand each of the words. c. Distinguish among the connotations (associations) of words with similar denotations (definitions) (e.g., *stingy*, *scrimping*, *economical*, *unwasteful*, *thrifty*). **6.** Acquire and accurately use grade-appropriate general academic and domain-specific words and phrases; gather vocabulary knowledge when considering a word or phrase important to comprehension or expression.	**5.** Demonstrate understanding of figurative language, word relationships, and nuances in word meanings. a. Interpret the intent or meaning of figures of speech (e.g., literary, religious, and mythological allusions; euphemisms) as used in context. b. Use the relationship between particular words (e.g., synonym/antonym, analogy) to better understand each of the words. c. Distinguish among the connotations (associations) of words with similar denotations (definitions) (e.g., *refined*, *respectful*, *polite*, *diplomatic*, *condescending*). **6.** Acquire and accurately use grade-appropriate general academic and domain-specific words and phrases; gather vocabulary knowledge when considering a word or phrase important to comprehension or expression.	**5.** Demonstrate understanding of figurative language, word relationships, and nuances in word meanings. a. Interpret the intent or meaning of figures of speech (e.g., verbal irony, puns, mixed metaphor) as used in context. b. Use the relationship between particular words (e.g., synonyms/antonyms, analogies) to better understand each of the words. c. Distinguish among the connotations (associations) of words with similar denotations (definitions) (e.g., *bullheaded*, *willful*, *firm*, *persistent*, *resolute*). **6.** Acquire and accurately use grade-appropriate general academic and domain-specific words and phrases; gather vocabulary knowledge when considering a word or phrase important to comprehension or expression.

Language Standards 6-12

The anchor standards and high school grade-specific standards work in tandem to define readiness expectations—the former providing broad standards, the latter providing additional specificity.

Grades 9-10 students:	Grades 11-12 students:
Conventions of Standard English	
1. Demonstrate command of the conventions of standard English grammar and usage when writing or speaking. a. Use parallel structure.* b. Use various types of phrases (noun, verb, adjectival, adverbial, participial, prepositional, absolute) and clauses (independent, dependent; noun, relative, adverbial) to convey specific meanings and add variety and interest to writing or presentations.	**1.** Demonstrate command of the conventions of standard English grammar and usage when writing or speaking. a. Apply the understanding that usage is a matter of convention, can change over time, and is sometimes contested. b. Resolve issues of complex or contested usage, consulting references (e.g., *Merriam-Webster's Dictionary of English Usage*, *Garner's Modern American Usag*e) as needed.
2. Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing. a. Use a semicolon (and perhaps a conjunctive adverb) to link two or more closely related independent clauses. b. Use a colon to introduce a list or quotation. c. Spell correctly.	**2.** Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing. a. Observe hyphenation conventions. b. Spell correctly.
Knowledge of Language	
3. Apply knowledge of language to understand how language functions in different contexts, to make effective choices for meaning or style, and to comprehend more fully when reading or listening. a. Write and edit work so that it conforms to the guidelines in a style manual (e.g., *MLA Handbook*, Turabian's *Manual for Writers*) appropriate for the discipline and writing type.	**3.** Apply knowledge of language to understand how language functions in different contexts, to make effective choices for meaning or style, and to comprehend more fully when reading or listening. a. Vary syntax for effect, consulting references (e.g., Tufte's *Artful Sentences*) for guidance as needed; apply an understanding of syntax to the study of complex texts when reading.

Language Standards 6-12

Grades 9-10 students:	Grades 11-12 students:
Vocabulary Acquisition and Use	
4. Determine or clarify the meaning of unknown and multiple-meaning words and phrases based on grades 9-10 reading and content, choosing flexibly from a range of strategies. a. Determine meanings of unfamiliar words by using knowledge of derivational roots and affixes, including cultural derivations (e.g., the root of photography and photosynthesis; kayak), context (e.g., the overall meaning of a sentence, paragraph, or text; a word's position or function in a sentence), dialectical English (e.g., Huck Finn), idiomatic expressions (e.g., "it drives me up a wall") as clues to the meaning of a word or phrase. b. Identify and correctly use patterns of word changes that indicate different meanings or parts of speech (e.g., *analyze*, *analysis*, *analytical*; *advocate*, *advocacy*). c. Consult general and specialized reference materials (e.g., dictionaries, glossaries, thesauruses), both print and digital, to find the pronunciation of a word or determine or clarify its precise meaning, its part of speech, or its etymology. d. Verify the preliminary determination of the meaning of a word or phrase (e.g., by checking the inferred meaning in context or in a dictionary). **5.** Demonstrate understanding of figurative language, word relationships, and nuances in word meanings. a. Interpret figures of speech (e.g., euphemism, oxymoron) in context and analyze their role in the text. b. Analyze nuances in the meaning of words with similar denotation (definition) or determine the meaning of analogies. **6.** Acquire and use accurately general academic and domain-specific words and phrases, sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression.	**4.** Determine or clarify the meaning of unknown and multiple-meaning words and phrases based on grades 11-12 reading and content, choosing flexibly from a range of strategies. a. Determine meanings of unfamiliar words by using knowledge of derivational roots and affixes, including cultural derivations (e.g., the root of photography and photosynthesis; kayak), context (e.g., the overall meaning of a sentence, paragraph, or text; a word's position or function in a sentence), dialectical English (e.g., Huck Finn), idiomatic expressions (e.g., "it drives me up a wall") as clues to the meaning of a word or phrase. b. Identify and correctly use patterns of word changes that indicate different meanings or parts of speech (e.g., *conceive*, *conception*, *conceivable*). c. Consult general and specialized reference materials (e.g., dictionaries, glossaries, thesauruses), both print and digital, to find the pronunciation of a word or determine or clarify its precise meaning, its part of speech, its etymology, or its standard usage. d. Verify the preliminary determination of the meaning of a word or phrase (e.g., by checking the inferred meaning in context or in a dictionary). **5.** Demonstrate understanding of figurative language, word relationships, and nuances in word meanings. a. Interpret figures of speech (e.g., hyperbole, paradox) in context and analyze their role in the text. b. Analyze nuances in the meaning of words with similar denotations (definition) or determine the meaning of analogies. **6.** Acquire and use accurately general academic and domain-specific words and phrases, sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression.

Standards for Literacy in History/Social Studies, Science, and Technical Subjects 6-12

Reading Standards for Literacy in History/Social Studies 6-12

The standards below begin in grade 6; standards for K-5 reading in history/social studies, science and technical subjects are integrated in the K-5 Reading standards. The Alaska Reading Anchor Standards and high school standards in literacy work in tandem to define college and career readiness expectations – the former providing broad standards, the latter providing additional specificity.

Grades 6-8 students:	Grades 9-10 students:	Grades 11-12 students:
Key Ideas and Details		
1. Cite specific textual evidence to support analysis of primary and secondary sources.	**1.** Cite specific textual evidence to support analysis of primary and secondary sources, attending to such features as the date and origin of the information.	**1.** Cite specific textual evidence to support analysis of primary and secondary sources, connecting insights gained from specific details to an understanding of the text as a whole.
2. Determine the central ideas or information of a primary or secondary source; provide an accurate summary of the source distinct from prior knowledge or opinions.	**2.** Determine the central ideas or information of a primary or secondary source; provide accurate summary of how key events or ideas develop over the course of the text.	**2.** Determine the central ideas or information of a primary or secondary source; provide accurate summary that makes clear the relationships among the key details and ideas.
3. Identify key steps in a text's description of a process related to history/social studies (e.g., how a bill becomes law, how interest rates are raised or lowered).	**3.** Analyze in detail a series of events described in a text; determine whether earlier events caused later ones or simply preceded them.	**3.** Evaluate various explanations for actions or events and determine which explanation best accords with textual evidence, acknowledging where the text leaves matters uncertain.
Craft and Structure		
4. Determine the meaning of words and phrases as they are used in a text, including vocabulary specific to domains related to history/social studies.	**4.** Determine the meaning of words and phrases as they are used in a text, including vocabulary describing political, social, or economic aspects of history/social studies.	**4.** Determine the meaning of words and phrases as they are used in a text, including figurative and connotative meanings; analyze the impact of specific word choices on meaning and tone, including analogies or allusions to other texts.
5. Describe how a text presents information (e.g., sequentially, comparatively, causally)	**5.** Analyze how a text uses structure to emphasize key points or advance an explanation or analysis.	**5.** Analyze in detail how a complex primary source is structured, including how key sentences, paragraphs, and larger portions of the text contribute to the whole.
6. Identify aspects of a text that reveal an author's point of view or purpose (e.g., loaded language, inclusion or avoidance of particular facts).	**6.** Compare the point of view of two or more authors for how they treat the same or similar topics, including which details they include and emphasize in their respective accounts.	**6.** Evaluate authors' differing points of view on the same historical event or issue by assessing the authors' claims, reasoning, and evidence.

Reading Standards for Literacy in History/Social Studies 6-12

Grades 6-8 students:	Grades 9-10 students:	Grades 11-12 students:
Integration of Knowledge and Ideas		
7. Integrate visual information (e.g., in charts, graphs, photographs, videos, or maps) with other information in print and digital texts.	**7.** Integrate quantitative or technical analysis (e.g., charts, research data) with qualitative analysis in print or digital texts.	**7.** Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., visually, quantitatively, as well as in words) in order to address a question or solve a problem.
8. Distinguish among fact, opinion, and reasoned judgment in a text.	**8.** Assess the extent to which the reasoning and evidence in a text support the author's claim.	**8.** Evaluate an author's premises, claims, and evidence by corroborating or challenging them with other information.
9. Analyze the relationship between a primary and secondary source on the same topic.	**9.** Compare and contrast treatments of the same topic in several primary and secondary sources.	**9.** Integrate information from diverse sources, both primary and secondary, into a coherent understanding of an idea or event, noting discrepancies among sources.
Range of Reading and Level of Text Complexity		
10. By the end of grade 8, read and comprehend history/social studies texts in the grades 6-8 text complexity band independently and proficiently.	**10.** By the end of grade 10, read and comprehend history/social studies texts in the grades 9-10 text complexity band independently and proficiently.	**10.** By the end of grade 12, read and comprehend history/social studies texts in the grades 11-12 text complexity band independently and proficiently.

Reading Standards for Literacy in Science and Technical Subjects 6-12

Grades 6-8 students:	Grades 9-10 students:	Grades 11-12 students:
Key Ideas and Details		
1. Cite specific textual evidence to support analysis of science and technical texts.	**1.** Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.	**1.** Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
2. Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions.	**2.** Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text.	**2.** Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.
3. Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.	**3.** Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.	**3.** Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.
Craft and Structure		
4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics.	**4.** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics.	**4.** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and topics.
5. Analyze the structure an author uses to organize a text, including how the major sections contribute to the whole and to an understanding of the topic.	**5.** Analyze the structure of the relationships among concepts in a text, including relationships among key terms *(e.g., force, friction, reaction force, energy).*	**5.** Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas.
6. Analysis the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text.	**6.** Analyze the author's purpose in providing an explanation, describing a p0rocedure, or discussing an experiment in a text, defining the question the author seeks to address.	**6.** Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved.

Reading Standards for Literacy in Science and Technical Subjects 6-12

Grades 6-8 students:	Grades 9-10 students:	Grades 11-12 students:
Integration of Knowledge and Ideas		
7. Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).	**7.** Translate quantitative or technical information expressed in words in a text into visual from (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.	**7.** Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
8. Distinguish among facts, reasoned judgment based on research findings, and speculation in a text.	**8.** Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem.	**8.** Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
9. Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.	**9.** Compare and contrast findings presented in a text to those from other sources (including their own experiments), noting when the findings support or contradict previous explanations or accounts.	**9.** Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon or concept, resolving conflicting information when possible.
Range of Reading and Level of Text Complexity		
10. By the end of grade 8, read and comprehend science/technical texts in the grades 6-8 text complexity band independently and proficiently.	**10.** By the end of grade 10, read and comprehend science/technical texts in the grades 9-10 text complexity band independently and proficiently.	**10.** By the end of grade 12, read and comprehend science/technical texts in the grades 11-12 text complexity band independently and proficiently.

Writing Standards for Literacy in History/Social Studies, Science and Technical Subjects 6-12

The standards below begin in grade 6; standards for K-5 writing in history/social studies, science, and technical subjects are integrated into the K-5 writing standards. The Alaska Writing Anchor Standards and high school standards in literacy work in tandem to define college and career readiness expectations – the former providing broad standards, the latter providing additional specificity.

Grades 6-8 students:	Grades 9-10 students:	Grades 11-12 students:
Text Types and Purposes		
1. Write arguments focused on discipline-specific content. a. Introduce claim(s) abut a topic or issue, acknowledge and distinguish the claim(s) from alternate or opposing claims, and organize the reasons and evidence logically. b. Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources. c. Use words, phrases, and clauses to create cohesion and clarify the relationships among claim(s), counterclaims, reasons, and evidence. d. Establish and maintain a formal style. e. Provide a concluding statement or section that follows from and supports the argument presented.	**1.** Write arguments focused on discipline-specific content. a. Introduce precise claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that establishes clear relationships among the claim(s), counterclaims, reasons, and evidence. b. Develop claim(s) and counterclaims fairly, supplying data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form and in a manner that anticipates the audience's knowledge level and concerns. c. Use words, phrases, and clauses to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons between reasons and evidence, and between claim(s) and counterclaims. d. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing. e. Provide a concluding statement or section that follows from and supports the argument presented.	**1.** Write arguments focused on discipline-specific content. a. Introduce precise claim(s), knowledgeable claim(s), establish the significance of the claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that logically sequences the claim(s), counterclaims, reasons, and evidence. b. Develop claim(s) and counterclaims fairly and thoroughly, supplying the most relevant data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form that anticipates the audience's knowledge level, concerns, values, and possible biases. c. Use words, phrases, and clauses as well as varied syntax to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons between reasons and evidence, and between claim(s) and counterclaims. d. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing. e. Provide a concluding statement or section that follows from and supports the argument presented.

Writing Standards for Literacy in History/Social Studies, Science and Technical Subjects 6-12

Grades 6-8 students:	Grades 9-10 students:	Grades 11-12 students:
2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes. a. Introduce a topic clearly, previewing what is to follow; organize ideas, concepts, and information into broader categories as appropriate to achieving purpose; include formatting (e.g., headings) graphics (e.g., charts, tables), and multimedia when useful to aiding comprehension.	**2.** Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes. a. Introduce a topic clearly, previewing what is to follow; organize ideas, concepts, and information, using strategies such as definition, classification, comparison/contrast, and cause/effect; include formatting (e.g., headings), graphics (e.g., charts, tables), and multimedia when useful to aiding comprehension.	**2.** Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes. a. Introduce a topic clearly, previewing what is to follow; organize ideas, concepts, and information into broader categories; include formatting (e.g., headings), graphics (e.g., charts, tables), and multimedia when useful to aiding comprehension.
b. Develop the topic with relevant facts, definitions, concrete details, quotations, or other information and examples. c. Use appropriate and varied transitions to create cohesion and clarify the relationships among ideas and concepts. d. Use precise language and domain-specific vocabulary to inform about or explain the topic. e. Establish and maintain a formal style and objective tone. f. Provide a concluding statement or section that follows from and supports the information or explanation presented.	b. Develop the topic with well-chosen, relevant, and sufficient facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic. c. Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among ideas and concepts. d. Use precise language and domain-specific vocabulary to manage the complexity of the topic and convey a style appropriate to the discipline and context as well as to the expertise of likely readers. e. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing. f. Provide a concluding statement or section that follows from and supports the information or explanation presented (e.g., articulating implications or the significance of the topic).	b. Develop the topic thoroughly by selecting the most significant and relevant facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic. c. Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among complex ideas and concepts. d. Use precise language and domain-specific vocabulary and techniques such as metaphor, simile, and analogy to manage the complexity of the topic; convey a knowledgeable stance in a style that responds to the discipline and context as well as to the expertise of likely readers. e. Provide a concluding statement or section that follows from and supports the information or explanation presented (e.g., articulating implications or the significance of the topic).

Writing Standards for Literacy in History/Social Studies, Science and Technical Subjects 6-12

Grades 6-8 students:	Grades 9-10 students:	Grades 11-12 students:
3. Not applicable as a separate requirement.	**3.** Not applicable as a separate requirement.	**3.** Not applicable as a separate requirement.

Note: Students' narrative skills continue to grow in these grades. The Standards require that students be able to incorporate narrative elements effectively into arguments and information/explanatory texts. In history/social studies, students must be able to incorporate narrative accounts into their analyses of individuals or events of historical import. In science and technical subjects, students must be able to write precise enough descriptions of the step-by-step procedures they use in their investigations or technical work that others can replicate them and (possibly) reach the same results.

Production and Distribution of Writing		
4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.	**4.** Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.	**4.** Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
5. With some guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on how well purpose and audience have been addressed.	**5.** Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.	**5.** Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on what is most significant for a specific purpose and audience.
6. Use technology, including the Internet, to produce and publish writing and present the relationships between information and ideas clearly and efficiently.	**6.** Use technology, including the Internet, to produce, publish, and update individual or shared writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically.	**6.** Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.
Research to Build and Present Knowledge		
7. Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.	**7.** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.	**7.** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

Writing Standards for Literacy in History/Social Studies, Science and Technical Subjects 6-12

Grades 6-8 students:	Grades 9-10 students:	Grades 11-12 students:
8. Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation.	**8.** Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.	**8.** Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.
9. Draw evidence from informational texts to support analysis, reflection, and research.	**9.** Draw evidence from informational texts to support analysis, reflection, and research.	**9.** Draw evidence from informational texts to support analysis, reflection, and research.
Range of Writing		
10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.	**10.** Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.	**10.** Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Glossary for English/Language Arts Standards

author's purpose

Purpose is the goal or objective the author is trying to accomplish; the intention or reason for writing a text; for example: to persuade, to entertain, to describe, to explain.

collegial

Marked by camaraderie among colleagues.

domain-specific words and phrases

Vocabulary specific to a particular field of study: analogous to tier-three words.

expository text

Nonfiction, factual prose written to explain or convey information.

fallacious

Embodying a fallacy.

figurative language

Language that moves beyond the literal in which a figure of speech is used to heighten the meaning; for example: hyperbole, metaphor, personification, or simile.

general academic words and phrases

Vocabulary common to written texts but not commonly a part of speech.

informational text

Explanatory writing that serves one or more closely related purposes: to increase readers' knowledge of a subject, to help readers better understand a procedure or process, or to provide readers with an enhanced comprehension of a concept. Informational/explanatory writing conveys information accurately.

literary text

This category is used to classify literary works, usually by form, technique, or content: novel, essay, short story, comedy, epic.

narrative writing

Writing that conveys experience, either real or imaginary, and uses time as its deep structure. It can be used for many purposes: inform, instruct, persuade, or entertain. Narratives take many forms: creative fictional stories, memoirs, anecdotes, and autobiographies.

persuasive writing

The purpose is to convince the reader of an idea, to change the reader's mind, or to move the reader to action: letters to the editor, political pamphlets.

register

A variety of language used for a specific purpose or in a particular social setting; appropriate register depends upon the audience, purpose, topic, and location; for example: a different type of language may be used for speaking to friends than to teachers.

scaffolding

Temporary guidance or assistance provided to a student by a teacher, another adult, or a more capable peer, enabling the student to perform a task he or she otherwise would not be able to do alone, with the goal of fostering the student's capacity to perform the task independently.

technical text

Practical, accurate, and precise communication of specialized information that imparts facts, persuades with facts, or analyzes data or problems. The format is clear and efficient, often including headings, itemized lists with bullets, diagrams, or tables: instruction manual, scientific article, sales letter, letter of recommendation, proposal, or memo

Department of Education
& Early Development

ALASKA MATHEMATICS STANDARDS

Adopted June 2012

For additional information on Alaska's standards, write:
Standards, Department of Education & Early Development
PO Box 110500 Juneau, Alaska 99811-0500
Or call, (907) 465-2900; or visit our website: http://education.alaska.gov

Table of Contents

Alaska English/Language Arts and Mathematics Content Standards

High academic standards are an important first step in ensuring that all Alaska's students have the tools they need for success. These standards reflect the collaborative work of Alaskan educators and national experts from the nonprofit National Center for the Improvement of Educational Assessment. Further, they are informed by public comments. Alaskan teachers have played a key role in this effort, ensuring that the standards reflect the realities of the classroom. Since work began in spring 2010, the standards have undergone a thoughtful and rigorous drafting and refining process.

A nationwide movement among the states and employers has called for America's schools to prepare students to be ready for postsecondary education and careers. Standards in English/language arts and mathematics build a foundation for college and career readiness. Students proficient in the standards read widely and deeply in a range of subjects, communicate clearly in written and spoken English, have the capacity to build knowledge on a subject, and understand and use mathematics.

Industry leaders were part of Alaska's standards review. Repeatedly these leaders placed the greatest weight on critical thinking and adaptability as essential skills in the workplace. Industry leaders believe that strengthening our K-12 system will help ensure that Alaskans are prepared for high-demand, good-wage jobs. Instructional expectations that include employability standards will help students prepare for a career.

Additionally, institutions of higher education were engaged in refining Alaska's standards. These educators focused on whether the standards would culminate in student preparedness. Students proficient in Alaska's standards will be prepared for credit-bearing courses in their first year of postsecondary education. It is critical that students can enter institutions of higher education ready to apply their knowledge, extend their learning, and gain technical and job-related skills.

These standards do not tell teachers how to teach, nor do they attempt to override the unique qualities of each student and classroom. They simply establish a strong foundation of knowledge and skills all students need for success after graduation. It is up to schools and teachers to decide how to put the standards into practice and incorporate other state and local standards, including cultural standards. In sum, students must be provided opportunities to gain skills and learn to apply them to real-world life and work situations.

Introduction to Mathematics Standards

The mathematics standards prepare Alaska students to be competitive on the national and world stage. These standards are a set of specific, rigorous expectations that build students' conceptual understanding, mathematical language, and application of processes and procedures coherently from one grade to the next so all students will be prepared for post-secondary experiences. The focus areas for each grade level and each conceptual category narrative establish a depth of knowledge as opposed to a breadth of knowledge across multiple standards in each grade level or content area.

The standards for mathematics stress both conceptual understanding and procedural skills to ensure students learn and can apply the critical information needed to succeed at each level.

- In kindergarten, the standards follow successful international models and recommendations by focusing kindergarten work on the number core: learning how numbers correspond to quantities, and learning how to put numbers together and take them apart (the beginnings of addition and subtraction).

- The K-5 standards provide students with a solid foundation in whole numbers, addition, subtraction, multiplication, division, fractions and decimals--which help young students build the foundation to successfully apply more demanding math concepts and procedures and move into applications.

- Having built a strong foundation in K-5, students can do hands-on learning in geometry, algebra and probability and statistics. Students who have completed 7th grade and mastered the content and skills through the 7th grade will be well-prepared for algebra in grade 8. The middle school standards are robust and provide a coherent and rich preparation for high school mathematics.

- The high school standards set a rigorous definition of readiness by helping students develop a depth of understanding and ability to apply mathematics to novel situations, as college students and employees regularly do.

Organization of Mathematics Standards

The Alaska Mathematics Standards define what students should understand and be able to do in their study of mathematics. Teachers ensure students achieve standards by using a variety of instructional strategies based on their students' needs.

The standards are divided into two areas of equal importance:

1. **The Standards for Mathematical Practice** are embedded at every grade level to establish habits of mind that will empower students to become mathematically literate. Instructional approaches that promote students' development of the Practices are critical to procedural fluency in mathematics.

2. **The Standards for Mathematical Content** are grade-level specific in kindergarten through grade 8. The high school content is organized by conceptual category. Taken together, the K-12 standards provide a scaffold that allows students to become increasingly more proficient in understanding and using mathematics. There is a gradual, steady progression leading to college and career readiness by the time students graduate from high school.

Each grade-level is supported with the inclusion of an Instructional Focus section. The Instructional Focus guides teachers toward the critical areas of emphasis. Each high school Conceptual Category includes a narrative that also guides teachers' instruction.

The Standards for Mathematical Practice

These eight standards bring the complexities of the world into focus and give schema for grappling with authentic and meaningful problems. The practice standards define experiences that build understanding of mathematics and ways of thinking through which students develop, apply, and assess their knowledge.

Algorithmic knowledge is no longer sufficient when preparing our students to become globally competitive. The knowledge of good practitioners goes beyond algorithmic learning and allows them to picture the problem and the many roads that may lead to a solution. They realize that mathematics is applicable outside of the classroom and are confident in their ability to apply mathematical concepts to all aspects of life. The Standards of Mathematical Practice allow students to deepen their understandings of mathematical concepts and cultivates their autonomy as mathematically literate and informed citizens. Employing mathematics as a means of synthesizing complex concepts and making informed decisions is paramount to success in all post-secondary endeavors.

Standards for Mathematical Practice									
1. Make sense of problems and persevere in solving them 2. Reason abstractly and quantitatively 3. Construct viable arguments and critique the reasoning of others 4. Model with mathematics					5. Use appropriate tools strategically 6. Attend to precision 7. Look for and make use of structure 8. Look for and express regularity in repeated reasoning				
Kindergarten	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**High School**

Instruction around the Standards for Mathematical Practices is delivered across all grades K-12. For each Standard for Mathematical Practice, there are grade-span descriptors that are meant to help students, parents and educators determine how these might be demonstrated by students. Implementing the practices to meet the descriptors will involve strengthening current teaching practices.

The Standards for Mathematical Content

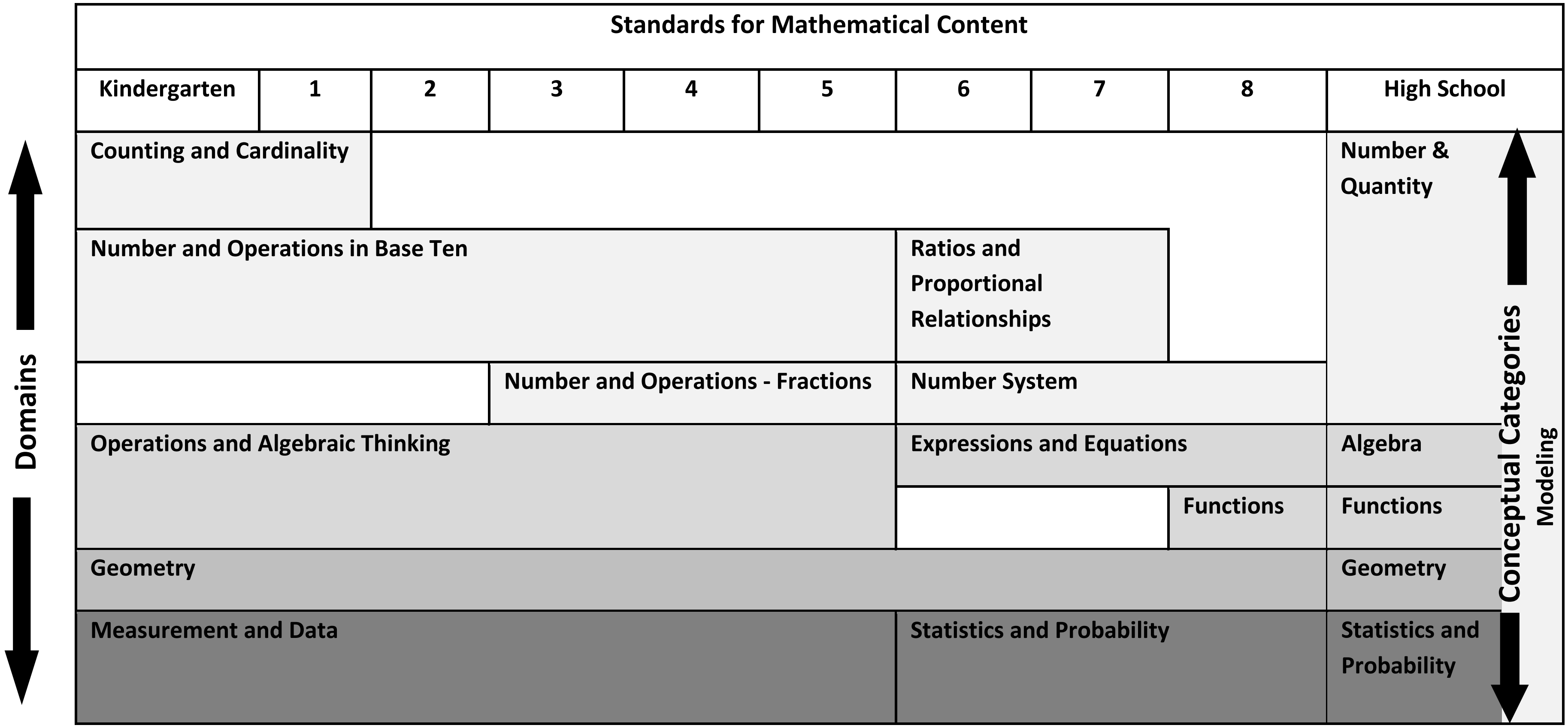
Each grade level in the K-8 standards is prefaced with an explanation of instructional focus areas for that grade level. Each conceptual category in the high school standards is prefaced with an explanation of the implication of that category to a student's mastery of mathematics. Specific modeling standards appear throughout the high school standards as indicated by an asterisk (*).

Additional mathematic standards that students should learn in order to take advanced courses such as calculus, advanced statistics, or discrete mathematics are indicated by a plus symbol (+). The plus symbol indicates that the standard is not required for all students.

K-8 Mathematical Domains:	**High School Conceptual Categories:**
1. Counting and Cardinality – CC	1. Number and Quantity – N
2. Operations and Algebraic Thinking – OA	2. Algebra – A
3. Number and Operations in Base Ten – NBT	3. Functions – F
4. Measurement and Data – MD	4. Modeling – M
5. Number and Operations – Fractions – NF	5. Geometry – G
6. Geometry – G	6. Statistics and Probability – P
7. Ratios and Proportional Relationships – RP	
8. The Number System – NS	
9. Expressions and Equations – EE	
10. Functions – F	
11. Statistics and Probability – SP	

The standards for mathematics stress both conceptual understanding and procedural skills to ensure students learn and can apply the critical information needed to succeed at each level. This creates a learning progression where the mathematics learned in elementary school provides the foundation for the study of statistics, probability, ratio and proportion, geometry, and algebra in middle school. This is, in turn, the base upon which the knowledge needed for success in colleges and careers can be developed in high school.

The standards organization is not intended to convey the order of instruction nor the length of time to devote to the topics. In the standards, the clusters have been arranged in the grade span to show the continuum between grades. The following table outlines the progression of the content from kindergarten through high school.



Domains are large groups of related standards. Each shaded row shows how domains at the earlier grades progress and lead to conceptual categories at the high school levels. The right side of the chart lists the five **conceptual categories** for high school. Selecting one conceptual category and moving left along the row shows the domains at the middle and elementary school levels from which this concept builds. Modeling, the sixth conceptual category, is incorporated throughout the other five high school categories.

Overall, the progressions of the standards begin and end in different grades, avoiding the re-teaching of concepts that should have been mastered. This allows for higher rigor overall, which is key to laying the foundation for high school mathematics standards and college/career preparedness.

For each of the grade-spans (K-2, 3-5, 6-8, and 9-12) an overview of the topics to be covered follows.

Overview of Mathematical Content Standards

Kindergarten	Grade 1	Grade 2
Counting and Cardinality • Know number names and the count sequence. • Count to tell the number of objects. • Compare numbers. **Operations and Algebraic Thinking** • Understand addition as putting together and adding to, and understand subtraction as taking apart and taking from. • Identify and continue patterns. **Number and Operations in Base Ten** • Work with numbers 11–19 to gain foundations for place value. **Measurement and Data** • Describe and compare measurable attributes. • Classify objects and count the number of objects in categories. • Work with time and money. **Geometry** • Identify and describe shapes. • Analyze, compare, create, and compose shapes.	**Counting and Cardinality** • Know ordinal names and counting flexibility. • Count to tell the number of objects. • Compare numbers. **Operations and Algebraic Thinking** • Represent and solve problems involving addition and subtraction. • Understand and apply properties of operations and the relationship between addition and subtraction. • Add and subtract up to 20. • Work with addition and subtraction equations. • Identify and continue patterns. **Number and Operations in Base Ten** • Extend the counting sequence. • Understand place value. • Use place value understanding and properties of operations to add and subtract. **Measurement and Data** • Measure lengths indirectly and by iterating length units. • Work with time and money. • Represent and interpret data. **Geometry** • Reason with shapes and their attributes.	**Operations and Algebraic Thinking** • Represent and solve problems involving addition and subtraction. • Add and subtract up to 20. • Work with equal groups of objects to gain foundations for multiplication. • Identify and continue patterns. **Number and Operations in Base Ten** • Understand place value. • Use place value understanding and properties of operations to add and subtract. **Measurement and Data** • Measure and estimate lengths in standard units. • Relate addition and subtraction to length. • Work with time and money. • Represent and interpret data. **Geometry** • Reason with shapes and their attributes.

Grade 3	Grade 4	Grade 5
Operations and Algebraic Thinking • Represent and solve problems involving multiplication and division. • Understand properties of multiplication and the relationship between multiplication and division. • Multiply and divide up to 100. • Solve problems involving the four operations, and identify and explain patterns in arithmetic. **Number and Operations in Base Ten** • Use place value understanding and properties of operations to perform multi-digit arithmetic. **Number and Operations—Fractions** • Develop understanding of fractions as numbers. **Measurement and Data** • Solve problems involving measurement and estimation of intervals of time, liquid volumes, and masses of objects. • Represent and interpret data. • Geometric measurement: understand concepts of area and relate area to multiplication and to addition. • Geometric measurement: recognize perimeter as an attribute of plane figures and distinguish between linear and area measures. **Geometry** • Reason with shapes and their attributes.	**Operations and Algebraic Thinking** • Use the four operations with whole numbers to solve problems. • Gain familiarity with factors and multiples. • Generate and analyze patterns. **Number and Operations in Base Ten** • Generalize place value understanding for multi-digit whole numbers. • Use place value understanding and properties of operations to perform multi-digit arithmetic. **Number and Operations—Fractions** • Extend understanding of fraction equivalence and ordering. • Build fractions from unit fractions by applying and extending previous understandings of operations on whole numbers. • Understand decimal notation for fractions, and compare decimal fractions. **Measurement and Data** • Solve problems involving measurement and conversion of measurements from a larger unit to a smaller unit and involving time. • Represent and interpret data. • Geometric measurement: understand concepts of angle and measure angles. **Geometry** • Draw and identify lines and angles, and classify shapes by properties of their lines and angles.	**Operations and Algebraic Thinking** • Write and interpret numerical expressions. • Analyze patterns and relationships. **Number and Operations in Base Ten** • Understand the place value system. • Perform operations with multi-digit whole numbers and with decimals to hundredths. **Number and Operations—Fractions** • Use equivalent fractions as a strategy to add and subtract fractions. • Apply and extend previous understandings of multiplication and division to multiply and divide fractions. **Measurement and Data** • Convert like measurement units within a given measurement system and solve problems involving time. • Represent and interpret data. • Geometric measurement: understand concepts of volume and relate volume to multiplication and to addition. **Geometry** • Graph points on the coordinate plane to solve real-world and mathematical problems. • Classify two-dimensional figures into categories based on their properties.

Grade 6	Grade 7	Grade 8
Ratios and Proportional Relationships • Understand ratio concepts and use ratio reasoning to solve problems. **The Number System** • Apply and extend previous understandings of multiplication and division to divide fractions by fractions. • Compute fluently with multi-digit numbers and find common factors and multiples. • Apply and extend previous understandings of numbers to the system of rational numbers. **Expressions and Equations** • Apply and extend previous understandings of arithmetic to algebraic expressions. • Reason about and solve one-variable equations and inequalities. • Represent and analyze quantitative relationships between dependent and independent variables. **Geometry** • Solve real-world and mathematical problems involving area, surface area, and volume. **Statistics and Probability** • Develop understanding of statistical variability. • Summarize and describe distributions.	**Ratios and Proportional Relationships** • Analyze proportional relationships and use them to solve real-world and mathematical problems. **The Number System** • Apply and extend previous understandings of operations with fractions to add, subtract, multiply, and divide rational numbers. **Expressions and Equations** • Use properties of operations to generate equivalent expressions. • Solve real-life and mathematical problems using numerical and algebraic expressions and equations. **Geometry** • Draw, construct and describe geometrical figures and describe the relationships between them. • Solve real-life and mathematical problems involving angle measure, area, surface area, and volume. **Statistics and Probability** • Use random sampling to draw inferences about a population. • Draw informal comparative inferences about two populations. • Investigate chance processes and develop, use, and evaluate probability models.	**The Number System** • Know that there are numbers that are not rational, and approximate them by rational numbers. **Expressions and Equations** • Work with radicals and integer exponents. • Understand the connections between proportional relationships, lines, and linear equations. • Analyze and solve linear equations and pairs of simultaneous linear equations. **Geometry** • Understand congruence and similarity using physical models, transparencies, or geometry software. • Understand and apply the Pythagorean Theorem. • Solve real-world and mathematical problems involving volume of cylinders, cones and spheres. **Statistics and Probability** • Investigate patterns of association in bivariate data. **Functions** • Define, evaluate, and compare functions. • Use functions to model relationships between quantities.

Overview of High School Content Standards

Modeling	Number and Quantity	Algebra
Modeling links classroom mathematics and statistics to everyday life, work, and decision-making. Modeling is the process of choosing and using appropriate mathematics and statistics to analyze empirical situations, to understand them better, and to improve decisions. Modeling is best interpreted not as a collection of isolated topics but rather in relation to other standards. Specific modeling standards appear throughout the high school standards indicated by an asterisk (*). If the asterisk appears on the heading for a group of standards, it should be understood to apply to all standards in that group. There are other individual standards under clusters, domains and conceptual categories that have connections to modeling. Additionally, model with mathematics is a Standard for Mathematical Practice. This practice will be started in kindergarten.	**The Real Number System** • Extend the properties of exponents to rational exponents. • Use properties of rational and irrational numbers. **Quantities*** • Reason quantitatively and use units to solve problems. **The Complex Number System** • Perform arithmetic operations with complex numbers. • Represent complex numbers and their operations on the complex plane. + • Use complex numbers in polynomial identities and equations. **Vector and Matrix Quantities** • Represent and model with vector quantities. + • Perform operations on vectors. + • Perform operations on matrices and use matrices in applications. +	**Seeing Structure in Expressions** • Interpret the structure of expressions. • Write expressions in equivalent forms to solve problems.* **Arithmetic with Polynomials and Rational Expressions** • Perform arithmetic operations on polynomials. • Understand the relationship between zeros and factors of polynomials. • Use polynomial identities to solve problems. • Rewrite rational expressions. **Creating Equations and Inequalities*** • Create equations and inequalities that describe numbers or relationships. **Reasoning with Equations and Inequalities** • Understand solving equations as a process of reasoning and explain the reasoning. • Solve equations and inequalities in one variable. • Solve systems of equations. • Represent and solve equations and inequalities graphically.

*Standards with connections to modeling. If asterisk appears on the category, domain, or cluster for a group of standards, it should be understood to apply to all standards in that group. There may be individual standards within clusters with connections to modeling.
+ Standards include additional mathematics that students should learn in order to take advanced courses such as calculus, advanced statistics, or discrete mathematics.

Functions	Geometry	Statistics and Probability*
Interpreting Functions • Understand the concept of a function and use function notation. • Interpret functions that arise in applications in terms of the context. • Analyze functions using different representations. **Building Functions** • Build a function that models a relationship between two quantities. • Build new functions from existing functions. **Linear, Quadratic, and Exponential Models*** • Construct and compare linear, quadratic, and exponential models and solve problems. • Interpret expressions for functions in terms of the situation they model. **Trigonometric Functions** • Extend the domain of trigonometric functions using the unit circle. • Model periodic phenomena with trigonometric functions. • Prove and apply trigonometric identities.	**Congruence** • Experiment with transformations in the plane. • Understand congruence in terms of rigid motions. • Prove geometric theorems. • Make geometric constructions. **Similarity, Right Triangles, and Trigonometry** • Understand similarity in terms of similarity transformations. • Prove theorems involving similarity. • Define trigonometric ratios and solve problems involving right triangles. • Apply trigonometry to general triangles. + **Circles** • Understand and apply theorems about circles. • Find arc lengths and areas of sectors of circles. **Expressing Geometric Properties with Equations** • Translate between the geometric description and the equation for a conic section. • Use coordinates to prove simple geometric theorems algebraically. **Geometric Measurement and Dimension** • Explain volume formulas and use them to solve problems. • Visualize relationships between two-dimensional and three-dimensional objects. **Modeling with Geometry** • Apply geometric concepts in modeling situations.*	**Interpreting Categorical and Quantitative Data** • Summarize, represent, and interpret data on a single count or measurement variable. • Summarize, represent, and interpret data on two categorical and quantitative variables. • Interpret linear models. **Making Inferences and Justifying Conclusions** • Understand and evaluate random processes underlying statistical experiments. • Make inferences and justify conclusions from sample surveys, experiments, and observational studies. **Conditional Probability and the Rules of Probability** • Understand independence and conditional probability and use them to interpret data. • Use the rules of probability to compute probabilities of compound events in a uniform probability model. **Using Probability to Make Decisions** • Calculate expected values and use them to solve problems. + • Use probability to evaluate outcomes of decisions. +

*Standards with connections to modeling. If the asterisk appears on the category, domain, or cluster for a group of standards, it should be understood to apply to all standards in that group. There may be individual standards within clusters with connections to modeling.
+ Standards include additional mathematics that students should learn in order to take advanced courses such as calculus, advanced statistics, or discrete mathematics.

Guide to Reading the Mathematical Content Standards

There are eleven domains within the K-8 Standards. Students advancing through the grades are expected to meet each year's grade-specific standards, and retain or further develop skills and understandings mastered in preceding grades. An instructional focus is included before each grade to support the implementation of the content.

K-8 Mathematical Domains:

1. Counting and Cardinality - CC
2. Operations and Algebraic Thinking - OA
3. Number and Operations in Base Ten - NBT
4. Measurement and Data - MD
5. Number and Operations - Fractions - NF
6. Geometry - G
7. Ratios and Proportional Relationships - RP
8. The Number System - NS
9. Expressions and Equations - EE
10. Functions - F
11. Statistics and Probability - SP

Domains are intended to convey coherent groupings of content. All domains are underlined.
Clusters are groups of related standards. Cluster headings are bolded.
Standards define what students should understand and be able to do. Standards are numbered. Any standard followed by an (L) indicates the standard is to be locally assessed.

K- 8 Grade Level

Domain

Cluster

Standard

Grade 4

<u>Number and Operations in Base Ten 4.NBT</u>

Generalize place value understanding for multi-digit whole numbers.

4.NBT.1. Recognize that in a multi-digit whole number, a digit in one place represents ten times what it represents in the place to its right. *For example, recognize that $700 \div 70 = 10$ by applying concepts of place value and division.*

4.NBT.2. Read and write multi-digit whole numbers using base-ten numerals, number names, and expanded form. Compare two multi-digit numbers based on the value of the digits in each place, using >, =, and < symbols to record the results of comparisons.

4.NBT.3. Use place value understanding to round multi-digit whole numbers to any place using a variety of estimation methods; be able to describe, compare, and contrast solutions.

The high school standards specify the mathematics that all students should study in order to be career and college ready. They are organized into conceptual categories, which are intended to portray a coherent view of high school mathematics. A student's work with any set of standards crosses a number of traditional course boundaries. For example, the Functions Standards would apply to many courses such as Algebra I or Algebra II. It is a district decision how to design course offerings covering the mathematics standards. Districts can use the traditional approach of Algebra I, Geometry, and Algebra II or implement an integrated approach. There are various high school math pathways to be considered.

There are six conceptual categories for high school. Each conceptual category in the high school standards is prefaced with a narrative and an explanation of the implication of that category to a student's mastery of mathematics.

High School Mathematical Conceptual Categories:

1. Number and Quantity - N
2. Algebra - A
3. Functions - F
4. Modeling - M
5. Geometry - G
6. Statistics and Probability - P

Conceptual Category → **Geometry Standards**

Domain → **Geometric Measurement and Dimension** **G-GMD**

Cluster → **Explain volume formulas and use them to solve problems**

Standard →

G-GMD.1. Explain how to find the formulas for the circumference of a circle, area of a circle, volume of a cylinder, pyramid, and cone.

G-GMD.2. (+) Give an informal argument using Cavalieri's principle for the formulas for the volume of a sphere and other solid figures.

G-GMD.3. Use volume formulas for cylinders, pyramids, cones, and spheres to solve problems.*

(+) Additional standards for advanced courses
(*) Standards with connection to modeling

Standards for Mathematical Practice

Alaska Standards for Mathematical Practice

The Standards for Mathematical Practice describe varieties of expertise that mathematics educators at all levels should seek to develop in their students. These practices rest on important “processes and proficiencies” with longstanding importance in mathematics education. The first of these are the NCTM process standards of problem solving, reasoning and proof, communication, representation, and connections. The second are the strands of mathematical proficiency specified in the National Research Council’s report Adding It Up: adaptive reasoning, strategic competence, conceptual understanding (comprehension of mathematical concepts, operations and relations), procedural fluency (skill in carrying out procedures flexibly, accurately, efficiently and appropriately), and productive disposition (habitual inclination to see mathematics as sensible, useful, and worthwhile, coupled with a belief in diligence and one’s own efficacy).

1. Make sense of problems and persevere in solving them
2. Reason abstractly and quantitatively
3. Construct viable arguments and critique the reasoning of others
4. Model with mathematics
5. Use appropriate tools strategically
6. Attend to precision
7. Look for and make use of structure
8. Look for and express regularity in repeated reasoning

Each Standard for Mathematical Practice listed below is followed by a set of grade-span descriptors. These descriptors of the Standards of Mathematical Practice are meant to help students, parents and educators to picture how these practices might be demonstrated by students. Within the grade span, students should apply the practices using specific grade-level content. Additionally, students at higher grade spans may revisit earlier grade-span proficiencies as the rigor of the content increases.

Connecting the Standards for Mathematical Practice and Mathematical Content

The Standards for Mathematical Practice describe ways in which developing student practitioners of the discipline of mathematics increasingly ought to engage with the subject matter as they grow in mathematical maturity and expertise throughout the elementary, middle and high school years. Designers of curricula, assessments, and professional development should all attend to the need to connect the mathematical practices to mathematical content in mathematics instruction. The Standards for Mathematical Content are a balanced combination of procedure and understanding. Expectations that begin with the word “understand” are often especially good opportunities to connect the practices to the content. Students who lack understanding of a topic may rely on procedures too heavily. Without a flexible base from which to work, they may be less likely to consider analogous problems, represent problems coherently, justify conclusions, apply the mathematics to practical situations, use technology mindfully to work with the mathematics, explain the mathematics accurately to other students, step back for an overview, or deviate from a known procedure to find a shortcut. In short, a lack of understanding effectively prevents a student from engaging in the mathematical practices. In this respect, those content standards which set an expectation of understanding are potential “points of intersection” between the Standards for Mathematical Content and the Standards for Mathematical Practice. These points of intersection are intended to be weighted toward central and generative concepts in the school mathematics curriculum that most merit the time, resources, innovative energies, and focus necessary to qualitatively improve the curriculum, instruction, assessment, professional development, and student achievement in mathematics.

1. Make sense of problems and persevere in solving them.

Mathematically proficient students start by explaining to themselves the meaning of a problem and looking for entry points to its solution. They analyze givens, constraints, relationships, and goals. They make conjectures about the form and meaning of the solution and plan a solution pathway rather than simply jumping into a solution attempt. They consider analogous problems, and try special cases and simpler forms of the original problem in order to gain insight into its solution. They monitor and evaluate their progress and change course if necessary. Older students might, depending on the context of the problem, transform algebraic expressions or change the viewing window on their graphing calculator to get the information they need. Mathematically proficient students can explain correspondences between equations, verbal descriptions, tables, and graphs or draw diagrams of important features and relationships, graph data, and search for regularity or trends. Younger students might rely on using concrete objects or pictures to help conceptualize and solve a problem. Mathematically proficient students check their answers to problems using a different method, and they continually ask themselves, "Does this make sense?" They can understand the approaches of others to solving complex problems and identify correspondences between different approaches.

In grades K-2 mathematically proficient students will:

- focus on the problem and check for alternate methods
- check if the solution makes sense

In grades 3-5 mathematically proficient students will:

- explain correspondences between equations, verbal descriptions, tables, and graphs
- draw diagrams of important features and relationships, graph data, and search for regularity or trends
- use concrete objects or pictures to help conceptualize and solve a problem
- understand the approaches of others to solving complex problems
- identify correspondences between different approaches
- check if the solution makes sense

In grades 6-8 mathematically proficient students will:

- explain correspondences between a new problem and previous problems
- represent algebraic expressions numerically, graphically, concretely/with manipulatives, verbally/written
- explain connections between the multiple representations
- determine the question that needs to be answered
- analyze a problem and make a plan for solving it
- choose a reasonable strategy
- identify the knowns and unknowns in a problem
- use previous knowledge and skills to simplify and solve problems
- break a problem into manageable parts or simpler problems
- solve a problem in more than one way

In grades 9-12 mathematically proficient students will:

- make connections between a new problem and previous problems
- determine the question that needs to be answered
- choose a reasonable strategy
- identify the knowns and unknowns in a problem
- use previous knowledge and skills to simplify and solve problems
- break a problem into manageable parts or simpler problems
- represent algebraic expressions numerically, graphically, concretely/with manipulatives, verbally/written
- explain connections between the multiple representations
- solve a problem in more than one way
- explain the meaning of a problem and look for an entry point
- analyze a problem and make a plan for solving it
- explain correspondence between differing approaches to identify regularity and trends
- check answer using a different method
- identify correspondence between different approaches
- monitor and evaluate progress and change course if necessary
- check the answers to problems using a different method and continually ask, “Does this make sense?”

2. Reason abstractly and quantitatively.

Mathematically proficient students make sense of quantities and their relationships in problem situations. They bring two complementary abilities to bear on problems involving quantitative relationships: the ability to *decontextualize*—to abstract a given situation and represent it symbolically and manipulate the representing symbols as if they have a life of their own, without necessarily attending to their referents—and the ability to *contextualize*, to pause as needed during the manipulation process in order to probe into the referents for the symbols involved. Quantitative reasoning entails habits of creating a coherent representation of the problem at hand; considering the units involved; attending to the meaning of quantities, not just how to compute them; and knowing and flexibly using different properties of operations and objects.

In grades K-2 mathematically proficient students will:

- represent a situation symbolically and/or with manipulatives
- create a coherent representation of the problem
- use units of measurement consistently

In grades 3-5 mathematically proficient students will:

- represent a situation symbolically
- create a coherent representation of the problem
- have the ability to show how problem has a realistic meaning
- reflect during the manipulation process in order to probe into the meanings for the symbols involved
- use units consistently

In grades 6-8 mathematically proficient students will:

- represent a situation symbolically and carry out its operations
- create a coherent representation of the problem
- translate an algebraic problem to a real-world context
- explain the relationship between the symbolic abstraction and the context of the problem
- compute using different properties
- consider the quantitative values, including units, for the numbers in a problem

In grades 9-12 mathematically proficient students will:

- decontextualize to abstract a given situation and represent it symbolically and manipulate the representing symbols.
- reflect during the manipulation process in order to probe into the meanings for the symbols involved
- create a coherent representation of the problem
- make sense of quantities and their relationships in problem situations
- attend to the meanings of quantities
- use flexibility with different properties of operations and objects
- translate an algebraic problem to a real-world context
- explain the relationship between the symbolic abstraction and the context of the problem
- compute using different properties
- consider the quantitative values, including units, for the numbers in a problem

3. Construct viable arguments and critique the reasoning of others.

Mathematically proficient students understand and use stated assumptions, definitions, and previously established results in constructing arguments. They make conjectures and build a logical progression of statements to explore the truth of their conjectures. They are able to analyze situations by breaking them into cases, and can recognize and use counterexamples. They justify their conclusions, communicate them to others, and respond to the arguments of others. They reason inductively about data, making plausible arguments that take into account the context from which the data arose. Mathematically proficient students are also able to compare the effectiveness of two plausible arguments, distinguish correct logic or reasoning from that which is flawed, and—if there is a flaw in an argument—explain what it is. Elementary students can construct arguments using concrete referents such as objects, drawings, diagrams, and actions. Such arguments can make sense and be correct, even though they are not generalized or made formal until later grades. Later, students learn to determine domains to which an argument applies. Students at all grades can listen or read the arguments of others, decide whether they make sense, and ask useful questions to clarify or improve the arguments.

In grades K-2 mathematically proficient students will:

- construct arguments using concrete referents such as objects, drawings, diagrams, and actions
- justify conclusions, communicate conclusions
- listen to arguments and decide whether the arguments make sense

In grades 3-5 mathematically proficient students will:

- construct arguments using concrete referents such as objects, drawings, diagrams, and actions
- justify conclusions, communicate conclusions, listen and respond to arguments, decide whether the argument makes sense, and ask questions to clarify the argument
- reason inductively about data, making plausible arguments that take into account the context from which the data arose

In grades 6-8 mathematically proficient students will:

- construct arguments using both concrete and abstract explanations
- justify conclusions, communicate conclusions, and respond to the arguments
- listen to arguments, critique their viability, and ask questions to clarify the argument
- compare effectiveness of two arguments by identifying and explaining both logical and/or flawed reasoning
- recognize general mathematical truths and use statements to justify the conjectures
- identify special cases or counter-examples that don't follow the mathematical rules
- infer meaning from data and make arguments using its context

In grades 9-12 mathematically proficient students will:

- construct arguments using both concrete and abstract explanations
- justify conclusions in a variety of ways, communicate the methodology, and respond to the arguments
- reason inductively about data and make plausible arguments that take into account the context from which the data arose
- understand and use stated assumptions, definitions, and previously established results in constructing arguments
- make conjectures and build a logical progression of statements to explore the truth of the conjectures
- analyze situations by breaking them into cases and recognize and use counter-examples
- recognize general mathematical truths and statements to justify the conjectures
- identify special cases or counter-examples that don't follow the mathematical rules
- infer meaning from data and make arguments using its context
- compare effectiveness of two arguments by identifying and explaining both logical and/or flawed reasoning

4. Model with mathematics.

Mathematically proficient students can apply the mathematics they know to solve problems arising in everyday life, society, and the workplace. In early grades, this might be as simple as writing an addition equation to describe a situation. In middle grades, a student might apply proportional reasoning to plan a school event or analyze a problem in the community. By high school, a student might use geometry to solve a design problem or use a function to describe how one quantity of interest depends on another. Mathematically proficient students who can apply what they know are comfortable making assumptions and approximations to simplify a complicated situation, realizing that these may need revision later. They are able to identify important quantities in a practical situation and map their relationships using such tools as diagrams, two-way tables, graphs, flowcharts and formulas. They can analyze those relationships mathematically to draw conclusions. They routinely interpret their mathematical results in the context of the situation and reflect on whether the results make sense, possibly improving the model if it has not served its purpose.

In grades K-2 mathematically proficient students will:

- apply mathematics to solve problems in everyday life
- identify important quantities in a practical situation and model the situation with manipulatives or pictures
- interpret mathematical results in the context of the situation and reflect on whether the results make sense

In grades 3-5 mathematically proficient students will:

- apply mathematics to solve problems arising in everyday life
- identify important quantities in a practical situation and model the situation using such tools as manipulatives, diagrams, two-way tables, graphs or pictures
- interpret mathematical results in the context of the situation and reflect on whether the results make sense
- apply mathematical knowledge, make assumptions and approximations to simplify a complicated situation

In grades 6-8 mathematically proficient students will:

- apply mathematics to solve problems arising in everyday life and society
- identify important quantities in a practical situation and map their relationships using such tools as diagrams, two-way tables, graphs, and formulas
- interpret their mathematical results in the context of the situation and reflect on whether the results make sense
- make assumptions and approximations to simplify a situation, realizing the final solution will need to be revised
- analyze quantitative relationships to draw conclusions
- reflect on whether their results make sense
- improve the model if it has not served its purpose

In grades 9-12 mathematically proficient students will:

- apply mathematics to solve problems in everyday life, society, and workplace
- identify important quantities in a practical situation and map the relationships using such tools as diagrams, two-way tables, graphs, flowcharts and formulas
- consistently interpret mathematical results in the context of the situation and reflect on whether the results make sense
- apply knowledge, making assumptions and approximations to simplify a complicated situation, realizing that these may need revision later
- make assumptions and approximations to simplify a situation, realizing the final solution will need to be revised
- identify important quantities in a practical situation and map their relationships using such tools as diagrams, two-way tables, graphs, and formulas
- analyze quantitative relationships to draw conclusions
- improve the model if it has not served its purpose

5. Use appropriate tools strategically.

Mathematically proficient students consider the available tools when solving a mathematical problem. These tools might include pencil and paper, concrete models, a ruler, a protractor, a calculator, a spreadsheet, a computer algebra system, a statistical package, or dynamic geometry software. Proficient students are sufficiently familiar with tools appropriate for their grade or course to make sound decisions about when each of these tools might be helpful, recognizing both the insight to be gained and their limitations. For example, mathematically proficient high school students analyze graphs of functions and solutions generated using a graphing calculator. They detect possible errors by strategically using estimation and other mathematical knowledge. When making mathematical models, they know that technology can enable them to visualize the results of varying assumptions, explore consequences, and compare predictions with data. Mathematically proficient students at various grade levels are able to identify relevant external mathematical resources, such as digital content located on a website, and use them to pose or solve problems. They are able to use technological tools to explore and deepen their understanding of concepts.

In grades K-2 mathematically proficient students will:

- select the available tools (such as pencil and paper, manipulatives, rulers, and available technology) when solving a mathematical problem
- be familiar with tools appropriate for the grade level to make sound decisions about when each of these tools might be helpful
- identify relevant external mathematical resources and use them to pose or solve problems
- use technological tools to explore and deepen their understanding of concepts

In grades 3-5 mathematically proficient students will:

- select the available tools (such as pencil and paper, manipulatives, rulers, calculators, a spreadsheet, and available technology) when solving a mathematical problem
- be familiar with tools appropriate for their grade level to make sound decisions about when each of these tools might be helpful
- identify relevant external mathematical resources and use them to pose or solve problems
- use technological tools to explore and deepen their understanding of concepts
- detect possible errors by strategically using estimation and other mathematical knowledge
- know that technology can enable them to visualize the results of varying assumptions, explore consequences, and compare predictions with data

In grades 6-8 mathematically proficient students will:

- select and use tools appropriate to the task: pencil and paper, protractor, visual and physical fraction models, algebra tiles, geometric models, calculator, spreadsheet, and interactive geometry software.
- use estimation and other mathematical knowledge to confirm the accuracy of their problem solving
- identify relevant external and digital mathematical resources and use them to pose or solve problems
- represent and compare possibilities visually with technology when solving a problem
- explore and deepen their understanding of concepts through the use of technological tools

In grades 9-12 mathematically proficient students will:

- select and accurately use appropriate, available tools (such as pencil and paper, concrete or virtual manipulatives such as geoboards and algebra tiles, graphing and simpler calculators, a spreadsheet, and available technology) when solving a mathematical problem
- identify relevant external and digital mathematical resources and use the resources to pose or solve problems
- detect possible errors by strategically using estimation and other mathematical knowledge
- use technology to visualize the results of varying assumptions, exploring consequences, comparing predictions with data, and deepening understanding of concepts

6. Attend to precision.

Mathematically proficient students try to communicate precisely to others. They try to use clear definitions in discussion with others and in their own reasoning. They state the meaning of the symbols they choose, including using the equal sign consistently and appropriately. They are careful about specifying units of measure, and labeling axes to clarify the correspondence with quantities in a problem. They calculate accurately and efficiently, express numerical answers with a degree of precision appropriate for the problem context. In the elementary grades, students give carefully formulated explanations to each other. By the time they reach high school they have learned to examine claims and make explicit use of definitions.

In grades K-2 mathematically proficient students will:

- give thoughtful explanations to each other
- use clear definitions and reasoning in discussion with others
- state the meaning of symbols they choose, including using the equal sign consistently and appropriately

In grades 3-5 mathematically proficient students will:

- give carefully formulated explanations to each other
- use clear definitions and reasoning in discussion with others
- state the meaning of symbols, including using the equal sign consistently and appropriately
- specify units of measure, and label axes to clarify the correspondence with quantities in a problem
- calculate accurately and efficiently
- express numerical answers with a degree of precision appropriate for the problem context

In grades 6-8 mathematically proficient students will:

- use clear definitions in explanations
- understand and use specific symbols accurately and consistently: equality, inequality, ratios, parenthesis for multiplication and division, absolute value, square root
- specify units of measure, and label axes to clarify the correspondence with quantities in a problem
- calculate accurately and efficiently, express numerical answers with a degree of precision appropriate for the problem context

In grades 9-12 mathematically proficient students will:

- communicate precisely to others
- use clear definitions in explanations
- use symbols consistently and appropriately

- specify units of measure, and label axes to clarify the correspondence with quantities in a problem
- calculate accurately and efficiently, express numerical answers with a degree of precision appropriate for the problem context
- examine claims and make explicit use of definitions

7. Look for and make use of structure.

Mathematically proficient students look closely to discern a pattern or structure. Young students, for example, might notice that three and seven more is the same amount as seven and three more, or they may sort a collection of shapes according to how many sides the shapes have. Later, students will see 7×8 equals the well remembered $7 \times 5 + 7 \times 3$, in preparation for learning about the distributive property. In the expression $x^2 + 9x + 14$, older students can see the 14 as 2×7 and the 9 as $2 + 7$. They recognize the significance of an existing line in a geometric figure and can use the strategy of drawing an auxiliary line for solving problems. They also can step back for an overview and shift perspective. They can see complicated things, such as some algebraic expressions, as single objects or as being composed of several objects. For example, they can see $5 - 3(x - y)^2$ as 5 minus a positive number times a square and use that to realize that its value cannot be more than 5 for any real numbers x and y.

In all grade levels mathematically proficient students will:

- discern a pattern or structure
- understand complex structures as single objects or as being composed of several objects
- check if the answer is reasonable

8. Look for and express regularity in repeated reasoning.

Mathematically proficient students notice if calculations are repeated, and look both for general methods and for shortcuts. Upper elementary students might notice when dividing 25 by 11 that they are repeating the same calculations over and over again, and conclude they have a repeating decimal. By paying attention to the calculation of slope as they repeatedly check whether points are on the line through (1, 2) with slope 3, middle school students might abstract the equation $(y - 2)/(x - 1) = 3$. Noticing the regularity in the way terms cancel when expanding $(x - 1)(x + 1)$, $(x - 1)(x^2 + x + 1)$, and $(x - 1)(x^3 + x^2 + x + 1)$ might lead them to the general formula for the sum of a geometric series. As they work to solve a problem, mathematically proficient students maintain oversight of the process, while attending to the details. They continually evaluate the reasonableness of their intermediate results.

In all grade levels mathematically proficient students will:

- identify if calculations or processes are repeated
- use alternative and traditional methods to solve problems
- evaluate the reasonableness of their intermediate results, while attending to the details

K-8 Mathematical Content Standards

Instructional Focus: Kindergarten through Second Grade

Kindergarten	Grade 1	Grade 2
In Kindergarten, instructional time should focus on two critical areas: (1) representing, relating, and operating on whole numbers, initially with sets of objects; (2) describing shapes and space. More learning time in Kindergarten should be devoted to number than to other topics. (1) Students use numbers, including written numerals, to represent quantities and to solve quantitative problems, such as counting objects in a set; counting out a given number of objects; comparing sets or numerals; and modeling simple joining and separating situations with sets of objects, or eventually with equations such as 5 + 2 = 7 and 7 – 2 = 5. (Kindergarten students should see addition and subtraction equations, and student writing of equations in kindergarten is encouraged, but it is not required.) Students choose, combine, and apply effective strategies for answering quantitative questions, including quickly recognizing the cardinalities of small sets of objects, counting and producing sets of given sizes, counting the number of objects in combined sets, or counting the number of objects that remain in a set after some are taken away.	In Grade 1, instructional time should focus on four critical areas: (1) developing understanding of addition, subtraction, and strategies for addition and subtraction within 20; (2) developing understanding of whole number relationships and place value, including grouping in tens and ones; (3) developing understanding of linear measurement and measuring lengths as iterating length units; and (4) reasoning about attributes of, and composing and decomposing geometric shapes. (1) Students develop strategies for adding and subtracting whole numbers based on their prior work with small numbers. They use a variety of models, including discrete objects and length-based models (e.g., cubes connected to form lengths), to model add-to, take-from, put-together, take-apart, and compare situations to develop meaning for the operations of addition and subtraction, and to develop strategies to solve arithmetic problems with these operations. Students understand connections between counting and addition and subtraction (e.g., adding two is the same as counting on two). They use properties of addition to add whole numbers and to create and use increasingly sophisticated strategies based on these properties (e.g., “making tens”) to solve addition and subtraction problems within 20. By comparing a variety of solution strategies, children build their understanding of the relationship between addition and subtraction.	In Grade 2, instructional time should focus on four critical areas: (1) extending understanding of base-ten notation; (2) building fluency with addition and subtraction; (3) using standard units of measure; and (4) describing and analyzing shapes. (1) Students extend their understanding of the base-ten system. This includes ideas of counting in fives, tens, and multiples of hundreds, tens, and ones, as well as number relationships involving these units, including comparing. Students understand multi-digit numbers (up to 1000) written in base-ten notation, recognizing that the digits in each place represent amounts of thousands, hundreds, tens, or ones (e.g., 853 is 8 hundreds + 5 tens + 3 ones). (2) Students use their understanding of addition to develop fluency with addition and subtraction within 100. They solve problems within 1000 by applying their understanding of models for addition and subtraction, and they develop, discuss, and use efficient, accurate, and generalizable methods to compute sums and differences of whole numbers in base-ten notation, using their understanding of place value and the properties of operations. They select and accurately apply methods that are appropriate for the context and the numbers involved to mentally calculate sums and differences for numbers with only tens or only hundreds.

(2) Students describe their physical world using geometric ideas (e.g., shape, orientation, spatial relations) and vocabulary. They identify, name, and describe basic two-dimensional shapes, such as squares, triangles, circles, rectangles, and hexagons, presented in a variety of ways (e.g., with different sizes and orientations), as well as three-dimensional shapes such as cubes, cones, cylinders, and spheres. They use basic shapes and spatial reasoning to model objects in their environment and to construct more complex shapes.	(2) Students develop, discuss, and use efficient, accurate, and generalizable methods to add within 100 and subtract multiples of 10. They compare whole numbers (at least to 100) to develop understanding of and solve problems involving their relative sizes. They think of whole numbers between 10 and 100 in terms of tens and ones (especially recognizing the numbers 11 to 19 as composed of a ten and some ones). Through activities that build number sense, they understand the order of the counting numbers and their relative magnitudes. (3) Students develop an understanding of the meaning and processes of measurement, including underlying concepts such as iterating (the mental activity of building up the length of an object with equal-sized units) and the transitivity principle for indirect measurement.[1] (4) Students compose and decompose plane or solid figures (e.g., put two triangles together to make a quadrilateral) and build understanding of part-whole relationships as well as the properties of the original and composite shapes. As they combine shapes, they recognize them from different perspectives and orientations, describe their geometric attributes, and determine how they are alike and different, to develop the background for measurement and for initial understandings of properties such as congruence and symmetry [1]Students should apply the principle of transitivity of measurement to make indirect comparisons, but they need not use this technical term.	(3) Students recognize the need for standard units of measure (centimeter and inch) and they use rulers and other measurement tools with the understanding that linear measure involves an iteration of units. They recognize that the smaller the unit, the more iterations they need to cover a given length. (4) Students describe and analyze shapes by examining their sides and angles. Students investigate, describe, and reason about decomposing and combining shapes to make other shapes. Through building, drawing, and analyzing two- and three-dimensional shapes, students develop a foundation for understanding area, volume, congruence, similarity, and symmetry in later grades.

Alaska Mathematics Standards Grades K-2

<table>
<tr><th>Grade K</th><th>Grade 1</th><th>Grade 2</th></tr>
<tr><td><u>Counting and Cardinality K.CC</u>
Know number names and the count sequence.
K.CC.1. Count to 100 by ones and by tens.

K.CC.2. Count forward beginning from a given number within the known sequence.

K.CC.3. Write numbers from 0 to 20. Represent a number of objects with a written numeral 0 - 20 (with 0 representing a count of no objects).

Count to tell the number of objects.
K.CC.4. Understand the relationship between numbers and quantities; connect counting to cardinality.
a. When counting objects, say the number names in standard order, pairing each object with one and only one number name and each number name with one and only one object.
b. Understand that the last number name said tells the number of objects counted. The number of objects is the same regardless of their arrangement or the order in which they were counted.
c. Understand that each successive number name refers to a quantity that is one larger.</td><td><u>Counting and Cardinality, 1.CC</u>
Know ordinal names and counting flexibility.

1.CC.1. Skip count by 2s and 5s.

1.CC.2. Use ordinal numbers correctly when identifying object position (e.g., first, second, third, etc.).

1.CC.3. Order numbers from 1 - 100. Demonstrate ability in counting forward and backward.

Count to tell the number of objects.
1.CC.4. Count a large quantity of objects by grouping into 10s and counting by 10s and 1s to find the quantity.</td><td></td></tr>
</table>

Grade K	Grade 1	Grade 2
K.CC.5. Count to answer "how many?" questions about as many as 20 things arranged in a line, a rectangular array or a circle, or as many as 10 things in a scattered configuration; given a number from 1-20, count out that many objects.		
Compare numbers. K.CC.6. Identify whether the number of objects in one group is greater than, less than, or equal to the number of objects in another group (e.g., by using matching, counting, or estimating strategies). K.CC.7. Compare and order two numbers between 1 and 10 presented as written numerals.	**Compare numbers.** 1.CC.5. Use the symbols for greater than, less than or equal to when comparing two numbers or groups of objects. 1.CC.6. Estimate how many and how much in a given set to 20 and then verify estimate by counting.	
<u>Operations and Algebraic Thinking K.OA</u> **Understand addition as putting together and adding to, and understand subtraction as taking apart and taking from.** K.OA.1. Represent addition and subtraction with objects, fingers, mental images, drawings, sounds (e.g., claps) acting out situations, verbal explanations, expressions, or equations.	<u>Operations and Algebraic Thinking 1.OA</u> **Represent and solve problems involving addition and subtraction.** 1.OA.1. Use addition and subtraction strategies to solve word problems (using numbers up to 20), involving situations of adding to, taking from, putting together, taking apart and comparing, with unknowns in all positions, using a number line (e.g., by using objects, drawings and equations). Record and explain using equation symbols and a symbol for the unknown number to represent the problem.	<u>Operations and Algebraic Thinking 2.OA</u> **Represent and solve problems involving addition and subtraction.** 2.OA.1. Use addition and subtraction strategies to estimate, then solve one- and two-step word problems (using numbers up to 100) involving situations of adding to, taking from, putting together, taking apart and comparing, with unknowns in all positions (e.g., by using objects, drawings and equations). Record and explain using equation symbols and a symbol for the unknown number to represent the problem.

Grade K	Grade 1	Grade 2
K.OA.2. Add or subtract whole numbers to 10 (e.g., by using objects or drawings to solve word problems). K.OA.3. Decompose numbers less than or equal to 10 into pairs in more than one way (e.g., by using objects or drawings, and record each decomposition by a drawing or equation). *For example, 5 = 2 + 3 and 5 = 4 + 1.* K.OA.4. For any number from 1- 4, find the number that makes 5 when added to the given number and, for any number from 1- 9, find the number that makes 10 when added to the given number (e.g., by using objects, drawings or 10 frames) and record the answer with a drawing or equation. K.OA.5. Fluently add and subtract numbers up to 5.	1.OA.2. Solve word problems that call for addition of three whole numbers whose sum is less than or equal to 20 (e.g., by using objects, drawings and equations). Record and explain using equation symbols and a symbol for the unknown number to represent the problem. **Understand and apply properties of operations and the relationship between addition and subtraction.** 1.OA.3. Apply properties of operations as strategies to add and subtract. (Students need not know the name of the property.) *For example: If 8 + 3 = 11 is known, then 3 + 8 = 11 is also known (Commutative property of addition). To add 2 + 6 + 4, the second two numbers can be added to make a ten, so 2 + 6 + 4 = 2 + 10 = 12 (Associative property of addition). Demonstrate that when adding zero to any number, the quantity does not change (Identity property of addition).* 1.OA.4. Understand subtraction as an unknown-addend problem. *For example, subtract 10 - 8 by finding the number that makes 10 when added to 8.*	

Grade K	Grade 1	Grade 2
	Add and subtract using numbers up to 20. 1.OA.5. Relate counting to addition and subtraction (e.g., by counting on 2 to add 2). 1.OA.6. Add and subtract using numbers up to 20, demonstrating fluency for addition and subtraction up to 10. Use strategies such as • counting on • making ten (8 + 6 = 8 + 2 + 4 = 10 + 4 = 14) • decomposing a number leading to a ten (13 - 4 = 13 - 3 - 1 = 10 - 1 = 9) • using the relationship between addition and subtraction, such as fact families, (8 + 4 = 12 and 12 - 8 = 4) • creating equivalent but easier or known sums (e.g., adding 6 + 7 by creating the known equivalent 6 + 6 + 1 = 12 + 1 = 13).	**Add and subtract using numbers up to 20.** 2.OA.2. Fluently add and subtract using numbers up to 20 using mental strategies. Know from memory all sums of two one-digit numbers.
	Work with addition and subtraction equations. 1.OA.7. Understand the meaning of the equal sign (e.g., read equal sign as "same as") and determine if equations involving addition and subtraction are true or false. *For example, which of the following equations are true and which are false?6 = 6, 7 = 8 - 1, 5 + 2 = 2 + 5, 4 + 1 = 5 + 2).* 1.OA.8. Determine the unknown whole number in an addition or subtraction equation. *For example, determine the unknown number that makes the equation true in each of the equations 8 + ? = 11, 6 + 6 = ?, 5 = ? - 3.*	**Work with equal groups of objects to gain foundations for multiplication.** 2.OA.3. Determine whether a group of objects (up to 20) is odd or even (e.g., by pairing objects and comparing, counting by 2s). Model an even number as two equal groups of objects and then write an equation as a sum of two equal addends. 2.OA.4. Use addition to find the total number of objects arranged in rectangular arrays with up to 5 rows and up to 5 columns. Write an equation to express the total as repeated addition (e.g., array of 4 by 5 would be 5 + 5 + 5 + 5 = 20).

Grade K	Grade 1	Grade 2
Identify and continue patterns. K.OA.6. Recognize, identify and continue simple patterns of color, shape, and size. <u>Number and Operations in Base Ten K.NBT</u> **Work with numbers 11-19 to gain foundations for place value.** K.NBT.1. Compose and decompose numbers from 11 to 19 into ten ones and some further ones (e.g., by using objects or drawings) and record each composition and decomposition by a drawing or equation (e.g., 18 = 10 + 8); understand that these numbers are composed of ten ones and one, two, three, four, five, six, seven, eight or nine ones.	**Identify and continue patterns.** 1.OA.9. Identify, continue and label patterns (e.g., aabb, abab). Create patterns using number, shape, size, rhythm or color. <u>Number and Operations in Base Ten 1.NBT</u> **Extend the counting sequence.** 1.NBT.1. Count to 120. In this range, read, write and order numerals and represent a number of objects with a written numeral. **Understand place value.** 1.NBT.2. Model and identify place value positions of two digit numbers. Include: a. 10 can be thought of as a bundle of ten ones, called a "ten". b. The numbers from 11 to 19 are composed of a ten and one, two, three, four, five, six, seven, eight or nine ones. c. The numbers 10, 20, 30, 40, 50, 60, 70, 80, 90, refer to one, two, three, four, five, six, seven, eight or nine tens (and 0 ones). 1.NBT.3. Compare two two-digit numbers based on meanings of the tens and ones digits, recording the results of comparisons with the symbols >, =, <.	**Identify and continue patterns.** 2.OA.5. Identify, continue and label number patterns (e.g., aabb, abab). Describe a rule that determines and continues a sequence or pattern. <u>Number and Operations in Base Ten 2.NBT</u> **Understand place value.** 2.NBT.1. Model and identify place value positions of three digit numbers. Include: a. 100 can be thought of as a bundle of ten tens --called a "hundred". b. The numbers 100, 200, 300, 400, 500, 600, 700, 800, 900 refer to one, two, three, four, five, six, seven, eight, or nine hundreds (and 0 tens and 0 ones). 2.NBT.2. Count up to 1000, skip-count by 5s, 10s and 100s. 2.NBT.3. Read, write, order up to 1000 using base-ten numerals, number names and expanded form. 2.NBT.4. Compare two three-digit numbers based on the meanings of the hundreds, tens and ones digits, using >, =, < symbols to record the results.

Grade K	Grade 1	Grade 2
	Use place value understanding and properties of operations to add and subtract. 1.NBT.4. Add using numbers up to 100 including adding a two-digit number and a one-digit number and adding a two-digit number and a multiple of 10. Use: • concrete models or drawings and strategies based on place value • properties of operations • and/or relationship between addition and subtraction. Relate the strategy to a written method and explain the reasoning used. Demonstrate in adding two-digit numbers, tens and tens are added, ones and ones are added and sometimes it is necessary to compose a ten from ten ones. 1.NBT.5. Given a two-digit number, mentally find 10 more or 10 less than the number, without having to count; explain the reasoning used. 1.NBT.6. Subtract multiples of 10 up to 100. Use: • concrete models or drawings • strategies based on place value • properties of operations • and/or the relationship between addition and subtraction. Relate the strategy to a written method and explain the reasoning used.	**Use place value understanding and properties of operations to add and subtract.** 2.NBT.5. Fluently add and subtract using numbers up to 100. Use: • strategies based on place value • properties of operations • and/or the relationship between addition and subtraction. 2.NBT.6. Add up to four two-digit numbers using strategies based on place value and properties of operations. 2.NBT.7. Add and subtract using numbers up to 1000. Use: • concrete models or drawings and strategies based on place value • properties of operations • and/or relationship between addition and subtraction. Relate the strategy to a written method and explain the reasoning used. Demonstrate in adding or subtracting three-digit numbers, hundreds and hundreds are added or subtracted, tens and tens are added or subtracted, ones and ones are added or subtracted and sometimes it is necessary to compose a ten from ten ones or a hundred from ten tens. 2.NBT.8. Mentally add 10 or 100 to a given number 100-900 and mentally subtract 10 or 100 from a given number.

Grade K	Grade 1	Grade 2
		2.NBT.9. Explain or illustrate the processes of addition or subtraction and their relationship using place value and the properties of operations.
<u>Measurement and Data K.MD</u> **Describe and compare measurable attributes.** K.MD.1. Describe measurable attributes of objects (e.g., length or weight). Match measuring tools to attribute (e.g., ruler to length). Describe several measurable attributes of a single object. K.MD.2. Make comparisons between two objects with a measurable attribute in common, to see which object has "more of"/"less of" the attribute, and describe the difference. *For example, directly compare the heights of two children and describe one child as taller/shorter.* **Classify objects and count the number of objects in each category.** K.MD.3. Classify objects into given categories (attributes). Count the number of objects in each category (limit category counts to be less than or equal to 10).	<u>Measurement and Data 1.MD</u> **Measure lengths indirectly and by iterating length units.** 1.MD.1. Measure and compare three objects using standard or non-standard units. 1.MD.2. Express the length of an object as a whole number of length units, by laying multiple copies of a shorter object (the length unit) end to end; understand that the length measurement of an object is the number of same-size length units that span it with no gaps or overlaps.	<u>Measurement and Data 2.MD</u> **Measure and estimate lengths in standard units.** 2.MD.1. Measure the length of an object by selecting and using standard tools such as rulers, yardsticks, meter sticks, and measuring tapes. 2.MD.2. Measure the length of an object twice using different length units for the two measurements. Describe how the two measurements relate to the size of the unit chosen. 2.MD.3. Estimate, measure and draw lengths using whole units of inches, feet, yards, centimeters and meters. 2.MD.4. Measure to compare lengths of two objects, expressing the difference in terms of a standard length unit. **Relate addition and subtraction to length.** 2.MD.5. Solve addition and subtraction word problems using numbers up to 100 involving length that are given in the same units (e.g., by using drawings of rulers). Write an equation with a symbol for the unknown to represent the problem. 2.MD.6. Represent whole numbers as lengths from 0 on a number line diagram with equally spaced points corresponding to the numbers 0, 1,2, …, and represent whole-number sums and differences within 100 on a number line diagram.

Grade K	Grade 1	Grade 2
Work with time and money. K.MD.4. Name in sequence the days of the week. K.MD.5. Tell time to the hour using both analog and digital clocks. K.MD.6. Identify coins by name.	**Work with time and money.** 1.MD.3. Tell and write time in half hours using both analog and digital clocks. 1.MD.4. Read a calendar distinguishing yesterday, today and tomorrow. Read and write a date. 1.MD.5. Recognize and read money symbols including $ and ¢. 1.MD.6. Identify values of coins (e.g., nickel = 5 cents, quarter = 25 cents). Identify equivalent values of coins up to $1 (e.g., 5 pennies = 1 nickel, 5 nickels = 1 quarter). **Represent and interpret data.** 1.MD.7. Organize, represent and interpret data with up to three categories. Ask and answer comparison and quantity questions about the data.	**Work with time and money.** 2.MD.7. Tell and write time to the nearest five minutes using a.m. and p.m. from analog and digital clocks. 2.MD.8. Solve word problems involving dollar bills and coins using the $ and ¢ symbols appropriately. **Represent and interpret data.** 2.MD.9. Collect, record, interpret, represent, and describe data in a table, graph or line plot. 2.MD.10. Draw a picture graph and a bar graph (with single-unit scale) to represent a data set with up to four categories. Solve simple put-together, take-apart and compare problems using information presented in a bar graph.

<table>
<tr><th>Grade K</th><th>Grade 1</th><th>Grade 2</th></tr>
<tr>
<td><u>Geometry K.G</u>
(shapes include squares, circles, triangles, rectangles, hexagons, cubes, cones, cylinders, and spheres)
Identify and describe shapes.
K.G.1. Describe objects in the environment using names of shapes and describe their relative positions (e.g., above, below, beside, in front of, behind, next to).

K.G.2. Name shapes regardless of their orientation or overall size.

K.G.3. Identify shapes as two-dimensional (flat) or three-dimensional (solid).

Analyze, compare, create, and compose shapes.
K.G.4. Analyze and compare two- and three-dimensional shapes, in different sizes and orientations, using informal language to describe their similarities, differences, parts (e.g., number of sides and vertices), and other attributes (e.g., having sides of equal lengths).

K.G.5. Build shapes (e.g., using sticks and clay) and draw shapes.

K.G.6. Put together two-dimensional shapes to form larger shapes (e.g., join two triangles with full sides touching to make a rectangle).</td>
<td><u>Geometry 1.G</u>
Reason with shapes and their attributes.
1.G.1. Distinguish between defining attributes (e.g., triangles are closed and three-sided) versus non-defining attributes. Identify shapes that have non-defining attributes (e.g., color, orientation, overall size). Build and draw shapes given specified attributes.

1.G.2. Compose (put together) two-dimensional or three-dimensional shapes to create a larger, composite shape, and compose new shapes from the composite shape.

1.G.3. Partition circles and rectangles into two and four equal shares. Describe the shares using the words, halves, fourths, and quarters and phrases half of, fourth of and quarter of. Describe the whole as two of or four of the shares. Understand for these examples that decomposing (break apart) into more equal shares creates smaller shares.</td>
<td><u>Geometry 2.G</u>
Reason with shapes and their attributes.
2.G.1. Identify and draw shapes having specified attributes, such as a given number of angles or a given number of equal faces compared visually, not by measuring. Identify triangles, quadrilaterals, pentagons, hexagons and cubes.

2.G.2. Partition a rectangle into rows and columns of same-size squares and count to find the total number of them.

2.G.3. Partition circles and rectangles into shares, describe the shares using the words halves, thirds, half of, a third of, etc., and describe the whole as two halves, three thirds, four fourths. Recognize that equal shares of identical wholes need not have the same shape.</td>
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Instructional Focus: Third Grade through Fifth Grade

Grade 3	Grade 4	Grade 5
In Grade 3, instructional time should focus on four critical areas: (1) developing understanding of multiplication and division and strategies for multiplication and division within 100; (2) developing understanding of fractions, especially unit fractions (fractions with numerator 1); (3) developing understanding of the structure of rectangular arrays and of area; and (4) describing and analyzing two-dimensional shapes. (1) Students develop an understanding of the meanings of multiplication and division of whole numbers through activities and problems involving equal-sized groups, arrays, and area models; multiplication is finding an unknown product, and division is finding an unknown factor in these situations. For equal-sized group situations, division can require finding the unknown number of groups or the unknown group size. Students use properties of operations to calculate products of whole numbers, using increasingly sophisticated strategies based on these properties to solve multiplication and division problems involving single-digit factors. By comparing a variety of solution strategies, students learn the relationship between multiplication and division. (2) Students develop an understanding of fractions, beginning with unit fractions. Students view fractions in general as being built out of unit fractions, and they use fractions along with visual fraction models to represent parts of a whole. Students understand that the size of a fractional part is relative to the size of the whole. For example, 1/2 of the paint in a small bucket could be less paint than 1/3 of the paint in a larger bucket, but 1/3 of a ribbon is longer than 1/5 of	In Grade 4, instructional time should focus on three critical areas: (1) developing understanding and fluency with multi-digit multiplication, and developing understanding of dividing to find quotients involving multi-digit dividends; (2) developing an understanding of fraction equivalence, addition and subtraction of fractions with like denominators, and multiplication of fractions by whole numbers; (3) understanding that geometric figures can be analyzed and classified based on their properties, such as having parallel sides, perpendicular sides, particular angle measures, and symmetry. (1) Students generalize their understanding of place value to 1,000,000, understanding the relative sizes of numbers in each place. They apply their understanding of models for multiplication (equal-sized groups, arrays, area models), place value, and properties of operations, in particular the distributive property, as they develop, discuss, and use efficient, accurate, and generalizable methods to compute products of multi-digit whole numbers. Depending on the numbers and the context, they select and accurately apply appropriate methods to estimate or mentally calculate products. They develop fluency with efficient procedures for multiplying whole numbers; understand and explain why the procedures work based on place value and properties of operations; and use them to solve problems. Students apply their understanding of models for division, place value, properties of operations, and the relationship of division to multiplication as they develop, discuss, and use efficient, accurate, and generalizable procedures to find quotients involving multi-digit dividends. They select and accurately apply appropriate	In Grade 5, instructional time should focus on three critical areas: (1) developing fluency with addition and subtraction of fractions, and developing understanding of the multiplication of fractions and of division of fractions in limited cases (unit fractions divided by whole numbers and whole numbers divided by unit fractions); (2) extending division to 2-digit divisors, integrating decimal fractions into the place value system and developing understanding of operations with decimals to hundredths, and developing fluency with whole number and decimal operations; and (3) developing understanding of volume. (1) Students apply their understanding of fractions and fraction models to represent the addition and subtraction of fractions with unlike denominators as equivalent calculations with like denominators. They develop fluency in calculating sums and differences of fractions, and make reasonable estimates of them. Students also use the meaning of fractions, of multiplication and division, and the relationship between multiplication and division to understand and explain why the procedures for multiplying and dividing fractions make sense. (Note: this is limited to the case of dividing unit fractions by whole numbers and whole numbers by unit fractions.) (2) Students develop understanding of why division procedures work based on the meaning of base-ten numerals and properties of operations. They finalize fluency with multi-digit addition, subtraction, multiplication, and division. They apply their understandings of models for decimals, decimal notation, and properties of operations to add and subtract decimals to

the same ribbon because when the ribbon is divided into 3 equal parts, the parts are longer than when the ribbon is divided into 5 equal parts. Students are able to use fractions to represent numbers equal to, less than, and greater than one. They solve problems that involve comparing fractions by using visual fraction models and strategies based on noticing equal numerators or denominators. (3) Students recognize area as an attribute of two-dimensional regions. They measure the area of a shape by finding the total number of same-size units of area required to cover the shape without gaps or overlaps, a square with sides of unit length being the standard unit for measuring area. Students understand that rectangular arrays can be decomposed into identical rows or into identical columns. By decomposing rectangles into rectangular arrays of squares, students connect area to multiplication, and justify using multiplication to determine the area of a rectangle. (4) Students describe, analyze, and compare properties of two-dimensional shapes. They compare and classify shapes by their sides and angles, and connect these with definitions of shapes. Students also relate their fraction work to geometry by expressing the area of part of a shape as a unit fraction of the whole.	methods to estimate and mentally calculate quotients, and interpret remainders based upon the context. (2) Students develop understanding of fraction equivalence and operations with fractions. They recognize that two different fractions can be equal (e.g., 15/9 = 5/3), and they develop methods for generating and recognizing equivalent fractions. Students extend previous understandings about how fractions are built from unit fractions, composing fractions from unit fractions, decomposing fractions into unit fractions, and using the meaning of fractions and the meaning of multiplication to multiply a fraction by a whole number. (3) Students describe, analyze, compare, and classify two-dimensional shapes. Through building, drawing, and analyzing two-dimensional shapes, students deepen their understanding of properties of two-dimensional objects and the use of them to solve problems involving symmetry.	hundredths. They develop fluency in these computations, and make reasonable estimates of their results. Students use the relationship between decimals and fractions, as well as the relationship between finite decimals and whole numbers (i.e., a finite decimal multiplied by an appropriate power of 10 is a whole number), to understand and explain why the procedures for multiplying and dividing finite decimals make sense. They compute products and quotients of decimals to hundredths efficiently and accurately. (3) Students recognize volume as an attribute of three-dimensional space. They understand that volume can be measured by finding the total number of same-size units of volume required to fill the space without gaps or overlaps. They understand that a 1-unit by 1-unit by 1-unit cube is the standard unit for measuring volume. They select appropriate units, strategies, and tools for solving problems that involve estimating and measuring volume. They decompose three-dimensional shapes and find volumes of right rectangular prisms by viewing them as decomposed into layers of arrays of cubes. They measure necessary attributes of shapes in order to determine volumes to solve real-world and mathematical problems.

Alaska Mathematics Standards Grades 3-5

Grade 3	Grade 4	Grade 5
Operations and Algebraic Thinking 3.OA **Represent and solve problems involving multiplication and division.** 3.OA.1. Interpret products of whole numbers (e.g., interpret 5 × 7 as the total number of objects in 5 groups of 7 objects each). *For example, show objects in rectangular arrays or describe a context in which a total number of objects can be expressed as 5 × 7.*	Operations and Algebraic Thinking 4.OA **Use the four operations with whole numbers to solve problems.** 4.OA.1. Interpret a multiplication equation as a comparison, e.g., interpret 35 = 5 × 7 as a statement that 35 is 5 groups of 7 and 7 groups of 5 (Commutative property). Represent verbal statements of multiplicative comparisons as multiplication equations.	Operations and Algebraic Thinking 5.OA **Write and interpret numerical expressions.** 5.OA.1. Use parentheses to construct numerical expressions, and evaluate numerical expressions with these symbols.
3.OA.2. Interpret whole-number quotients of whole numbers (e.g., interpret 56 ÷ 8 as the number of objects in each share when 56 objects are partitioned equally into 8 shares, or as a number of shares when 56 objects are partitioned into equal shares of 8 objects each). *For example, deconstruct rectangular arrays or describe a context in which a number of shares or a number of groups can be expressed as 56 ÷ 8.*	4.OA.2. Multiply or divide to solve word problems involving multiplicative comparison (e.g., by using drawings and equations with a symbol for the unknown number to represent the problem or missing numbers in an array). Distinguish multiplicative comparison from additive comparison.	5.OA.2. Write simple expressions that record calculations with numbers, and interpret numerical expressions without evaluating them. *For example, express the calculation "add 8 and 7, then multiply by 2" as 2 x (8 + 7). Recognizing that 3 x (18932 + 921) is three times as large as 18932 + 921, without having to calculate the indicated sum or product.*
3.OA.3. Use multiplication and division numbers up to 100 to solve word problems in situations involving equal groups, arrays, and measurement quantities (e.g., by using drawings and equations with a symbol for the unknown number to represent the problem).	4.OA.3. Solve multistep word problems posed with whole numbers and having whole-number answers using the four operations, including problems in which remainders must be interpreted. Represent these problems using equations with a letter standing for the unknown quantity. Assess the reasonableness of answers using mental computation and estimation strategies including rounding.	

Grade 3	Grade 4	Grade 5
3.OA.4. Determine the unknown whole number in a multiplication or division equation relating three whole numbers. *For example, determine the unknown number that makes the equation true in each of the equations 8 x ? = 48, 5 = ? ÷ 3, 6 x 6 = ?* **Understand properties of multiplication and the relationship between multiplication and division.** 3.OA.5. Make, test, support, draw conclusions and justify conjectures about properties of operations as strategies to multiply and divide. (Students need not use formal terms for these properties.) • Commutative property of multiplication: If 6 × 4 = 24 is known, then 4 × 6 = 24 is also known. • Associative property of multiplication: 3 × 5 × 2 can be found by 3 × 5 = 15, then 15 × 2 = 30, or by 5 × 2 = 10, then 3 × 10 = 30. • Distributive property: Knowing that 8 × 5 = 40 and 8 × 2 = 16, one can find 8 × 7 as 8 × (5 + 2) = (8 × 5) + (8 × 2) = 40 + 16 = 56. • Inverse property (relationship) of multiplication and division. 3.OA.6. Understand division as an unknown-factor problem. *For example, find 32 ÷ 8 by finding the number that makes 32 when multiplied by 8.*	**Gain familiarity with factors and multiples.** 4.OA.4. • Find all factor pairs for a whole number in the range 1–100. • Explain the correlation/differences between multiples and factors. • Determine whether a given whole number in the range 1–100 is a multiple of a given one-digit number. • Determine whether a given whole number in the range 1–100 is prime or composite.	

Grade 3	Grade 4	Grade 5
Multiply and divide up to 100. 3.OA.7. Fluently multiply and divide numbers up to 100, using strategies such as the relationship between multiplication and division (e.g., knowing that 8 ×5 = 40, one knows 40 ÷ 5 = 8) or properties of operations. By the end of Grade 3, know from memory all products of two one-digit numbers. **Solve problems involving the four operations, and identify and explain patterns in arithmetic.** 3.OA.8. Solve and create two-step word problems using any of the four operations. Represent these problems using equations with a symbol (box, circle, question mark) standing for the unknown quantity. Assess the reasonableness of answers using mental computation and estimation strategies including rounding. 3.OA.9. Identify arithmetic patterns (including patterns in the addition table or multiplication table) and explain them using properties of operations. *For example, observe that 4 times a number is always even, and explain why 4 times a number can be decomposed into two equal addends.*	**Generate and analyze patterns.** 4.OA.5. Generate a number, shape pattern, table, t-chart, or input/output function that follows a given rule. Identify apparent features of the pattern that were not explicit in the rule itself. Be able to express the pattern in algebraic terms. *For example, given the rule "Add 3" and the starting number 1, generate terms in the resulting sequence and observe that the terms appear to alternate between odd and even numbers. Explain informally why the numbers will continue to alternate in this way.* 4.OA.6. Extend patterns that use addition, subtraction, multiplication, division or symbols, up to 10 terms, represented by models (function machines), tables, sequences, or in problem situations. (L)	**Analyze patterns and relationships.** 5.OA.3. Generate two numerical patterns using two given rules. Identify apparent relationships between corresponding terms. Form ordered pairs consisting of corresponding terms from the two patterns, and graph the ordered pairs on a coordinate plane. *For example, given the rule "Add 3" and the starting number 0, and given the rule "Add 6" and the starting number 0, generate terms in the resulting sequences, and observe that the terms in one sequence are twice the corresponding terms in the other sequence. Explain informally why this is so.*

Grade 3	Grade 4	Grade 5
<u>Number and Operations in Base Ten 3.NBT</u> **Use place value understanding and properties of operations to perform multi-digit arithmetic.** 3.NBT.1. Use place value understanding to round whole numbers to the nearest 10 or 100. 3.NBT.2. Use strategies and/or algorithms to fluently add and subtract with numbers up to 1000, demonstrating understanding of place value, properties of operations, and/or the relationship between addition and subtraction. 3.NBT.3. Multiply one-digit whole numbers by multiples of 10 in the range 10-90 (e.g., 9 x 80, 10 x 60) using strategies based on place value and properties of operations.	<u>Number and Operations in Base Ten 4.NBT</u> **Generalize place value understanding for multi-digit whole numbers.** 4.NBT.1. Recognize that in a multi-digit whole number, a digit in one place represents ten times what it represents in the place to its right. *For example, recognize that 700 ÷ 70 = 10 by applying concepts of place value and division.* 4.NBT.2. Read and write multi-digit whole numbers using base-ten numerals, number names, and expanded form. Compare two multi-digit numbers based on the value of the digits in each place, using >, =, and < symbols to record the results of comparisons. 4.NBT.3. Use place value understanding to round multi-digit whole numbers to any place using a variety of estimation methods; be able to describe, compare, and contrast solutions. **Use place value understanding and properties of operations to perform multi-digit arithmetic.** 4.NBT.4. Fluently add and subtract multi-digit whole numbers using any algorithm. Verify the reasonableness of the results.	<u>Number and Operations in Base Ten 5.NBT</u> **Understand the place value system.** 5.NBT.1. Recognize that in a multi-digit number, a digit in one place represents 10 times as much as it represents in the place to its right and 1/10 of what it represents in the place to its left. 5.NBT.2. Explain and extend the patterns in the number of zeros of the product when multiplying a number by powers of 10, and explain and extend the patterns in the placement of the decimal point when a decimal is multiplied or divided by a power of 10. Use whole-number exponents to denote powers of 10. 5.NBT.3. Read, write, and compare decimals to thousandths. a. Read and write decimals to thousandths using base-ten numerals, number names, and expanded form [e.g., 347.392 = 3 x 100 + 4 x 10 + 7 x 1 + 3 (1/10) + 9 (1/100) + 2 (1/1000)]. b. Compare two decimals to thousandths place based on meanings of the digits in each place, using >, =, and < symbols to record the results of comparisons.

Grade 3	Grade 4	Grade 5
	4.NBT.5. Multiply a whole number of up to four digits by a one-digit whole number, and multiply two two-digit numbers, using strategies based on place value and the properties of operations. Illustrate and explain the calculation by using equations, rectangular arrays, and/or area models. 4.NBT.6. Find whole-number quotients and remainders with up to four-digit dividends and one-digit divisors, using strategies based on place value, the properties of operations, and/or the relationship between multiplication and division. Illustrate and explain the calculation by using equations, rectangular arrays, and/or area models.	5.NBT.4. Use place values understanding to round decimals to any place. **Perform operations with multi-digit whole numbers and with decimals to hundredths.** 5.NBT.5. Fluently multiply multi-digit whole numbers using a standard algorithm. 5.NBT.6. Find whole-number quotients of whole numbers with up to four-digit dividends and two-digit divisors, using strategies based on place value, the properties of operations, and/or the relationship between multiplication and division. Illustrate and explain the calculation by using equations, rectangular arrays, number lines, real life situations, and/or area models. 5.NBT.7. Add, subtract, multiply, and divide decimals to hundredths, using concrete models or drawings and strategies based on place value, properties of operations, and/or the relationship between the operations. Relate the strategy to a written method and explain their reasoning in getting their answers.

Grade 3	Grade 4	Grade 5
Number and Operations—Fractions 3.NF (limited in this grade to fractions with denominators 2, 3, 4, 6, and 8) **Develop understanding of fractions as numbers.** 3.NF.1. Understand a fraction $1/b$ (e.g., 1/4) as the quantity formed by 1 part when a whole is partitioned into b (e.g., 4) equal parts; understand a fraction a/b (e.g., 2/4) as the quantity formed by a (e.g., 2) parts of size $1/b$. (e.g., 1/4) 3.NF.2. Understand a fraction as a number on the number line; represent fractions on a number line diagram. a. Represent a fraction $1/b$ (e.g., 1/4) on a number line diagram by defining the interval from 0 to 1 as the whole and partitioning it into b (e.g., 4) equal parts. Recognize that each part has size $1/b$ (e.g., 1/4) and that the endpoint of the part based at 0 locates the number $1/b$ (e.g., 1/4) on the number line. b. Represent a fraction a/b (e.g., 2/8) on a number line diagram or ruler by marking off a lengths $1/b$ (e.g., 1/8) from 0. Recognize that the resulting interval has size a/b (e.g., 2/8) and that its endpoint locates the number a/b (e.g., 2/8) on the number line.	Number and Operations—Fractions 4.NF (limited in this grade to fractions with denominators 2, 3, 4, 5, 6, 8, 10, 12, and 100) **Extend understanding of fraction equivalence and ordering.** 4.NF.1. Explain why a fraction a/b is equivalent to a fraction $(n \times a)/(n \times b)$ by using visual fraction models, with attention to how the number and size of the parts differ even though the two fractions themselves are the same size. Use this principle to recognize and generate equivalent fractions. 4.NF.2. Compare two fractions with different numerators and different denominators (e.g., by creating common denominators or numerators, or by comparing to a benchmark fraction such as 1/2). Recognize that comparisons are valid only when the two fractions refer to the same whole. Record the results of comparisons with symbols >, =, or <, and justify the conclusions (e.g., by using a visual fraction model).	Number and Operations—Fractions 5.NF **Use equivalent fractions as a strategy to add and subtract fractions.** 5.NF.1. Add and subtract fractions with unlike denominators (including mixed numbers) by replacing given fractions with equivalent fractions in such a way as to produce an equivalent sum or difference of fractions with like denominators. *For example, $2/3 + 5/4 = 8/12 + 15/12 = 23/12$. (In general, $a/b + c/d = (ad + bc)/bd$.)* 5.NF.2. Solve word problems involving addition and subtraction of fractions referring to the same whole, including cases of unlike denominators (e.g., by using visual fraction models or equations to represent the problem). Use benchmark fractions and number sense of fractions to estimate mentally and check the reasonableness of answers. *For example, recognize an incorrect result $2/5 + 1/2 = 3/7$, by observing that $3/7 < 1/2$.*

Grade 3	Grade 4	Grade 5
3.NF.3. Explain equivalence of fractions in special cases, and compare fractions by reasoning about their size. a. Understand two fractions as equivalent if they are the same size (modeled) or the same point on a number line. b. Recognize and generate simple equivalent fractions (e.g., 1/2 = 2/4, 4/6 = 2/3). Explain why the fractions are equivalent (e.g., by using a visual fraction model). c. Express and model whole numbers as fractions, and recognize and construct fractions that are equivalent to whole numbers. *For example: Express 3 in the form 3 = 3/1; recognize that 6/1 = 6; locate 4/4 and 1 at the same point of a number line diagram.* d. Compare two fractions with the same numerator or the same denominator by reasoning about their size. Recognize that comparisons are valid only when the two fractions refer to the same whole. Record the results of comparisons with the symbols >, =, or <, and justify the conclusions (e.g., by using a visual fraction model).	**Build fractions from unit fractions by applying and extending previous understandings of operations on whole numbers.** 4.NF.3. Understand a fraction a/b with $a > 1$ as a sum of fractions $1/b$. a. Understand addition and subtraction of fractions as joining and separating parts referring to the same whole. b. Decompose a fraction into a sum of fractions with the same denominator in more than one way, recording each decomposition by an equation. Justify decompositions (e.g., by using a visual fraction model). *For example: 3/8 = 1/8 + 1/8 + 1/8 ;3/8 = 1/8 + 2/8 ; 2 1/8 = 1 + 1 + 1/8 = 8/8 + 8/8 + 1/8.* c. Add and subtract mixed numbers with like denominators (e.g., by replacing each mixed number with an equivalent fraction, and/or by using properties of operations and the relationship between addition and subtraction). d. Solve word problems involving addition and subtraction of fractions referring to the same whole and having like denominators (e.g., by using visual fraction models and equations to represent the problem).	**Apply and extend previous understandings of multiplication and division to multiply and divide fractions.** 5.NF.3. Interpret a fraction as division of the numerator by the denominator ($a/b = a \div b$). Solve word problems involving division of whole numbers leading to answers in the form of fractions or mixed numbers (e.g., by using visual fraction models or equations to represent the problem). *For example, interpret 3/4 as the result of dividing 3 by 4, noting that 3/4 multiplied by 4 equals 3, and that when 3 wholes are shared equally among 4 people each person has a share of size 3/4. If 9 people want to share a 50-pound sack of rice equally by weight, how many pounds of rice should each person get? Between what two whole numbers does your answer lie?* 5.NF.4. Apply and extend previous understandings of multiplication to multiply a fraction or whole number by a fraction. a. Interpret the product $(a/b) \times q$ as a parts of a partition of q into b equal parts; equivalently, as the result of a sequence of operations $a \times q \div b$. *For example, use a visual fraction model to show (2/3) × 4 = 8/3, and create a story context for this equation. Do the same with (2/3) × (4/5) = 8/15. (In general, (a/b) × (c/d) = ac/bd.)* b. Find the area of a rectangle with fractional side lengths by tiling it with unit squares of the appropriate unit fraction side lengths, and show that the area is the same as would be found by multiplying the side lengths. Multiply fractional side lengths to find areas of rectangles, and represent fraction products as rectangular areas.

Grade 3	Grade 4	Grade 5
	4.NF.4. Apply and extend previous understandings of multiplication to multiply a fraction by a whole number. a. Understand a fraction *a*/*b* as a multiple of 1/*b*. *For example, use a visual fraction model to represent 5/4 as the product 5 × (1/4), recording the conclusion by the equation 5/4 = 5 × (1/4).* b. Understand a multiple of *a*/*b* as a multiple of 1/*b*, and use this understanding to multiply a fraction by a whole number. *For example, use a visual fraction model to express 3 × (2/5) as 6 × (1/5), recognizing this product as 6/5. (In general, n × (a/b) = (n × a)/b.)* c. Solve word problems involving multiplication of a fraction by a whole number (e.g., by using visual fraction models and equations to represent the problem). Check for the reasonableness of the answer. *For example, if each person at a party will eat 3/8 of a pound of roast beef, and there will be 5 people at the party, how many pounds of roast beef will be needed? Between what two whole numbers does your answer lie?*	5.NF.5. Interpret multiplication as scaling (resizing), by: a. Comparing the size of a product to the size of one factor on the basis of the size of the other factor, without performing the indicated multiplication. b. Explaining why multiplying a given number by a fraction greater than 1 results in a product greater than the given number (recognizing multiplication by whole numbers greater than 1 as a familiar case); explaining why multiplying a given number by a fraction less than 1 results in a product smaller than the given number; and relating the principle of fraction equivalence *a*/*b* = (*n* × *a*)/(*n* × *b*) to the effect of multiplying *a*/*b* by 1. (Division of a fraction by a fraction is not a requirement at this grade.) 5.NF.6. Solve real-world problems involving multiplication of fractions and mixed numbers (e.g., by using visual fraction models or equations to represent the problem).

Grade 3	Grade 4	Grade 5
	Understand decimal notation for fractions, and compare decimal fractions. 4.NF.5. Express a fraction with denominator 10 as an equivalent fraction with denominator 100, and use this technique to add two fractions with respective denominators 10 and 100. *For example, express 3/10 as 30/100, and add 3/10 + 4/100 = 34/100.* 4.NF.6. Use decimal notation for fractions with denominators 10 or 100. *For example, rewrite 0.62 as 62/100; describe a length as 0.62 meters; locate 0.62 on a number line diagram.* 4.NF.7. Compare two decimals to hundredths by reasoning about their size. Recognize that comparisons are valid only when the two decimals refer to the same whole. Record the results of comparisons with the symbols >, =, or <, and justify the conclusions (e.g., by using a visual model).	5.NF.7. Apply and extend previous understandings of division to divide unit fractions by whole numbers and whole numbers by unit fractions. a. Interpret division of a unit fraction by a non-zero whole number, and compute such quotients. *For example, create a story context for (1/3) ÷ 4, and use a visual fraction model to show the quotient. Use the relationship between multiplication and division to explain that (1/3) ÷ 4 = 1/12 because (1/12) × 4 = 1/3.* b. Interpret division of a whole number by a unit fraction, and compute such quotients. *For example, create a story context for 4 ÷ (1/5), and use a visual fraction model to show the quotient. Use the relationship between multiplication and division to explain that 4 ÷ (1/5) = 20 because 20 × (1/5) = 4.* c. Solve real-world problems involving division of unit fractions by non-zero whole numbers and division of whole numbers by unit fractions (e.g., by using visual fraction models and equations to represent the problem). *For example, how much chocolate will each person get if 3 people share 1/2 lb of chocolate equally? How many 1/3-cup servings are in 2 cups of raisins?*

Grade 3	Grade 4	Grade 5
Measurement and Data 3.MD **Solve problems involving measurement and estimation of intervals of time, liquid volumes, and masses of objects.** 3.MD.1. Tell and write time to the nearest minute and measure time intervals in minutes. Solve word problems involving addition and subtraction of time intervals in minutes or hours (e.g., by representing the problem on a number line diagram or clock). 3.MD.2. Estimate and measure liquid volumes and masses of objects using standard units of grams (g), kilograms (kg), and liters (l). (Excludes compound units such as cm^3 and finding the geometric volume of a container.) Add, subtract, multiply, or divide to solve and create one-step word problems involving masses or volumes that are given in the same units (e.g., by using drawings, such as a beaker with a measurement scale, to represent the problem). (Excludes multiplicative comparison problems [problems involving notions of "times as much."])	Measurement and Data 4.MD **Solve problems involving measurement and conversion of measurements from a larger unit to a smaller unit, and involving time.** 4.MD.1. Know relative sizes of measurement units within one system of units including km, m, cm; kg, g; lb, oz.; l, ml; hr, min, sec. Within a single system of measurement, express measurements in a larger unit in terms of a smaller unit. Record measurement equivalents in a two-column table. *For example, know that 1 ft is 12 times as long as 1 in. Express the length of a 4-ft snake as 48 in. Generate a conversion table for feet and inches listing the number pairs (1, 12), (2, 24), (3, 36).* 4.MD.2. Use the four operations to solve word problems involving distances, intervals of time, liquid volumes, masses of objects, and money, including problems involving simple fractions or decimals, and problems that require expressing measurements given in a larger unit in terms of a smaller unit. Represent measurement quantities using diagrams such as number line diagrams that feature a measurement scale.	Measurement and Data 5.MD **Convert like measurement units within a given measurement system and solve problems involving time.** 5.MD.1. Identify, estimate measure, and convert equivalent measures within systems English length (inches, feet, yards, miles) weight (ounces, pounds, tons) volume (fluid ounces, cups, pints, quarts, gallons) temperature (Fahrenheit) Metric length (millimeters, centimeters, meters, kilometers) volume (milliliters, liters), temperature (Celsius), (e.g., convert 5 cm to 0.05 m), and use these conversions in solving multi-step, real-world problems using appropriate tools. 5.MD.2. Solve real-world problems involving elapsed time between world time zones. (L)

Grade 3	Grade 4	Grade 5
3.MD.3. Select an appropriate unit of English, metric, or non-standard measurement to estimate the length, time, weight, or temperature (L)	4.MD.3. Apply the area and perimeter formulas for rectangles in real-world and mathematical problems. *For example, find the width of a rectangular room given the area of the flooring and the length, by viewing the area formula as a multiplication equation with an unknown factor.* 4.MD.4. Solve real-world problems involving elapsed time between U.S. time zones (including Alaska Standard time). (L)	
Represent and interpret data. 3.MD.4. Draw a scaled picture graph and a scaled bar graph to represent a data set with several categories. Solve one- and two-step "how many more" and "how many less" problems using information presented in scaled bar graphs. *For example, draw a bar graph in which each square in the bar graph might represent 5 pets.*	**Represent and interpret data.** 4.MD.5. Make a line plot to display a data set of measurements in fractions of a unit (1/2, 1/4, 1/8). Solve problems involving addition and subtraction of fractions by using information presented in line plots. *For example, from a line plot find and interpret the difference in length between the longest and shortest specimens in an insect collection.*	**Represent and interpret data.** 5.MD.3. Make a line plot to display a data set of measurements in fractions of a unit (1/2, 1/4, 1/8). Solve problems involving information presented in line plots. *For example, given different measurements of liquid in identical beakers, find the amount of liquid each beaker would contain if the total amount in all the beakers were redistributed equally*.
3.MD.5. Measure and record lengths using rulers marked with halves and fourths of an inch. Make a line plot with the data, where the horizontal scale is marked off in appropriate units—whole numbers, halves, or quarters. 3.MD.6. Explain the classification of data from real-world problems shown in graphical representations. Use the terms minimum and maximum. (L)	4.MD.6. Explain the classification of data from real-world problems shown in graphical representations including the use of terms range and mode with a given set of data. (L)	5.MD.4. Explain the classification of data from real-world problems shown in graphical representations including the use of terms mean and median with a given set of data. (L)

Grade 3	Grade 4	Grade 5
Geometric measurement: understand concepts of area and relate area to multiplication and to addition. 3.MD.7. Recognize area as an attribute of plane figures and understand concepts of area measurement. a. A square with side length 1 unit is said to have "one square unit" and can be used to measure area. b. Demonstrate that a plane figure which can be covered without gaps or overlaps by *n* (e.g., 6) unit squares is said to have an area of *n* (e.g., 6) square units. 3.MD.8. Measure areas by tiling with unit squares (square centimeters, square meters, square inches, square feet, and improvised units).	**Geometric measurement: understand concepts of angle and measure angles.** 4.MD.7. Recognize angles as geometric shapes that are formed wherever two rays share a common endpoint, and understand the following concepts of angle measurement: a. An angle is measured with reference to a circle with its center at the common endpoint of the rays, by considering the fraction of the circular arc between the points where the two rays intersect the circle. An angle that turns through 1/360 of a circle is called a "one-degree angle," and can be used to measure angles. b. An angle that turns through *n* one-degree angles is said to have an angle measure of *n* degrees. 4.MD.8. Measure and draw angles in whole-number degrees using a protractor. Estimate and sketch angles of specified measure. 4.MD.9. Recognize angle measure as additive. When an angle is divided into non-overlapping parts, the angle measure of the whole is the sum of the angle measures of the parts. Solve addition and subtraction problems to find unknown angles on a diagram in real-world and mathematical problems (e.g., by using an equation with a symbol for the unknown angle measure).	**Geometric measurement: understand concepts of volume and relate volume to multiplication and to addition**. 5.MD.5. Recognize volume as an attribute of solid figures and understand concepts of volume measurement. a. A cube with side length 1 unit, called a "unit cube," is said to have "one cubic unit" of volume, and can be used to measure volume. b. A solid figure that can be packed without gaps or overlaps using *n* unit cubes is said to have a volume of *n* cubic units. 5.MD.6. Estimate and measure volumes by counting unit cubes, using cubic cm, cubic in, cubic ft, and non-standard units.

Grade 3	Grade 4	Grade 5
3.MD.9. Relate area to the operations of multiplication and addition. a. Find the area of a rectangle with whole-number side lengths by tiling it, and show that the area is the same as would be found by multiplying the side lengths. *For example, after tiling rectangles, develop a rule for finding the area of any rectangle.* b. Multiply side lengths to find areas of rectangles with whole number side lengths in the context of solving real-world and mathematical problems, and represent whole-number products as rectangular areas in mathematical reasoning. c. Use area models (rectangular arrays) to represent the distributive property in mathematical reasoning. Use tiling to show in a concrete case that the area of a rectangle with whole-number side lengths a and $b + c$ is the sum of $a \times b$ and $a \times c$. d. Recognize area as additive. Find areas of rectilinear figures by decomposing them into non-overlapping rectangles and adding the areas of the non-overlapping parts, applying this technique to solve real-world problems. *For example, the area of a 7 by 8 rectangle can be determined by decomposing it into a 7 by 3 rectangle and a 7 by 5 rectangle.*		5.MD.7. Relate volume to the operations of multiplication and addition and solve real-world and mathematical problems involving volume. a. Estimate and find the volume of a right rectangular prism with whole-number side lengths by packing it with unit cubes, and show that the volume is the same as would be found by multiplying the edge lengths, equivalently by multiplying the height by the area of the base. Demonstrate the associative property of multiplication by using the product of three whole numbers to find volumes (length x width x height). b. Apply the formulas $V = l \times w \times h$ and $V = b \times h$ for rectangular prisms to find volumes of right rectangular prisms with whole number edge lengths in the context of solving real-world and mathematical problems. c. Recognize volume as additive. Find volumes of solid figures composed of two non-overlapping right rectangular prisms by adding the volumes of the non-overlapping parts, applying this technique to solve real-world problems.

Grade 3	Grade 4	Grade 5
Geometric measurement: recognize perimeter as an attribute of plane figures and distinguish between linear and area measures. 3.MD.10. Solve real-world and mathematical problems involving perimeters of polygons, including: • finding the perimeter given the side lengths, • finding an unknown side length, • exhibiting rectangles with the same perimeter and different areas, • exhibiting rectangles with the same area and different perimeters.	.	
<u>Geometry 3.G</u> **Reason with shapes and their attributes**. 3.G.1. Categorize shapes by different attribute classifications and recognize that shared attributes can define a larger category. Generalize to create examples or non-examples. 3.G.2. Partition shapes into parts with equal areas. Express the area of each part as a unit fraction of the whole. *For example, partition a shape into 4 parts with equal area, and describe the area of each part as 1/4 of the area of the shape.*	<u>Geometry 4.G</u> **Draw and identify lines and angles, and classify shapes by properties of their lines and angles.** 4.G.1. Draw points, lines, line segments, rays, angles (right, acute, obtuse), and perpendicular, parallel, and intersecting line segments. Identify these in two-dimensional (plane) figures. 4.G.2. Classify two-dimensional (plane) figures based on the presence or absence of parallel or perpendicular lines, or the presence or absence of angles of a specified size. Recognize right triangles as a category, and identify right triangles. 4.G.3. Recognize a line of symmetry for a two-dimensional (plane) figure as a line across the figure such that the figure can be folded along the line into matching parts. Identify line-symmetric figures and draw lines of symmetry.	<u>Geometry 5.G</u> **Graph points on the coordinate plane to solve real-world and mathematical problems.** 5.G.1. Use a pair of perpendicular number lines, called axes, to define a coordinate system, with the intersection of the lines (the origin) arranged to coincide with the 0 on each line and a given point in the plane located by using an ordered pair of numbers, called its coordinates. Understand that the first number indicates how far to travel from the origin in the direction of one axis, and the second number indicates how far to travel in the direction of the second axis, with the convention that the names of the two axes and the coordinates correspond (e.g., *x*-axis and *x*-coordinate, *y*-axis and *y*-coordinate).

Grade 3	Grade 4	Grade 5
		5.G.2. Represent real-world and mathematical problems by graphing points in the first quadrant of the coordinate plane, and interpret coordinate values of points in the context of the situation. **Classify two-dimensional (plane) figures into categories based on their properties.** 5.G.3. Understand that attributes belonging to a category of two-dimensional (plane) figures also belong to all subcategories of that category. *For example, all rectangles have four right angles and squares are rectangles, so all squares have four right angles.* 5.G.4. Classify two-dimensional (plane) figures in a hierarchy based on attributes and properties.

Instructional Focus: Sixth Grade through Eighth Grade

Grade 6	Grade 7	Grade 8
In Grade 6, instructional time should focus on four critical areas: (1) connecting ratio and rate to whole number multiplication and division and using concepts of ratio and rate to solve problems; (2) completing understanding of division of fractions and extending the notion of number to the system of rational numbers, which includes negative numbers; (3) writing, interpreting, and using expressions and equations; and (4) developing understanding of statistical thinking. (1) Students use reasoning about multiplication and division to solve ratio and rate problems about quantities. By viewing equivalent ratios and rates as deriving from, and extending, pairs of rows (or columns) in the multiplication table, and by analyzing simple drawings that indicate the relative size of quantities, students connect their understanding of multiplication and division with ratios and rates. Thus students expand the scope of problems for which they can use multiplication and division to solve problems, and they connect ratios and fractions. Students solve a wide variety of problems involving ratios and rates. (2) Students use the meaning of fractions, the meanings of multiplication and division, and the relationship between multiplication and division to understand and explain why the procedures for dividing fractions make sense. Students use these operations to solve problems. Students extend their previous understandings of number and the ordering of numbers to the full system of rational numbers, which includes negative rational numbers, and in particular negative integers. They reason about the order and absolute value of	In Grade 7, instructional time should focus on four critical areas: (1) developing understanding of and applying proportional relationships; (2) developing understanding of operations with rational numbers and working with expressions and linear equations; (3) solving problems involving scale drawings and informal geometric constructions, and working with two- and three-dimensional shapes to solve problems involving area, surface area, and volume; and (4) drawing inferences about populations based on samples. (1) Students extend their understanding of ratios and develop understanding of proportionality to solve single- and multi-step problems. Students use their understanding of ratios and proportionality to solve a wide variety of percent problems, including those involving discounts, interest, taxes, tips, and percent increase or decrease. Students solve problems about scale drawings by relating corresponding lengths between the objects or by using the fact that relationships of lengths within an object are preserved in similar objects. Students graph proportional relationships and understand the unit rate informally as a measure of the steepness of the related line, called the slope. They distinguish proportional relationships from other relationships. (2) Students develop a unified understanding of number, recognizing fractions, decimals (that have a finite or a repeating decimal representation), and percents as different representations of rational numbers. Students extend addition, subtraction, multiplication, and division to all rational numbers, maintaining the properties of operations and the relationships	In Grade 8, instructional time should focus on three critical areas: (1) formulating and reasoning about expressions and equations, including modeling an association in bivariate data with a linear equation, and solving linear equations and systems of linear equations; (2) grasping the concept of a function and using functions to describe quantitative relationships; (3) analyzing two- and three-dimensional space and figures using distance, angle, similarity, and congruence, and understanding and applying the Pythagorean Theorem. (1) Students use linear equations and systems of linear equations to represent, analyze, and solve a variety of problems. Students recognize equations for proportions ($y/x = m$ or $y = mx$) as special linear equations ($y = mx + b$), understanding that the constant of proportionality (m) is the slope, and the graphs are lines through the origin. They understand that the slope (m) of a line is a constant rate of change, so that if the input or x-coordinate changes by an amount A, the output or y-coordinate changes by the amount $m \cdot A$. Students also use a linear equation to describe the association between two quantities in bivariate data (such as arm span vs. height for students in a classroom). At this grade, fitting the model and assessing its fit to the data are done informally. Interpreting the model in the context of the data requires students to express a relationship between the two quantities in question and to interpret components of the relationship (such as slope and y-intercept) in terms of the situation. Students strategically choose and efficiently implement procedures to solve linear equations in one variable, understanding that when they use the properties

rational numbers and about the location of points in all four quadrants of the coordinate plane. (3) Students understand the use of variables in mathematical expressions. They write expressions and equations that correspond to given situations, evaluate expressions, and use expressions and formulas to solve problems. Students understand that expressions in different forms can be equivalent, and they use the properties of operations to rewrite expressions in equivalent forms. Students know that the solutions of an equation are the values of the variables that make the equation true. Students use properties of operations and the idea of maintaining the equality of both sides of an equation to solve simple one-step equations. Students construct and analyze tables, such as tables of quantities that are in equivalent ratios, and they use equations (such as $3x = y$) to describe relationships between quantities. (4) Building on and reinforcing their understanding of number, students begin to develop their ability to think statistically. Students recognize that a data distribution may not have a definite center and that different ways to measure center yield different values. The median measures center in the sense that it is roughly the middle value. The mean measures center in the sense that it is the value that each data point would take on if the total of the data values were redistributed equally, and also in the sense that it is a balance point. Students recognize that a measure of variability (interquartile range or mean absolute deviation) can also be useful for summarizing data because two very different sets of data can have the same mean and median yet be distinguished by their variability. Students learn to describe and summarize numerical data sets, identifying clusters, peaks, gaps, and	between addition and subtraction, and multiplication and division. By applying these properties, and by viewing negative numbers in terms of everyday contexts (e.g., amounts owed or temperatures below zero), students explain and interpret the rules for adding, subtracting, multiplying, and dividing with negative numbers. They use the arithmetic of rational numbers as they formulate expressions and equations in one variable and use these equations to solve problems. (3) Students continue their work with area from Grade 6, solving problems involving the area and circumference of a circle and surface area of three-dimensional objects. In preparation for work on congruence and similarity in Grade 8 they reason about relationships among two-dimensional figures using scale drawings and informal geometric constructions, and they gain familiarity with the relationships between angles formed by intersecting lines. Students work with three-dimensional figures, relating them to two-dimensional figures by examining cross-sections. They solve real-world and mathematical problems involving area, surface area, and volume of two- and three-dimensional objects composed of triangles, quadrilaterals, polygons, cubes and right prisms. (4) Students build on their previous work with single data distributions to compare two data distributions and address questions about differences between populations. They begin informal work with random sampling to generate data sets and learn about the importance of representative samples for drawing inferences.	of equality and the concept of logical equivalence, they maintain the solutions of the original equation. Students solve systems of two linear equations in two variables and relate the systems to pairs of lines in the plane; these intersect, are parallel, or are the same line. Students use linear equations, systems of linear equations, linear functions, and their understanding of slope of a line to analyze situations and solve problems. (2) Students grasp the concept of a function as a rule that assigns to each input exactly one output. They understand that functions describe situations where one quantity determines another. They can translate among representations and partial representations of functions (noting that tabular and graphical representations may be partial representations), and they describe how aspects of the function are reflected in the different representations. (3) Students use ideas about distance and angles, how they behave under translations, rotations, reflections, and dilations, and ideas about congruence and similarity to describe and analyze two-dimensional figures and to solve problems. Students show that the sum of the angles in a triangle is the angle formed by a straight line, and that various configurations of lines give rise to similar triangles because of the angles created when a transversal cuts parallel lines. Students understand the statement of the Pythagorean Theorem and its converse, and can explain why the Pythagorean Theorem holds, for example, by decomposing a square in two different ways. They apply the Pythagorean Theorem to find distances between points on the coordinate plane, to find lengths, and to analyze polygons. Students complete their work on volume by solving problems involving cones, cylinders, and spheres.

symmetry, considering the context in which the data were collected. Students in Grade 6 also build on their work with area in elementary school by reasoning about relationships among shapes to determine area, surface area, and volume. They find areas of right triangles, other triangles, and special quadrilaterals by decomposing these shapes, rearranging or removing pieces, and relating the shapes to rectangles. Using these methods, students discuss, develop, and justify formulas for areas of triangles and parallelograms. Students find areas of polygons and surface areas of prisms and pyramids by decomposing them into pieces whose area they can determine. They reason about right rectangular prisms with fractional side lengths to extend formulas for the volume of a right rectangular prism to fractional side lengths. They prepare for work on scale drawings and constructions in Grade 7 by drawing polygons in the coordinate plane.		

Alaska Mathematics Standards Grades 6-8

Grade 6	Grade 7	Grade 8
Ratios and Proportional Relationships 6.RP **Understand ratio concepts and use ratio reasoning to solve problems.** 6.RP.1. Write and describe the relationship in real life context between two quantities using ratio language. *For example, "The ratio of wings to beaks in the bird house at the zoo was 2:1, because for every 2 wings there was 1 beak." "For every vote candidate A received, candidate C received nearly three votes."* 6.RP.2. Understand the concept of a unit rate (a/b associated with a ratio $a:b$ with $b \neq 0$, and use rate language in the context of a ratio relationship) and apply it to solve real-world problems (e.g., unit pricing, constant speed). *For example, "This recipe has a ratio of 3 cups of flour to 4 cups of sugar, so there is 3/4 cup of flour for each cup of sugar." "We paid $75 for 15 hamburgers, which is a rate of $5 per hamburger."*	Ratios and Proportional Relationships 7.RP **Analyze proportional relationships and use them to solve real-world and mathematical problems.** 7.RP.1. Compute unit rates associated with ratios of fractions, including ratios of lengths, areas and other quantities measured in like or different units. *For example, if a person walks 1/2 mile in each 1/4 hour, compute the unit rate as the complex fraction 1/2/1/4 miles per hour, equivalently 2 miles per hour or apply a given scale factor to find missing dimensions of similar figures.* 7.RP.2. Recognize and represent proportional relationships between quantities. Make basic inferences or logical predictions from proportional relationships. a. Decide whether two quantities are in a proportional relationship (e.g., by testing for equivalent ratios in a table or graphing on a coordinate plane and observing whether the graph is a straight line through the origin). b. Identify the constant of proportionality (unit rate) in tables, graphs, equations, diagrams, and verbal descriptions of proportional relationships in real-world situations.	

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6.RP.3. Use ratio and rate reasoning to solve real-world and mathematical problems (e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations). a. Make tables of equivalent ratios relating quantities with whole number measurements, find missing values in the tables, and plot the pairs of values on the coordinate plane. Use tables to compare ratios, and understand equivalencies. b. Solve unit rate problems including those involving unit pricing and constant speed. *For example, if it took 7 hours to mow 4 lawns, then at that rate how many lawns could be mowed in 35 hours? At what rate were lawns being mowed?* c. Find a percent of a quantity as a rate per 100 (e.g., 30% of a quantity means 30/100 times the quantity); solve problems involving finding the whole, given a part and the percent. d. Use ratio reasoning to convert measurement units between given measurement systems (e.g., convert kilometers to miles); manipulate and transform units appropriately when multiplying or dividing quantities.	c. Represent proportional relationships by equations and multiple representations such as tables, graphs, diagrams, sequences, and contextual situations. *For example, if total cost t is proportional to the number n of items purchased at a constant price p, the relationship between the total cost and the number of items can be expressed as t = pn*. d. Understand the concept of unit rate and show it on a coordinate plane. Explain what a point *(x, y)* on the graph of a proportional relationship means in terms of the situation, with special attention to the points (0, 0) and (1, *r)* where *r* is the unit rate. 7.RP.3. Use proportional relationships to solve multistep ratio and percent problems. *Examples: simple interest, tax, markups and markdowns, gratuities and commissions, fees, percent increase and decrease, percent error*.	

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The Number System 6.NS **Apply and extend previous understandings of multiplication and division to divide fractions by fractions.** 6.NS.1. Interpret and compute quotients of fractions, and solve word problems involving division of fractions by fractions (e.g., by using visual fraction models and equations to represent the problem). *For example, create a story context for (2/3) ÷ (3/4) and use a visual fraction model to show the quotient; use the relationship between multiplication and division to explain that (2/3) ÷ (3/4) = 8/9 because 3/4 of 8/9 is 2/3. (In general (a/b) ÷ (c/d) = ad/bc.) How much chocolate will each person get if 3 people share 1/2 lb of chocolate equally? How many 3/4-cup servings are in 2/3 of a cup of yogurt? How wide is a rectangular strip of land with length 3/4 mi and area 1/2 square mi?*	The Number System 7.NS **Apply and extend previous understandings of operations with fractions to add, subtract, multiply, and divide rational numbers.** 7.NS.1. Apply and extend previous understandings of addition and subtraction to add and subtract rational numbers; represent addition and subtraction on a horizontal or vertical number line diagram. a. Show that a number and its opposite have a sum of 0 (additive inverses). Describe situations in which opposite quantities combine to make 0. *For example, a hydrogen atom has 0 charge because its two constituents are oppositely charged.* b. Understand addition of rational numbers ($p + q$ as the number located a distance $\|q\|$ from p, in the positive or negative direction depending on whether q is positive or negative). Interpret sums of rational numbers by describing real-world contexts. c. Understand subtraction of rational numbers as adding the additive inverse, $p – q = p + (–q)$. Show that the distance between two rational numbers on the number line is the absolute value of their difference, and apply this principle in real-world contexts. d. Apply properties of operations as strategies to add and subtract rational numbers.	The Number System 8.NS **Know that there are numbers that are not rational, and approximate them by rational numbers.** 8.NS.1. Classify real numbers as either rational (the ratio of two integers, a terminating decimal number, or a repeating decimal number) or irrational. 8.NS.2. Order real numbers, using approximations of irrational numbers, locating them on a number line. *For example, show that √2 is between 1 and 2, then between 1.4 and 1.5, and explain how to continue on to get better approximations.* 8.NS.3. Identify or write the prime factorization of a number using exponents. (L)

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Compute fluently with multi-digit numbers and find common factors and multiples. 6.NS.2. Fluently multiply and divide multi-digit whole numbers using the standard algorithm. Express the remainder as a whole number, decimal, or simplified fraction; explain or justify your choice based on the context of the problem. 6.NS.3. Fluently add, subtract, multiply, and divide multi-digit decimals using the standard algorithm for each operation. Express the remainder as a terminating decimal, or a repeating decimal, or rounded to a designated place value. 6.NS.4. Find the greatest common factor of two whole numbers less than or equal to 100 and the least common multiple of two whole numbers less than or equal to 12. Use the distributive property to express a sum of two whole numbers 1–100 with a common factor as a multiple of a sum of two whole numbers with no common factor. *For example, express 36 + 8 as 4 (9 + 2).*	7.NS.2. Apply and extend previous understandings of multiplication and division and of fractions to multiply and divide rational numbers and use equivalent representations. a. Understand that multiplication is extended from fractions to rational numbers by requiring that operations continue to satisfy the properties of operations, particularly the distributive property, leading to products such as $(–1)(–1) = 1$ and the rules for multiplying signed numbers. Interpret products of rational numbers by describing real-world contexts. b. Understand that integers can be divided, provided that the divisor is not zero, and every quotient of integers (with non-zero divisor) is a rational number. If p and q are integers, then $–(p/q) = (–p)/q = p/(–q)$. Interpret quotients of rational numbers by describing real-world contexts. c. Apply and name properties of operations used as strategies to multiply and divide rational numbers. d. Convert a rational number to a decimal using long division; know that the decimal form of a rational number terminates in 0s or eventually repeats. e. Convert between equivalent fractions, decimals, or percents.	

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Apply and extend previous understandings of numbers to the system of rational numbers. 6.NS.5 Understand that positive and negative numbers describe quantities having opposite directions or values (e.g., temperature above/below zero, elevation above/below sea level, credits/debits, positive/negative electric charge); use positive and negative numbers to represent quantities in real-world contexts, explain the meaning of 0 in each situation. 6.NS.6. Understand a rational number as a point on the number line. Extend number line diagrams and coordinate axes familiar from previous grades to represent points on the line and in the plane with negative number coordinates. a. Recognize opposite signs of numbers as indicating locations on opposite sides of 0 on the number line; Recognize that the opposite of the opposite of a number is the number itself [e.g., –(–3) = 3] and that 0 is its own opposite. b. Understand signs of numbers in ordered pairs as indicating locations in quadrants of the coordinate plane; recognize that when two ordered pairs differ only by signs, the locations of the points are related by reflections across one or both axes. c. Find and position integers and other rational numbers on a horizontal or vertical number line diagram; find and position pairs of integers and other rational numbers on a coordinate plane.	7.NS.3. Solve real-world and mathematical problems involving the four operations with rational numbers. (Computations with rational numbers extend the rules for manipulating fractions to complex fractions.) *For example, use models, explanations, number lines, real life situations, describing or illustrating the effect of arithmetic operations on rational numbers (fractions, decimals).*	

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6.NS.7. Understand ordering and absolute value of rational numbers. a. Interpret statements of inequality as statements about the relative position of two numbers on a number line diagram. *For example, interpret –3 > –7 as a statement that –3 is located to the right of –7 on a number line oriented from left to right.* b. Write, interpret, and explain statements of order for rational numbers in real-world contexts. *For example, write –3 ^{o}C > –7 ^{o}C to express the fact that –3 ^{o}C is warmer than –7 ^{o}C.* c. Understand the absolute value of a rational number as its distance from 0 on the number line; interpret absolute value as magnitude for a positive or negative quantity in a real-world situation. *For example, for an account balance of –30 dollars, write |–30| = 30 to describe the size of the debt in dollars.* d. Distinguish comparisons of absolute value from statements about order. *For example, recognize that an account balance less than -30 dollars represents a debt greater than 30 dollars.* 6.NS.8. Solve real-world and mathematical problems by graphing points in all four quadrants of the coordinate plane. Include use of coordinates and absolute value to find distances between points with the same first coordinate or the same second coordinate.		

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<u>Expressions and Equations 6.EE</u> **Apply and extend previous understandings of arithmetic to algebraic expressions.** 6.EE.1. Write and evaluate numerical expressions involving whole-number exponents. *For example, multiply by powers of 10 and products of numbers using exponents.* $(7^3 = 7 \cdot 7 \cdot 7)$ 6.EE.2. Write, read, and evaluate expressions in which letters stand for numbers. a. Write expressions that record operations with numbers and with letters standing for numbers. *For example, express the calculation "Subtract y from 5" as* $5 - y$. b. Identify parts of an expression using mathematical terms (sum, term, product, factor, quotient, coefficient); view one or more parts of an expression as a single entity. *For example, describe the expression* $2(8 + 7)$ *as a product of two factors; view* $(8 + 7)$ *as both a single entity and a sum of two terms.* c. Evaluate expressions and formulas. Include formulas used in real-world problems. Perform arithmetic operations, including those involving whole number exponents, in the conventional order with or without parentheses. (Order of Operations) 6.EE.3. Apply the properties of operations to generate equivalent expressions. Model (e.g., manipulatives, graph paper) and apply the distributive, commutative, identity, and inverse properties with integers and variables by writing equivalent expressions. *For example, apply the distributive property to the expression* $3(2 + x)$ *to produce the equivalent expression* $6 + 3x$.	<u>Expressions and Equations 7.EE</u> **Use properties of operations to generate equivalent expressions.** 7.EE.1. Apply properties of operations as strategies to add, subtract, factor, expand and simplify linear expressions with rational coefficients. 7.EE.2. Understand that rewriting an expression in different forms in a problem context can shed light on the problem and how the quantities in it are related. *For example,* $a + 0.05a = 1.05a$ *means that "increase by 5%" is the same as "multiply by 1.05."* **Solve real-life and mathematical problems using numerical and algebraic expressions and equations.** 7.EE.3. Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form and assess the reasonableness of answers using mental computation and estimation strategies. *For example: If a woman making $25 an hour gets a 10% raise, she will make an additional 1/10 of her salary an hour, or $2.50, for a new salary of $27.50. If you want to place a towel bar 9 3/4 inches long in the center of a door that is 27 1/2 inches wide, you will need to place the bar about 9 inches from each edge; this estimate can be used as a check on the exact computation.*	<u>Expressions and Equations 8.EE</u> **Work with radicals and integer exponents.** 8.EE.1. Apply the properties (product, quotient, power, zero, negative exponents, and rational exponents) of integer exponents to generate equivalent numerical expressions. *For example,* $3^2 \times 3^{-5} = 3^{-3} = 1/3^3 = 1/27$. 8.EE.2. Use square root and cube root symbols to represent solutions to equations of the form $x^2 = p$ and $x^3 = p$, where p is a positive rational number. Evaluate square roots of small perfect squares and cube roots of small perfect cubes. Know that $\sqrt{2}$ is irrational. 8.EE.3. Use numbers expressed in the form of a single digit times an integer power of 10 to estimate very large or very small quantities, and to express how many times as much one is than the other. *For example, estimate the population of the United States as* 3×10^8 *and the population of the world as* 7×10^9*, and determine that the world population is more than 20 times larger.* 8.EE.4. Perform operations with numbers expressed in scientific notation, including problems where both standard notation and scientific notation are used. Use scientific notation and choose units of appropriate size for measurements of very large or very small quantities. Interpret scientific notation that has been generated by technology.

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6.EE.4. Identify when two expressions are equivalent (i.e., when the two expressions name the same number regardless of which value is substituted into them). *For example, the expressions $y + y + y$ and $3y$ are equivalent because they name the same number regardless of which number y stands for.* **Reason about and solve one-variable equations and inequalities.** 6.EE.5. Understand solving an equation or inequality as a process of answering a question: which values from a specified set, if any, make the equation or inequality true? Use substitution to determine whether a given number in a specified set makes an equation or inequality true. *For example: does 5 make $3x > 7$ true?* 6.EE.6. Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set. 6.EE.7. Solve real-world and mathematical problems by writing and solving equations of the form $x + p = q$ and $px = q$ for cases in which p, q and x are all nonnegative rational numbers.	7.EE.4. Use variables to represent quantities in a real-world or mathematical problem, and construct multi-step equations and inequalities to solve problems by reasoning about the quantities. a. Solve word problems leading to equations of the form $px + q = r$ and $p(x + q) = r$, where p, q, and r are specific rational numbers. *For example, the perimeter of a rectangle is 54 cm. Its length is 6 cm. What is its width?* b. Solve word problems leading to inequalities of the form $px + q > r$ or $px + q < r$, where p, q, and r are specific rational numbers. Graph the solution set of the inequality and interpret it in the context of the problem. *For example: As a salesperson, you are paid \$50 per week plus \$3 per sale. This week you want your pay to be at least \$100. Write an inequality for the number of sales you need to make, and describe the solutions.*	**Understand the connections between proportional relationships, lines, and linear equations.** 8.EE.5. Graph linear equations such as $y = mx + b$, interpreting m as the slope or rate of change of the graph and b as the y-intercept or starting value. Compare two different proportional relationships represented in different ways. *For example, compare a distance-time graph to a distance-time equation to determine which of two moving objects has greater speed.* 8.EE.6. Use similar triangles to explain why the slope m is the same between any two distinct points on a non-vertical line in the coordinate plane; derive the equation $y = mx$ for a line through the origin and the equation $y = mx + b$ for a line intercepting the vertical axis at b. **Analyze and solve linear equations and pairs of simultaneous linear equations.** 8.EE.7. Solve linear equations in one variable. a. Give examples of linear equations in one variable with one solution, infinitely many solutions, or no solutions. Show which of these possibilities is the case by successively transforming the given equation into simpler forms, until an equivalent equation of the form $x = a$, $a = a$, or $a = b$ results (where a and b are different numbers). b. Solve linear equations with rational coefficients, including equations whose solutions require expanding expressions using the distributive property and combining like terms.

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6.EE.8. Write an inequality of the form $x > c$ or $x < c$ to represent a constraint or condition in a real-world or mathematical problem. Recognize that inequalities of the form $x > c$ or $x < c$ have infinitely many solutions; represent solutions of such inequalities on number line diagrams. **Represent and analyze quantitative relationships between dependent and independent variables.** 6.EE.9. Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation. *For example, in a problem involving motion at constant speed, list and graph ordered pairs of distances and times, and write the equation $d = 65t$ to represent the relationship between distance and time.*		8.EE.8. Analyze and solve systems of linear equations. a. Show that the solution to a system of two linear equations in two variables is the intersection of the graphs of those equations because points of intersection satisfy both equations simultaneously. b. Solve systems of two linear equations in two variables and estimate solutions by graphing the equations. Simple cases may be done by inspection. *For example, $3x + 2y = 5$ and $3x + 2y = 6$ have no solution because $3x + 2y$ cannot simultaneously be 5 and 6.* c. Solve real-world and mathematical problems leading to two linear equations in two variables. *For example, given coordinates for two pairs of points, determine whether the line through the first pair of points intersects the line through the second pair.*

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Geometry 6.G **Solve real-world and mathematical problems involving area, surface area, and volume.** 6.G.1. Find the area of right triangles, other triangles, special quadrilaterals, and polygons by composing or decomposing into other polygons (e.g., rectangles and triangles). Apply these techniques in the context of solving real-world and mathematical problems. 6.G.2. Apply the standard formulas to find volumes of prisms. Use the attributes and properties (including shapes of bases) of prisms to identify, compare or describe three-dimensional figures including prisms and cylinders. 6.G.3. Draw polygons in the coordinate plane given coordinates for the vertices; determine the length of a side joining the coordinates of vertices with the same first or the same second coordinate. Apply these techniques in the context of solving real-world and mathematical problems. 6.G.4. Represent three-dimensional figures (e.g., prisms) using nets made up of rectangles and triangles, and use the nets to find the surface area of these figures. Apply these techniques in the context of solving real-world and mathematical problems. 6.G.5. Identify, compare or describe attributes and properties of circles (radius, and diameter). (L)	Geometry 7.G **Draw, construct, and describe geometrical figures and describe the relationships between them.** 7.G.1. Solve problems involving scale drawings of geometric figures, including computing actual lengths and areas from a scale drawing and reproducing a scale drawing at a different scale. 7.G.2. Draw (freehand, with ruler and protractor, and with technology) geometric shapes including polygons and circles with given conditions. Focus on constructing triangles from three measures of angles or sides, noticing when the conditions determine a unique triangle, more than one triangle, or no triangle. 7.G.3. Describe the two-dimensional figures, i.e., cross-section, that result from slicing three-dimensional figures, as in plane sections of right rectangular prisms and right rectangular pyramids. **Solve real-life and mathematical problems involving angle measure, area, surface area, and volume.** 7.G.4. Know the formulas for the area and circumference of a circle and use them to solve problems; give an informal derivation of the relationship between the circumference and area of a circle. 7.G.5. Use facts about supplementary, complementary, vertical, and adjacent angles in a multi-step problem to write and solve simple equations for an unknown angle in a figure.	Geometry 8.G **Understand congruence and similarity using physical models, transparencies, or geometry software.** 8.G.1. Through experimentation, verify the properties of rotations, reflections, and translations (transformations) to figures on a coordinate plane). a. Lines are taken to lines, and line segments to line segments of the same length. b. Angles are taken to angles of the same measure. c. Parallel lines are taken to parallel lines. 8.G.2. Demonstrate understanding of congruence by applying a sequence of translations, reflections, and rotations on two-dimensional figures. Given two congruent figures, describe a sequence that exhibits the congruence between them. 8.G.3. Describe the effect of dilations, translations, rotations, and reflections on two-dimensional figures using coordinates. 8.G.4. Demonstrate understanding of similarity, by applying a sequence of translations, reflections, rotations, and dilations on two-dimensional figures. Describe a sequence that exhibits the similarity between them.

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	7.G.6. Solve real-world and mathematical problems involving area, volume and surface area of two- and three-dimensional objects composed of triangles, quadrilaterals, polygons, cubes, and right prisms.	8.G.5. Justify using informal arguments to establish facts about • the angle sum of triangles (sum of the interior angles of a triangle is 180º), • measures of exterior angles of triangles, • angles created when parallel lines are cut be a transversal (e.g., alternate interior angles), and • angle-angle criterion for similarity of triangles. **Understand and apply the Pythagorean Theorem.** 8.G.6. Explain the Pythagorean Theorem and its converse. 8.G.7. Apply the Pythagorean Theorem to determine unknown side lengths in right triangles in real-world and mathematical problems in two and three dimensions. 8.G.8. Apply the Pythagorean Theorem to find the distance between two points in a coordinate system. **Solve real-world and mathematical problems involving volume of cylinders, cones, and spheres.** 8.G.9. Identify and apply the formulas for the volumes of cones, cylinders, and spheres and use them to solve real-world and mathematical problems.

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Statistics and Probability 6.SP **Develop understanding of statistical variability.** 6.SP.1. Recognize a statistical question as one that anticipates variability in the data related to the question and accounts for it in the answers. *For example, "How old am I?" is not a statistical question, but "How old are the students in my school?" is a statistical question because one anticipates variability in students' ages.* 6.SP.2. Understand that a set of data has a distribution that can be described by its center (mean, median, or mode), spread (range), and overall shape and can be used to answer a statistical question. 6.SP.3. Recognize that a measure of center (mean, median, or mode) for a numerical data set summarizes all of its values with a single number, while a measure of variation (range) describes how its values vary with a single number. **Summarize and describe distributions.** 6.SP.4. Display numerical data in plots on a number line, including dot or line plots, histograms and box (box and whisker) plots.	Statistics and Probability 7.SP **Use random sampling to draw inferences about a population.** 7.SP.1. Understand that statistics can be used to gain information about a population by examining a reasonably sized sample of the population; generalizations about a population from a sample are valid only if the sample is representative of that population. Understand that random sampling tends to produce representative samples and support valid inferences. 7.SP.2. Use data from a random sample to draw inferences about a population with an unknown characteristic of interest. Generate multiple samples (or simulated samples) of the same size to gauge the variation in estimates or predictions. *For example, estimate the mean word length in a book by randomly sampling words from the book; predict the winner of a school election based on randomly sampled survey data. Gauge how far off the estimate or prediction might be.* **Draw informal comparative inferences about two populations.** 7.SP.3. Informally assess the degree of visual overlap of two numerical data distributions with similar variabilities, measuring the difference between the centers by expressing it as a multiple of a measure of variability. *For example, the mean height of players on the basketball team is 10 cm greater than the mean height of players on the soccer team, about twice the variability (mean absolute deviation) on either team; on a dot plot, the separation between the two distributions of heights is noticeable.*	Statistics and Probability 8.SP **Investigate patterns of association in bivariate data.** 8.SP.1. Construct and interpret scatter plots for bivariate measurement data to investigate patterns of association between two quantities. Describe patterns such as clustering, outliers, positive or negative association, linear association, and nonlinear association. 8.SP.2. Explain why straight lines are widely used to model relationships between two quantitative variables. For scatter plots that suggest a linear association, informally fit a straight line, and informally assess the model fit by judging the closeness of the data points to the line. 8.SP.3. Use the equation of a linear model to solve problems in the context of bivariate measurement data, interpreting the slope and *y*-intercept. *For example, in a linear model for a biology experiment, interpret a slope of 1.5 cm/hr as meaning that an additional hour of sunlight each day is associated with an additional 1.5 cm in mature plant height.* 8.SP.4. Construct and interpret a two-way table summarizing data on two categorical variables collected from the same subjects and use relative frequencies to describe possible association between the two variables. *For example, collect data from students in your class on whether or not they have a curfew on school nights and whether or not they have assigned chores at home. Is there evidence that those who have a curfew also tend to have chores?*

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6.SP.5. Summarize numerical data sets in relation to their context, such as by: a. Reporting the number of observations (occurrences). b. Describing the nature of the attribute under investigation, including how it was measured and its units of measurement. c. Giving quantitative measures of center (median and/or mean) and variability (interquartile range), as well as describing any overall pattern and any outliers with reference to the context in which the data were gathered. d. Relating the choice of measures of center and variability to the shape of the data distribution and the context in which the data were gathered. 6.SP.6. Analyze whether a game is mathematically fair or unfair by explaining the probability of all possible outcomes. (L) 6.SP.7. Solve or identify solutions to problems involving possible combinations (e.g., if ice cream sundaes come in 3 flavors with 2 possible toppings, how many different sundaes can be made using only one flavor of ice cream with one topping?) (L)	7.SP.4. Use measures of center and measures of variability for numerical data from random samples to draw informal comparative inferences about two populations. *For example, decide whether the words in a chapter of a seventh-grade science book are generally longer than the words in a chapter of a fourth-grade science book.* **Investigate chance processes and develop, use, and evaluate probability models.** 7.SP.5. Understand that the probability of a chance event is a number between 0 and 1 that expresses the likelihood of the event occurring. Larger numbers indicate greater likelihood. A probability near 0 indicates an unlikely event, a probability around 1/2 indicates an event that is neither unlikely nor likely, and a probability near 1 indicates a likely event. 7.SP.6. Approximate the probability of a chance event by collecting data on the chance process that produces it and observing its long-run relative frequency, and predict the approximate relative frequency given the probability. *For example, when rolling a number cube 600 times, predict that a 3 or 6 would be rolled roughly 200 times, but probably not exactly 200 times.*	

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	7.SP.7. Develop a probability model and use it to find probabilities of events. Compare probabilities from a model to observed frequencies; if the agreement is not good, explain possible sources of the discrepancy. a. Design a uniform probability model by assigning equal probability to all outcomes, and use the model to determine probabilities of events. *For example, if a student is selected at random from a class, find the probability that Jane will be selected and the probability that a girl will be selected.* b. Design a probability model (which may not be uniform) by observing frequencies in data generated from a chance process. *For example, find the approximate probability that a spinning penny will land heads up or that a tossed paper cup will land open-end down. Do the outcomes for the spinning penny appear to be equally likely based on the observed frequencies?* 7.SP.8. Find probabilities of compound events using organized lists, tables, tree diagrams, and simulation. a. Understand that, just as with simple events, the probability of a compound event is the fraction of outcomes in the sample space for which the compound event occurs. b. Represent sample spaces for compound events using methods such as organized lists, tables and tree diagrams. For an event described in everyday language (e.g., “rolling double sixes”), identify the outcomes in the sample space which compose the event.	

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	c. Design and use a simulation to generate frequencies for compound events. *For example, use random digits as a simulation tool to approximate the answer to the question: If 40% of donors have type A blood, what is the probability that it will take at least 4 donors to find one with type A blood?*	Functions 8.F **Define, evaluate, and compare functions.** 8.F.1. Understand that a function is a rule that assigns to each input (the domain) exactly one output (the range). The graph of a function is the set of ordered pairs consisting of an input and the corresponding output. For example, use the vertical line test to determine functions and non-functions. 8.F.2. Compare properties of two functions, each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions). *For example, given a linear function represented by a table of values and a linear function represented by an algebraic expression, determine which function has the greater rate of change.* 8.F.3. Interpret the equation $y = mx + b$ as defining a linear function, whose graph is a straight line; give examples of functions that are not linear. *For example, the function* $A = s^2$ *giving the area of a square as a function of its side length is not linear because its graph contains the points (1,1), (2,4) and (3,9), which are not on a straight line.*

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		Use functions to model relationships between quantities. 8.F.4. Construct a function to model a linear relationship between two quantities. Determine the rate of change and initial value of the function from a description of a relationship or from two (x, y) values, including reading these from a table or from a graph. Interpret the rate of change and initial value of a linear function in terms of the situation it models, and in terms of its graph or a table of values. 8.F.5. Given a verbal description between two quantities, sketch a graph. Conversely, given a graph, describe a possible real-world example. *For example, graph the position of an accelerating car or tossing a ball in the air.*

High School Mathematical Content Standards

Courses and Transitions

The high school standards specify the mathematics that all students should study in order to be career and college ready. They are organized into conceptual categories, which are intended to portray a coherent view of high school mathematics. A student's work with any set of standards crosses a number of traditional course boundaries. For example, the Functions Standards would apply to different courses such as Algebra I or Algebra II.

These standards do not mandate the sequence of high school courses. However, the organization of high school courses is a critical component to implementation of the standards. It is a district decision how to design course offerings covering the mathematics standards. Districts can use the traditional approach of Algebra I, Geometry, and Algebra II or implement an integrated approach. There are various high school math pathways to be considered and likely additional model pathways based on these standards will become available as well.

The standards themselves do not dictate curriculum, pedagogy, or delivery of content. In particular, districts may handle the transition to high school in different ways. For example, many students in the U.S. today take Algebra I in the 8th grade, and in some districts and states this is a requirement. By completing grade 7 standards successfully, students have met the prerequisites and are prepared for Algebra I by 8th grade. The standards are designed to permit districts and states to continue existing policies concerning Algebra I in 8th grade.

Another major transition is the transition from high school to post-secondary education for college and careers. The evidence concerning college and career readiness shows clearly that the knowledge, skills, and practices important for readiness include a great deal of mathematics prior to the boundary defined by (+) symbols in these standards. Indeed, some of the highest priority content for college and career readiness comes from grades 6-8. This body of material includes powerfully useful proficiencies such as applying ratio reasoning in real-world and mathematical problems, computing fluently with positive and negative fractions and decimals, and solving real-world and mathematical problems involving angle measure, area, surface area, and volume. Because important standards for college and career readiness are distributed across grades and courses, systems for evaluating college and career readiness should reach as far back in the standards as grades 6-8.

Narrative of Standards – Modeling

Modeling links classroom mathematics and statistics to everyday life, work, and decision-making. Modeling is the process of choosing and using appropriate mathematics and statistics to analyze empirical situations, to understand them better, and to improve decisions. Quantities and their relationships in physical, economic, public policy, social, and everyday situations can be modeled using mathematical and statistical methods. When making mathematical models, technology is valuable for varying assumptions, exploring consequences, and comparing predictions with data.

A model can be very simple, such as writing total cost as a product of unit price and number bought, or using a geometric shape to describe a physical object like a coin. Even such simple models involve making choices. It is up to us whether to model a coin as a three-dimensional cylinder, or whether a two-dimensional disk works well enough for our purposes. Other situations—modeling a delivery route, a production schedule, or a comparison of loan amortizations—need more elaborate models that use other tools from the mathematical sciences. Real-world situations are not organized and labeled for analysis; formulating tractable models, representing such models, and analyzing them is appropriately a creative process. Like every such process, this depends on acquired expertise as well as creativity.

Some examples of such situations might include:

- Estimating how much water and food is needed for emergency relief in a devastated city of 3 million people, and how it might be distributed.
- Planning a table tennis tournament for 7 players at a club with 4 tables, where each player plays against each other player.
- Designing the layout of the stalls in a school fair so as to raise as much money as possible.
- Analyzing stopping distance for a car.
- Modeling savings account balance, bacterial colony growth, or investment growth.
- Engaging in critical path analysis, e.g., applied to turnaround of an aircraft at an airport.
- Analyzing risk in situations such as extreme sports, pandemics, and terrorism.
- Relating population statistics to individual predictions.

In situations like these, the models devised depend on a number of factors: How precise an answer do we want or need? What aspects of the situation do we most need to understand, control, or optimize? What resources of time and tools do we have? The range of models that we can create and analyze is also constrained by the limitations of our mathematical, statistical, and technical skills, and our ability to recognize significant variables and relationships among them. Diagrams of various kinds, spreadsheets and other technology, and algebra are powerful tools for understanding and solving problems drawn from different types of real-world situations.

One of the insights provided by mathematical modeling is that essentially the same mathematical or statistical structure can sometimes model seemingly different situations. Models can also shed light on the mathematical structures themselves, for example, as when a model of bacterial growth makes more vivid the explosive growth of the exponential function.

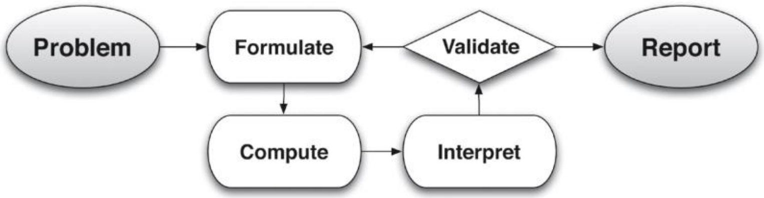
The basic modeling cycle is summarized in the diagram below. It involves (1) identifying variables in the situation and selecting those that represent essential features, (2) formulating a model by creating and selecting geometric, graphical, tabular, algebraic, or statistical representations that describe relationships between the variables, (3) analyzing and performing operations on these relationships to draw conclusions, (4) interpreting the results of the mathematics in terms of the original situation, (5) validating the conclusions by comparing them with the situation, and then either improving the model or, if it is acceptable, (6) reporting on the conclusions and the reasoning behind them. Choices, assumptions, and approximations are present throughout this cycle.

In descriptive modeling, a model simply describes the phenomena or summarizes them in a compact form. Graphs of observations are a familiar descriptive model— for example, graphs of global temperature and atmospheric CO2 over time.

Analytic modeling seeks to explain data on the basis of deeper theoretical ideas, albeit with parameters that are empirically based; for example, exponential growth of bacterial colonies (until cut-off mechanisms such as pollution or starvation intervene) follows from a constant reproduction rate. Functions are an important tool for analyzing such problems.

Graphing utilities, spreadsheets, computer algebra systems, and dynamic geometry software are powerful tools that can be used to model purely mathematical phenomena (e.g., the behavior of polynomials) as well as physical phenomena.

Modeling Standards. Modeling is best interpreted not as a collection of isolated topics but rather in relation to other standards. Making mathematical models is a Standard for Mathematical Practice, and specific modeling standards appear throughout the high school standards indicated by an asterisk (*).



Numbers and Number Systems. During the years from kindergarten to 8th grade, students must repeatedly extend their conception of number. At first, "number" means "counting number": 1, 2, 3... . Soon after that, 0 is used to represent "none" and the whole numbers are formed by the counting numbers together with zero. The next extension is fractions. At first, fractions are barely numbers and tied strongly to pictorial representations. Yet by the time students understand division of fractions, they have a strong concept of fractions as numbers and have connected them, via their decimal representations, with the base-ten system used to represent the whole numbers. During middle school, fractions are augmented by negative fractions to form the rational numbers. In Grade 8, students extend this system once more, augmenting the rational numbers with the irrational numbers to form the real numbers. In high school, students will be exposed to yet another extension of number, when the real numbers are augmented by the imaginary numbers to form the complex numbers.

With each extension of number, the meanings of addition, subtraction, multiplication, and division are extended. In each new number system—integers, rational numbers, real numbers, and complex numbers—the four operations stay the same in two important ways: They have the commutative, associative, and distributive properties and their new meanings are consistent with their previous meanings.

Extending the properties of whole-number exponents leads to new and productive notation. For example, properties of whole-number exponents suggest that $(5^{1/3})^3$ should be $5^{(1/3)3} = 5^1 = 5$ and that $5^{1/3}$ should be the cube root of 5.

Calculators, spreadsheets, and computer algebra systems can provide ways for students to become better acquainted with these new number systems and their notation. They can be used to generate data for numerical experiments, to help understand the workings of matrix, vector, and complex number algebra, and to experiment with non-integer exponents.

Quantities. In real-world problems, the answers are usually not numbers but quantities: numbers with units, which involves measurement. In their work in measurement up through grade 8, students primarily measure commonly used attributes such as length, area, and volume. In high school, students encounter a wider variety of units in modeling, e.g., acceleration, currency conversions, derived quantities such as person-hours and heating degree days, social science rates such as per-capita income, and rates in everyday life such as points scored per game or batting averages. They also encounter novel situations in which they themselves must conceive the attributes of interest. For example, to find a good measure of overall highway safety, they might propose measures such as fatalities per year, fatalities per year per driver, or fatalities per vehicle-mile traveled. Such a conceptual process is sometimes called quantification. Quantification is important for science, as when surface area suddenly "stands out" as an important variable in evaporation. Quantification is also important for companies, which must conceptualize relevant attributes and create or choose suitable measures for them.

Number and Quantity Standards

The Real Number System	**N – RN**

Extend the properties of exponents to rational exponents.

N-RN.1. Explain how the definition of the meaning of rational exponents follows from extending the properties of integer exponents to those values, allowing for a notation for radicals in terms of rational exponents. *For example, we define $5^{1/3}$ to be the cube root of 5 because we want $(5^{1/3})^3 = 5^{(1/3)3}$ to hold, so $(5^{1/3})^3$ must equal 5.*

N-RN.2. Rewrite expressions involving radicals and rational exponents using the properties of exponents. *For example: Write equivalent representations that utilize both positive and negative exponents.*

Use properties of rational and irrational numbers.

N-RN.3. Explain why the sum or product of two rational numbers is rational; that the sum of a rational number and an irrational number is irrational; and that the product of a nonzero rational number and an irrational number is irrational.

Quantities*	**N – Q**

Reason quantitatively and use units to solve problems.

N-Q.1. Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

N-Q.2. Define appropriate quantities for the purpose of descriptive modeling.

N-Q.3. Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

The Complex Number System	**N - CN**

Perform arithmetic operations with complex numbers.

N-CN.1. Know there is a complex number i such that $i^2 = -1$, and every complex number has the form $a + bi$ with a and b real.

N-CN.2. Use the relation $i^2 = -1$ and the commutative, associative, and distributive properties to add, subtract, and multiply complex numbers.

N-CN.3. (+) Find the conjugate of a complex number; use conjugates to find moduli and quotients of complex numbers.

Represent complex numbers and their operations on the complex plane.

N-CN.4. (+) Represent complex numbers on the complex plane in rectangular and polar form (including real and imaginary numbers), and explain why the rectangular and polar forms of a given complex number represent the same number.

N-CN.5. (+) Represent addition, subtraction, multiplication, and conjugation of complex numbers geometrically on the complex plane; use properties of this representation for computation. *For example,* $(1 - \sqrt{3}i)^3 = 8$ *because* $(1 - \sqrt{3}i)$ *has modulus 2 and argument 120°.*

N-CN.6. (+) Calculate the distance between numbers in the complex plane as the modulus of the difference, and the midpoint of a segment as the average of the numbers at its endpoints.

Use complex numbers in polynomial identities and equations.

N-CN.7. Solve quadratic equations with real coefficients that have complex solutions.

N-CN.8. (+) Extend polynomial identities to the complex numbers. *For example, rewrite* $x^2 + 4$ *as* $(x + 2i)(x - 2i)$.

N-CN.9. (+) Know the Fundamental Theorem of Algebra; show that it is true for quadratic polynomials.

Vector and Matrix Quantities — N – VM

Represent and model with vector quantities.

N-VM.1. (+) Recognize vector quantities as having both magnitude and direction. Represent vector quantities by directed line segments, and use appropriate symbols for vectors and their magnitudes (e.g., ***v***, |***v***|, ||***v***||, ***v***).

N-VM.2. (+) Find the components of a vector by subtracting the coordinates of an initial point from the coordinates of a terminal point.

N-VM.3. (+) Solve problems involving velocity and other quantities that can be represented by vectors.

Perform operations on vectors.

N-VM.4. (+) Add and subtract vectors.

a. Add vectors end-to-end, component-wise, and by the parallelogram rule. Understand that the magnitude of a sum of two vectors is typically not the sum of the magnitudes.

b. Given two vectors in magnitude and direction form, determine the magnitude and direction of their sum.

c. Understand vector subtraction $\boldsymbol{v} - \boldsymbol{w}$ as $\boldsymbol{v} + (-\boldsymbol{w})$, where $-\boldsymbol{w}$ is the additive inverse of $\boldsymbol{w}$, with the same magnitude as $\boldsymbol{w}$ and pointing in the opposite direction. Represent vector subtraction graphically by connecting the tips in the appropriate order, and perform vector subtraction component-wise.

N-VM.5. (+) Multiply a vector by a scalar.

a. Represent scalar multiplication graphically by scaling vectors and possibly reversing their direction; perform scalar multiplication component-wise, e.g., as $c(v_x, v_y) = (cv_x, cv_y)$.

b. Compute the magnitude of a scalar multiple $c\boldsymbol{v}$ using $||c\boldsymbol{v}|| = |c|\boldsymbol{v}$. Compute the direction of $c\boldsymbol{v}$ knowing that when $|c|\boldsymbol{v} \neq 0$, the direction of $c\boldsymbol{v}$ is either along $\boldsymbol{v}$ (for $c > 0$) or against $\boldsymbol{v}$ (for $c < 0$).

Perform operations on matrices and use matrices in applications.

N-VM.6. (+) Use matrices to represent and manipulate data, e.g., to represent payoffs or incidence relationships in a network.

N-VM.7. (+) Multiply matrices by scalars to produce new matrices, e.g., as when all of the payoffs in a game are doubled.

N-VM.8. (+) Add, subtract, and multiply matrices of appropriate dimensions.

N-VM.9. (+) Understand that, unlike multiplication of numbers, matrix multiplication for square matrices is not a commutative operation, but still satisfies the associative and distributive properties.

N-VM.10. (+) Understand that the zero and identity matrices play a role in matrix addition and multiplication similar to the role of 0 and 1 in the real numbers. The determinant of a square matrix is nonzero if and only if the matrix has a multiplicative inverse.

N-VM.11. (+) Multiply a vector (regarded as a matrix with one column) by a matrix of suitable dimensions to produce another vector. Work with matrices as transformations of vectors.

N-VM.12. (+) Work with 2 × 2 matrices as a transformations of the plane, and interpret the absolute value of the determinant in terms of area.

Narrative of Standards - Algebra

Expressions. An expression is a record of a computation with numbers, symbols that represent numbers, arithmetic operations, exponentiation, and, at more advanced levels, the operation of evaluating a function. Conventions about the use of parentheses and the order of operations assure that each expression is unambiguous. Creating an expression that describes a computation involving a general quantity requires the ability to express the computation in general terms, abstracting from specific instances.

Reading an expression with comprehension involves analysis of its underlying structure. This may suggest a different but equivalent way of writing the expression that exhibits some different aspect of its meaning. For example, $p + 0.05p$ can be interpreted as the addition of a 5% tax to a price p. Rewriting $p + 0.05p$ as $1.05p$ shows that adding a tax is the same as multiplying the price by a constant factor.

Algebraic manipulations are governed by the properties of operations and exponents, and the conventions of algebraic notation. At times, an expression is the result of applying operations to simpler expressions. For example, $p + 0.05p$ is the sum of the simpler expressions p and $0.05p$. Viewing an expression as the result of operation on simpler expressions can sometimes clarify its underlying structure.

A spreadsheet or a computer algebra system (CAS) can be used to experiment with algebraic expressions, perform complicated algebraic manipulations, and understand how algebraic manipulations behave.

Equations and Inequalities. An equation is a statement of equality between two expressions, often viewed as a question asking for which values of the variables the expressions on either side are in fact equal. These values are the solutions to the equation. An identity, in contrast, is true for all values of the variables; identities are often developed by rewriting an expression in an equivalent form.

The solutions of an equation in one variable form a set of numbers; the solutions of an equation in two variables form a set of ordered pairs of numbers, which can be plotted in the coordinate plane. Two or more equations and/or inequalities form a system. A solution for such a system must satisfy every equation and inequality in the system.

An equation can often be solved by successively deducing from it one or more simpler equations. For example, one can add the same constant to both sides without changing the solutions, but squaring both sides might lead to extraneous solutions. Strategic competence in solving includes looking ahead for productive manipulations and anticipating the nature and number of solutions.

Some equations have no solutions in a given number system, but have a solution in a larger system. For example, the solution of $x + 1 = 0$ is an integer, not a whole number; the solution of $2x + 1 = 0$ is a rational number, not an integer; the solutions of $x^2 - 2 = 0$ are real numbers, not rational numbers; and the solutions of $x^2 + 2 = 0$ are complex numbers, not real numbers.

The same solution techniques used to solve equations can be used to rearrange formulas. For example, the formula for the area of a trapezoid, $A = ((b_1+b_2)/2)h$, can be solved for h using the same deductive process.

Inequalities can be solved by reasoning about the properties of inequality. Many, but not all, of the properties of equality continue to hold for inequalities and can be useful in solving them.

Connections to Functions and Modeling. Expressions can define functions, and equivalent expressions define the same function. Asking when two functions have the same value for the same input leads to an equation; graphing the two functions allows for finding approximate solutions of the equation. Converting a verbal description to an equation, inequality, or system of these is an essential skill in modeling.

Algebra Standards

Seeing Structure in Expressions	**A - SSE**

Interpret the structure of expressions.

A-SSE.1. Interpret expressions that represent a quantity in terms of its context.*

a. Interpret parts of an expression, such as terms, factors, and coefficients.

b. Interpret complicated expressions by viewing one or more of their parts as a single entity. *For example, interpret* $P(1+r)^n$ *as the product of P and a factor not depending on P.*

A-SSE.2. Use the structure of an expression to identify ways to rewrite it. *For example, see* $x^4 - y^4$ *as* $(x^2)^2 - (y^2)^2$, *thus recognizing it as a difference of squares that can be factored as* $(x^2 - y^2)(x^2 + y^2)$.

Write expressions in equivalent forms to solve problems.

A-SSE.3. Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression.*

a. Factor a quadratic expression to reveal the zeros of the function it defines. *For example,* $x^2 + 4x +3 = (x +3)(x +1)$.

b. Complete the square in a quadratic expression to reveal the maximum or minimum value of the function it defines. *For example,* $x^2 + 4x + 3 = (x + 2)^2 - 1$.

c. Use the properties of exponents to transform expressions for exponential functions. *For example the expression* 1.15^t *can be rewritten as* $(1.15^{1/12})^{12t} \approx 1.012^{12t}$ *to reveal the approximate equivalent monthly interest rate if the annual rate is 15%.*

A-SSE.4. Derive the formula for the sum of a finite geometric series (when the common ratio is not 1), and use the formula to solve problems. *For example, calculate mortgage payments.**

Arithmetic with Polynomials and Rational Expressions — A - APR

Perform arithmetic operations on polynomials.

A-APR.1. Add, subtract, and multiply polynomials. Understand that polynomials form a system similar to the integers, namely, they are closed under the operations of addition, subtraction, and multiplication.

Understand the relationship between zeros and factors of polynomials.

A-APR.2. Know and apply the Remainder Theorem: For a polynomial $p(x)$ and a number a, the remainder on division by $x - a$ is $p(a)$, so $p(a) = 0$ if and only if $(x - a)$ is a factor of $p(x)$.

A-APR.3. Identify zeros of polynomials when suitable factorizations are available, and use the zeros to construct a rough graph of the function defined by the polynomial.

Use polynomial identities to solve problems.

A-APR.4. Prove polynomial identities and use them to describe numerical relationships. *For example, the polynomial identity* $(x^2 + y^2)^2 = (x^2 - y^2)^2 + (2xy)^2$ *can be used to generate Pythagorean triples.*

A-APR.5. (+) Know and apply the Binomial Theorem for the expansion of $(x + y)^n$ in powers of x and y for a positive integer n, where x and y are any numbers, with coefficients determined for example by Pascal's Triangle.

Rewrite rational expressions.

A-APR.6. Rewrite simple rational expressions in different forms; write $a(x)/b(x)$ in the form $q(x) + r(x)/b(x)$, where $a(x)$, $b(x)$, $q(x)$, and $r(x)$ are polynomials with the degree of $r(x)$ less than the degree of $b(x)$, using inspection, long division, or, for the more complicated examples, a computer algebra system.

A-APR.7. (+) Add, subtract, multiply, and divide rational expressions. Understand that rational expressions form a system similar to the rational numbers, closed under addition, subtraction, multiplication, and division by a nonzero rational expression.

Creating Equations and Inequalities* A – CED

Create equations and inequalities that describe numbers or relationships.

A-CED.1. Create equations and inequalities in one variable and use them to solve problems. *Include equations arising from linear and quadratic functions, and simple rational and exponential functions.*

A-CED.2. Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.

A-CED.3. Represent constraints by equations or inequalities, and by systems of equations and/or inequalities, and interpret solutions as viable or nonviable options in a modeling context. *For example, represent inequalities describing cost constraints in various situations.*

A-CED.4. Rearrange formulas (literal equations) to highlight a quantity of interest, using the same reasoning as in solving equations. *For example, rearrange Ohm's law V = IR to highlight resistance R.*

Reasoning with Equations and Inequalities A – REI

Understand solving equations as a process of reasoning and explain the reasoning.

A-REI.1. Apply properties of mathematics to justify steps in solving equations in one variable.

A-REI.2. Solve simple rational and radical equations in one variable, and give examples showing how extraneous solutions may arise.

Solve equations and inequalities in one variable.

A-REI.3. Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters.

A-REI.4. Solve quadratic equations in one variable.

a. Use the method of completing the square to transform any quadratic equation in x into an equation of the form $(x – p)^2 = q$ that has the same solutions. Derive the quadratic formula from this form.

b. Solve quadratic equations by inspection (e.g., for $x^2 = 49$), taking square roots, completing the square, the quadratic formula and factoring, as appropriate to the initial form of the equation. Recognize when the quadratic formula gives complex solutions and write them as $a \pm bi$ for real numbers a and b.

Solve systems of equations.

A-REI.5. Show that, given a system of two equations in two variables, replacing one equation by the sum of that equation and a multiple of the other produces a system with the same solutions.

A-REI.6. Solve systems of linear equations exactly and approximately, e.g., with graphs or algebraically, focusing on pairs of linear equations in two variables.

A-REI.7. Solve a simple system consisting of a linear equation and a quadratic equation in two variables algebraically and graphically. *For example, find the points of intersection between the line* $y = -3x$ and the circle $x^2 + y^2 = 3$.

A-REI.8. (+) Represent a system of linear equations as a single matrix equation in a vector variable.

A-REI.9. (+) Find the inverse of a matrix if it exists and use it to solve systems of linear equations (using technology for matrices of dimension 3×3 or greater).

Represent and solve equations and inequalities graphically.

A-REI.10. Understand that the graph of an equation in two variables is the set of all its solutions plotted in the coordinate plane, often forming a curve (which could be a line).

A-REI.11. Explain why the x-coordinates of the points where the graphs of the equations $y = f(x)$ and $y = g(x)$ intersect are the solutions of the equation $f(x) = g(x)$; find the solutions approximately, e.g., using technology to graph the functions, make tables of values, or find successive approximations. Include cases where $f(x)$ and/or $g(x)$ are linear, polynomial, rational, absolute value, exponential, and logarithmic functions.*

A-REI.12. Graph the solutions to a linear inequality in two variables as a half-plane (excluding the boundary in the case of a strict inequality), and graph the solution set to a system of linear inequalities in two variables as the intersection of the corresponding half-planes.

Narrative of Standards - Functions

Functions. describe situations where one quantity determines another. For example, the return on $10,000 invested at an annualized percentage rate of 4.25% is a function of the length of time the money is invested. Because we continually make theories about dependencies between quantities in nature and society, functions are important tools in the construction of mathematical models.

In school mathematics, functions usually have numerical inputs and outputs and are often defined by an algebraic expression. For example, the time in hours it takes for a car to drive 100 miles is a function of the car's speed in miles per hour, v; the rule $T(v) = 100/v$ expresses this relationship algebraically and defines a function whose name is T.

The set of inputs to a function is called its domain. We often infer the domain to be all inputs for which the expression defining a function has a value, or for which the function makes sense in a given context.

A function can be described in various ways, such as by a graph (e.g., the trace of a seismograph); by a verbal rule, as in, "I'll give you a state, you give me the capital city;" by an algebraic expression like $f(x) = a + bx$; or by a recursive rule. The graph of a function is often a useful way of visualizing the relationship of the function models, and manipulating a mathematical expression for a function can throw light on the function's properties.

Functions presented as expressions can model many important phenomena. Two important families of functions characterized by laws of growth are linear functions, which grow at a constant rate, and exponential functions, which grow at a constant percent rate. Linear functions with a constant term of zero describe proportional relationships.

A graphing utility or a computer algebra system can be used to experiment with properties of these functions and their graphs and to build computational models of functions, including recursively defined functions.

Connections to Expressions, Equations, Modeling, and Coordinates. Determining an output value for a particular input involves evaluating an expression; finding inputs that yield a given output involves solving an equation. Questions about when two functions have the same value for the same input lead to equations, whose solutions can be visualized from the intersection of their graphs. Because functions describe relationships between quantities, they are frequently used in modeling. Sometimes functions are defined by a recursive process, which can be displayed effectively using a spreadsheet or other technology.

Functions Standards

Interpreting Functions	F - IF

Understand the concept of a function and use function notation.

F-IF.1. Understand that a function from one set (called the domain) to another set (called the range) assigns to each element of the domain exactly one element of the range. If f is a function and x is an element of its domain, then $f(x)$ denotes the output of f corresponding to the input x. The graph of f is the graph of the equation $y = f(x)$.

F-IF.2. Use function notation, evaluate functions for inputs in their domains, and interpret statements that use function notation in terms of a context.

F-IF.3. Recognize that sequences are functions, sometimes defined recursively, whose domain is a subset of the integers. *For example, the Fibonacci sequence is defined recursively by* $f(0) = f(1) = 1$, $f(n + 1) = f(n) + f(n - 1)$ *for* $n \geq 1$.

Interpret functions that arise in applications in terms of the context.

F-IF.4. For a function that models a relationship between two quantities,

- interpret key features of graphs and tables in terms of the quantities, and
- sketch graphs showing key features given a verbal description of the relationship.

*Key features include: intercepts; intervals where the function is increasing, decreasing, positive, or negative; relative maximums and minimums; symmetries; end behavior; and periodicity.**

F-IF.5. Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. *For example, if the function h(n) gives the number of person-hours it takes to assemble n engines in a factory, then negative numbers would be an inappropriate domain for the function.**

F-IF.6. Calculate and interpret the average rate of change of a function (presented symbolically or as a table) over a specified interval. Estimate the rate of change from a graph.*

Analyze functions using different representations.

F-IF.7. Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases.*

a. Graph linear and quadratic functions and show intercepts, maxima, and minima.

b. Graph square root, cube root, and piecewise-defined functions, including step functions and absolute value functions.

c. Graph polynomial functions, identifying zeros (using technology) or algebraic methods when suitable factorizations are available, and showing end behavior.

d. (+) Graph rational functions, identifying zeros and discontinuities (asymptotes/holes) using technology, and algebraic methods when suitable factorizations are available, and showing end behavior.

e. Graph exponential and logarithmic functions, showing intercepts and end behavior, and trigonometric functions, showing period, midline, and amplitude.

F-IF.8. Write a function defined by an expression in different but equivalent forms to reveal and explain different properties of the function.

a. Use the process of factoring and completing the square in a quadratic function to show zeros, extreme values, and symmetry of the graph, and interpret these in terms of a context.

b. Use the properties of exponents to interpret expressions for exponential functions. *For example, identify percent rate of change in functions such as* $y = (1.02)^t$, $y = (0.97)^t$, $y = (1.01)^{12t}$, $y = (1.2)^{t/10}$, *and classify them as representing exponential growth or decay.*

F-IF.9. Compare properties of two functions each represented in a different way (algebraically, graphically, numerically, in tables, or by verbal descriptions). *For example, given a graph of one quadratic function and an algebraic expression for another, say which has the larger maximum.*

Building Functions F - BF

Build a function that models a relationship between two quantities.

F-BF.1. Write a function that describes a relationship between two quantities.*

a. Determine an explicit expression, a recursive process, or steps for calculation from a context.

b. Combine standard function types using arithmetic operations. *For example, build a function that models the temperature of a cooling body by adding a constant function to a decaying exponential, and relate these functions to the model.*

c. (+) Compose functions. *For example, if T(y) is the temperature in the atmosphere as a function of height, and h(t) is the height of a weather balloon as a function of time, then T(h(t)) is the temperature at the location of the weather balloon as a function of time.*

F-BF.2. Write arithmetic and geometric sequences both recursively and with an explicit formula, use them to model situations, and translate between the two forms.*

Build new functions from existing functions.

F-BF.3. Identify the effect on the graph of replacing $f(x)$ by $f(x) + k$, $k\,f(x)$, $f(kx)$, and $f(x + k)$ for specific values of k (both positive and negative); find the value of k given the graphs. *Experiment with cases and illustrate an explanation of the effects on the graph using technology. Include recognizing even and odd functions from their graphs and algebraic expressions for them.*

F-BF.4. Find inverse functions.

a. Solve an equation of the form $f(x) = c$ for a simple function f that has an inverse and write an expression for the inverse. *For example, $f(x) = 2x^3$ for $x > 0$ or $f(x) = (x + 1)/(x – 1)$ for $x \neq 1$.*

b. (+) Verify by composition that one function is the inverse of another.

c. (+) Read values of an inverse function from a graph or a table, given that the function has an inverse.

d. (+) Produce an invertible function from a non-invertible function by restricting the domain.

F-BF.5. (+) Understand the inverse relationship between exponents and logarithms and use this relationship to solve problems involving logarithms and exponents.

Linear, Quadratic, and Exponential Models*	**F – LE**

Construct and compare linear, quadratic, and exponential models and solve problems.

F-LE.1. Distinguish between situations that can be modeled with linear functions and with exponential functions.

a. Show that linear functions grow by equal differences over equal intervals, and that exponential functions grow by equal factors over equal intervals.
b. Recognize situations in which one quantity changes at a constant rate per unit interval relative to another.
c. Recognize situations in which a quantity grows or decays by a constant percent rate per unit interval relative to another.

F-LE.2. Construct linear and exponential functions, including arithmetic and geometric sequences, given a graph, a description of a relationship, or input-output table of values.

F-LE.3. Observe using graphs and tables that a quantity increasing exponentially eventually exceeds a quantity increasing linearly, quadratically, or (more generally) as a polynomial function.

F-LE.4. For exponential models, express as a logarithm the solution to $ab^{ct} = d$ where a, c, and d are numbers and the base b is 2, 10, or e; evaluate the logarithm using technology.

Interpret expressions for functions in terms of the situation they model.

F-LE.5. Interpret the parameters in a linear or exponential function in terms of a context.

Trigonometric Functions — F - TF

Extend the domain of trigonometric functions using the unit circle.

F-TF.1. Understand radian measure of an angle as the length of the arc on the unit circle subtended by the angle.

F-TF.2. Explain how the unit circle in the coordinate plane enables the extension of trigonometric functions to all real numbers, interpreted as radian measures of angles traversed counterclockwise around the unit circle.

F-TF.3. (+) Use special triangles to determine geometrically the values of sine, cosine, tangent for $\pi/3$, $\pi/4$ and $\pi/6$, and use the unit circle to express the values of sine, cosines, and tangent for $\pi - x$, $\pi + x$, and $2\pi - x$ in terms of their values for x, where x is any real number.

F-TF.4. (+) Use the unit circle to explain symmetry (odd and even) and periodicity of trigonometric functions.

Model periodic phenomena with trigonometric functions.

F-TF.5. Choose trigonometric functions to model periodic phenomena with specified amplitude, frequency, and midline.*

F-TF.6. (+) Understand that restricting a trigonometric function to a domain on which it is always increasing or always decreasing allows its inverse to be constructed.

F-TF.7. (+) Use inverse functions to solve trigonometric equations that arise in modeling contexts; evaluate the solutions using technology, and interpret them in terms of the context.*

Prove and apply trigonometric identities.

F-TF.8. Prove the Pythagorean identity $\sin^2(\theta) + \cos^2(\theta) = 1$ and use it to calculate trigonometric ratios.

F-TF.9. (+) Prove the addition and subtraction formulas for sine, cosine, and tangent and use them to solve problems.

Narrative of Standards - Geometry

An understanding of the attributes and relationships of geometric objects can be applied in diverse contexts—interpreting a schematic drawing, estimating the amount of wood needed to frame a sloping roof, rendering computer graphics, or designing a sewing pattern for the most efficient use of material.

Although there are many types of geometry, school mathematics is devoted primarily to plane Euclidean geometry, studied both synthetically (without coordinates) and analytically (with coordinates). Euclidean geometry is characterized most importantly by the Parallel Postulate, that through a point not on a given line there is exactly one parallel line. (Spherical geometry, in contrast, has no parallel lines.)

During high school, students begin to formalize their geometry experiences from elementary and middle school, using more precise definitions and developing careful proofs. Later in college some students develop Euclidean and other geometries carefully from a small set of axioms.

The concepts of congruence, similarity, and symmetry can be understood from the perspective of geometric transformation. Fundamental are the rigid motions: translations, rotations, reflections, and combinations of these, all of which are here assumed to preserve distance and angles (and therefore shapes generally). Reflections and rotations each explain a particular type of symmetry, and the symmetries of an object offer insight into its attributes—as when the reflective symmetry of an isosceles triangle assures that its base angles are congruent.

In the approach taken here, two geometric figures are defined to be congruent if there is a sequence of rigid motions that carries one onto the other. This is the principle of superposition. For triangles, congruence means the equality of all corresponding pairs of sides and all corresponding pairs of angles. During the middle grades, through experiences drawing triangles from given conditions, students notice ways to specify enough measures in a triangle to ensure that all triangles drawn with those measures are congruent. Once these triangle congruence criteria (ASA, SAS, and SSS) are established using rigid motions, they can be used to prove theorems about triangles, quadrilaterals, and other geometric figures.

Similarity transformations (rigid motions followed by dilations) define similarity in the same way that rigid motions define congruence, thereby formalizing the similarity ideas of "same shape" and "scale factor" developed in the middle grades. These transformations lead to the criterion for triangle similarity that two pairs of corresponding angles are congruent.

The definitions of sine, cosine, and tangent for acute angles are founded on right triangles and similarity, and, with the Pythagorean Theorem, are fundamental in many real-world and theoretical situations. The Pythagorean Theorem is generalized to nonright triangles by the Law of Cosines. Together, the Laws of Sines and Cosines embody the triangle congruence criteria for the cases where three pieces of information suffice to completely solve a triangle. Furthermore, these laws yield two possible solutions in the ambiguous case, illustrating that Side-Side-Angle is not a congruence criterion.

Analytic geometry connects algebra and geometry, resulting in powerful methods of analysis and problem solving. Just as the number line associates numbers with locations in one dimension, a pair of perpendicular axes associates pairs of numbers with locations in two dimensions. This correspondence between numerical coordinates and geometric points allows methods from algebra to be applied to geometry and vice versa. The solution set of an equation becomes a geometric curve, making visualization a tool for doing and understanding algebra. Geometric shapes can be described by equations, making algebraic manipulation into a tool for geometric understanding, modeling, and proof. Geometric transformations of the graphs of equations correspond to algebraic changes in their equations.

Dynamic geometry environments provide students with experimental and modeling tools that allow them to investigate geometric phenomena in much the same way as computer algebra systems allow them to experiment with algebraic phenomena.

Connections to Equations. The correspondence between numerical coordinates and geometric points allows methods from algebra to be applied to geometry and vice versa. The solution set of an equation becomes a geometric curve, making visualization a tool for doing and understanding algebra. Geometric shapes can be described by equations, making algebraic manipulation into a tool for geometric understanding, modeling, and proof.

Geometry Standards

Congruence	**G - CO**

Experiment with transformations in the plane.

G-CO.1. Demonstrates understanding of key geometrical definitions, including angle, circle, perpendicular line, parallel line, line segment, and transformations in Euclidian geometry. Understand undefined notions of point, line, distance along a line, and distance around a circular arc.

G-CO.2. Represent transformations in the plane using, e.g., transparencies and geometry software; describe transformations as functions that take points in the plane as inputs and give other points as outputs. Compare transformations that preserve distance and angle to those that do not (e.g., translation versus horizontal stretch).

G-CO.3. Given a rectangle, parallelogram, trapezoid, or regular polygon, describe the rotations and reflections that carry it onto itself.

G-CO.4. Develop definitions of rotations, reflections, and translations in terms of angles, circles, perpendicular lines, parallel lines, and line segments.

G-CO.5. Given a geometric figure and a rotation, reflection, or translation, draw the transformed figure using, e.g., graph paper, tracing paper, or geometry software. Specify a sequence of transformations that will carry a given figure onto another.

Understand congruence in terms of rigid motions.

G-CO.6. Use geometric descriptions of rigid motions to transform figures and to predict the effect of a given rigid motion on a given figure; given two figures, use the definition of congruence in terms of rigid motions to decide if they are congruent.

G-CO.7. Use the definition of congruence in terms of rigid motions to show that two triangles are congruent if and only if corresponding pairs of sides and corresponding pairs of angles are congruent.

G-CO.8. Explain how the criteria for triangle congruence (ASA, SAS, SSS, AAS, and HL) follow from the definition of congruence in terms of rigid motions.

Prove geometric theorems.

G-CO.9. Using methods of proof including direct, indirect, and counter examples to prove theorems about lines and angles. Theorems include: vertical angles are congruent; when a transversal crosses parallel lines, alternate interior angles are congruent and corresponding angles are congruent; points on a perpendicular bisector of a line segment are exactly those equidistant from the segment's endpoints.

G-CO.10. Using methods of proof including direct, indirect, and counter examples to prove theorems about triangles. Theorems include: measures of interior angles of a triangle sum to 180°; base angles of isosceles triangles are congruent; the segment joining midpoints of two sides of a triangle is parallel to the third side and half the length; the medians of a triangle meet at a point.

G-CO.11. Using methods of proof including direct, indirect, and counter examples to prove theorems about parallelograms. Theorems include: opposite sides are congruent, opposite angles are congruent, the diagonals of a parallelogram bisect each other, and conversely, rectangles are parallelograms with congruent diagonals.

Make geometric constructions.

G-CO.12. Make formal geometric constructions with a variety of tools and methods (compass and straightedge, string, reflective devices, paper folding, dynamic geometric software, etc.). Copying a segment; copying an angle; bisecting a segment; bisecting an angle; constructing perpendicular lines, including the perpendicular bisector of a line segment; and constructing a line parallel to a given line through a point not on the line.

G-CO.13. Construct an equilateral triangle, a square, and a regular hexagon inscribed in a circle.

Similarity, Right Triangles, and Trigonometry	G - SRT

Understand similarity in terms of similarity transformations.

G-SRT.1. Verify experimentally the properties of dilations given by a center and a scale factor:

a. A dilation takes a line not passing through the center of the dilation to a parallel line, and leaves a line passing through the center unchanged.

b. The dilation of a line segment is longer or shorter in the ratio given by the scale factor.

G-SRT.2. Given two figures, use the definition of similarity in terms of transformations to explain whether or not they are similar.

G-SRT.3. Use the properties of similarity transformations to establish the AA criterion for two triangles to be similar.

Prove theorems involving similarity.

G-SRT.4. Prove theorems about triangles. *Theorems include: a line parallel to one side of a triangle divides the other two proportionally, and conversely.*

G-SRT.5. Apply congruence and similarity properties and prove relationships involving triangles and other geometric figures.

Define trigonometric ratios and solve problems involving right triangles.

G-SRT.6. Understand that by similarity, side ratios in right triangles are properties of the angles in the triangle, leading to definitions of trigonometric ratios for acute angles.

G-SRT.7. Explain and use the relationship between the sine and cosine of complementary angles.

G-SRT.8. Use trigonometric ratios and the Pythagorean Theorem to solve right triangles in applied problems.*

Apply trigonometry to general triangles.

G-SRT.9. (+) Derive the formula $A = 1/2\ ab\ \sin(C)$ for the area of a triangle by drawing an auxiliary line from a vertex perpendicular to the opposite side.

G-SRT.10. (+) Prove the Laws of Sines and Cosines and use them to solve problems.

G-SRT.11. (+) Understand and apply the Law of Sines and the Law of Cosines to find unknown measurements in right and non-right triangles (e.g., surveying problems, resultant forces).

Circles — G - C

Understand and apply theorems about circles.

G-C.1. Prove that all circles are similar.

G-C.2. Identify and describe relationships among inscribed angles, radii, and chords. *Include the relationship between central, inscribed, and circumscribed angles; inscribed angles on a diameter are right angles; the radius of a circle is perpendicular to the tangent where the radius intersects the circle.*

G-C.3. Construct the inscribed and circumscribed circles of a triangle, and prove properties of angles for a quadrilateral inscribed in a circle.

G-C.4. (+) Construct a tangent line from a point outside a given circle to the circle.

Find arc lengths and areas of sectors of circles.

G-C.5. Use and apply the concepts of arc length and areas of sectors of circles. Determine or derive using similarity the fact that the length of the arc intercepted by an angle is proportional to the radius, and define the radian measure of the angle as the constant of proportionality; derive the formula for the area of a sector.

Expressing Geometric Properties with Equations — G - GPE

Translate between the geometric description and the equation for a conic section.

G-GPE.1. Determine or derive the equation of a circle of given center and radius using the Pythagorean Theorem; complete the square to find the center and radius of a circle given by an equation.

G-GPE.2. Determine or derive the equation of a parabola given a focus and directrix.

G-GPE.3. (+) Derive the equations of ellipses and hyperbolas given foci and directrices.

Use coordinates to prove simple geometric theorems algebraically.

G-GPE.4. Perform simple coordinate proofs. For example, prove or disprove that a figure defined by four given points in the coordinate plane is a rectangle; prove or disprove that the point (1, $\sqrt{3}$) lies on the circle centered at the origin and containing the point (0, 2).

G-GPE.5. Prove the slope criteria for parallel and perpendicular lines and use them to solve geometric problems (e.g., find the equation of a line parallel or perpendicular to a given line that passes through a given point).

G-GPE.6. Find the point on a directed line segment between two given points that partitions the segment in a given ratio.

G-GPE.7. Use coordinates to compute perimeters of polygons and areas of triangles and rectangles, e.g., using the distance formula.*

Geometric Measurement and Dimension — G - GMD

Explain volume formulas and use them to solve problems.

G-GMD.1. Explain how to find the formulas for the circumference of a circle, area of a circle, volume of a cylinder, pyramid, and cone.

G-GMD.2. (+) Give an informal argument using Cavalieri's principle for the formulas for the volume of a sphere and other solid figures.

G-GMD.3. Use volume formulas for cylinders, pyramids, cones, and spheres to solve problems. *For example: Solve problems requiring determination of a dimension not given.**

Visualize relationships between two-dimensional and three-dimensional objects.

G-GMD.4. Identify the shapes of two-dimensional cross-sections of three-dimensional objects, and identify three-dimensional objects generated by rotations of two-dimensional objects.

Modeling with Geometry — G - MG

Apply geometric concepts in modeling situations.

G-MG.1. Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).*

G-MG.2. Apply concepts of density based on area and volume in modeling situations (e.g., persons per square mile, BTUs per cubic foot).*

G-MG.3. Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).*

Narrative of Standards - Statistics and Probability*

Decisions or predictions are often based on data—numbers in context. These decisions or predictions would be easy if the data always sent a clear message, but the message is often obscured by variability. Statistics provides tools for describing variability in data and for making informed decisions that take it into account.

Data are gathered, displayed, summarized, examined, and interpreted to discover patterns and deviations from patterns. Quantitative data can be described in terms of key characteristics: measures of shape, center, and spread. The shape of a data distribution might be described as symmetric, skewed, flat, or bell shaped, and it might be summarized by a statistic measuring center (such as mean or median) and a statistic measuring spread (such as standard deviation or interquartile range). Different distributions can be compared numerically using these statistics or compared visually using plots. Knowledge of center and spread are not enough to describe a distribution. Which statistics to compare, which plots to use, and what the results of a comparison might mean, depend on the question to be investigated and the real-life actions to be taken.

Randomization has two important uses in drawing statistical conclusions. First, collecting data from a random sample of a population makes it possible to draw valid conclusions about the whole population, taking variability into account. Second, randomly assigning individuals to different treatments allows a fair comparison of the effectiveness of those treatments. A statistically significant outcome is one that is unlikely to be due to chance alone, and this can be evaluated only under the condition of randomness. The conditions under which data are collected are important in drawing conclusions from the data; in critically reviewing uses of statistics in public media and other reports, it is important to consider the study design, how the data were gathered, and the analyses employed as well as the data summaries and the conclusions drawn.

Random processes can be described mathematically by using a probability model: a list or description of the possible outcomes (the sample space), each of which is assigned a probability. In situations such as flipping a coin, rolling a number cube, or drawing a card, it might be reasonable to assume various outcomes are equally likely. In a probability model, sample points represent outcomes and combine to make up events; probabilities of events can be computed by applying the Addition and Multiplication Rules. Interpreting these probabilities relies on an understanding of independence and conditional probability, which can be approached through the analysis of two-way tables.

Technology plays an important role in statistics and probability by making it possible to generate plots, regression functions, and correlation coefficients, and to simulate many possible outcomes in a short amount of time.

Connections to Functions and Modeling. Functions may be used to describe data; if the data suggest a linear relationship, the relationship can be modeled with a regression line, and its strength and direction can be expressed through a correlation coefficient.

Statistics and Probability Standards*

Interpreting Categorical and Quantitative Data **S - ID**

Summarize, represent, and interpret data on a single count or measurement variable.

S-ID.1. Represent data with plots on the real number line (dot plots, histograms, and box plots).

S-ID.2. Use statistics appropriate to the shape of the data distribution to compare center (median, mean) and spread (interquartile range, standard deviation) of two or more different data sets.

S-ID.3. Interpret differences in shape, center, and spread in the context of the data sets, accounting for possible effects of extreme data points (outliers). *For example: Justify why median price of homes or income is used instead of the mean.*

S-ID.4. Use the mean and standard deviation of a data set to fit it to a normal distribution and to estimate population percentages. Recognize that there are data sets for which such a procedure is not appropriate. Use calculators, spreadsheets, and tables to estimate areas under the normal curve.

Summarize, represent, and interpret data on two categorical and quantitative variables.

S-ID.5. Summarize categorical data for two categories in two-way frequency tables. Interpret relative frequencies in the context of the data (including joint, marginal, and conditional relative frequencies). Recognize possible associations and trends in the data.

S-ID.6. Represent data on two quantitative variables on a scatter plot, and describe how the variables are related.

a. Fit a function to the data; use functions fitted to data to solve problems in the context of the data. *Use given functions or choose a function suggested by the context. Emphasize linear, quadratic, and exponential models.*

b. Informally assess the fit of a function by plotting and analyzing residuals. *For example: Describe solutions to problems that require interpolation and extrapolation.*

c. Fit a linear function for a scatter plot that suggests a linear association.

Interpret linear models.

S-ID.7. Interpret the slope (rate of change) and the intercept (constant term) of a linear model in the context of the data.

S-ID.8. Compute (using technology) and interpret the correlation coefficient of a linear fit.

S-ID.9. Distinguish between correlation and causation.

Making Inferences and Justifying Conclusions — S - IC

Understand and evaluate random processes underlying statistical experiments.

S-IC.1. Understand statistics as a process for making inferences about population parameters based on a random sample from that population.

S-IC.2. Decide if a specified model is consistent with results from a given data-generating process, e.g., using simulation. *For example, a model says a spinning coin falls heads up with probability 0.5. Would a result of 5 tails in a row cause you to question the model?*

Make inferences and justify conclusions from sample surveys, experiments, and observational studies.

S-IC.3. Recognize the purposes of and differences among sample surveys, experiments, and observational studies; explain how randomization relates to each.

S-IC.4. Use data from a sample survey to estimate a population mean or proportion; develop a margin of error through the use of simulation models for random sampling.

S-IC.5. Use data from a randomized experiment to compare two treatments; use simulations to decide if differences between parameters are significant.

S-IC.6. Evaluate reports based on data.

Conditional Probability and the Rules of Probability — S - CP

Understand independence and conditional probability and use them to interpret data.

S-CP.1. Describe events as subsets of a sample space (the set of outcomes) using characteristics (or categories) of the outcomes, or as unions, intersections, or complements of other events (“or,” “and,” “not”).

S-CP.2. Understand that two events *A* and *B* are independent if the probability of *A* and *B* occurring together is the product of their probabilities, and use this characterization to determine if they are independent.

S-CP.3. Understand the conditional probability of *A* given *B* as *P*(*A* and *B*)/*P*(*B*), and interpret independence of *A* and *B* as saying that the conditional probability of *A* given *B* is the same as the probability of *A*, and the conditional probability of *B* given *A* is the same as the probability of *B*.

S-CP.4. Construct and interpret two-way frequency tables of data when two categories are associated with each object being classified. Use the two-way table as a sample space to decide if events are independent and to approximate conditional probabilities. *For example, collect data from a random sample of students in your school on their favorite subject among math, science, and English. Estimate the probability that a randomly selected student from your school will favor science given that the student is in 10th grade. Do the same for other subjects and compare the results.*

S-CP.5. Recognize and explain the concepts of conditional probability and independence in everyday language and everyday situations. *For example, compare the chance of having lung cancer if you are a smoker with the chance of being a smoker if you have lung cancer.*

Use the rules of probability to compute probabilities of compound events in a uniform probability model.

S-CP.6. Find the conditional probability of *A* given *B* as the fraction of *B*'s outcomes that also belong to *A,* and interpret the answer in terms of the model.

S-CP.7. Apply the Addition Rule, P(A or B) = P(A) + P(B) – P(A and B), and interpret the answer in terms of the model.

S-CP.8. (+) Apply the general Multiplication Rule in a uniform probability model, P(A and B) = P(A)P(B|A) = P(B)P(A|B), and interpret the answer in terms of the model.

S-CP.9. (+) Use permutations and combinations to compute probabilities of compound events and solve problems.

Using Probability to Make Decisions S - MD

Calculate expected values and use them to solve problems.

S-MD.1. (+) Define a random variable for a quantity of interest by assigning a numerical value to each event in a sample space; graph the corresponding probability distribution using the same graphical displays as for data distributions.

S-MD.2. (+) Calculate the expected value of a random variable; interpret it as the mean of the probability distribution.

S-MD.3. (+) Develop a probability distribution for a random variable defined for a sample space in which theoretical probabilities can be calculated; find the expected value*. For example, find the theoretical probability distribution for the number of correct answers obtained by guessing on all five questions of a multiple-choice test where each question has four choices, and find the expected grade under various grading schemes.*

S-MD.4. (+) Develop a probability distribution for a random variable defined for a sample space in which probabilities are assigned empirically; find the expected value. *For example, find a current data distribution on the number of TV sets per household in the United States, and calculate the expected number of sets per household. How many TV sets would you expect to find in 100 randomly selected households?*

Use probability to evaluate outcomes of decisions.

S-MD.5. (+) Weigh the possible outcomes of a decision by assigning probabilities to payoff values and finding expected values.

a. Find the expected payoff for a game of chance. *For example, find the expected winnings from a state lottery ticket or a game at a fast-food restaurant.*

b. Evaluate and compare strategies on the basis of expected values. *For example, compare a high-deductible versus a low-deductible automobile insurance policy using various, but reasonable, chances of having a minor or a major accident.*

S-MD.6. (+) Use probabilities to make fair decisions (e.g., drawing by lots, using a random number generator).

S-MD.7. (+) Analyze decisions and strategies using probability concepts (e.g., product testing, medical testing, pulling a hockey goalie at the end of a game).

Glossary for Alaska Mathematics Standards

addition and subtraction within 5, 10, 20, 100, or 1000

Addition or subtraction of two whole numbers with whole number answers, and with sum or minuend in the range 0-5, 0-10, 0-20, or 0-100, respectively. Example: 8 + 2 = 10 is an addition within 10, 14 – 5 = 9 is a subtraction within 20, and 55 – 18 = 37 is a subtraction within 100.

additive inverses

Two numbers whose sum is 0 are additive inverses of one another. Example: 3/4 and – 3/4 are additive inverses of one another because 3/4 + (– 3/4) = (– 3/4) + 3/4 = 0.

associative property of addition

See Table 3 in this Glossary.

associative property of multiplication

See Table 3 in this Glossary.

bivariate data

Pairs of linked numerical observations. Example: a list of heights and weights for each player on a football team. Box plot. A method of visually displaying a distribution of data values by using the median, quartiles, and extremes of the data set. A box shows the middle 50% of the data.[1]

cardinality

Cardinal numbers, known as the "counting numbers," indicate quantity.

commutative property

See Table 3 in this Glossary.

complex fraction

A fraction *A/B* where *A* and/or *B* are fractions (*B* nonzero).

computation algorithm

A set of predefined steps applicable to a class of problems that gives the correct result in every case when the steps are carried out correctly. *See also:* computation strategy.

computation strategy

Purposeful manipulations that may be chosen for specific problems, may not have a fixed order, and may be aimed at converting one problem into another. *See also:* computation algorithm.

congruent

Two plane or solid figures are congruent if one can be obtained from the other by rigid motion (a sequence of rotations, reflections, and translations).

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[1] Adapted from Wisconsin Department of Public Instruction, http://dpi.wi.gov/standards/mathglos.html, accessed Mar 2, 2010.

counting on

A strategy for finding the number of objects in a group without having to count every member of the group. For example, if a stack of books is known to have 8 books and 3 more books are added to the top, it is not necessary to count the stack all over again. One can find the total by counting on—pointing to the top book and saying "eight," following this with "nine, ten, eleven. There are eleven books now."

dot plot

See: line plot

dilation

A transformation that moves each point along the ray through the point emanating from a fixed center, and multiplies distances from the center by a common scale factor.

expanded form

A multi-digit number is expressed in expanded form when it is written as a sum of single-digit multiples of powers of ten. For example, 643 = 600 + 40 + 3.

expected value

For a random variable, the weighted average of its possible values, with weights given by their respective probabilities.

first quartile

For a data set with median *M*, the first quartile is the median of the data values less than *M*. Example: For the data set {1, 3, 6, 7, 10, 12, 14, 15, 22, 120}, the first quartile is 6.[2] *See also:* median, third quartile, interquartile range.

fraction

A number expressible in the form *a/b* where *a* is a whole number and *b* is a positive whole number. (The word fraction in these standards always refers to a non-negative number.) *See also:* rational number.

identity property of 0

See Table 3 in this Glossary.

independently combined probability models

Two probability models are said to be combined independently if the probability of each ordered pair in the combined model equals the product of the original probabilities of the two individual outcomes in the ordered pair.

integer

A number expressible in the form *a* or –*a* for some whole number *a*.

interquartile range

A measure of variation in a set of numerical data, the interquartile range is the distance between the first and third quartiles of the data set. Example: For the data set {1, 3, 6, 7, 10, 12, 14, 15, 22, 120}, the interquartile range is 15 – 6 = 9. See also: first quartile, third quartile.

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[2] Many different methods for computing quartiles are in use. The method defined here is sometimes called the More and McCabe method. See Langford, E., "Quartiles in Elementary Statistics," *Journal of Statistics Education*, Volume 14, number 3 (2006).

line plot

A method of visually displaying a distribution of data values where each data value is shown as a dot or mark above a number line. Also known as a dot plot.[3]

mean

A measure of center in a set of numerical data, computed by adding the values in a list and then dividing by the number of values in the list.[4] Example: For the data set {1, 3, 6, 7, 10, 12, 14, 15, 22, 120}, the mean is 21.

mean absolute deviation

A measure of variation in a set of numerical data, computed by adding the distances between each data value and the mean, then dividing by the number of data values. Example: For the data set {2, 3, 6, 7, 10, 12, 14, 15, 22, 120}, the mean absolute deviation is 20.

median

A measure of center in a set of numerical data. The median of a list of values is the value appearing at the center of a sorted version of the list—or the mean of the two central values, if the list contains an even number of values. Example: For the data set {2, 3, 6, 7, 10, 12, 14, 15, 22, 90}, the median is 11.

midline

In the graph of a trigonometric function, the horizontal line halfway between its maximum and minimum values. Multiplication and division within 100. Multiplication or division of two whole numbers with whole number answers, and with product or dividend in the range 0-100. Example: 72 ÷ 8 = 9.

multiplicative inverses

Two numbers whose product is 1 are multiplicative inverses of one another. Example: 3/4 and 4/3 are multiplicative inverses of one another because 3/4 × 4/3 = 4/3 × 3/4 = 1.

number line diagram.

A diagram of the number line used to represent numbers and support reasoning about them. In a number line diagram for measurement quantities, the interval from 0 to 1 on the diagram represents the unit of measure for the quantity.

ordinality

Ordinal numbers indicate the order or rank of things in a set (e.g., sixth in line; fourth place).

percent rate of change

A rate of change expressed as a percent. Example: if a population grows from 50 to 55 in a year, it grows by 5/50 = 10% per year.

probability distribution

The set of possible values of a random variable with a probability assigned to each.

probability

A number between 0 and 1 used to quantify likelihood for processes that have uncertain outcomes (such as tossing a coin, selecting a person at random from a group of people, tossing a ball at a target, or testing for a medical condition).

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[3] Adapted from Wisconsin Department of Public Instruction, op. cit.

[4] To be more precise, this defines the *arithmetic mean*.

probability model

A probability model is used to assign probabilities to outcomes of a chance process by examining the nature of the process. The set of all outcomes is called the sample space, and their probabilities sum to 1. *See also:* uniform probability model.

properties of equality

See Table 4 in this Glossary.

properties of inequality

See Table 5 in this Glossary.

properties of operation

See Table 3 in this Glossary.

random variable

An assignment of a numerical value to each outcome in a sample space. Rational expression. A quotient of two polynomials with a non-zero denominator.

rational expression

A quotient of two polynomials with a non-zero denominator.

rational number

A number expressible in the form *a/b* or – *a/b* for some fraction *a/b*. The rational numbers include the integers.

rectilinear figure

A polygon all angles of which are right angles.

rigid motion

A transformation of points in space consisting of a sequence of one or more translations, reflections, and/or rotations. Rigid motions are here assumed to preserve distances and angle measures.

repeating decimal

The decimal form of a rational number. *See also:* terminating decimal.

sample space

In a probability model for a random process, a list of the individual outcomes that are to be considered.

scatter plot

A graph in the coordinate plane representing a set of bivariate data. For example, the heights and weights of a group of people could be displayed on a scatter plot.[5]

similarity transformation

A rigid motion followed by a dilation.

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[5] Adapted from Wisconsin Department of Public Instruction, op. cit.

tape diagram

A drawing that looks like a segment of tape, used to illustrate number relationships. Also known as a strip diagram, bar model, fraction strip, or length model.

terminating decimal

A decimal is called terminating if its repeating digit is 0.

third quartile

For a data set with median *M*, the third quartile is the median of the data values greater than *M*. *For example*: For the data set {2, 3, 6, 7, 10, 12, 14, 15, 22, 120}, the third quartile is 15. *See also:* median, first quartile, interquartile range.

transitivity principle for indirect measurement

If the length of object A is greater than the length of object B, and the length of object B is greater than the length of object C, then the length of object A is greater than the length of object C. This principle applies to measurement of other quantities as well.

uniform probability model

A probability model which assigns equal probability to all outcomes. *See also:* probability model.

vector

A quantity with magnitude and direction in the plane or in space, defined by an ordered pair or triple of real numbers.

visual fraction model

A tape diagram, number line diagram, or area model.

whole numbers

The numbers 0, 1, 2, 3,...

Table 1: Common addition and subtraction situations[1]

	Result Unknown	Change Unknown	Start Unknown
Add To	Two bunnies sat on the grass. Three more bunnies hopped there. How many bunnies are on the grass now? 2 + 3 = ?	Two bunnies were sitting on the grass. Some more bunnies hopped there. Then there were five bunnies. How many bunnies hopped over to the first two? 2 + ? = 5	Some bunnies were sitting on the grass. Three more bunnies hopped there. Then there were five bunnies. How many bunnies were on the grass before? ? + 3 = 5
Take from	Five apples were on the table. I ate two apples. How many apples are on the table now? 5 – 2 = ?	Five apples were on the table. I ate some apples. Then there were three apples. How many apples did I eat? 5 – ? = 3	Some apples were on the table. I ate two apples. Then there were three apples. How many apples were on the table before? ? – 2 = 3
	Total Unknown	**Addend Unknown**	**Both Addends Unknown[2]**
Put Together/ Take Apart[3]	Three red apples and two green apples are on the table. How many apples are on the table? 3 + 2 = ?	Five apples are on the table. Three are red and the rest are green. How many apples are green? 3 + ? = 5, 5 – 3 = ?	Grandma has five flowers. How many can she put in her red vase and how many in her blue vase? 5 = 0 + 5, 5 = 5 + 0 5 = 1 + 4, 5 = 4 + 1 5 = 2 + 3, 5 = 3 + 2
	Difference Unknown	**Bigger Unknown**	**Smaller Unknown**
Compare[4]	(“How many more?” version): Lucy has two apples. Julie has five apples. How many more apples does Julie have than Lucy? (“How many fewer?” version): Lucy has two apples. Julie has five apples. How many fewer apples does Lucy have than Julie? 2 + ? = 5, 5 – 2 = ?	(Version with “more”): Julie has three more apples than Lucy. Lucy has two apples. How many apples does Julie have? (Version with “fewer”): Lucy has 3 fewer apples than Julie. Lucy has two apples. How many apples does Julie have? 2 + 3 = ?, 3 + 2 = ?	(Version with “more”): Julie has three more apples than Lucy. Julie has five apples. How many apples does Lucy have? (Version with “fewer”): Lucy has 3 fewer apples than Julie. Julie has five apples. How many apples does Lucy have? 5 – 3 = ?, ? + 3 = 5

[1]*Adapted from Box 2-4 of the National Research Council (2009, op. cit., pp. 32, 33).*

[2]*These take apart situations can be used to show all the decompositions of a given number. The associated equations, which have the total on the left of the equal sign, help children understand that the = sign does not always mean makes or results in but always does mean is the same number as.*

[3]*Either addend can be unknown, so there are three variations of these problem situations. Both Addends Unknown is a productive extension of this basic situation, especially for small numbers less than or equal to 10.*

[4]*For the Bigger Unknown or Smaller Unknown situations, one version directs the correct operation (the version using more for the bigger unknown and using less for the smaller unknown). The other versions are more difficult.*

Table 2: Common multiplication and division situations[5]

	Unknown Product	Group Size Unknown ("How many in each group?" Division)	Number of Groups Unknown ("How many groups?" Division)
	3 x 6 = ?	3 x ? = 18, and 18 ÷ 3 = ?	? x 6 = 18, and 18 ÷ 6 = ?
Equal Groups	There are 3 bags with 6 plums in each bag. How many plums are there in all? Measurement example. You need 3 lengths of string, each 6 inches long. How much string will you need altogether?	If 18 plums are shared equally into 3 bags, then how many plums will be in each bag? Measurement example. You have 18 inches of string, which you will cut into 3 equal pieces. How long will each piece of string be?	If 18 plums are to be packed 6 to a bag, then how many bags are needed? Measurement example. You have 18 inches of string, which you will cut into pieces that are 6 inches long. How many pieces of string will you have?
Array[6], Area[7]	There are 3 rows of apples with 6 apples in each row. How many apples are there? Area example. What is the area of a 3 cm by 6 cm rectangle?	If 18 apples are arranged into 3 equal rows, how many apples will be in each row? Area example. A rectangle has area 18 square centimeters. If one side is 3 cm long, how long is a side next to it?	If 18 apples are arranged into equal rows of 6 apples, how many rows will there be? Area example. A rectangle has area 18 square centimeters. If one side is 6 cm long, how long is a side next to it?
Compare	A blue hat costs \$6. A red hat costs 3 times as much as the blue hat. How much does the red hat cost? Measurement example. A rubber band is 6 cm long. How long will the rubber band be when it is stretched to be 3 times as long?	A red hat costs \$18 and that is 3 times as much as a blue hat costs. How much does a blue hat cost? Measurement example. A rubber band is stretched to be 18 cm long and that is 3 times as long as it was at first. How long was the rubber band at first?	A red hat costs \$18 and a blue hat costs \$6. How many times as much does the red hat cost as the blue hat? Measurement example. A rubber band was 6 cm long at first. Now it is stretched to be 18 cm long. How many times as long is the rubber band now as it was at first?
General	*a x b = ?*	*a x ? = p, and p ÷ a = ?*	*? x b = p, and p ÷ b = ?*

[5]*The first examples in each cell are examples of discrete things. These are easier for students and should be given before the measurement examples.*

[6]*The language in the array examples shows the easiest form of array problems. A harder form is to use the terms rows and columns: The apples in the grocery window are in 3 rows and 6 columns. How many apples are in there? Both forms are valuable.*

[7]*Area involves arrays of squares that have been pushed together so that there are no gaps or overlaps, so array problems include these especially important measurement situations.*

Table 3. The properties of operations.

Here a, b and c stand for arbitrary numbers in a given number system. The properties of operations apply to the rational number system, the real number system, and the complex number system.

Associative property of addition	$(a + b) + c = a + (b + c)$
Commutative property of addition	$a + b = b + a$
Additive identity property of 0	$a + 0 = 0 + a = a$
Existence of additive inverses	For every a there exists $–a$ so that $a + (–a) = (–a) + a = 0$.
Associative property of multiplication	$(a \times b) \times c = a \times (b \times c)$
Commutative property of multiplication	$a \times b = b \times a$
Multiplicative identity property of 1	$a \times 1 = 1 \times a = a$
Existence of multiplicative inverses	For every $a \neq 0$ there exists $1/a$ so that $a \times 1/a = 1/a \times a = 1$.
Distributive property of multiplication over addition	$a \times (b + c) = a \times b + a \times c$

Table 4. The properties of equality.

Here *a*, *b* and *c* stand for arbitrary numbers in the rational, real, or complex number systems.

Reflexive property of equality	$a = a$
Symmetric property of equality	If $a = b$, then $b = a$.
Transitive property of equality	If $a = b$ and $b = c$, then $a = c$.
Addition property of equality	If $a = b$, then $a + c = b + c$.
Subtraction property of equality	If $a = b$, then $a – c = b – c$.
Multiplication property of equality	If $a = b$, then $a \times c = b \times c$.
Division property of equality	If $a = b$, then b may be substituted for a in any expression containing a.
Substitution property of equality	If $a = b$ and $c \neq 0$, then $a \div c = b \div c$.

Table 5. The properties of inequality.

Here *a, b* and *c* stand for arbitrary numbers in the rational or real number systems.

Exactly one of the following is true: $a < b$, $a = b$, $a > b$.
If $a > b$ and $b > c$ then $a > c$.
If $a > b$, then $b < a$.
If $a > b$, then $–a < –b$.
If $a > b$, then $a \pm c > b \pm c$.
If $a > b$ and $c > 0$, then $a \times c > b \times c$.
If $a > b$ and $c < 0$, then $a \times c < b \times c$.
If $a > b$ and $c > 0$, then $a \div c > b \div c$.
If $a > b$ and $c < 0$, then $a \div c < b \div c$.

DEPT. OF EDUCATION AND
EARLY DEVELOPMENT

K-12 Science Standards for Alaska

For additional information on Alaska's standards, write:
Standards, Department of Education & Early Development
PO Box 110500 Juneau, Alaska 99811-0500
Or call, (907) 465-2900; or visit our website (http://education.alaska.gov)

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Science Standards for Alaska

Introduction

Science and technology have been essential to the people for Alaska in its past, its present, and will be increasingly important in the future. Providing a firm foundation in science education for all students in Alaska is a bright opportunity and essential challenge. The State's science standards provide the foundation for defining what students should know and be able to do in terms of scientific knowledge and skills.

Development Process

In October of 2017, the Alaska Department of Education and Early Development (DEED) began a statewide application process to identify teachers, principals, curriculum directors, science specialists, and other qualified individuals to serve as writers and reviewers and aid in the creation of new science standards for the State of Alaska.

Out of the pool of applicants, 15 diverse professionals were selected based upon merit, to serve on the science content standards Writing Committee. An additional 15 individuals were chosen to review the writing committee's recommendations.

The Writing Committee was provided with the following charge:

- The Writing Committee will identify and review influential sets of science content standards (e.g., Next Generation Science Standards; standards for the NAEP, PISA, and TIMSS assessments; science standards from College Board and ACT; standards from other leading states; science standards from leading textbook publishers; and past science standards such as AAAS' Project 2061).
- The Writing Committee will identify, modify, write, and compile a recommended set of science content standards drawing on its members' expertise and review of relevant materials. Ideally, the Writing Committee will produce a set of content standards to guide curriculum and instruction in the state. In addition, the Writing Committee will provide recommendations regarding the state summative assessment in science.
- The Writing Committee will receive feedback from the Review Committee. Following review, the Writing Committee will make appropriate changes. The Writing Committee will send its recommended set of science content standards to the Alaska Department of Education and Early Development, which will review and send to the State Board.

In April of 2018, the first meeting of the Writing Committee was held in Anchorage. From this review, the team decided to use the Next Generation Science Standards (NGSS) as a basis for Science Standards for Alaska due to its three-dimensional design, and focus on science for all students. The three-dimensional design provides students with a context for the content of science, how science knowledge is acquired and understood, and how the individual sciences are connected through concepts that have universal meaning across disciplines.

It was the committee's decision to shape the Science Standards for Alaska around the NGSS, with a strong focus on relevance to Alaskan students and allow educators the flexibility to determine the best way to help students meet the standards, based on local needs.

Following the first meeting, Writing Committee suggestions were sent to Reviewers for questions and comments. The Writing Committee met again in June of 2018 to discuss reviewers' input and revise the standards based on the feedback received.

Subsequently the Writing Committee's revisions went back to the Review Committee for a second round of review. The Reviewers' comments were again presented to the Writing Committee in October of 2018.

In October of 2018, the Writing Committee met again, reviewed comments of the Review Team, and finalized recommendations regarding the Science Standards for Alaska, to be submitted to the Alaska Board of Education for review and adoption.

Relation of the Science Standards for Alaska and the NGSS

The Science Standards for Alaska are largely the same as the NGSS. The Writing Committee strongly supported the general architecture and approach of the NGSS, and made no changes to the scientific content. The revisions made by the Writing Committee included:

- Adding many examples of how the standards could be made more relevant for students in Alaska by showing applications of scientific principles and skills in an Alaskan context
- Rephrasing several content standards statements to make them clearer and/or more age-appropriate
- Fewer than a handful of NGSS content standards were combined, moved to a different grade, or deleted.

The Science Standards for Alaska contain two main parts: Performance Expectations and Foundational Statements. These are also found in the NGSS. In addition, the NGSS standards have a third part, called "Connections" that provide information for how the science content standards are related to each other and to other widely-used content standards in reading, writing, and mathematics. The Writing Committee recommended not incorporating the Connections information as a part of the state-adopted science content standards because such connections are likely to change more rapidly than the science standards. The Writing Committee endorsed DEED providing such information, along with other support materials as supplemental to the actual state science standards.

How to Read the Science Standards for Alaska[1]

The Science Standards for Alaska are distinct from prior science standards in three essential ways.

1) Performance. Prior standards documents listed what students should “know” or “understand.” These ideas needed to be translated into performances that could be assessed to determine whether or not students met the standard. Different interpretations sometimes resulted in assessments that were not aligned with curriculum and instruction. The Science Standards for Alaska has avoided this difficulty by developing performance expectations that state what students should be able to do in order to demonstrate that they have met the standard, thus providing the same clear and specific targets for curriculum, instruction, and assessment.
2) Foundations. Each performance expectation incorporates all three dimensions from the Framework— a science or engineering practice, a disciplinary core idea, and a crosscutting concept. The symbol “︾” indicates foundational statements are continued onto the next page.
3) Coherence. Each set of performance expectations lists connections to other ideas within the disciplines of science and engineering, and with Common Core State Standards in Mathematics and English Language Arts.

This chapter describes how these three unique characteristics are embodied in the format of the standards, beginning with the “system architecture.”

The Framework: A Vision For Science K-12

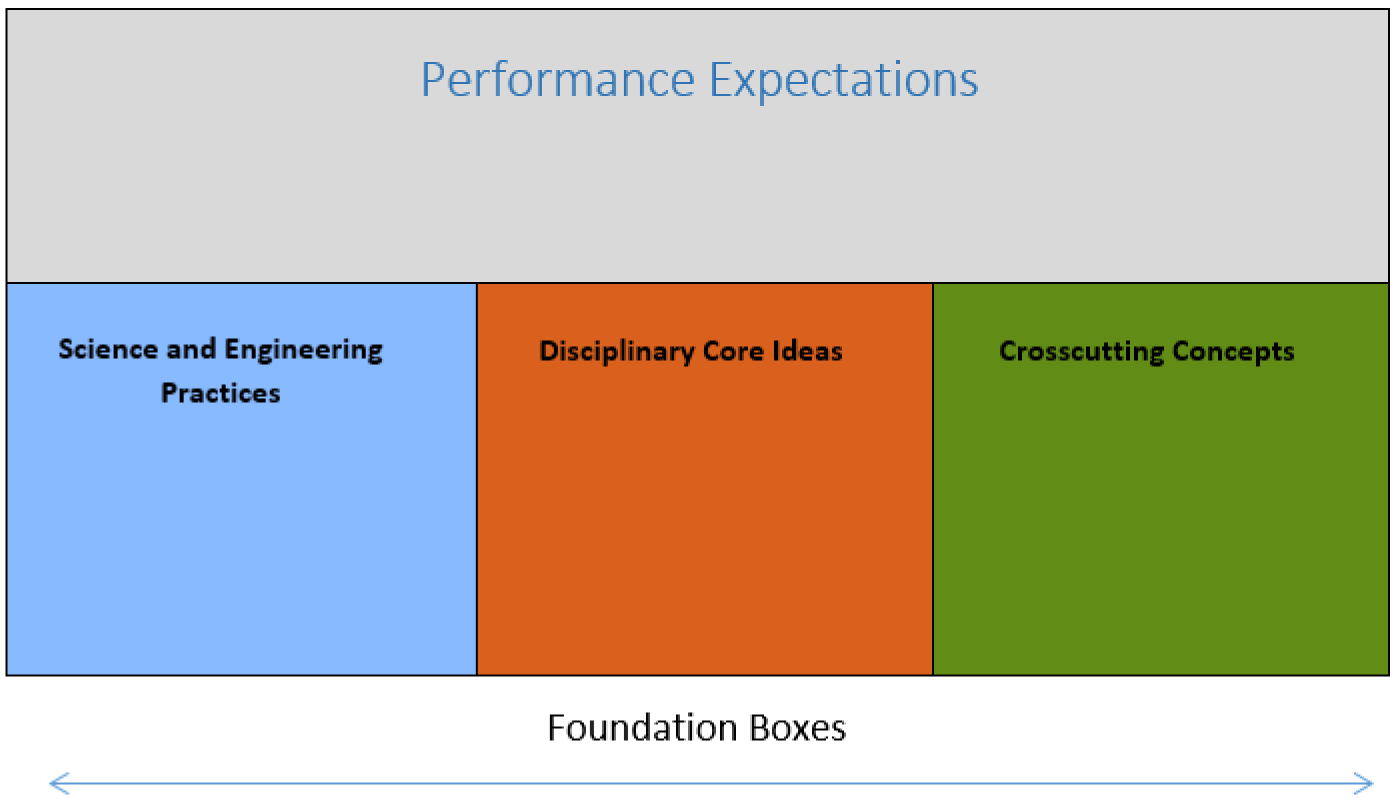
Science, engineering, and technology permeate nearly every facet of modern life and hold the key to solving many of humanity’s most pressing current and future challenges, The United States’ position in the global economy is declining, in part because U.S. workers lack fundamental knowledge in these fields. To address the critical issues of U.S. competitiveness and to better prepare the workforce, *A Framework for K-12 Science Education* proposes a new approach to K-12 science education that will capture students’ interest and provide them with the necessary foundational knowledge in the field.

[1] This section paraphrases and quotes extensively from NGSS Lead States. 2013. Next Generation Science Standards: For States, By States. Washington, DC: The National Academies Press.

System Architecture

As shown in the illustration below, each set of performance expectations has a title. Below the title is a box containing the performance expectations. Below that are three foundation boxes, which list (from left to right) the specific science and engineering practices (SEPs), disciplinary core ideas (DCIs), and crosscutting concepts (CCCs) that were combined to produce the performance expectations (PEs) above. These sections are described in further detail below.

3. Interdependent Relationships in Ecosystems: Environmental Impacts on Organisms



Performance Expectations (PEs)

The Science Standards for Alaska are expressed as Performance Expectations.

Performance Expectations are statements about what students should know and be able to do at the end of instruction. Each performance expectation combines the practices of science and engineering, the disciplinary core ideas, and the cross cutting concepts into a single statement of what is to be assessed. These are the elements of Three Dimensional Learning.

The Performance Expectations in the Science Standards for Alaska are targets for assessment. For students to achieve such performances, they will need regular opportunities to engage in learning that blends all three dimensions of the standards throughout their classroom experiences, from Kindergarten through High School. The performance expectations set the learning goals for students, then students, teachers, and districts decide how to reach those learning targets.

When instruction is consistent with the Framework and the NGSS, students will be actively engaged in the full range of scientific and engineering practices and applying the crosscutting concepts in the context of investigating multiple core ideas.

In three-dimensional learning student work is driven by questions arising from phenomena or by an engineering design problem. Students are supported in connecting their learning across units and courses to build a coherent understanding of science ideas and of the crosscutting concepts.

Students have opportunities to apply their developing science knowledge to explain phenomena or design solutions to real world problems. They interact with others as they conduct investigations; represent data; interpret evidence; gather additional information, and develop explanations, models, and arguments.

The Science Content Standards for Alaska are for all students, and all students are expected to achieve proficiency with respect to all of the performance expectations in the Alaska standards.

The Science Content Standards for Alaska provide a foundation for rigorous advanced courses in science or engineering that some students may choose to take. Students interested in pursuing science further (through Advanced Placement or other advanced courses) should have the opportunity to do so.

In the example below, notice how the performance expectation combines the practices and ideas that students need to learn, while it suggests ways of assessing whether or not third graders have the capabilities and understandings specified in the three foundation boxes.

2-PS1-2

Students who demonstrate understanding can: Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose.*

Clarification Statement: Examples of properties could include, strength, flexibility, hardness, texture, and absorbency.

Assessment Boundary: Assessment of quantitative measurements is limited to length.

The performance expectations above were developed using the following elements from the NRC document A Framework for K-12 Science Education.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data • Analyze data from tests of an object or tool to determine if it works as intended.	**PS1.A: Structure and Properties of Matter** • Different properties are suited to different purposes.	**Cause and Effect** • Simple tests can be designed to gather evidence to support or refute student ideas about causes. **Connections to Engineering, Technology, and Applications of Science** **Influence of Engineering, Technology, and Science, on Society and the Natural World** • Every human-made product is designed by applying some knowledge of the natural world and is built using materials derived from the natural world.

As in this example, the performance expectations marked with an asterisk* integrate traditional science content with engineering through a practice or disciplinary core idea. (https://www.nextgenscience.org)

As shown in the example, most of the performance expectations are followed by one or two additional statements. These include Clarification Statements, which supply examples or additional clarification to the performance expectations including connections to Alaskan phenomena where applicable; and Assessment Boundary Statements, which specify the limits to large-scale assessment.

The **codes for the performance expectations** were derived from the Framework. As with the titles, the **first digit** indicates a Grade Level from Kindergarten to Grade 5. Middle School and High School Performance Expectations are organized by Grade Bands. Middle School (MS) is Grades 6-8, and High School (HS) is Grades 9-12. The next **alpha-numeric code** specifies the discipline, core idea and sub-idea. All of these codes are shown in the table below, derived from the Framework. Finally, the **number at the end of each code** indicates the order in which that statement appeared as a DCI in the Framework. Connections to the **Nature of Science** concepts can be found in either the practices or crosscutting concepts foundation boxes.

Foundation Boxes

While the performance expectations can stand alone, a more coherent and complete view of what students should be able to do comes when the performance expectations are viewed in tandem with the contents of the foundation boxes that lie just below the performance expectations. These three boxes include the science and engineering practices, disciplinary core ideas, and crosscutting concepts, derived from the Framework, that were used to construct this set of performance expectations.

Science and Engineering Practices (SEPs). The blue box on the left includes just the science and engineering practices used to construct the performance expectations in the box above. These statements are derived from and grouped by the eight categories detailed in the Framework to further explain the science and engineering practices important to emphasize in each grade band. Most sets of performance expectations emphasize only a few of the practice categories; however, all practices are emphasized within a grade band. Teachers should be encouraged to utilize several practices in any instruction, and need not be limited by the performance expectation, which is only intended to guide assessment.

The Science and Engineering Practices include:

- Asking questions and defining problems
- Developing and using models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using Mathematics and computational thinking
- Constructing explanations and designing solutions
- Engaging in argument from evidence
- Obtaining, evaluating, and communicating information

The “Practices of Science and Engineering” replace the use of science processes or skills, to reflect the knowledge that is specific to each practice, along with particular skills.

Disciplinary Core Ideas (DCIs). The orange foundation box in the middle of the Performance Expectation sample includes statements taken from the Framework about the most essential ideas in the major science disciplines that all students should understand during 13 years of school. Including these detailed statements was very helpful to the NGSS writing team as they analyzed and “unpacked” the disciplinary core ideas and sub-ideas to reach a level that is helpful in describing what each student should understand about each sub-idea at the end of grades 2, 5, 8, and 12. Although they appear in paragraph form in the Framework, here they are bulleted to be certain that each statement is distinct.

The number of core ideas has been reduced in the Science Standards for Alaska to allow a deeper look into each concept and develop a strong foundation of knowledge regarding these ideas. The Framework lists 11 core ideas, four in life science, four in physical science, and three in Earth and Space Science. The core ideas are divided into a total of 39 sub-ideas, and each sub-idea is elaborated in a list of what students should understand about that sub-idea at the end of grades 2, 5, 8, and 12. We have called these grade-specific statements Disciplinary Core Ideas (DCIs).

Science Standards for Alaska Disciplinary Core Ideas	
Physical Sciences PS1: Matter and its interactions PS2: Motion and stability: Forces and interactions PS3: Energy PS4: Waves and their applications in technologies for information transfer	**Life Sciences** LS1: From molecules to organisms: Structures and processes LS2: Ecosystems: Interactions, energy, and dynamics LS3: Heredity: Inheritance and variation of traits LS4: Biological evolution: Unity and diversity
Earth and Space Sciences ESS1: Earth’s place in the universe ESS2: Earth’s systems ESS3: Earth and human activity	**Engineering, Technology, Applications of Science** ETS1: Engineering design

Crosscutting Concepts (CCCs). The green box on the right of the sample Performance Expectation (PE), includes statements derived from the Framework's list of Crosscutting Concepts, which apply to one or more of the performance expectations in the box above. Most sets of Performance Expectations limit the number of crosscutting concepts so as to focus on those that are readily apparent when considering the Disciplinary Core Ideas. However, all are emphasized within a grade band. Again, the list is not exhaustive nor is it intended to limit instruction.

Using Crosscutting Concepts to Engage Students. In three-dimensional learning, crosscutting concepts are the dimension that provides a scaffold upon which teachers and students can organize the cognitive structures for unifying the science disciplines. The crosscutting concepts are featured as one of the three dimensions in the performance expectations outlining what students should know and be able to do.

The Crosscutting Concepts include big ideas in science such as:

- Patterns
- Cause and Effect
- Scale, Proportion, and Quantity
- Systems and Systems Models
- Energy and Matter
- Structure and Function
- Stability and Change

The Crosscutting Concepts can be used to discuss phenomena, evidence, and questions students develop during investigations or data analysis. Prompts for using the Crosscutting Concepts can be located on this website.

KINDERGARTEN

The performance expectations in kindergarten help students formulate answers to questions such as: “What happens if you push or pull an object harder? Where do animals live and why do they live there? What is the weather like today and how is it different from yesterday?” Kindergarten performance expectations include PS2, PS3, LS1, ESS2, ESS3, and ETS1

Disciplinary Core Ideas from the NRC Framework. Students are expected to develop understanding of patterns and variations in local weather and the purpose of weather forecasting to prepare for, and respond to, severe weather. Students are able to apply an understanding of the effects of different strengths or different directions of pushes and pulls on the motion of an object to analyze a design solution. Students are also expected to develop understanding of what plants and animals (including humans) need to survive and the relationship between their needs and where they live.

The crosscutting concepts of patterns; cause and effect; systems and system models; interdependence of science, engineering, and technology; and influence of engineering, technology, and science on society and the natural world are called out as organizing concepts for these disciplinary core ideas. In the kindergarten performance expectations, students are expected to demonstrate grade-appropriate proficiency in asking questions, developing and using models, planning and carrying out investigations, analyzing and interpreting data, designing solutions, engaging in argument from evidence, and obtaining, evaluating, and communicating information. Students are expected to use these practices to demonstrate understanding of the core ideas.

K. Forces and Interactions: Pushes and Pulls

Students who demonstrate understanding can:

K-PS2-1

Plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object. [Clarification Statement: Examples of pushes or pulls could include a string attached to an object being pulled, a person pushing an object, a person stopping a rolling ball, and two objects colliding and pushing on each other.] [Assessment Boundary: Assessment is limited to different relative strengths or different directions, but not both at the same time. Assessment does not include non-contact pushes or pulls such as those produced by magnets.]

K-PS2-2

Analyze data to determine if a design solution works as intended to change the speed or direction of an object with a push or a pull.* [Clarification Statement: Examples of problems requiring a solution could include having a marble or other object move a certain distance, follow a particular path, and knock down other objects. Examples of solutions could include tools such as a ramp to increase the speed of the object and a structure that would cause an object such as a marble or ball to turn.] [Assessment Boundary: Assessment does not include friction as a mechanism for change in speed.]

K-PS2-1

Students who demonstrate mastery can: Plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object.

Clarification Statement: Examples of pushes or pulls could include a string attached to an object being pulled, a person pushing an object, a person stopping a rolling ball, and two objects colliding and pushing on each other.

Assessment Boundary: Assessment is limited to different relative strengths or different directions, but not both at the same time. Assessment does not include non-contact pushes or pulls such as those produced by magnets.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations • With guidance, plan and conduct an investigation in collaboration with peers. **Connections to the Nature of Science** **Scientific Investigations Use a Variety of Methods** • Scientists use different ways to study the world.	**PS2.A: Forces and Motion** • Pushes and pulls can have different strengths and directions. • Pushing or pulling on an object can change the speed or direction of its motion and can start or stop it. **PS2.B: Types of Interactions** • When objects touch or collide, they push on one another and can change motion. **PS3.C: Relationship Between Energy and Forces** • A bigger push or pull makes things speed up or slow down more quickly. (*secondary*)	**Cause and Effect** • Simple tests can be designed to gather evidence to support or refute student ideas about causes.

K-PS2-2

Students who demonstrate understanding can: Analyze data to determine if a design solution works as intended to change the speed or direction of an object with a push or a pull.*

Clarification Statement: Examples of problems requiring a solution could include having a marble or other object move a certain distance, follow a particular path, and knock down other objects. Examples of solutions could include tools such as a ramp to increase the speed of the object and a structure that would cause an object such as a marble or ball to turn.

Assessment Boundary: Assessment does not include friction as a mechanism for change in speed.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data • Analyze data from tests of an object or tool to determine if it works as intended.	**PS2.A: Forces and Motion** • Pushes and pulls can have different strengths and directions. • Pushing or pulling on an object can change the speed or direction of its motion and can start or stop it. **ETS1.A: Defining Engineering Problems** • A situation that people want to change or create can be approached as a problem to be solved through engineering. Such problems may have many acceptable solutions. (*secondary*)	**Cause and Effect** • Simple tests can be designed to gather evidence to support or refute student ideas about causes.

K. Interdependent Relationships in Ecosystems: Animals, Plants, and Their Environment

Students who demonstrate understanding can:

K-LS1-1

Use observations to describe patterns of what plants and animals (including humans) need to survive. [Clarification Statement: Examples of patterns could include that animals need to take in food but plants do not; the different kinds of food needed by different types of animals; the requirement of plants to have light; and, that all living things need water.]

K-ESS2-2

Construct an argument supported by evidence for how plants and animals (including humans) can change the environment to meet their needs. [Clarification Statement: Examples of plants and animals changing their environment could include a squirrel digs in the ground to hide its food and tree roots can break concrete, or local plant and animal observations.]

K-ESS3-1

Use a model to represent the relationship between the needs of different plants and animals (including humans) and the places they live. [Clarification Statement: Examples of relationships could include that deer eat buds and leaves, therefore, they usually live in forested areas; and, grasses need sunlight so they often grow in meadows. Plants, animals, and their surroundings make up a system. Explain the characteristics of the model and the relationships.]

K-ESS3-3

Communicate solutions that will reduce the impact of humans on the land, water, air, and/or other living things in the local environment.* [Clarification Statement: Examples of human impact on the land could include cutting trees to produce paper and using resources to produce bottles. Examples of solutions could include reusing paper and recycling cans and bottles.]

K-LS1-1

Students who demonstrate understanding can: Use observations to describe patterns of what plants and animals (including humans) need to survive.

Clarification Statement: Examples of patterns could include that animals need to take in food but plants do not; the different kinds of food needed by different types of animals; the requirement of plants to have light; and, that all living things need water.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data • Use observations (firsthand or from media) to describe patterns in the natural world in order to answer scientific questions. **Connections to Nature of Science** **Scientific Knowledge is Based on Empirical Evidence** • Scientists look for patterns and order when making observations about the world.	**LS1.C: Organization for Matter and Energy Flow in Organisms** • All animals need food in order to live and grow. They obtain their food from plants or from other animals. Plants need water and light to live and grow.	**Patterns** • Patterns in the natural and human designed world can be observed and used as evidence.

K-ESS2-2

Students who demonstrate understanding can: Construct an argument supported by evidence for how plants and animals (including humans) can change the environment to meet their needs.

Clarification Statement: Examples of plants and animals changing their environment could include a squirrel digs in the ground to hide its food and tree roots can break concrete, or local plant and animal observations.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence • Construct an argument with evidence to support a claim.	**ESS2.E: Biogeology** • Plants and animals can change their environment. **ESS3.C: Human Impacts on Earth Systems** • Things that people do to live comfortably can affect the world around them. But they can make choices that reduce their impacts on the land, water, air, and other living things. (*secondary*)	**Systems and System Models** • Systems in the natural and designed world have parts that work together.

K-ESS3-1

Students who demonstrate understanding can: Use a model to represent the relationship between the needs of different plants and animals (including humans) and the places they live.

Clarification Statement: Examples of relationships could include that deer eat buds and leaves, therefore, they usually live in forested areas; and, grasses need sunlight so they often grow in meadows. Plants, animals, and their surroundings make up a system. Explain the characteristics of the model and the relationships.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Use a model to represent relationships in the natural world.	**ESS3.A: Natural Resources** • Living things need water, air, and resources from the land, and they live in places that have the things they need. Humans use natural resources for everything they do.	**Systems and System Models** • Systems in the natural and designed world have parts that work together

K-ESS3-3

Students who demonstrate understanding can: Communicate solutions that will reduce the impact of humans on the land, water, air, and/or other living things in the local environment.*

Clarification Statement: Examples of human impact on the land could include cutting trees to produce paper and using resources to produce bottles. Examples of solutions could include reusing paper and recycling cans and bottles.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Obtaining, Evaluating, and Communicating Information • Communicate solutions with others in oral and/or written forms using models and/or drawings that provide detail about scientific ideas.	**ESS3.C: Human Impacts on Earth Systems** • Things that people do to live comfortably can affect the world around them. But they can make choices that reduce their impacts on the land, water, air, and other living things. **ETS1.B: Developing Possible Solutions** • Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people. (*secondary*)	**Cause and Effect** • Events have causes that generate observable patterns.

K. Weather and Climate

Students who demonstrate understanding can:

K-PS3-1

Make observations to determine the effect of sunlight on Earth's surface. [Clarification Statement: Local observation of duration of sunlight. Examples of Earth's surface could include sand, soil, rocks, and water.] [*Assessment Boundary: Assessment of temperature is limited to relative measures such as warmer/cooler.*]

K-PS3-2

Use tools and materials to design and build a structure that will reduce the warming effect of sunlight on an area.* [Clarification Statement: Examples of structures could include umbrellas, canopies, and tents that minimize the warming effect of the sun. Explain the characteristics of the structure and their effect on the temperature.]

K-ESS2-1

Use and share observations of local weather conditions to describe patterns over time. [Clarification Statement: Examples of qualitative observations could include descriptions of the weather (such as sunny, cloudy, rainy, and warm); examples of quantitative observations could include numbers of sunny, windy, and rainy days in a month. Examples of patterns could include that it is usually cooler in the morning than in the afternoon and the number of sunny days versus cloudy days in different months.] [*Assessment Boundary: Assessment of quantitative observations limited to whole numbers and relative measures such as warmer/cooler.*]

K-ESS3-2

Ask questions to obtain information about the purpose of weather forecasting to prepare for, and respond to, severe weather.*
[Clarification Statement: Emphasis is on local forms of severe weather.]

K-PS3-1

Students who demonstrate understanding can: Make observations to determine the effect of sunlight on Earth's surface.

Clarification Statement: Local observation of duration of sunlight. Examples of Earth's surface could include sand, soil, rocks, and water.

Assessment Boundary: Assessment of temperature is limited to relative measures such as warmer/cooler.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations • Make observations (firsthand or from media) to collect data that can be used to make comparisons. **Connections to Nature of Science** **Scientific Investigations Use a Variety of Methods** • Scientists use different ways to study the world.	**PS3.B: Conservation of Energy and Energy Transfer** • Sunlight warms Earth's surface.	**Cause and Effect** • Events have causes that generate observable patterns.

K-PS3-2

Students who demonstrates understanding can: Use tools and materials to design and build a structure that will reduce the warming effect of sunlight on an area.*

Clarification Statement: Examples of structures could include umbrellas, canopies, and tents that minimize the warming effect of the sun. Explain the characteristics of the structure and their effect on the temperature.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions • Use tools and materials provided to design and build a device that solves a specific problem or a solution to a specific problem.	**PS3.B: Conservation of Energy and Energy Transfer** • Sunlight warms Earth's surface.	**Cause and Effect** • Events have causes that generate observable patterns.

K-ESS2-1

Students who demonstrate understanding can: Use and share observations of local weather conditions to describe patterns over time.

Clarification Statement: Examples of qualitative observations could include descriptions of the weather (such as sunny, cloudy, rainy, and warm); examples of quantitative observations could include numbers of sunny, windy, and rainy days in a month. Examples of patterns could include that it is usually cooler in the morning than in the afternoon and the number of sunny days versus cloudy days in different months.

Assessment Boundary: Assessment of quantitative observations limited to whole numbers and relative measures such as warmer/cooler.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data • Use observations (firsthand or from media) to describe patterns in the natural world in order to answer scientific questions. **Connections to Nature of Science** **Science Knowledge is Based on Empirical Evidence** • Scientists look for patterns and order when making observations about the world.	**ESS2.D: Weather and Climate** • Weather is the combination of sunlight, wind, snow or rain, and temperature in a particular region at a particular time. People measure these conditions to describe and record the weather and to notice patterns over time.	**Patterns** • Patterns in the natural world can be observed, used to describe phenomena, and used as evidence.

K-ESS3-2

Students who demonstrate understanding can: Ask questions to obtain information about the purpose of weather forecasting to prepare for, and respond to, severe weather.*

Clarification Statement: Emphasis is on local forms of severe weather.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Asking Questions and Defining Problems • Ask questions based on observations to find more information about the designed world. **Obtaining, Evaluating, and Communicating Information** • Read grade-appropriate texts and/or use media to obtain scientific information to describe patterns in the natural world.	**ESS3.B: Natural Hazards** • Some kinds of severe weather are more likely than others in a given region. Weather scientists forecast severe weather so that the communities can prepare for and respond to these events. **ETS1.A: Defining and Delimiting an Engineering Problem** • Asking questions, making observations, and gathering information are helpful in thinking about problems. (*secondary*)	**Cause and Effect** • Events have causes that generate observable patterns. **Connections to Engineering, Technology, and Applications of Science** **Interdependence of Science, Engineering, and Technology** • People encounter questions about the natural world every day. **Influence of Engineering, Technology, and Science on Society and the Natural World** • People depend on various technologies in their lives; human life would be very different without technology.

FIRST GRADE

The performance expectations in first grade help students formulate answers to questions such as: “What happens when materials vibrate? What happens when there is no light? What are some ways plants and animals meet their needs so that they can survive and grow? How are parents and their children similar and different? What objects are in the sky and how do they seem to move?” First grade performance expectations include PS4, LS1, LS3, and ESS1

Disciplinary Core Ideas from the NRC Framework. Students are expected to develop understanding of the relationship between sound and vibrating materials as well as between the availability of light and ability to see objects. The idea that light travels from place to place can be understood by students at this level through determining the effect of placing objects made with different materials in the path of a beam of light. Students are also expected to develop understanding of how plants and animals use their external parts to help them survive, grow, and meet their needs as well as how behaviors of parents and offspring help the offspring survive. The understanding is developed that young plants and animals are like, but not exactly the same as, their parents. Students are able to observe, describe, and predict some patterns of the movement of objects in the sky.

The crosscutting concepts of patterns; cause and effect; structure and function; and influence of engineering, technology, and science on society and the natural world are called out as organizing concepts for these disciplinary core ideas. In the first grade performance expectations, students are expected to demonstrate grade-appropriate proficiency in planning and carrying out investigations, analyzing and interpreting data, constructing explanations and designing solutions, and obtaining, evaluating, and communicating information. Students are expected to use these practices to demonstrate understanding of the core ideas.

1. Waves: Light and Sound

Students who demonstrate understanding can:

1-PS4-1

Plan and conduct investigations to provide evidence that vibrating materials can make sound and that sound can make materials vibrate. [Clarification Statement: Examples of vibrating materials that make sound could include tuning forks and plucking a stretched string. Examples of how sound can make matter vibrate could include holding a piece of paper near a speaker making sound and holding an object near a vibrating tuning fork or a person making a hunting call.]

1-PS4-2

Make observations to construct an evidence-based account that objects in darkness can be seen only when illuminated. [Clarification Statement: Examples of observations could include those made in a completely dark room, a pinhole box, and a video of a cave explorer with a flashlight. Illumination could be from an external light source or by an object giving off its own light.]

1-PS4-3

Plan and conduct investigations to determine the effect of placing objects made with different materials in the path of a beam of light. [Clarification Statement: Examples of materials could include those that are transparent (such as clear plastic), translucent (such as wax paper), opaque (such as cardboard), and reflective (such as a mirror).] [*Assessment Boundary: Assessment does not include the speed of light.*]

1-PS4-4

Use tools and materials to design and build a device that uses light or sound to solve the problem of communicating over a distance.* [Clarification Statement: Examples of devices could include a light source to send signals, paper cup and string “telephones,” and a pattern of drum beats. Explain how the device works.] [*Assessment Boundary: Assessment does not include technological details for how communication devices work.*]

1-PS4-1

Students who demonstrate understanding can: Plan and conduct investigations to provide evidence that vibrating materials can make sound and that sound can make materials vibrate.

Clarification Statement: Examples of vibrating materials that make sound could include tuning forks and plucking a stretched string. Examples of how sound can make matter vibrate could include holding a piece of paper near a speaker making sound and holding an object near a vibrating tuning fork or a person making a hunting call.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations • Plan and conduct investigations collaboratively to produce evidence to answer a question. **Connections to Nature of Science** **Scientific Investigations Use a Variety of Methods** • Science investigations begin with a question. • Scientists use different ways to study the world.	**PS4.A: Wave Properties** • Sound can make matter vibrate, and vibrating matter can make sound.	**Cause and Effect** • Simple tests can be designed to gather evidence to support or refute student ideas about causes.

1-PS4-2

Students who demonstrate understanding can: Make observations to construct an evidence-based account that objects in darkness can be seen only when illuminated.

Clarification Statement: Examples of observations could include those made in a completely dark room, a pinhole box, and a video of a cave explorer with a flashlight. Illumination could be from an external light source or by an object giving off its own light.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions • Make observations (firsthand or from media) to construct an evidence-based account for natural phenomena.	**PS4.B: Electromagnetic Radiation** • Objects can be seen if light is available to illuminate them or if they give off their own light.	**Cause and Effect** • Simple tests can be designed to gather evidence to support or refute student ideas about causes.

1-PS4-3

Students who demonstrate understanding can: Plan and conduct investigations to determine the effect of placing objects made with different materials in the path of a beam of light.

Clarification Statement: Examples of materials could include those that are transparent (such as clear plastic), translucent (such as wax paper), opaque (such as cardboard), and reflective (such as a mirror).

Assessment Boundary: Assessment does not include the speed of light.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations • Plan and conduct investigations collaboratively to produce evidence to answer a question.	**PS4.B: Electromagnetic Radiation** • Some materials allow light to pass through them, others allow only some light through and others block all the light and create a dark shadow on any surface beyond them, where the light cannot reach. Mirrors can be used to redirect a light beam. (Boundary: The idea that light travels from place to place is developed through experiences with light sources, mirrors, and shadows, but no attempt is made to discuss the speed of light.)	**Cause and Effect** • Simple tests can be designed to gather evidence to support or refute student ideas about causes.

1-PS4-4

Students who demonstrate understanding can: Use tools and materials to design and build a device that uses light or sound to solve the problem of communicating over a distance.*

Clarification Statement: Examples of devices could include a light source to send signals, paper cup and string “telephones,” and a pattern of drum beats. Explain how the device works.

Assessment Boundary: Assessment does not include technological details for how communication devices work.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions • Use tools and materials provided to design a device that solves a specific problem.	**PS4.C: Information Technologies and Instrumentation** • People also use a variety of devices to communicate (send and receive information) over long distances.	**Connections to Engineering, Technology, and Applications of Science** **Influence of Engineering, Technology, and Science, on Society and the Natural World** • People depend on various technologies in their lives; human life would be very different without technology.

1. Structure, Function, and Information Processing

Students who demonstrate understanding can:

1-LS1-1

Use materials to design a solution to a human problem by mimicking how plants and/or animals use their external parts to help them survive, grow, and meet their needs.* [Clarification Statement: Examples of human problems that can be solved by mimicking plant or animal solutions could include designing clothing or equipment to protect bicyclists by mimicking turtle shells (e.g., protective helmets), acorn shells, mollusks, and animal scales; stabilizing structures by mimicking animal tails and roots on plants; keeping out intruders by mimicking thorns on branches and animal quills; detecting intruders by mimicking eyes and ears; use of camouflage, or tools such as snowshoes. Explain how the solution solves the problem described.]

1-LS1-2

Read texts and use media to determine patterns in behavior of parents and offspring that help offspring survive. [Clarification Statement: Examples of patterns of behaviors could include the signals that offspring make (such as crying, cheeping, and other vocalizations) and the responses of the parents (such as feeding, comforting, and protecting the offspring).]

1-LS3-1

Make observations to construct an evidence-based account that young plants and animals are like, but not exactly like, their parents. [Clarification Statement: Examples of patterns could include features plants or animals share. Examples of observations could include leaves from the same kind of plant are the same shape but can differ in size; and, a particular breed of dog looks like its parents but is not exactly the same.] [*Assessment Boundary: Assessment does not include inheritance or animals that undergo metamorphosis or hybrids.*]

1-LS1-1

Students who demonstrate understanding can: Use materials to design a solution to a human problem by mimicking how plants and/or animals use their external parts to help them survive, grow, and meet their needs.*

Clarification Statement: Examples of human problems that can be solved by mimicking plant or animal solutions could include designing clothing or equipment to protect bicyclists by mimicking turtle shells (e.g., protective helmets), acorn shells, mollusks, and animal scales; stabilizing structures by mimicking animal tails and roots on plants; keeping out intruders by mimicking thorns on branches and animal quills; detecting intruders by mimicking eyes and ears; use of camouflage, or tools such as snowshoes. Explain how the solution solves the problem described.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

<table>
<tr><th>Science and Engineering Practices</th><th>Disciplinary Core Ideas</th><th>Crosscutting Concepts</th></tr>
<tr>
<td>Constructing Explanations and Designing Solutions
• Use materials to design a device that solves a specific problem or a solution to a specific problem.</td>
<td>LS1.A: Structure and Function
• All organisms have external parts. Different animals use their body parts in different ways to see, hear, grasp objects, protect themselves, move from place to place, and seek, find, and take in food, water and air. Plants also have different parts (roots, stems, leaves, flowers, fruits) that help them survive and grow.

LS1.D: Information Processing
• Animals have body parts that capture and convey different kinds of information needed for growth and survival. Animals respond to these inputs with behaviors that help them survive. Plants also respond to some external inputs.</td>
<td>Structure and Function
• The shape and stability of structures of natural and designed objects are related to their function(s).

Connections to Engineering, Technology, and Applications of Science

Influence of Science, Engineering and Technology on Society and the Natural World
• Every human-made product is designed by applying some knowledge of the natural world and is built using materials derived from the natural world.</td>
</tr>
</table>

1-LS1-2

Students who demonstrate understanding can: Read texts and use media to determine patterns in behavior of parents and offspring that help offspring survive.

Clarification Statement: Examples of patterns of behaviors could include the signals that offspring make (such as crying, cheeping, and other vocalizations) and the responses of the parents (such as feeding, comforting, and protecting the offspring).

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Obtaining, Evaluating, and Communicating Information • Read grade-appropriate texts and use media to obtain scientific information to determine patterns in the natural world. **Connections to Nature of Science** **Scientific Knowledge is Based on Empirical Evidence** • Scientists look for patterns and order when making observations about the world.	**LS1.B: Growth and Development of Organisms** • Adult plants and animals can have young. In many kinds of animals, parents and the offspring themselves engage in behaviors that help the offspring to survive.	**Patterns** • Patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence.

1-LS3-1

Students who demonstrate understanding can: Make observations to construct an evidence-based account that young plants and animals are like, but not exactly like, their parents.

Clarification Statement: Examples of patterns could include features plants or animals share. Examples of observations could include leaves from the same kind of plant are the same shape but can differ in size; and, a particular breed of dog looks like its parents but is not exactly the same.

Assessment Boundary: Assessment does not include inheritance or animals that undergo metamorphosis or hybrids.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions • Make observations (firsthand or from media) to construct an evidence-based account for natural phenomena.	**LS3.A: Inheritance of Traits** • Young animals are very much, but not exactly like, their parents. Plants also are very much, but not exactly, like their parents. **LS3.B: Variation of Traits** • Individuals of the same kind of plant or animal are recognizable as similar but can also vary in many ways.	**Patterns** • Patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence.

1. Space Systems: Patterns and Cycles

Students who demonstrate understanding can:

1-ESS1-1

Use observations of the sun, moon, stars, and tides to describe patterns that can be predicted. [Clarification Statement: Examples of patterns could include that the sun and moon appear to rise in one part of the sky, move across the sky, and set; and stars other than our sun are visible at night but not during the day.] [*Assessment Boundary: Assessment of star patterns is limited to stars being seen at night and not during the day. Students not required to know the mechanisms that control tides.*]

1-ESS1-2

Make and graph observations at different times of year to relate the amount of daylight to the time of year, and graph findings. [Clarification Statement: Emphasis is on relative comparisons of the amount of daylight in the winter to the amount in the spring or fall.] [*Assessment Boundary: Assessment is limited to relative amounts of daylight, not quantifying the hours or time of daylight.*]

1-ESS1-1

Students who demonstrate understanding can: Use observations of the sun, moon, stars, and tides to describe patterns that can be predicted.

Clarification Statement: Examples of patterns could include that the sun and moon appear to rise in one part of the sky, move across the sky, and set; and stars other than our sun are visible at night but not during the day.

Assessment Boundary: Assessment of star patterns is limited to stars being seen at night and not during the day. Students not required to know the mechanisms that control tides.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data • Use observations (firsthand or from media) to describe patterns in the natural world in order to answer scientific questions.	**ESS1.A: The Universe and its Stars** • Patterns of the motion of the sun, moon, and stars in the sky can be observed, described, and predicted.	**Patterns** • Patterns in the natural world can be observed, used to describe phenomena, and used as evidence. **Connections to Nature of Science** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Science assumes natural events happen today as they happened in the past. • Many events are repeated.

1-ESS1-2

Students who demonstrate understanding can: Make and graph observations at different times of year to relate the amount of daylight to the time of year, and graph findings.

Clarification Statement: Emphasis is on relative comparisons of the amount of daylight in the winter to the amount in the spring or fall.

Assessment Boundary: Assessment is limited to relative amounts of daylight, not quantifying the hours or time of daylight.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations • Make observations (firsthand or from media) to collect data that can be used to make comparisons.	**ESS1.B: Earth and the Solar System** • Seasonal patterns of sunrise and sunset can be observed, described, and predicted.	**Patterns** • Patterns in the natural world can be observed, used to describe phenomena, and used as evidence.

SECOND GRADE

The performance expectations in second grade help students formulate answers to questions such as: “How does land change and what are some things that cause it to change? What are the different kinds of land and bodies of water? How are materials similar and different from one another, and how do the properties of the materials relate to their use? What do plants need to grow? How many types of living things live in a place?” Second grade performance expectations include PS1, LS2, LS4, ESS1, ESS2, and ETS1

Disciplinary Core Ideas from the NRC Framework. Students are expected to develop an understanding of what plants need to grow and how plants depend on animals for seed dispersal and pollination. Students are also expected to compare the diversity of life in different habitats. An understanding of observable properties of materials is developed by students at this level through analysis and classification of different materials. Students are able to apply their understanding of the idea that wind and water can change the shape of the land to compare design solutions to slow or prevent such change. Students are able to use information and models to identify and represent the shapes and kinds of land and bodies of water in an area and where water is found on Earth.

The crosscutting concepts of patterns; cause and effect; energy and matter; structure and function; stability and change; and influence of engineering, technology, and science on society and the natural world are called out as organizing concepts for these disciplinary core ideas. In the second grade performance expectations, students are expected to demonstrate grade- appropriate proficiency in developing and using models, planning and carrying out investigations, analyzing and interpreting data, constructing explanations and designing solutions, engaging in argument from evidence, and obtaining, evaluating, and communicating information. Students are expected to use these practices to demonstrate understanding of the core ideas.

2. Structure and Properties of Matter

Students who demonstrate understanding can:

2-PS1-1

Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties. [Clarification Statement: Observations could include color, texture, hardness, and flexibility. Patterns could include the similar properties that different materials share.]

2-PS1-2

Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose.* [Clarification Statement: Examples of properties could include, strength, flexibility, hardness, texture, and absorbency.] [*Assessment Boundary: Assessment of quantitative measurements is limited to length.*]

2-PS1-3

Make observations to construct an evidence-based account of how an object made of a small set of pieces can be disassembled and made into a new object. [Clarification Statement: Examples of pieces could include blocks, building bricks, or other assorted small objects.]

2-PS1-4

Construct an argument with evidence that some changes caused by heating or cooling can be reversed and some cannot. [Clarification Statement: Examples of reversible changes could include materials such as water and butter at different temperatures. Examples of irreversible changes could include cooking an egg, freezing a plant leaf, and burning wood.]

2-PS1-1

Students who demonstrate understanding can: Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties.

Clarification Statement: Observations could include color, texture, hardness, and flexibility. Patterns could include the similar properties that different materials share.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations • Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence to answer a question.	**PS1.A: Structure and Properties of Matter** • Different kinds of matter exist and many of them can be either solid or liquid, depending on temperature. Matter can be described and classified by its observable properties.	**Patterns** • Patterns in the natural and human designed world can be observed.

2-PS1-2

Students who demonstrate understanding can: Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose.*

Clarification Statement: Examples of properties could include, strength, flexibility, hardness, texture, and absorbency.

Assessment Boundary: Assessment of quantitative measurements is limited to length.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data • Analyze data from tests of an object or tool to determine if it works as intended.	**PS1.A: Structure and Properties of Matter** • Different properties are suited to different purposes.	**Cause and Effect** • Simple tests can be designed to gather evidence to support or refute student ideas about causes. **Connections to Engineering, Technology, and Applications of Science** **Influence of Engineering, Technology, and Science, on Society and the Natural World** • Every human-made product is designed by applying some knowledge of the natural world and is built using materials derived from the natural world.

2-PS1-3

Students who demonstrate understanding can: Make observations to construct an evidence-based account of how an object made of a small set of pieces can be disassembled and made into a new object.

Clarification Statement: Examples of pieces could include blocks, building bricks, or other assorted small objects.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions • Make observations (firsthand or from media) to construct an evidence-based account for natural phenomena.	**PS1.A: Structure and Properties of Matter** • Different properties are suited to different purposes. • A great variety of objects can be built up from a small set of pieces.	**Energy and Matter** • Objects may break into smaller pieces and be put together into larger pieces, or change shapes. **Connections to Engineering, Technology, and Applications of Science** **Influence of Engineering, Technology, and Science, on Society and the Natural World** • Make observations from several sources to construct an evidence-based account for natural phenomena.

2-PS1-4

Students who demonstrate understanding can: Construct an argument with evidence that some changes caused by heating or cooling can be reversed and some cannot.

Clarification Statement: Examples of reversible changes could include materials such as water and butter at different temperatures. Examples of irreversible changes could include cooking an egg, freezing a plant leaf, and burning wood.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence • Construct an argument with evidence to support a claim. **Connections to Nature of Science** **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** • Science searches for cause and effect relationships to explain natural events.	**PS1.B: Chemical Reactions** • Heating or cooling a substance may cause changes that can be observed. Sometimes these changes are reversible, and sometimes they are not.	**Cause and Effect** • Events have causes that generate observable patterns.

2. Interdependent Relationships in Ecosystems

Students who demonstrate understanding can:

2-LS2-1

Plan and conduct an investigation to determine if plants need sunlight and water to grow. [*Assessment Boundary: Assessment is limited to testing one variable at a time.*]

2-LS2-2

Develop a simple model that mimics the function of an animal in dispersing seeds or pollinating plants.* [Clarification Statement: Examples can include those components that mimic the natural structure of an animal that helps it disperse seeds (e.g., hair that snares seeds, squirrel cheek pouches that transport seeds) or that mimic the natural structure of an animal that helps it pollinate plants (e.g., bees have fuzzy bodies to which pollen sticks, hummingbirds have bills that transport pollen). Explain how the model disperses seeds or pollinates plants.]

2-LS4-1

Make observations of plants and animals to compare the diversity of life in different habitats. [Clarification Statement: Emphasis is on the diversity of living things in each of a variety of different habitats.] [*Assessment Boundary: Assessment does not include specific animal and plant names in specific habitats.*]

2-LS2-1

Students who demonstrate understanding can: Plan and conduct an investigation to determine if plants need sunlight and water to grow.

Assessment Boundary: Assessment is limited to testing one variable at a time.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations • Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence to answer a question.	**LS2.A: Interdependent Relationships in Ecosystems** • Plants depend on water and light to grow.	**Cause and Effect** • Events have causes that generate observable patterns.

2-LS2-2

Students who demonstrate understanding can: Develop a simple model that mimics the function of an animal in dispersing seeds or pollinating plants.*

Clarification Statement: Examples can include those components that mimic the natural structure of an animal that helps it disperse seeds (e.g., hair that snares seeds, squirrel cheek pouches that transport seeds) or that mimic the natural structure of an animal that helps it pollinate plants (e.g., bees have fuzzy bodies to which pollen sticks, hummingbirds have bills that transport pollen). Explain how the model disperses seeds or pollinates plants.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Develop a simple model based on evidence to represent a proposed object or tool.	**LS2.A: Interdependent Relationships in Ecosystems** • Plants depend on animals for pollination or to move their seeds around. **ETS1.B: Developing Possible Solutions** • Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people. *(secondary)*	**Structure and Function** • The shape and stability of structures of natural and designed objects are related to their function(s).

2-LS4-1

Students who demonstrate understanding can: Make observations of plants and animals to compare the diversity of life in different habitats.

Clarification Statement: Emphasis is on the diversity of living things in each of a variety of different habitats.

Assessment Boundary: Assessment does not include specific animal and plant names in specific habitats.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations • Make observations (firsthand or from media) to collect data which can be used to make comparisons. **Connections to Nature of Science** **Scientific Knowledge is Based on Empirical Evidence** • Scientists look for patterns and order when making observations about the world.	**LS4.D: Biodiversity and Humans** • There are many different kinds of living things in any area, and they exist in different places on land and in water.	

2. Earth's Systems: Processes that Shape the Earth

Students who demonstrate understanding can:

2-ESS1-1

Use information from several sources to provide evidence that Earth events can occur quickly or slowly. [Clarification Statement: Examples of events and timescales could include volcanic explosions, earthquakes, tsunamis, avalanches, and landslides, which happen quickly and events such as erosion of rocks and movement of glaciers, which occur slowly.] [*Assessment Boundary: Assessment does not include quantitative measurements of timescales.*]

2-ESS2-1

Compare multiple solutions designed to slow or prevent wind or water from changing the shape of the land.* [Clarification Statement: Examples of solutions could include different designs of dikes and windbreaks to hold back wind and water, and different designs for using shrubs, grass, and trees to hold back the land. Discuss the solutions for controlling erosion.]

2-ESS2-2

Develop a model to represent the shapes and kinds of land and bodies of water in an area. [Clarifying Statement: Discuss the features of the models.] [*Assessment Boundary: Assessment does not include quantitative scaling in models.*]

2-ESS2-3

Obtain information to identify where water is found on Earth and that it can be solid or liquid.

2-ESS1-1

Students who demonstrate understanding can: Use information from several sources to provide evidence that Earth events can occur quickly or slowly.

Clarification Statement: Examples of events and timescales could include volcanic explosions, earthquakes, tsunamis, avalanches, and landslides, which happen quickly and events such as erosion of rocks and movement of glaciers, which occur slowly.

Assessment Boundary: Assessment does not include quantitative measurements of timescales.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions • Make observations from several sources to construct an evidence-based account for natural phenomena.	**ESS1.C: The History of Planet Earth** • Some events happen very quickly; others occur very slowly, over a time period much longer than one can observe.	**Stability and Change** • Things may change slowly or rapidly.

2-ESS2-1

Students who demonstrate understanding can: Compare multiple solutions designed to slow or prevent wind or water from changing the shape of the land.*

Clarification Statement: Examples of solutions could include different designs of dikes and windbreaks to hold back wind and water, and different designs for using shrubs, grass, and trees to hold back the land. Discuss the solutions for controlling erosion.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions • Compare multiple solutions to a problem.	**ESS2.A: Earth Materials and Systems** • Wind and water can change the shape of the land. **ETS1.C: Optimizing the Design Solution** • Because there is always more than one possible solution to a problem, it is useful to compare and test designs. *(secondary)*	**Stability and Change** • Things may change slowly or rapidly. **Connections to Engineering, Technology, and Applications of Science** **Influence of Engineering, Technology, and Science on Society and the Natural World** • Developing and using technology has impacts on the natural world. **Connections to Nature of Science** **Science Addresses Questions About the Natural and Material World** • Scientists study the natural and material world.

2-ESS2-2

Students who demonstrate mastery can: Develop a model to represent the shapes and kinds of land and bodies of water in an area.

Clarification Statement: Discuss the features of the models.

Assessment Boundary: Assessment does not include quantitative scaling in models.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Develop a model to represent patterns in the natural world.	**ESS2.B: Plate Tectonics and Large-Scale System Interactions** • Maps show where things are located. One can map the shapes and kinds of land and water in any area.	**Patterns** • Patterns in the natural world can be observed.

2-ESS2-3

Students who demonstrate mastery can: Obtain information to identify where water is found on Earth and that it can be solid or liquid.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Obtaining, Evaluating, and Communicating Information • Obtain information using various texts, text features (e.g., headings, tables of contents, glossaries, electronic menus, icons), and other media that will be useful in answering a scientific question.	**ESS2.C: The Roles of Water in Earth's Surface Processes** • Water is found in the ocean, rivers, lakes, and ponds. Water exists as solid ice and in liquid form.	**Patterns** • Patterns in the natural world can be observed.

K-2.Engineering Design

Students who demonstrate understanding can:

K-2-ETS1-1

Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.

K-2-ETS1-2

Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem. [Clarifying Statement: Explain how the model functions to solve the problem.]

K-2-ETS1-3

Analyze and discuss data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.

K-2-ETS1-1

Students who demonstrate understanding can: Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Asking Questions and Defining Problems • Ask questions based on observations to find more information about the natural and/or designed world(s). • Define a simple problem that can be solved through the development of a new or improved object or tool.	**ETS1.A: Defining and Delimiting Engineering Problems** • A situation that people want to change or create can be approached as a problem to be solved through engineering. • Asking questions, making observations, and gathering information are helpful in thinking about problems. • Before beginning to design a solution, it is important to clearly understand the problem.	

K-2-ETS1-2

Students who demonstrate understanding can: Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.

Clarifying Statement: Explain how the model functions to solve the problem.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Develop a simple model based on evidence to represent a proposed object or tool.	**ETS1.B: Developing Possible Solutions** • Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people.	**Structure and Function** • The shape and stability of structures of natural and designed objects are related to their function(s).

K-2-ETS1-3

Students who demonstrate understanding can: Analyze and discuss data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data • Analyze data from tests of an object or tool to determine if it works as intended.	**ETS1.C: Optimizing the Design Solution** • Because there is always more than one possible solution to a problem, it is useful to compare and test designs.	

THIRD GRADE

The performance expectations in third grade help students formulate answers to questions such as: "What is typical weather in different parts of the world and during different times of the year? How can the impact of weather-related hazards be reduced? How do organisms vary in their traits? How are plants, animals, and environments of the past similar or different from current plants, animals, and environments? What happens to organisms when their environment changes? How do equal and unequal forces on an object affect the object? How can magnets be used?" Third grade performance expectations include PS2, LS1, LS2, LS3, LS4, ESS2, and ESS3.

Disciplinary Core Ideas from the NRC Framework. Students are able to organize and use data to describe typical weather conditions expected during a particular season. By applying their understanding of weather-related hazards, students are able to make a claim about the merit of a design solution that reduces the impacts of such hazards. Students are expected to develop an understanding of the similarities and differences of organisms' life cycles. An understanding that organisms have different inherited traits, and that the environment can also affect the traits that an organism develops, is acquired by students at this level. In addition, students are able to construct an explanation using evidence for how the variations in characteristics among individuals of the same species may provide advantages in surviving, finding mates, and reproducing. Students are expected to develop an understanding of types of organisms that lived long ago and also about the nature of their environments. Third graders are expected to develop an understanding of the idea that when the environment changes some organisms survive and reproduce, some move to new locations, some move into the transformed environment, and some die. Students are able to determine the effects of balanced and unbalanced forces on the motion of an object and the cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other. They are then able to apply their understanding of magnetic interactions to define a simple design problem that can be solved with magnets.

The crosscutting concepts of patterns; cause and effect; scale, proportion, and quantity; systems and system models; interdependence of science, engineering, and technology; and influence of engineering, technology, and science on society and the natural world are called out as organizing concepts for these disciplinary core ideas. In the third grade performance expectations, students are expected to demonstrate grade-appropriate proficiency in asking questions and defining problems; developing and using models, planning and carrying out investigations, analyzing and interpreting data, constructing explanations and designing solutions, engaging in argument from evidence, and obtaining, evaluating, and communicating information. Students are expected to use these practices to demonstrate understanding of the core ideas.

3. Forces and Interactions

Students who demonstrate understanding can:

3-PS2-1

Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object. [Clarification Statement: Examples could include an unbalanced force on one side of a ball can make it start moving; and, balanced forces pushing on a box from both sides will not produce any motion at all.] [*Assessment Boundary: Assessment is limited to one variable at a time: number, size, or direction of forces. Assessment does not include quantitative force size, only qualitative and relative. Assessment is limited to gravity being addressed as a force that pulls objects down.*]

3-PS2-2

Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion. [Clarification Statement: Examples of motion with a predictable pattern could include a child swinging in a swing, a ball rolling back and forth in a bowl, and two children on a see-saw.] [*Assessment Boundary: Assessment does not include technical terms such as period and frequency.*]

3-PS2-3

Ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other. [Clarification Statement: Examples of an electric force could include the force on hair from an electrically charged balloon and the electrical forces between a charged rod and pieces of paper; examples of a magnetic force could include the force between two permanent magnets, the force between an electromagnet and steel paperclips, and the force exerted by one magnet versus the force exerted by two magnets. Examples of cause and effect relationships could include how the distance between objects affects strength of the force and how the orientation of magnets affects the direction of the magnetic force.] [*Assessment Boundary: Assessment is limited to forces produced by objects that can be manipulated by students, and electrical interactions are limited to static electricity.*]

3-PS2-4

Define a simple design problem that can be solved by applying scientific ideas about magnets.* [Clarification Statement: Examples of problems could include constructing a latch to keep a door shut and creating a device to keep two moving objects from touching each other.]

3-PS2-1

Students who demonstrate understanding can: Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.

Clarification Statement: Examples could include an unbalanced force on one side of a ball can make it start moving; and, balanced forces pushing on a box from both sides will not produce any motion at all.

Assessment Boundary: Assessment is limited to one variable at a time: number, size, or direction of forces. Assessment does not include quantitative force size, only qualitative and relative. Assessment is limited to gravity being addressed as a force that pulls objects down.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations • Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. **Connections to the Nature of Science** **Scientific Investigations Use a Variety of Methods** • Scientific investigations use a variety of methods, tools, and techniques.	**PS2.A: Forces and Motion** • Each force acts on one particular object and has both strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the object's speed or direction of motion. (Boundary: Qualitative and conceptual, but not quantitative addition of forces are used at this level.) **PS2.B: Types of Interactions** • Objects in contact exert forces on each other.	**Cause and Effect** • Cause and effect relationships are routinely identified.

3-PS2-2

Students who demonstrate understanding can: Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion.

Clarification Statement: Examples of motion with a predictable pattern could include a child swinging in a swing, a ball rolling back and forth in a bowl, and two children on a see-saw.

Assessment Boundary: Assessment does not include technical terms such as period and frequency.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations • Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution. **Connections to the Nature of Science** **Scientific Knowledge is Based on Empirical Evidence** • Science findings are based on recognizing patterns.	**PS2.A: Forces and Motion** • The patterns of an object's motion in various situations can be observed and measured; when that past motion exhibits a regular pattern, future motion can be predicted from it. (Boundary: Technical terms, such as magnitude, velocity, momentum, and vector quantity, are not introduced at this level, but the concept that some quantities need both size and direction to be described is developed.)	**Patterns** • Patterns of change can be used to make predictions.

3-PS2-3

Students who demonstrate understanding can: Ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other.

Clarification Statement: Examples of an electric force could include the force on hair from an electrically charged balloon and the electrical forces between a charged rod and pieces of paper; examples of a magnetic force could include the force between two permanent magnets, the force between an electromagnet and steel paperclips, and the force exerted by one magnet versus the force exerted by two magnets. Examples of cause and effect relationships could include how the distance between objects affects strength of the force and how the orientation of magnets affects the direction of the magnetic force.

Assessment Boundary: Assessment is limited to forces produced by objects that can be manipulated by students, and electrical interactions are limited to static electricity.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Asking Questions and Defining Problems • Ask questions that can be investigated based on patterns such as cause and effect relationships.	**PS2.B: Types of Interactions** • Electric, and magnetic forces between a pair of objects do not require that the objects be in contact. The sizes of the forces in each situation depend on the properties of the objects and their distances apart and, for forces between two magnets, on their orientation relative to each other.	**Cause and Effect** • Cause and effect relationships are routinely identified, tested, and used to explain change.

3-PS2-4

Students who demonstrate understanding can: Define a simple design problem that can be solved by applying scientific ideas about magnets.*

Clarification Statement: Examples of problems could include constructing a latch to keep a door shut and creating a device to keep two moving objects from touching each other.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Asking Questions and Defining Problems • Define a simple problem that can be solved through the development of a new or improved object or tool.	**PS2.B: Types of Interactions** • Electrical and magnetic forces between a pair of objects do not require that the objects b in contact. The sizes of the forces in each situation depend on the properties of the objects and their distances apart and, for forces between two magnets, on their orientation relative to each other.	**Connections to Engineering, Technology, and Applications of Science** **Interdependence of Science, Engineering, and Technology** • Scientific discoveries about the natural world can often lead to new and improved technologies, which are developed through the engineering design process.

3. Interdependent Relationships in Ecosystems: Environmental Impacts on Organisms

Students who demonstrate understanding can:

3-LS2-1

Construct an argument that some animals form groups that help members survive. [Clarification Statement: Alaska examples may include wolves, musk ox, caribou, and schools of fish.]

3-LS4-1

Analyze and interpret data from fossils to provide evidence of the organisms and the environments in which they lived long ago. [Clarification Statement: Examples of data could include type, size, and distributions of fossil organisms. Examples of fossils and environments could include marine fossils found on dry land, tropical plant fossils found in Arctic areas, and fossils of extinct organisms.] [*Assessment Boundary: Assessment does not include identification of specific fossils or present plants and animals. Assessment is limited to major fossil types and relative ages.*]

3-LS4-3

Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all. [Clarification Statement: Examples of evidence could include needs and characteristics of the organisms and habitats involved. The organisms and their habitat make up a system in which the parts depend on each other.]

3-LS4-4

Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.* [Clarification Statement: Examples of environmental changes could include changes in land characteristics, water distribution, temperature, food, and other organisms. Solution may be created or provided. Students evaluate the solution to the problem to determine the merit of the solution. Students describe how well the proposed solution meets the given criteria and constraints to reduce the impact of the problem created by the environmental change in the system.] [*Assessment Boundary: Assessment is limited to a single environmental change. Assessment does not include the greenhouse effect or climate change*.]

3-LS2-1

Students who demonstrate understanding can: Construct an argument that some animals form groups that help members survive.

Clarification Statement: Alaska examples may include wolves, musk ox, caribou, and schools of fish.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence • Construct an argument with evidence, data, and/or a model.	**LS2.D: Social Interactions and Group Behavior** • Being part of a group helps animals obtain food, defend themselves, and cope with changes. Groups may serve different functions and vary dramatically in size. (*Note: Moved from K–2*)	**Cause and Effect** • Cause and effect relationships are routinely identified and used to explain change.

3-LS4-1

Students who demonstrate understanding can: Analyze and interpret data from fossils to provide evidence of the organisms and the environments in which they lived long ago.

Clarification Statement: Examples of data could include type, size, and distributions of fossil organisms. Examples of fossils and environments could include marine fossils found on dry land, tropical plant fossils found in Arctic areas, and fossils of extinct organisms.

Assessment Boundary: Assessment does not include identification of specific fossils or present plants and animals. Assessment is limited to major fossil types and relative ages.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data • Analyze and interpret data to make sense of phenomena using logical reasoning.	**LS4.A: Evidence of Common Ancestry and Diversity** • Some kinds of plants and animals that once lived on Earth are no longer found anywhere. (*Note: moved from K-2*) • Fossils provide evidence about the types of organisms that lived long ago and also about the nature of their environments.	**Scale, Proportion, and Quantity** • Observable phenomena exist from very short to very long time periods. **Connections to Engineering, Technology, and Application of Science** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Science assumes a consistent pattern in natural systems.

3-LS4-3

Students who demonstrate understanding can: Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all.

Clarification Statement: Examples of evidence could include needs and characteristics of the organisms and habitats involved. The organisms and their habitat make up a system in which the parts depend on each other.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence • Construct an argument with evidence.	**LS4.C: Adaptation** • For any particular environment, some kinds of organisms survive well, some survive less well, and some cannot survive at all.	**Cause and Effect** • Cause and effect relationships are routinely identified and used to explain change. **Connections to Engineering, Technology, and Application of Science** **Interdependence of Science, Engineering, and Technology** • Knowledge of relevant scientific concepts and research findings is important to engineering. **Connection to Nature of Science** **Science is a Human Endeavor** • Most scientists and engineers work in teams.

3-LS4-4

Students who demonstrate understanding can: Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.*

Clarification Statement: Examples of environmental changes could include changes in land characteristics, water distribution, temperature, food, and other organisms. Solution may be created or provided. Students evaluate the solution to the problem to determine the merit of the solution. Students describe how well the proposed solution meets the given criteria and constraints to reduce the impact of the problem created by the environmental change in the system.

Assessment Boundary: Assessment is limited to a single environmental change. Assessment does not include the greenhouse effect or climate change.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence • Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem.	**LS2.C: Ecosystem Dynamics, Functioning, and Resilience** • When the environment changes in ways that affect a place's physical characteristics, temperature, or availability of resources, some organisms survive and reproduce, others move to new locations, yet others move into the transformed environment, and some die. (*secondary*) **LS4.D: Biodiversity and Humans** • Populations live in a variety of habitats, and change in those habitats affects the organisms living there.	**Systems and System Models** • A system can be described in terms of its components and their interactions.

3. Inheritance and Variation of Traits: Life Cycles and Traits

Students who demonstrate understanding can:

3-LS1-1

Develop models to describe that organisms have unique and diverse life cycles but all have in common birth, growth, reproduction, and death. [Clarification Statement: Changes organisms, such as salmon, wooly bear caterpillar, frogs, go through during their life form a pattern.] [*Assessment Boundary: Assessment of plant life cycles is limited to those of flowering plants. Assessment does not include details of human reproduction*.]

3-LS3-1

Analyze and interpret data to provide evidence that plants and animals have traits inherited from parents and that variation of these traits exists in a group of similar organisms. [Clarification Statement: Patterns are the similarities and differences in traits shared between offspring and their parents, or among siblings. Emphasis is on organisms other than humans.] [*Assessment Boundary: Assessment does not include genetic mechanisms of inheritance and prediction of traits. Assessment is limited to non-human examples*.]

3-LS3-2

Use evidence to support the explanation that traits can be influenced by the environment. [Clarification Statement: Examples of the environment affecting a trait could include normally tall plants grown with insufficient water are stunted; a pet dog that is given too much food and little exercise may become overweight; and, comparison of plants and animals in Arctic regions versus non-Arctic regions.]

3-LS4-2

Use evidence to construct an explanation for how the variations in characteristics among individuals of the same species may provide advantages in surviving, finding mates, and reproducing. [Clarification Statement: Examples of cause and effect relationships could be plants that have larger thorns than other plants may be less likely to be eaten by predators; and, animals that have better camouflage coloration than other animals may be more likely to survive and therefore more likely to leave offspring.]

3-LS1-1

Students who demonstrate understanding can: Develop models to describe that organisms have unique and diverse life cycles but all have in common birth, growth, reproduction, and death.

Clarification Statement: Changes organisms, such as salmon, wooly bear caterpillar, frogs, go through during their life form a pattern.

Assessment Boundary: Assessment of plant life cycles is limited to those of flowering plants. Assessment does not include details of human reproduction.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Develop models to describe phenomena. **Connections to Nature of Science** **Scientific Knowledge is Based on Empirical Evidence** • Science findings are based on recognizing patterns.	**LS1.B: Growth and Development of Organisms** • Reproduction is essential to the continued existence of every kind of organism. Plants and animals have unique and diverse life cycles.	**Patterns** • Patterns of change can be used to make predictions.

3-LS3-1

Students who demonstrate understanding can: Analyze and interpret data to provide evidence that plants and animals have traits inherited from parents and that variation of these traits exists in a group of similar organisms.

Clarification Statement: Patterns are the similarities and differences in traits shared between offspring and their parents, or among siblings. Emphasis is on organisms other than humans.

Assessment Boundary: Assessment does not include genetic mechanisms of inheritance and prediction of traits. Assessment is limited to non-human examples.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data • Analyze and interpret data to make sense of phenomena using logical reasoning.	**LS3.A: Inheritance of Traits** • Many characteristics of organisms are inherited from their parents. **LS3.B: Variation of Traits** • Different organisms vary in how they look and function because they have different inherited information.	**Patterns** • Similarities and differences in patterns can be used to sort and classify natural phenomena.

3-LS3-2

Students who demonstrate understanding can: Use evidence to support the explanation that traits can be influenced by the environment.

Clarification Statement: Examples of the environment affecting a trait could include normally tall plants grown with insufficient water are stunted; a pet dog that is given too much food and little exercise may become overweight; and, comparison of plants and animals in Arctic regions versus non-Arctic regions.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions • Use evidence (e.g., observations, patterns) to support an explanation.	**LS3.A: Inheritance of Traits** • Other characteristics result from individuals' interactions with the environment, which can range from diet to learning. Many characteristics involve both inheritance and environment. **LS3.B: Variation of Traits** • The environment also affects the traits that an organism develops.	**Cause and Effect** • Cause and effect relationships are routinely identified and used to explain change.

3-LS4-2

Students who demonstrate understanding can: Use evidence to construct an explanation for how the variations in characteristics among individuals of the same species may provide advantages in surviving, finding mates, and reproducing.

Clarification Statement: Examples of cause and effect relationships could be plants that have larger thorns than other plants may be less likely to be eaten by predators; and, animals that have better camouflage coloration than other animals may be more likely to survive and therefore more likely to leave offspring.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions • Use evidence (e.g., observations, patterns) to construct an explanation.	**LS4.B: Natural Selection** • Sometimes the differences in characteristics between individuals of the same species provide advantages in surviving, finding mates, and reproducing.	**Cause and Effect** • Cause and effect relationships are routinely identified and used to explain change.

3. Weather and Climate

Students who demonstrate understanding can:

3-ESS2-1

Represent data in tables and graphical displays to describe typical weather conditions expected during a particular season. [Clarification Statement: Examples of data at this grade level could include student-generated graphs of average temperature, precipitation, and wind direction.] [*Assessment Boundary: Assessment of graphical displays is limited to pictographs and bar graphs. Assessment does not include climate change*.]

3-ESS2-2

Obtain and combine information to describe climates in different regions of the world.

3-ESS3-1

Make a claim about the merit of a design solution that reduces the impacts of a weather-related hazard.* [Clarification Statement: Examples of design solutions to weather-related hazards could include barriers to prevent storm erosion or flooding (e.g., from storm surges), or buildup of snow drifts; wind resistant roofs, lightning rods, and other weather hazards such as white-out conditions.]

3-ESS2-1

Students who demonstrate understanding can: Represent data in tables and graphical displays to describe typical weather conditions expected during a particular season.

Clarification Statement: Examples of data at this grade level could include student-generated graphs of average temperature, precipitation, and wind direction.

Assessment Boundary: Assessment of graphical displays is limited to pictographs and bar graphs. Assessment does not include climate change.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data • Represent data in tables and various graphical displays (bar graphs and pictographs) to reveal patterns that indicate relationships.	**ESS2.D: Weather and Climate** • Scientists record patterns of the weather across different times and areas so that they can make predictions about what kind of weather might happen next.	**Patterns** • Patterns of change can be used to make predictions.

3-ESS2-2

Students who demonstrate understanding can: Obtain and combine information to describe climates in different regions of the world.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Obtaining, Evaluating, and Communicating Information • Obtain and combine information from books and other reliable media to explain phenomena.	**ESS2.D: Weather and Climate** • Climate describes a range of an area's typical weather conditions and the extent to which those conditions vary over years.	**Patterns** • Patterns of change can be used to make predictions.

3-ESS3-1

Students who demonstrate understanding can: Make a claim about the merit of a design solution that reduces the impacts of a weather-related hazard.*

Clarification Statement: Examples of design solutions to weather-related hazards could include barriers to prevent storm erosion or flooding (e.g., from storm surges), or buildup of snow drifts; wind resistant roofs, lightning rods, and other weather hazards such as white-out conditions.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence • Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem.	**ESS3.B: Natural Hazards** • A variety of natural hazards result from natural processes. Humans cannot eliminate natural hazards but can take steps to reduce their impacts. (*Note: This Disciplinary Core Idea is also addressed by 4-ESS3-2.*)	**Cause and Effect** • Cause and effect relationships are routinely identified, tested, and used to explain change. **Connections to Engineering, Technology, and Application of Science** **Influence of Engineering, Technology, and Science on Society and the Natural World** • Engineers improve existing technologies or develop new ones to increase their benefits (e.g. better artificial limbs), decrease known risks (e.g. seatbelts in cars), and meet societal demands (e.g. cell phones). **Connections to Nature of Science** **Science is a Human Endeavor** • Science affects everyday life.

FOURTH GRADE

The performance expectations in fourth grade help students formulate answers to questions such as: “What are waves and what are some things they can do? How can water, ice, wind and vegetation change the land? What patterns of Earth’s features can be determined with the use of maps? How do internal and external structures support the survival, growth, behavior, and reproduction of plants and animals? What is energy and how is it related to motion? How is energy transferred? How can energy be used to solve a problem?” Fourth grade performance expectations include PS3, PS4, LS1, ESS1, ESS2, ESS3, and ETS1

Disciplinary Core Ideas from the NRC Framework. Students are able to use a model of waves to describe patterns of waves in terms of amplitude and wavelength, and that waves can cause objects to move. Students are expected to develop understanding of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation. They apply their knowledge of natural Earth processes to generate and compare multiple solutions to reduce the impacts of such processes on humans. In order to describe patterns of Earth’s features, students analyze and interpret data from maps. Fourth graders are expected to develop an understanding that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction. By developing a model, they describe that an object can be seen when light reflected from its surface enters the eye. Students are able to use evidence to construct an explanation of the relationship between the speed of an object and the energy of that object. Students are expected to develop an understanding that energy can be transferred from place to place by sound, light, heat, and electric currents or from object to object through collisions. They apply their understanding of energy to design, test, and refine a device that converts energy from one form to another.

The crosscutting concepts of patterns; cause and effect; energy and matter; systems and system models; interdependence of science, engineering, and technology; and influence of engineering, technology, and science on society and the natural world are called out as organizing concepts for these disciplinary core ideas. In the fourth grade performance expectations, students are expected to demonstrate grade-appropriate proficiency in asking questions, developing and using models, planning and carrying out investigations, analyzing and interpreting data, constructing explanations and designing solutions, engaging in argument from evidence, and obtaining, evaluating, and communicating information. Students are expected to use these practices to demonstrate understanding of the core ideas.

4. Energy

Students who demonstrate understanding can:

4-PS3-1

Use evidence to construct an explanation relating the speed of an object to the energy of that object. [*Assessment Boundary: Assessment does not include quantitative measures of changes in the speed of an object or on any precise or quantitative definition of energy*.]

4-PS3-2

Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents. [*Assessment Boundary: Assessment does not include quantitative measurements of energy*.]

4-PS3-3

Ask questions and predict outcomes about the changes in energy that occur when objects collide. [Clarification Statement: Emphasis is on the change in the energy due to the change in speed, not on the forces, as objects interact. Examples may be at different scales, such as bouncing balls, car crashes, and plate tectonics (e.g., collisions of land to land, ice to ice, and ice to land).] [*Assessment Boundary: Assessment does not include quantitative measurements of energy*.]

4-PS3-4

Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.* [Clarification Statement: Examples of devices could include electric circuits that convert electrical energy into motion energy of a vehicle, light, or sound; and, a passive solar heater that converts light into heat. Examples of constraints could include the materials, cost, or time to design the device.] [*Assessment Boundary: Devices should be limited to those that convert motion energy to electric energy or use stored energy to cause motion or produce light or sound*.]

4-ESS3-1

Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment. [Clarification Statement: Examples of renewable energy resources could include wind energy, water behind dams, tidal, geothermal, and sunlight; non-renewable energy resources are fossil fuels and fissile materials. Examples of environmental effects could include loss of habitat due to dams, loss of habitat due to surface mining, and air pollution from burning of fossil fuels.]

4-PS3-1

Students who demonstrate understanding can: Use evidence to construct an explanation relating the speed of an object to the energy of that object.

Assessment Boundary: Assessment does not include quantitative measures of changes in the speed of an object or on any precise or quantitative definition of energy.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions • Use evidence (e.g., measurements, observations, patterns) to construct an explanation	**PS3.A: Definitions of Energy** • The faster a given object is moving, the more energy it possesses.	**Energy and Matter** • Energy can be transferred in various ways and between objects.

4-PS3-2

Students who demonstrate understanding can: Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.

Assessment Boundary: Assessment does not include quantitative measurements of energy.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations • Make observations to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution.	**PS3.A: Definitions of Energy** • Energy can be moved from place to place by moving objects or through sound, light, or electric currents. **PS3.B: Conservation of Energy and Energy Transfer** • Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced. • Light also transfers energy from place to place. • Energy can also be transferred from place to place by electric currents, which can then be used locally to produce motion, sound, heat, or light. The currents may have been produced to begin with by transforming the energy of motion into electrical energy.	**Energy and Matter** • Energy can be transferred in various ways and between objects.

4-PS3-3

Students who demonstrate understanding can: Ask questions and predict outcomes about the changes in energy that occur when objects collide.

Clarification Statement: Emphasis is on the change in the energy due to the change in speed, not on the forces, as objects interact. Examples may be at different scales, such as bouncing balls, car crashes, and plate tectonics (e.g., collisions of land to land, ice to ice, and ice to land).

Assessment Boundary: Assessment does not include quantitative measurements of energy.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Asking Questions and Defining Problems • Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships.	**PS3.A: Definitions of Energy** • Energy can be moved from place to place by moving objects or through sound, light, or electric currents. **PS3.B: Conservation of Energy and Energy Transfer** • Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced. **PS3.C: Relationship Between Energy and Forces** • When objects collide, the contact forces transfer energy so as to change the objects' motions.	**Energy and Matter** • Energy can be transferred in various ways and between objects.

4-PS3-4

Students who demonstrate understanding can: Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.*

Clarification Statement: Examples of devices could include electric circuits that convert electrical energy into motion energy of a vehicle, light, or sound; and, a passive solar heater that converts light into heat. Examples of constraints could include the materials, cost, or time to design the device.

Assessment Boundary: Devices should be limited to those that convert motion energy to electric energy or use stored energy to cause motion or produce light or sound.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions • Apply scientific ideas to solve design problems.	**PS3.B: Conservation of Energy and Energy Transfer** • Energy can also be transferred from place to place by electric currents, which can then be used locally to produce motion, sound, heat, or light. The currents may have been produced to begin with by transforming the energy of motion into electrical energy. **PS3.D: Energy in Chemical Processes and Everyday Life** • The expression “produce energy” typically refers to the conversion of stored energy into a desired form for practical use. ≚	**Energy and Matter** • Energy can be transferred in various ways and between objects. **Connections to Engineering, Technology, and Application of Science** **Influence of Science, Engineering, and Technology on Society and the Natural World** • Engineers improve existing technologies or develop new ones **Connections to Nature of Science** **Science is a Human Endeavor** • Most scientists and engineers work in teams. • Science affects everyday life.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
	ETS1.A: Defining Engineering Problems • Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (*Secondary*)	

4-ESS3-1

Students who demonstrate understanding can: Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.

Clarification Statement: Examples of renewable energy resources could include wind energy, water behind dams, tidal, geothermal, and sunlight; non-renewable energy resources are fossil fuels and fissile materials. Examples of environmental effects could include loss of habitat due to dams, loss of habitat due to surface mining, and air pollution from burning of fossil fuels.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Obtaining, Evaluating, and Communicating Information • Obtain and combine information from books and other reliable media to explain phenomena.	**ESS3.A: Natural Resources** • Energy and fuels that humans use are derived from natural sources, and their use affects the environment in multiple ways. Some resources are renewable over time, and others	**Cause and Effect** • Cause and effect relationships are routinely identified and used to explain change. **Connections to Engineering, Technology, and Application of Science** **Interdependence of Science, Engineering, and Technology** • Knowledge of relevant scientific concepts and research findings is important in engineering. **Influence of Science, Engineering, and Technology on Society and the Natural World** • Over time, people's needs and wants change, as do their demands for new and improved technologies.

4. Waves

Students who demonstrate understanding can:

4-PS4-1

Develop and use a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move. [Clarification Statement: Examples of models could include diagrams, analogies, and physical models using wire to illustrate wavelength and amplitude of waves.] [*Assessment Boundary: Assessment does not include interference effects, electromagnetic waves, non-periodic waves, or quantitative models of amplitude and wavelength*.]

4-PS4-3

Generate and compare multiple solutions that use patterns to transfer information.* [Clarification Statement: Examples of solutions could include drums sending coded information through sound waves, using a grid of 1's and 0's representing black and white to send information about a picture, and using Morse code to send text.]

4-PS4-1

Students who demonstrate understanding can: Develop and use a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move.

Clarification Statement: Examples of models could include diagrams, analogies, and physical models using wire to illustrate wavelength and amplitude of waves.

Assessment Boundary: Assessment does not include interference effects, electromagnetic waves, non-periodic waves, or quantitative models of amplitude and wavelength.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Develop a model using an analogy, example, or abstract representation to describe a scientific principle. **Connections to Nature of Science** **Scientific Knowledge is Based on Empirical Evidence** • Science findings are based on recognizing patterns.	**PS4.A: Wave Properties** • Waves, which are regular patterns of motion, can be made in water by disturbing the surface. When waves move across the surface of deep water, the water goes up and down in place; there is no net motion in the direction of the wave except when the water meets a beach. (*Note: This grade band endpoint was moved from K–2*.) • Waves of the same type can differ in amplitude (height of the wave) and wavelength (spacing between wave peaks).	**Patterns** • Similarities and differences in patterns can be used to sort, classify, and analyze simple rates of change for natural phenomena.

4-PS4-3

Students who demonstrate understanding can: Generate and compare multiple solutions that use patterns to transfer information.*

Clarification Statement: Examples of solutions could include drums sending coded information through sound waves, using a grid of 1's and 0's representing black and white to send information about a picture, and using Morse code to send text.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions • Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution.	**PS4.C: Information Technologies and Instrumentation** • Digitized information can be transmitted over long distances without significant degradation. High-tech devices, such as computers or cell phones, can receive and decode information—convert it from digitized form to voice—and vice versa. **ETS1.C: Optimizing The Design Solution** • Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (*Secondary*)	**Patterns** • Similarities and differences in patterns can be used to sort and classify designed products. **Connections to Engineering, Technology, and Application of Science** **Interdependence of Science, Engineering, and Technology** • Knowledge of relevant scientific concepts and research findings is important in engineering.

4. Structure, Function, and Information Processing

Students who demonstrate understanding can:

4-PS4-2

Develop a model to describe that light reflecting from objects and entering the eye allows objects to be seen. [*Assessment Boundary: Assessment does not include knowledge of specific colors reflected and seen, the cellular mechanisms of vision, or how the retina works*.]

4-LS1-1

Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction. [Clarification Statement: Examples of structures could include thorns, stems, roots, colored petals, heart, stomach, lung, brain, skin, gills, scales, and bones.] [*Assessment Boundary: Assessment is limited to macroscopic structures within plant and animal systems.*]

4-LS1-2

Use a model to describe that animals receive different types of information through their senses, process the information in their brain, and respond to the information in different ways. [Clarification Statement: Emphasis is on systems of information transfer. Examples may include salmon homing, responses of marine invertebrates to sound and smell, and sonar communication among whales and other marine mammals.] [*Assessment Boundary: Assessment does not include the mechanisms by which the brain stores and recalls information or the mechanisms of how sensory receptors function*.]

4-PS4-2

Students who demonstrate understanding can: Develop a model to describe that light reflecting from objects and entering the eye allows objects to be seen.

Assessment Boundary: Assessment does not include knowledge of specific colors reflected and seen, the cellular mechanisms of vision, or how the retina works.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Develop a model to describe phenomena.	**PS4.B: Electromagnetic Radiation** • An object can be seen when light reflected from its surface enters the eyes.	**Cause and Effect** • Cause and effect relationships are routinely identified.

4-LS1-1

Students who demonstrate understanding can: Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.

Clarification Statement: Examples of structures could include thorns, stems, roots, colored petals, heart, stomach, lung, brain, skin, gills, scales, and bones.

Assessment Boundary: Assessment is limited to macroscopic structures within plant and animal systems.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence • Construct an argument with evidence, data, and/or a model.	**LS1.A: Structure and Function** • Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction.	**Systems and System Models** • A system can be described in terms of its components and their interactions.

4-LS1-2

Students who demonstrate understanding can: Use a model to describe that animals receive different types of information through their senses, process the information in their brain, and respond to the information in different ways.

Clarification Statement: Emphasis is on systems of information transfer. Examples may include salmon homing, responses of marine invertebrates to sound and smell, and sonar communication among whales and other marine mammals.

Assessment Boundary: Assessment does not include the mechanisms by which the brain stores and recalls information or the mechanisms of how sensory receptors function.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Use a model to test interactions concerning the functioning of a natural system.	**LS1.D: Information Processing** • Different sense receptors are specialized for particular kinds of information, which may be then processed by the animal's brain. Animals are able to use their perceptions and memories to guide their actions.	**Systems and System Models** • A system can be described in terms of its components and their interactions.

4. Earth's Systems: Processes that Shape the Earth

Students who demonstrate understanding can:

4-ESS1-1

Identify evidence from patterns in rock formations and fossils in rock layers to support an explanation for changes in a landscape over time. [Clarification Statement: Examples of evidence from patterns could include rock layers with marine shell fossils above rock layers with plant fossils and no shells, indicating a change from land to water over time; a canyon with different rock layers in the walls and a river in the bottom, indicating that over time a river cut through the rock.] [*Assessment Boundary: Assessment does not include specific knowledge of the mechanism of rock formation or memorization of specific rock formations and layers. Assessment is limited to relative time*.]

4-ESS2-1

Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation. [Clarification Statement: Examples of variables to test could include angle of slope in the downhill movement of water, amount of vegetation, speed of wind, relative rate of deposition, cycles of freezing and thawing of water, cycles of heating and cooling, and volume of water flow.] [*Assessment Boundary: Assessment is limited to a single form of weathering or erosion*.]

4-ESS2-2

Analyze and interpret data from maps to describe patterns of Earth's features. [Clarification Statement: Maps can include topographic maps of Earth's land and ocean floor, as well as maps of the locations of mountains, continental boundaries, volcanoes, and earthquakes.]

4-ESS3-2

Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.* [Clarification Statement: Examples of solutions could include designing an earthquake resistant building and improving monitoring of volcanic activity.] [*Assessment Boundary: Assessment is limited to earthquakes, floods, tsunamis, and volcanic eruptions.*]

4-ESS1-1

Students who demonstrate understanding can: Identify evidence from patterns in rock formations and fossils in rock layers to support an explanation for changes in a landscape over time.

Clarification Statement: Examples of evidence from patterns could include rock layers with marine shell fossils above rock layers with plant fossils and no shells, indicating a change from land to water over time; a canyon with different rock layers in the walls and a river in the bottom, indicating that over time a river cut through the rock.

Assessment Boundary: Assessment does not include specific knowledge of the mechanism of rock formation or memorization of specific rock formations and layers. Assessment is limited to relative time.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions • Identify the evidence that supports particular points in an explanation.	**ESS1.C: The History of Planet Earth** • Local, regional, and global patterns of rock formations reveal changes over time due to earth forces, such as earthquakes. The presence and location of certain fossil types indicate the order in which rock layers were formed.	**Patterns** • Patterns can be used as evidence to support an explanation. **Connections to Nature of Science** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Science assumes consistent patterns in natural systems.

4-ESS2-1

Students who demonstrate understanding can: Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation.

Clarification Statement: Examples of variables to test could include angle of slope in the downhill movement of water, amount of vegetation, speed of wind, relative rate of deposition, cycles of freezing and thawing of water, cycles of heating and cooling, and volume of water flow.

Assessment Boundary: Assessment is limited to a single form of weathering or erosion.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations • Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon.	**ESS2.A: Earth Materials and Systems** • Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around. **ESS2.E: Biogeology** • Living things affect the physical characteristics of their regions.	**Cause and Effect** • Cause and effect relationships are routinely identified, tested, and used to explain change.

4-ESS2-2

Students who demonstrate understanding can: Analyze and interpret data from maps to describe patterns of Earth's features.

Clarification Statement: Maps can include topographic maps of Earth's land and ocean floor, as well as maps of the locations of mountains, continental boundaries, volcanoes, and earthquakes.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data • Analyze and interpret data to make sense of phenomena using logical reasoning.	**ESS2.B: Plate Tectonics and Large-Scale System Interactions** • The locations of mountain ranges, deep ocean trenches, ocean floor structures, earthquakes, and volcanoes occur in patterns. Most earthquakes and volcanoes occur in bands that are often along the boundaries between continents and oceans. Major mountain chains form inside continents or near their edges. Maps can help locate the different land and water features areas of Earth.	**Patterns** • Patterns can be used as evidence to support an explanation.

4-ESS3-2

Students who demonstrate understanding can: Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.*

Clarification Statement: Examples of solutions could include designing an earthquake resistant building and improving monitoring of volcanic activity.

Assessment Boundary: Assessment is limited to earthquakes, floods, tsunamis, and volcanic eruptions.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions • Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution.	**ESS3.B: Natural Hazards** • A variety of hazards result from natural processes (e.g., earthquakes, tsunamis, volcanic eruptions). Humans cannot eliminate the hazards but can take steps to reduce their impacts. **ETS1.B: Designing Solutions to Engineering Problems** • Testing a solution involves investigating how well it performs under a range of likely conditions. (*Secondary*)	**Cause and Effect** • Cause and effect relationships are routinely identified, tested, and used to explain change. **Connections to Engineering, Technology, and Application of Science** **Influence of Science, Engineering, and Technology on Society and the Natural World** • Engineers improve existing technologies or develop new ones to increase their benefits, to decrease known risks, and to meet societal demands.

FIFTH GRADE

The performance expectations in fifth grade help students formulate answers to questions such as: "When matter changes, does its weight change? How much water can be found in different places on Earth? Can new substances be created by combining other substances? How does matter cycle through ecosystems? Where does the energy in food come from and what is it used for? How do lengths and directions of shadows or relative lengths of day and night change from day to day, and how does the appearance of some stars change in different seasons?" Fifth grade performance expectations include PS1, PS2, PS3, LS1, LS2, ESS1, ESS2, and ESS3

Disciplinary Core Ideas from the NRC Framework. Students are able to describe that matter is made of particles too small to be seen through the development of a model. Students develop an understanding of the idea that regardless of the type of change that matter undergoes, the total weight of matter is conserved. Students determine whether the mixing of two or more substances results in new substances. Through the development of a model using an example, students are able to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact. They describe and graph data to provide evidence about the distribution of water on Earth. Students develop an understanding of the idea that plants get the materials they need for growth chiefly from air and water. Using models, students can describe the movement of matter among plants, animals, decomposers, and the environment and that energy in animals' food was once energy from the sun. Students are expected to develop an understanding of patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.

The crosscutting concepts of patterns; cause and effect; scale, proportion, and quantity; energy and matter; and systems and systems models are called out as organizing concepts for these disciplinary core ideas. In the fifth grade performance expectations, students are expected to demonstrate grade-appropriate proficiency in developing and using models, planning and carrying out investigations, analyzing and interpreting data, using mathematics and computational thinking, engaging in argument from evidence, and obtaining, evaluating, and communicating information; and to use these practices to demonstrate understanding of the core ideas.

5. Structure and Properties of Matter

Students who demonstrate understanding can:

5-PS1-1

Develop and use a model to describe that matter is made of particles too small to be seen. [Clarification Statement: Examples of evidence supporting a model could include adding air to expand a basketball, compressing air in a syringe, dissolving sugar in water, and evaporating salt water.] [*Assessment Boundary: Assessment does not include the atomic-scale mechanism of evaporation and condensation or defining the unseen particles*.]

5-PS1-2

Measure and graph quantities to provide evidence that regardless of the type of change that occurs when heating, cooling, or mixing substances, the total weight of matter is conserved. [Clarification Statement: Examples of reactions or changes could include phase changes, dissolving, and mixing that form new substances.] [*Assessment Boundary: Assessment does not include distinguishing mass and weight.*]

5-PS1-3

Make observations and measurements to identify materials based on their properties. [Clarification Statement: Examples of materials to be identified could include baking soda and other powders, metals, minerals, and liquids. Examples of properties could include color, hardness, reflectivity, electrical conductivity, thermal conductivity, response to magnetic forces, and solubility; density is not intended as an identifiable property.] [*Assessment Boundary: Assessment does not include density or distinguishing mass and weight*.]

5-PS1-4

Conduct an investigation to determine whether the mixing of two or more substances results in new substances. [Clarifying Statement: Share finding from the investigation.]

5-PS1-1

Students who demonstrate understanding can: Develop and use a model to describe that matter is made of particles too small to be seen.

Clarification Statement: Examples of evidence supporting a model could include adding air to expand a basketball, compressing air in a syringe, dissolving sugar in water, and evaporating salt water.

Assessment Boundary: Assessment does not include the atomic-scale mechanism of evaporation and condensation or defining the unseen particles.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Use models to describe phenomena.	**PS1.A: Structure and Properties of Matter** • Matter of any type can be subdivided into particles that are too small to see, but even then the matter still exists and can be detected by other means. A model showing that gases are made from matter particles that are too small to see and are moving freely around in space can explain many observations, including the inflation and shape of a balloon and the effects of air on larger particles or objects.	**Scale, Proportion, and Quantity** • Natural objects exist from the very small to the immensely large.

5-PS1-2

Students who demonstrate understanding can: Measure and graph quantities to provide evidence that regardless of the type of change that occurs when heating, cooling, or mixing substances, the total weight of matter is conserved.

Clarification Statement: Examples of reactions or changes could include phase changes, dissolving, and mixing that form new substances.

Assessment Boundary: Assessment does not include distinguishing mass and weight.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematics and Computational Thinking • Measure and graph quantities such as weight to address scientific and engineering questions and problems.	**PS1.A: Structure and Properties of Matter** • The amount (weight) of matter is conserved when it changes form, even in transitions in which it seems to vanish. **PS1.B: Chemical Reactions** • No matter what reaction or change in properties occurs, the total weight of the substances does not change. (Boundary: Mass and weight are not distinguished at this grade level.)	**Scale, Proportion, and Quantity** • Standard units are used to measure and describe physical quantities such as weight, time, temperature, and volume. **Connections to Nature of Science** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Science assumes consistent patterns in natural systems.

5-PS1-3

Students who demonstrate understanding can: Make observations and measurements to identify materials based on their properties.

Clarification Statement: Examples of materials to be identified could include baking soda and other powders, metals, minerals, and liquids. Examples of properties could include color, hardness, reflectivity, electrical conductivity, thermal conductivity, response to magnetic forces, and solubility; density is not intended as an identifiable property.

Assessment Boundary: Assessment does not include density or distinguishing mass and weight.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations • Make observations and measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon.	**PS1.A: Structure and Properties of Matter** • Measurements of a variety of properties can be used to identify materials. (Boundary: At this grade level, mass and weight are not distinguished, and no attempt is made to define the unseen particles or explain the atomic-scale mechanism of evaporation and condensation.)	**Scale, Proportion, and Quantity** • Standard units are used to measure and describe physical quantities such as weight, time, temperature, and volume.

5-PS1-4

Students who demonstrate understanding can: Conduct an investigation to determine whether the mixing of two or more substances results in new substances.

Clarifying Statement: Share finding from the investigation.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations • Conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.	**PS1.B: Chemical Reactions** • When two or more different substances are mixed, a new substance with different properties may be formed.	**Cause and Effect** • Cause and effect relationships are routinely identified and used to explain change.

5. Matter and Energy in Organisms and Ecosystems

Students who demonstrate understanding can:

5-PS3-1

Use models to describe that energy in animals' food (used for body repair, growth, and motion and to maintain body warmth) was once energy from the sun. [Clarification Statement: Examples of models could include diagrams, and flow charts.]

5-LS1-1

Support an argument that plants get the materials they need for growth chiefly from air and water. [Clarification Statement: Emphasis is on the idea that plant matter comes mostly from air and water, not from the soil.]

5-LS2-1

Develop and describe a model that describes the movement of matter among plants, animals, decomposers, and the environment. [Clarification Statement: Emphasis is on the idea that matter that is not food (air, water, decomposed materials in soil) is changed by plants into matter that is food. Examples of systems could include organisms, ecosystems, and the Earth.] [*Assessment Boundary: Assessment does not include molecular explanations*.]

5-PS3-1

Students who demonstrate understanding can: Use models to describe that energy in animals' food (used for body repair, growth, and motion and to maintain body warmth) was once energy from the sun.

Clarification Statement: Examples of models could include diagrams, and flow charts.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Use models to describe phenomena.	**PS3.D: Energy in Chemical Processes and Everyday Life** • The energy released [from] food was once energy from the sun that was captured by plants in the chemical process that forms plant matter (from air and water). **LS1.C: Organization for Matter and Energy Flow in Organisms** • Food provides animals with the materials they need for body repair and growth and the energy they need to maintain body warmth and for motion. (*Secondary*)	**Energy and Matter** • Energy can be transferred in various ways and between objects.

5-LS1-1

Students who demonstrate understanding can: Support an argument that plants get the materials they need for growth chiefly from air and water.

Clarification Statement: Emphasis is on the idea that plant matter comes mostly from air and water, not from the soil.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence • Support an argument with evidence, data, or a model.	**LS1.C: Organization for Matter and Energy Flow in Organisms** • Plants acquire their material for growth chiefly from air and water.	**Energy and Matter** • Matter is transported into, out of, and within systems.

5-LS2-1

Students who demonstrate understanding can: Develop and describe a model that describes the movement of matter among plants, animals, decomposers, and the environment.

Clarification Statement: Emphasis is on the idea that matter that is not food (air, water, decomposed materials in soil) is changed by plants into matter that is food. Examples of systems could include organisms, ecosystems, and the Earth.

Assessment Boundary: Assessment does not include molecular explanations.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Develop a model to describe phenomena. **Connections to the Nature of Science** **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** • Science explanations describe the mechanisms for natural events.	**LS2.A: Interdependent Relationships in Ecosystems** • The food of almost any kind of animal can be traced back to plants. Organisms are related in food webs in which some animals eat plants for food and other animals eat the animals that eat plants. Some organisms, such as fungi and bacteria, break down dead organisms (both plants or plants parts and animals) and therefore operate as "decomposers." Decomposition eventually restores (recycles) some materials back to the soil. Organisms can survive only in environments in which their particular needs are met. A healthy ecosystem is one in which multiple species of different types are each able to meet their needs in a relatively stable web of life. Newly introduced species can damage the balance of an ecosystem.	**Systems and System Models** • A system can be described in terms of its components and their interactions.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
	LS2.B: Cycles of Matter and Energy Transfer in Ecosystems • Matter cycles between the air and soil and among plants, animals, and microbes as these organisms live and die. Organisms obtain gases, and water, from the environment, and release waste matter (gas, liquid, or solid) back into the environment.	

5. Earth’s Systems

Students who demonstrate understanding can:

5-ESS2-1

Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere (water), cryosphere (ice), and/or atmosphere interact. [Clarification Statement: Examples could include the influence of the ocean on ecosystems, landform shape, and climate; the influence of the atmosphere on landforms and ecosystems through weather and climate; and the influence of mountain ranges on winds and clouds in the atmosphere. The geosphere, hydrosphere, cryosphere, atmosphere, and biosphere are each a system.] [*Assessment Boundary: Assessment is limited to the interactions of two systems at a time*.]

5-ESS2-2

Describe and graph the amounts of salt water and fresh water in various reservoirs to provide evidence about the distribution of water on Earth. [Clarification Statement: Examples could include lakes, rivers, glaciers, sea ice, oceans, groundwater, and polar ice caps. Represent and interpret the data represented by the graphical displays.] [*Assessment Boundary: Assessment is limited to oceans, lakes, rivers, glaciers, ground water, and polar ice caps, and does not include the atmosphere*.]

5-ESS3-1

Obtain and combine information about ways individual communities use science ideas to protect the Earth’s resources and environment.

5-ESS2-1

Students who demonstrate understanding can: Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere (water), cryosphere (ice), and/or atmosphere interact.

Clarification Statement: Examples could include the influence of the ocean on ecosystems, landform shape, and climate; the influence of the atmosphere on landforms and ecosystems through weather and climate; and the influence of mountain ranges on winds and clouds in the atmosphere. The geosphere, hydrosphere, cryosphere, atmosphere, and biosphere are each a system.

Assessment Boundary: Assessment is limited to the interactions of two systems at a time.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Develop a model using an example to describe a scientific principle.	**ESS2.A: Earth Materials and Systems** • Earth's major systems are the geosphere (solid and molten rock, soil, and sediments), the hydrosphere (water and ice), the atmosphere (air), and the biosphere (living things, including humans). These systems interact in multiple ways to affect Earth's surface materials and processes. The ocean supports a variety of ecosystems and organisms, shapes landforms, and influences climate. Winds and clouds in the atmosphere interact with the landforms to determine patterns of weather.	**Systems and System Models** • A system can be described in terms of its components and their interactions.

5-ESS2-2

Students who demonstrate understanding can: Describe and graph the amounts of salt water and fresh water in various reservoirs to provide evidence about the distribution of water on Earth.

Clarification Statement: Examples could include lakes, rivers, glaciers, sea ice, oceans, groundwater, and polar ice caps. Represent and interpret the data represented by the graphical displays.

Assessment Boundary: Assessment is limited to oceans, lakes, rivers, glaciers, ground water, and polar ice caps, and does not include the atmosphere.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematics and Computational Thinking • Describe and graph quantities such as area and volume to address scientific questions.	**ESS2.C: The Roles of Water in Earth's Surface Processes** • Nearly all of Earth's available water is in the ocean. Most fresh water is in glaciers or underground; only a tiny fraction is in streams, lakes, wetlands, and the atmosphere.	**Scale, Proportion, and Quantity** • Standard units are used to measure and describe physical quantities such as weight and volume.

5-ESS3-1

Students who demonstrate understanding can: Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Obtaining, Evaluating, and Communicating Information • Obtain and combine information from books and/or other reliable media to explain phenomena or solutions to a design problem.	**ESS3.C: Human Impacts on Earth Systems** • Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments.	**Systems and System Models** • A system can be described in terms of its components and their interactions. **Connections to Nature of Science** **Science Addresses Questions About the Natural and Material World.** • Science findings are limited to questions that can be answered with empirical evidence.

5. Space Systems: Stars and the Solar System

Students who demonstrate understanding can:

5-PS2-1

Support an argument that the gravitational force exerted by Earth on objects is directed toward the center of the Earth. [Clarification Statement: "Down" is a local description of the direction that points toward the center of the spherical Earth.] [*Assessment Boundary: Assessment does not include mathematical representation of gravitational force.*]

5-ESS1-1

Support an argument that differences in the apparent brightness of the sun compared to other stars is due to their relative distances from the Earth. [*Assessment Boundary: Assessment is limited to relative distances, not sizes, of stars. Assessment does not include other factors that affect apparent brightness (such as stellar masses, age, and stage).*]

5-ESS1-2

Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, daily appearance of the moon, and the seasonal appearance of some stars in the night sky. [Clarification Statement: Examples of patterns could include the position and motion of Earth with respect to the sun and selected stars that are visible only in particular months.] [*Assessment Boundary: Assessment does not include causes of seasons.*]

5-PS2-1

Students who demonstrate understanding can: Support an argument that the gravitational force exerted by Earth on objects is directed toward the center of the Earth.

Clarification Statement: "Down" is a local description of the direction that points toward the center of the spherical Earth.

Assessment Boundary: Assessment does not include mathematical representation of gravitational force.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence • Support an argument with evidence, data, or a model.	**PS2.B: Types of Interactions** • The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center.	**Cause and Effect** • Cause and effect relationships are routinely identified and used to explain change.

5-ESS1-1

Students who demonstrate understanding can: Support an argument that differences in the apparent brightness of the sun compared to other stars is due to their relative distances from the Earth.

Assessment Boundary: Assessment is limited to relative distances, not sizes, of stars. Assessment does not include other factors that affect apparent brightness (such as stellar masses, age, and stage).

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence • Support an argument with evidence, data, or a model.	**ESS1.A: The Universe and its Stars** • The sun is a star that appears larger and brighter than other stars because it is closer. Stars range greatly in their distance from Earth.	**Scale, Proportion, and Quantity** • Natural objects exist from the very small to the immensely large.

5-ESS1-2

Students who demonstrate understanding can: Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, daily appearance of the moon, and the seasonal appearance of some stars in the night sky.

Clarification Statement: Examples of patterns could include the position and motion of Earth with respect to the sun and selected stars that are visible only in particular months.

Assessment Boundary: Assessment does not include causes of seasons.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data • Represent data in graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships.	**ESS1.B: Earth and the Solar System** • The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily changes in the length and direction of shadows; and different positions of the sun, moon, and stars at different times of the day, month, and year.	**Patterns** • Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena.

3-5.Engineering Design

Students who demonstrate understanding can:

3-5-ETS1-1

Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

3-5-ETS1-2

Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

3-5-ETS1-3

Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

3-5-ETS1-1

Students who demonstrate understanding can: Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Asking Questions and Defining Problems • Define a simple problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost.	**ETS1.A: Defining and Delimiting Engineering Problems** • Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.	**Influence of Engineering, Technology, and Science on Society and the Natural World** • People's needs and wants change over time, as do their demands for new and improved technologies.

3-5-ETS1-2

Students who demonstrate understanding can: Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions • Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design problem.	**ETS1.B: Developing Possible Solutions** • Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. • At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs.	**Influence of Engineering, Technology, and Science on Society and the Natural World** • Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands.

3-5-ETS1-3

Students who demonstrate understanding can: Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations • Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials is considered.	**ETS1.B: Developing Possible Solutions** • Tests are often designed to identify failure points or difficulties which suggest the elements of a design that need to be improved. **ETS1.C: Optimizing the Design Solution** • Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints.	

MIDDLE SCHOOL PHYSICAL SCIENCES

Students in middle school continue to develop understanding of four core ideas in the physical sciences. The middle school performance expectations in the Physical Sciences build on the K – 5 ideas and capabilities to allow learners to explain phenomena central to the physical sciences but also to the life sciences and earth and space science. The performance expectations in physical science blend the core ideas with scientific and engineering practices and crosscutting concepts to support students in developing useable knowledge to explain real world phenomena in the physical, biological, and earth and space sciences. In the physical sciences, performance expectations at the middle school level focus on students developing understanding of several scientific practices. These include developing and using models, planning and conducting investigations, analyzing and interpreting data, using mathematical and computational thinking, and constructing explanations; and to use these practices to demonstrate understanding of the core ideas. Students are also expected to demonstrate understanding of several of engineering practices including design and evaluation.

The performance expectations in the topic **Structure and Properties of Matter** help students to formulate an answer to the questions: "How can particles combine to produce a substance with different properties? How does thermal energy affect particles?" by building understanding of what occurs at the atomic and molecular scale. By the end of middle school, students will be able to apply understanding that pure substances have characteristic properties and are made from a single type of atom or molecule. They will be able to provide molecular level accounts to explain states of matters and changes between states. The crosscutting concepts of cause and effect; scale, proportion and quantity; structure and function; interdependence of science, engineering, and technology; and influence of science, engineering and technology on society and the natural world are called out as organizing concepts for these disciplinary core ideas. In these performance expectations, students are expected to demonstrate proficiency in developing and using models, and obtaining, evaluating, and communicating information. Students use these scientific and engineering practices to demonstrate understanding of the core ideas.

The performance expectations in the topic **Chemical Reactions** help students to formulate an answer to the questions: "What happens when new materials are formed? What stays the same and what changes?" by building understanding of what occurs at the atomic and molecular scale during chemical reactions. By the end of middle school, students will be able to provide molecular level accounts to explain that chemical reactions involve regrouping of atoms to form new substances, and that atoms rearrange during chemical reactions. Students are also able to apply an understanding of the design and the process of optimization in engineering to chemical reaction systems. The crosscutting concepts of patterns and energy and matter are called out as organizing concepts for these disciplinary core ideas. In these performance expectations, students are expected to demonstrate proficiency in developing and using models, analyzing and interpreting data, and designing solutions. Students use these scientific and engineering practices to demonstrate understanding of the core ideas.

The performance expectations in the topic **Forces and Interactions** focus on helping students understand ideas related to why some objects will keep moving, why objects fall to the ground and why some materials are attracted to each other while others are not. Students answer the question, "How can one describe physical interactions between objects and within systems of objects?" At the middle school level, the PS2 Disciplinary Core Idea from the NRC Framework is broken down into two sub-ideas: Forces and Motion and Types of interactions. By the end of middle school, students will be able to apply Newton's Third Law of Motion to relate forces to explain the motion of objects. Students also apply ideas about gravitational, electrical, and magnetic forces to explain a variety of phenomena including beginning ideas about why some materials attract each other while other repel. In particular, students will develop understanding that gravitational interactions are always attractive but that electrical and magnetic forces can be both attractive and negative. Students also develop ideas that objects can exert forces on each other even though the objects are not in contact, through fields. Students are also able to apply an engineering practice and concept to solve a problem caused when objects collide. The crosscutting concepts of cause and effect; system and system models; stability and change; and the influence of science, engineering, and technology on society and the natural world serve as organizing concepts for these disciplinary core ideas. In these performance expectations, students are expected to demonstrate proficiency in asking questions, planning and carrying out investigations, and designing solutions, and engaging in argument; and to use these practices to demonstrate understanding of the core ideas.

The performance expectations in the topic **Energy** help students formulate an answer to the question, "How can energy be transferred from one object or system to another?" At the middle school level, the PS3 Disciplinary Core Idea from the NRC Framework is broken down into four sub-core ideas: Definitions of Energy, Conservation of Energy and Energy Transfer, the Relationship between Energy and Forces, and Energy in Chemical Process and Everyday Life. Students develop their understanding of important qualitative ideas about energy including that the interactions of objects can be explained and predicted using the concept of transfer of energy from one object or system of objects to another, and that that the total change of energy in any system is always equal to the total energy transferred into or out of the system. Students understand that objects that are moving have kinetic energy and that objects may also contain stored (potential) energy, depending on their relative positions. Students will also come to know the difference between energy and temperature, and begin to develop an understanding of the relationship between force and energy. Students are also able to apply an understanding of design to the process of energy transfer. The crosscutting concepts of scale, proportion, and quantity; systems and system models; and energy are called out as organizing concepts for these disciplinary core ideas. These performance expectations expect students to demonstrate proficiency in developing and using models, planning investigations, analyzing and interpreting data, and designing solutions, and engaging in argument from evidence; and to use these practices to demonstrate understanding of the core ideas in PS3.

The performance expectations in the topic **Waves and Electromagnetic Radiation** help students formulate an answer to the question, "What are the characteristic properties of waves and how can they be used?" At the middle school level, the PS4 Disciplinary Core Idea from the NRC Framework is broken down into Wave Properties, Electromagnetic Radiation, and Information Technologies and Instrumentation. Students are able to describe and predict characteristic properties and behaviors of waves when the waves interact with matter. Students can apply an understanding of waves as a means to send digital information. The crosscutting concepts of patterns and structure and function are used as organizing concepts for these disciplinary core ideas. These performance expectations focus on students demonstrating proficiency in developing and using models, using mathematical thinking, and obtaining, evaluating and communicating information; and to use these practices to demonstrate understanding of the core ideas.

MS. Structure and Properties of Matter

Students who demonstrate understanding can:

MS-PS1-1

Develop models to describe the atomic composition of simple molecules and extended structures. [Clarification Statement: Emphasis is on developing models of molecules that vary in complexity. Examples of simple molecules could include ammonia and methanol. Examples of extended structures could include sodium chloride or diamonds. Examples of molecular-level models could include drawings, 3D ball and stick structures, or computer representations showing different molecules with different types of atoms.] [*Assessment Boundary: Assessment does not include valence electrons and bonding energy, discussing the ionic nature of subunits of complex structures, or a complete description of all individual atoms in a complex molecule or extended structure is not required.*]

MS-PS1-3

Collect information that supports the idea that synthetic materials come from the use of natural resources, and analyze the positive and negative effects of use and development of synthetics on society. [Clarification Statement: Emphasis is on natural resources that undergo a chemical process to form the synthetic material. Examples of new materials could include new medicine, foods, and alternative fuels.] [*Assessment Boundary: Assessment is limited to qualitative information*.]

MS-PS1-4

Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed. [Clarification Statement: Emphasis is on qualitative molecular-level models of solids, liquids, and gases to show that adding or removing thermal energy increases or decreases kinetic energy of the particles until a change of state occurs. Examples of models could include drawing and diagrams. Examples of particles could include molecules or inert atoms. Examples of pure substances could include water, carbon dioxide, and helium.]

MS-PS1-1

Students who demonstrate understanding can: Develop models to describe the atomic composition of simple molecules and extended structures.

Clarification Statement: Emphasis is on developing models of molecules that vary in complexity. Examples of simple molecules could include ammonia and methanol. Examples of extended structures could include sodium chloride or diamonds. Examples of molecular-level models could include drawings, 3D ball and stick structures, or computer representations showing different molecules with different types of atoms.

Assessment Boundary: Assessment does not include valence electrons and bonding energy, discussing the ionic nature of subunits of complex structures, or a complete description of all individual atoms in a complex molecule or extended structure is not required.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Develop a model to predict and/or describe phenomena.	**PS1.A: Structure and Properties of Matter** • Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. • Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals).	**Scale, Proportion, and Quantity** • Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.

MS-PS1-3

Students who demonstrate understanding can: Collect information that supports the idea that synthetic materials come from the use of natural resources, and analyze the positive and negative effects of use and development of synthetics on society.

Clarification Statement: Clarification Statement: Emphasis is on natural resources that undergo a chemical process to form the synthetic material. Examples of new materials could include new medicine, foods, and alternative fuels.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Obtaining, Evaluating, and Communicating Information • Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence.	**PS1.A: Structure and Properties of Matter** • Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. **PS1.B: Chemical Reactions** • Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants	**Structure and Function** • Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used. **Connections to Engineering, Technology, and Applications of Science** **Interdependence of Science, Engineering, and Technology** • Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
		Influence of Science, Engineering, and Technology on Society and the Natural World • The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by difference in such factors as climate, natural resources, and economic conditions. Thus, technology use varies from region to region and over time.

MS-PS1-4

Students who demonstrate understanding can: Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.

Clarification Statement: Emphasis is on qualitative molecular-level models of solids, liquids, and gases to show that adding or removing thermal energy increases or decreases kinetic energy of the particles until a change of state occurs. Examples of models could include drawing and diagrams. Examples of particles could include molecules or inert atoms. Examples of pure substances could include water, carbon dioxide, and helium.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Develop a model to predict and/or describe phenomena.	**PS1.A: Structure and Properties of Matter** • Gases and liquids are made of molecules or inert atoms that are moving about relative to each other. • In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations. • The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter. ⩔	**Cause and Effect** • Cause and effect relationships may be used to predict phenomena in natural or designed systems.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
	PS3.A: Definitions of Energy • The term "heat" as used in everyday language refers both to thermal energy (the motion of atoms or molecules within a substance) and the transfer of that thermal energy from one object to another. In science, heat is used only for this second meaning; it refers to the energy transferred due to the temperature difference between two objects. (*Secondary*) • Temperature is not a measure of energy; the relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present. (*Secondary*)	

MS. Chemical Reactions

Students who demonstrate understanding can:

MS-PS1-2

Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred. [Clarification Statement: Examples of reactions could include burning sugar or steel wool, fat reacting with sodium hydroxide, and mixing zinc with hydrogen chloride.] [*Assessment boundary: Assessment is limited to analysis of the following properties: density, melting point, boiling point, solubility, flammability, and odor*.]

MS-PS1-5

Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved. [Clarification Statement: Emphasis is on law of conservation of matter and on physical models or drawings, including digital forms that represent atoms.] [*Assessment Boundary: Assessment does not include the use of atomic masses, balancing symbolic equations, or intermolecular forces*.]

MS-PS1-6

Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes. * [Clarification Statement: Emphasis is on the design, controlling the transfer of energy to the environment, and modification of a device using factors such as type and concentration of a substance. Examples of chemical process designs could involve dissolving ammonium chloride or calcium chloride and chemical heat packs. Examples of physical process designs could involve a plastic bag and hot water. Alaskan physical examples could include: countercurrent exchange in the limbs and surfaces of Arctic animals and the DIFFERENCE IN THE albedo effect of open ocean water vs. sea ice.] [*Assessment Boundary: Assessment is limited to the criteria of amount, time, and temperature of substance in testing the device*.]

MS-PS1-2

Students who demonstrate understanding can: Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.

Clarification Statement: Examples of reactions could include burning sugar or steel wool, fat reacting with sodium hydroxide, and mixing zinc with hydrogen chloride.

Assessment Boundary: Assessment is limited to analysis of the following properties: density, melting point, boiling point, solubility, flammability, and odor.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data • Analyze and interpret data to determine similarities and differences in findings. **Connections to Nature of Science** **Scientific Knowledge is based on Empirical Evidence** • Science knowledge is based upon logical and conceptual connections between evidence and explanations.	**PS1.A: Structure and Properties of Matter** • Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. **PS1.B: Chemical Reactions** • Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants	**Patterns** • Macroscopic patterns are related to the nature of microscopic and atomic-level structure.

MS-PS1-5

Students who demonstrate understanding can: Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved.

Clarification Statement: Emphasis is on law of conservation of matter and on physical models or drawings, including digital forms that represent atoms.

Assessment Boundary: Assessment does not include the use of atomic masses, balancing symbolic equations, or intermolecular forces.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Develop a model to describe unobservable mechanisms **Connections to Nature of Science** **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** • Laws are regularities or mathematical descriptions of natural phenomena.	**PS1.B: Chemical Reactions** • Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. • The total number of each type of atom is conserved, and thus the mass does not change.	**Energy and Matter** • Matter is conserved because atoms are conserved in physical and chemical processes.

MS-PS1-6

Students who demonstrate understanding can: Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes. *

Clarification Statement: Emphasis is on the design, controlling the transfer of energy to the environment, and modification of a device using factors such as type and concentration of a substance. Examples of chemical process designs could involve dissolving ammonium chloride or calcium chloride and chemical heat packs. Examples of physical process designs could involve a plastic bag and hot water. Alaskan physical examples could include: countercurrent exchange in the limbs and surfaces of Arctic animals and the DIFFERENCE IN THE albedo effect of open ocean water vs. sea ice.

Assessment Boundary: Assessment is limited to the criteria of amount, time, and temperature of substance in testing the device.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions • Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints.	**PS1.B: Chemical Reactions** • Some chemical reactions release energy, others store energy. **ETS1.B: Developing Possible Solutions** • A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. **ETS1.C: Optimizing the Design Solution** • Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of the characteristics may be incorporated into the new design.	**Energy and Matter** • The transfer of energy can be tracked as energy flows through a designed or natural system.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
	• The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution.	

MS. Forces and Interactions

Students who demonstrate understanding can:

MS-PS2-1

Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.* [Clarification Statement: Examples of practical problems could include the impact of collisions between two cars, between a car and stationary objects, and between a meteor and a space vehicle.] [*Assessment Boundary: Assessment is limited to vertical or horizontal interactions in one dimension*.]

MS-PS2-2

Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object. [Clarification Statement: Emphasis is on balanced (Newton's First Law) and unbalanced forces in a system, qualitative comparisons of forces, mass and changes in motion (Newton's Second Law), frame of reference, and specification of units.] [*Assessment Boundary: Assessment is limited to forces and changes in motion in one-dimension in an inertial reference frame and to change in one variable at a time. Assessment does not include the use of trigonometry*.]

MS-PS2-3

Ask questions about data to determine the factors that affect the strength of electric and magnetic forces. [Clarification Statement: Examples of devices that use electric and magnetic forces could include electromagnets, electric motors, or generators. Examples of data could include the effect of the number of turns of wire on the strength of an electromagnet, the effect of increasing the number or strength of magnets on the speed of an electric motor, or a change in the range and intensity of the aurora over time.] [*Assessment Boundary: Assessment about questions that require quantitative answers is limited to proportional reasoning and algebraic thinking*.]

MS-PS2-4

Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects. [Clarification Statement: Examples of evidence for arguments could include data generated from simulations or digital tools; and charts displaying mass, strength of interaction, distance from the Sun, and orbital periods of objects within the solar system.] [*Assessment Boundary: Assessment does not include Newton's Law of Gravitation or Kepler's Laws*.]

MS-PS2-5

Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact. [Clarification Statement: Examples of this phenomenon could include the interactions of magnets, electrically-charged strips of tape, and electrically-charged pith balls. Examples of investigations could include firsthand experiences or simulations.] [*Assessment Boundary: Assessment is limited to electric and magnetic fields, and limited to qualitative evidence for the existence of fields.*]

MS-PS2-1

Students who demonstrate understanding can: Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.

Clarification Statement: Examples of practical problems could include the impact of collisions between two cars, between a car and stationary objects, and between a meteor and a space vehicle.

Assessment Boundary: Assessment is limited to vertical or horizontal interactions in one dimension.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions • Apply scientific ideas or principles to design an object, tool, process, or system.	**PS2.A: Forces and Motion** • For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton's third law).	**Systems and System Models** • Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy and matter flows within systems. **Connections to Engineering, Technology, and Applications of Science** **Influence of Science, Engineering, and Technology on Society and the Natural World** • The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions.

MS-PS2-2

Students who demonstrate understanding can: Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.

Clarification Statement: Emphasis is on balanced (Newton's First Law) and unbalanced forces in a system, qualitative comparisons of forces, mass and changes in motion (Newton's Second Law), frame of reference, and specification of units.

Assessment Boundary: Assessment is limited to forces and changes in motion in one-dimension in an inertial reference frame and to change in one variable at a time. Assessment does not include the use of trigonometry.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations • Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim. **Connections to Nature of Science** **Scientific Knowledge is Based on Empirical Evidence** • Scientific knowledge is based on logical and conceptual connections between evidence and explanations.	**PS2.A: Forces and Motion** • The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. • All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared.	**Stability and Change** • Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales.

MS-PS2-3

Students who demonstrate understanding can: Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.

Clarification Statement: Examples of devices that use electric and magnetic forces could include electromagnets, electric motors, or generators. Examples of data could include the effect of the number of turns of wire on the strength of an electromagnet, the effect of increasing the number or strength of magnets on the speed of an electric motor, or a change in the range and intensity of the aurora over time.

Assessment Boundary: Assessment about questions that require quantitative answers is limited to proportional reasoning and algebraic thinking.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Asking Questions and Defining Problems • Ask questions that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles.	**PS2.B: Types of Interactions** • Electric and magnetic (electromagnetic) forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects.	**Cause and Effect** • Cause and effect relationships may be used to predict phenomena in natural or designed systems.

MS-PS2-4

Students who demonstrate understanding can: Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.

Clarification Statement: Examples of evidence for arguments could include data generated from simulations or digital tools; and charts displaying mass, strength of interaction, distance from the Sun, and orbital periods of objects within the solar system.

Assessment Boundary: Assessment does not include Newton's Law of Gravitation or Kepler's Laws.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence • Construct and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. **Connections to Nature of Science** **Scientific Knowledge is Based on Empirical Evidence** • Scientific knowledge is based on logical and conceptual connections between evidence and explanations.	**PS2.B: Types of Interactions** • Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass (e.g., Earth and the sun).	**Systems and System Models** • Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy and matter flows within systems.

MS-PS2-5

Students who demonstrate understanding can: Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.

Clarification Statement: Examples of this phenomenon could include the interactions of magnets, electrically-charged strips of tape, and electrically-charged pith balls. Examples of investigations could include first-hand experiences or simulations.

Assessment Boundary: Assessment is limited to electric and magnetic fields, and limited to qualitative evidence for the existence of fields.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations • Conduct an investigation and evaluate the experimental design to produce data to serve as the basis for evidence that can meet the goals of the investigation.	**PS2.B: Types of Interactions** • Forces that act at a distance (electrical, magnetic, and gravitational) can be explained by fields that extend through space and can be mapped by their effect on a test object (a charged object, or a ball, respectively).	**Cause and Effect** • Cause and effect relationships may be used to predict phenomena in natural or designed systems.

MS. Energy

Students who demonstrate understanding can:

MS-PS3-1

Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object. [Clarification Statement: Emphasis is on descriptive relationships between kinetic energy and mass separately from kinetic energy and speed. Examples could include riding a bicycle at different speeds, rolling different sizes of rocks downhill, and getting hit by a whiffle ball versus a tennis ball.]

MS-PS3-2

Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system. [Clarification Statement: Emphasis is on relative amounts of potential energy, not on calculations of potential energy. Examples of objects within systems interacting at varying distances could include: the Earth and either a roller coaster cart at varying positions on a hill or objects at varying heights on shelves, changing the direction/orientation of a magnet, and a balloon with static electrical charge being brought closer to a classmate's hair. Examples of models could include representations, diagrams, pictures, and written descriptions of systems.] [*Assessment Boundary: Assessment is limited to two objects and electric, magnetic, and gravitational interactions.*]

MS-PS3-3

Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer. [Clarification Statement: Examples of devices could include an insulated box, a solar cooker, a Styrofoam cup, or traditional seasonal clothing or dwellings.] [*Assessment Boundary: Assessment does not include calculating the total amount of thermal energy transferred*.]

MS-PS3-4

Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample. [Clarification Statement: Examples of experiments could include comparing final water temperatures after different masses of ice melted in the same volume of water with the same initial temperature, the temperature change of samples of different materials with the same mass as they cool or heat in the environment, or the same material with different masses when a specific amount of energy is added.] [*Assessment Boundary: Assessment does not include calculating the total amount of thermal energy transferred*.]

MS-PS3-5

Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object. [Clarification Statement: Examples of empirical evidence used in arguments could include an inventory or other representation of the energy before and after the transfer in the form of temperature changes or motion of object.] [*Assessment Boundary: Assessment does not include calculations of energy*.]

MS-PS3-1

Student who demonstrate understanding: Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.

Clarification Statement: Emphasis is on descriptive relationships between kinetic energy and mass separately from kinetic energy and speed. Examples could include riding a bicycle at different speeds, rolling different sizes of rocks downhill, and getting hit by a whiffle ball versus a tennis ball.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data • Construct and interpret graphical displays of data to identify linear and nonlinear relationships.	**PS3.A: Definitions of Energy** • Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed.	**Scale, Proportion, and Quantity** • Proportional relationships (e.g. speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes.

MS-PS3-2

Students who demonstrate understanding: Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.

Clarification Statement: Emphasis is on relative amounts of potential energy, not on calculations of potential energy. Examples of objects within systems interacting at varying distances could include: the Earth and either a roller coaster cart at varying positions on a hill or objects at varying heights on shelves, changing the direction/orientation of a magnet, and a balloon with static electrical charge being brought closer to a classmate's hair. Examples of models could include representations, diagrams, pictures, and written descriptions of systems.

Assessment Boundary: Assessment is limited to two objects and electric, magnetic, and gravitational interactions.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Develop a model to describe unobservable mechanisms.	**PS3.A: Definitions of Energy** • A system of objects may also contain stored (potential) energy, depending on their relative positions. **PS3.C: Relationship Between Energy and Forces** • When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object.	**Systems and System Models** • Models can be used to represent systems and their interactions – such as inputs, processes, and outputs – and energy and matter flows within systems.

MS-PS3-3

Students who demonstrate understanding: Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.

Clarification Statement: Examples of devices could include an insulated box, a solar cooker, a Styrofoam cup, or traditional seasonal clothing or dwellings.

Assessment Boundary: Assessment does not include calculating the total amount of thermal energy transferred.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions • Apply scientific ideas or principles to design, construct, and test a design of an object, tool, process or system.	**PS3.A: Definitions of Energy** • Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present. **PS3.B: Conservation of Energy and Energy Transfer** • Energy is spontaneously transferred out of hotter regions or objects and into colder ones.	**Energy and Matter** • The transfer of energy can be tracked as energy flows through a designed or natural system.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
	ETS1.A: Defining and Delimiting an Engineering Problem • The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that is likely to limit possible solutions. (*Secondary*) **ETS1.B: Developing Possible Solutions** • A solution needs to be tested, and then modified on the basis of the test results in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (*Secondary*)	

MS-PS3-4

Students who demonstrate understanding: Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample.

Clarification Statement: Examples of experiments could include comparing final water temperatures after different masses of ice melted in the same volume of water with the same initial temperature, the temperature change of samples of different materials with the same mass as they cool or heat in the environment, or the same material with different masses when a specific amount of energy is added.

Assessment Boundary: Assessment does not include calculating the total amount of thermal energy transferred.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations • Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim. **Connections to Nature of Science** **Scientific Knowledge is Based on Empirical Evidence** • Scientific knowledge is based on logical and conceptual connections between evidence and explanations.	**PS3.A: Definitions of Energy** • Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present. **PS3.B: Conservation of Energy and Energy Transfer** • The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment.	**Scale, Proportion, and Quantity** • Proportional relationships (e.g. speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes.

MS-PS3-5

Students who demonstrate understanding: Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.

Clarification Statement: Examples of empirical evidence used in arguments could include an inventory or other representation of the energy before and after the transfer in the form of temperature changes or motion of object.

Assessment Boundary: Assessment does not include calculations of energy.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence • Construct, use, and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon. **Connections to Nature of Science** **Scientific Knowledge is Based on Empirical Evidence** • Scientific knowledge is based on logical and conceptual connections between evidence and explanations.	**PS3.B: Conservation of Energy and Energy Transfer** • When the motion energy of an object changes, there is inevitably some other change in energy at the same time.	**Energy and Matter** • Energy may take different forms (e.g. energy in fields, thermal energy, and energy of motion).

MS. Waves and Electromagnetic Radiation

Students who demonstrate understanding can:

MS-PS4-1

Qualitatively and quantitatively describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave. [Clarification Statement: Examples can include waves modeled with a jump rope, slinky, water, seismic activity, and sound.] [*Assessment Boundary: Assessment does not include electromagnetic waves and is limited to standard repeating waves*.]

MS-PS4-2

Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials. [Clarification Statement: Emphasis is on both light and mechanical waves (including sound). Examples of models could include drawings, simulations, and written descriptions. Alaskan examples include whale echolocation, or use of sonar projection of the sea floor and fish populations.] [*Assessment Boundary: Assessment is limited to qualitative applications pertaining to light and mechanical waves.*]

MS-PS4-3

Integrated with HS PS4-2

MS-PS4-1

Students who demonstrate understanding: Qualitatively and quantitatively describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave.

Clarification Statement: Examples can include waves modeled with a jump rope, slinky, water, seismic activity, and sound.

Assessment Boundary: Assessment does not include electromagnetic waves and is limited to standard repeating waves.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematics and Computational Thinking • Use mathematical representations to describe and/or support scientific conclusions and design solutions. **Connections to Nature of Science** **Scientific Knowledge is Based on Empirical Evidence** • Science knowledge is based upon logical and conceptual connections between evidence and explanations.	**PS4.A: Wave Properties** • A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude.	**Patterns** • Graphs and charts can be used to identify patterns in data.

MS-PS4-2

Students who demonstrate understanding: Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.

Clarification Statement: Emphasis is on both light and mechanical waves (including sound). Examples of models could include drawings, simulations, and written descriptions. Alaskan examples include whale echolocation, or use of sonar projection of the sea floor and fish populations.

Assessment Boundary: Assessment is limited to qualitative applications pertaining to light and mechanical waves.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Develop and use a model to describe phenomena.	**PS4.A: Wave Properties** • A sound wave needs a medium through which it is transmitted. **PS4.B: Electromagnetic Radiation** • When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light. • The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends. • A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media. • However, because light can travel through space, it cannot be a matter wave, like sound or water waves.	**Structure and Function** • Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.

MS-PS4-3

Integrated with HS PS4-2

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Obtaining, Evaluating, and Communicating Information • Integrate qualitative scientific and technical information in written text with that contained in media and visual displays to clarify claims and findings.	**PS4.C: Information Technologies and Instrumentation** • Digitized signals (sent as wave pulses) are a more reliable way to encode and transmit information.	**Structure and Function** • Structures can be designed to serve particular functions. **Connections to Engineering, Technology, and Applications of Science** **Influence of Science, Engineering, and Technology on Society and the Natural World** • Technologies extend the measurement, exploration, modeling, and computational capacity of scientific investigations. **Connections to Nature of Science** **Science is a Human Endeavor** • Advances in technology influence the progress of science and science has influenced advances in technology.

MIDDLE SCHOOL LIFE SCIENCES

Students in middle school develop understanding of key concepts to help them make sense of the life sciences. These ideas build upon students' science understanding from earlier grades and from the disciplinary core ideas, science and engineering practices, and crosscutting concepts of other experiences with physical and earth sciences. There are five life science topics in middle school: 1) Structure, Function, and Information Processing, 2) Growth, Development, and Reproduction of Organisms, 3) Matter and Energy in Organisms and Ecosystems, 4) Interdependent Relationships in Ecosystems, and 5) Natural Selection and Adaptations. The performance expectations in middle school blend core ideas with scientific and engineering practices and crosscutting concepts to support students in developing useable knowledge across the science disciplines. While the performance expectations in middle school life science couple particular practices with specific disciplinary core ideas, instructional decisions should include use of many science and engineering practices integrated in the performance expectations. The concepts and practices in the performance expectations are based on the grade-band endpoints described in A Framework for K-12 Science Education (NRC, 2012).

The Performance Expectations in **Structure, Function, and Information Processing** help students formulate an answer to the question, "How do the structures of organisms contribute to life's functions?" Middle school students can plan and carry out investigations to develop evidence that living organisms are made of cells and to determine the relationship of organisms to the environment. Students can use understanding of cell theory to develop physical and conceptual models of cells. They can construct explanations for the interactions of systems in cells and organisms and how organisms gather and use information from the environment. By the end of their studies, students understand that all organisms are made of cells, that special structures are responsible for particular functions in organisms, and that for many organisms the body is a system of multiple interacting subsystems that form a hierarchy from cells to the body. Crosscutting concepts of cause and effect, structure and function, and matter and energy are called out as organizing concepts for these core ideas.

The Performance Expectations in **Growth, Development, and Reproduction of Organisms** help students formulate an answer to the question, "How do organisms grow, develop, and reproduce?" Students understand how the environment and genetic factors determine the growth of an individual organism. They also demonstrate understanding of the genetic implications for sexual and asexual reproduction. Students can develop evidence to support their understanding of the structures and behaviors that increase the likelihood of successful reproduction by organisms. They have a beginning understanding of the ways humans can select for specific traits, the role of technology, genetic modification, and the nature of ethical responsibilities related to selective breeding. At the end of middle school, students can explain how selected structures, functions, and behaviors of organisms change in predictable ways as they progress from birth to old age. Students can use the practices of analyzing and interpreting data, using models, conducting investigations and communicating information. Crosscutting concepts of structure and function, change and stability, and matter and energy flow in organisms support understanding across this topic.

The Performance Expectations in **Matter and Energy in Organisms and Ecosystems** help students formulate answers to the questions: "How do organisms obtain and use matter and energy? How do matter and energy move through an ecosystem?" Middle school students can use conceptual and physical models to explain the transfer of energy and cycling of matter as they construct explanations for the role of photosynthesis in cycling matter in ecosystems. They can construct explanations for the cycling of matter in organisms and the interactions of organisms to obtain the matter and energy from the ecosystem to survive and grow. Students have a grade-appropriate understanding and use of the practices of investigations, constructing arguments based on evidence, and oral and written communication. They understand that sustaining life requires substantial energy and matter inputs and the structure and functions of organisms contribute to the capture, transformation, transport, release, and elimination of matter and energy. Adding to these crosscutting concepts is a deeper understanding of systems and system models that ties the performances expectations in this topic together.

The Performance Expectations in **Interdependent Relationships in Ecosystems** help students formulate an answer to the question, "How do organisms interact with other organisms in the physical environment to obtain matter and energy? To answer the question, middle school students construct explanations for the interactions in ecosystems and the scientific, economic, political, and social justifications used in making decisions about maintaining biodiversity in ecosystems. Students can use models, construct evidence-based explanations, and use argumentation from evidence. Students understand that organisms and populations of organisms are dependent on their environmental interactions both with other organisms and with nonliving factors. They also understand the limits of resources influence the growth of organisms and populations, which may result in competition for those limited resources. Crosscutting concepts of matter and energy, systems and system models, and cause and effect are used by students to support understanding the phenomena they study.

The Performance Expectations in **Natural Selection and Adaptations** help students formulate answers to the questions: "How does genetic variation among organisms in a species affect survival and reproduction? How does the environment influence genetic traits in populations over multiple generations?" Middle school students can analyze data from the fossil record to describe evidence of the history of life on Earth and can construct explanations for similarities in organisms. They have a beginning understanding of the role of variation in natural selection and how this leads to speciation. They have a grade-appropriate understanding and use of the practices of analyzing graphical displays; using mathematical models; and gathering, reading, and communicating information. The crosscutting concept of cause and effect is central to this topic.

MS. Structure, Function, and Information Processing

Students who demonstrate understanding can:

MS-LS1-1.

Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells. [Clarification Statement: Emphasis is on developing evidence that living things are made of cells, distinguishing between living and non-living things, and understanding that living things may be made of one cell or many and varied cells.]

MS-LS1-2.

Develop and use a model to describe the function of a cell as a whole and ways the parts of cells contribute to the function. [Clarification Statement: Emphasis is on the cell functioning as a whole system and the primary role of identified parts of the cell, specifically the nucleus, chloroplasts, mitochondria, cell membrane, and cell wall.] [*Assessment Boundary: Assessment of organelle structure/function relationships is limited to the cell wall and cell membrane. Assessment of the function of the other organelles is limited to their relationship to the whole cell. Assessment does not include the biochemical function of cells or cell parts*.]

MS-LS1-3.

Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells. [Clarification Statement: Emphasis is on the conceptual understanding that cells form tissues and tissues form organs specialized for particular body functions. Examples could include the interaction of subsystems within a system and the normal functioning of those systems.] [*Assessment Boundary: Assessment does not include the mechanism of one body system independent of others. Assessment is limited to the circulatory, excretory, digestive, respiratory, muscular, and nervous systems.*]

MS-LS1-8.

Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories. [*Assessment Boundary: Assessment does not include mechanisms for the transmission of this information.*]

MS-LS1-1

Students who demonstrate understanding can: Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells.

Clarification Statement: Emphasis is on developing evidence that living things are made of cells, distinguishing between living and non-living things, and understanding that living things may be made of one cell or many and varied cells.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations • Conduct an investigation to produce data to serve as the basis for evidence that meet the goals of an investigation.	**LS1.A: Structure and Function** • All living things are made up of cells, which is the smallest unit that can be said to be alive. An organism may consist of one single cell (unicellular) or many different numbers and types of cells (multicellular).	**Scale, Proportion, and Quantity** • Phenomena that can be observed at one scale may not be observable at another scale. **Connections to Engineering, Technology, and Applications of Science** **Interdependence of Science, Engineering, and Technology** • Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems.

MS-LS1-2

Students who demonstrate understanding can: Develop and use a model to describe the function of a cell as a whole and ways the parts of cells contribute to the function.

Clarification Statement: Emphasis is on the cell functioning as a whole system and the primary role of identified parts of the cell, specifically the nucleus, chloroplasts, mitochondria, cell membrane, and cell wall.

Assessment Boundary: Assessment of organelle structure/function relationships is limited to the cell wall and cell membrane. Assessment of the function of the other organelles is limited to their relationship to the whole cell. Assessment does not include the biochemical function of cells or cell parts.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Develop and use a model to describe phenomena.	**LS1.A: Structure and Function** • Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell.	**Structure and Function** • Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the relationships among its parts, therefore complex natural and designed structures/systems can be analyzed to determine how they function.

MS-LS1-3

Students who demonstrate understanding can: Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.

Clarification Statement: Emphasis is on the conceptual understanding that cells form tissues and tissues form organs specialized for particular body functions. Examples could include the interaction of subsystems within a system and the normal functioning of those systems.

Assessment Boundary: Assessment does not include the mechanism of one body system independent of others. Assessment is limited to the circulatory, excretory, digestive, respiratory, muscular, and nervous systems.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence • Use an oral and written argument supported by evidence to support or refute an explanation or a model for a phenomenon.	**LS1.A: Structure and Function** • In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions.	**Systems and System Models** • Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. **Connections to Nature of Science** **Science is a Human Endeavor** • Scientists and engineers are guided by habits of mind such as intellectual honesty, tolerance of ambiguity, skepticism, and openness to new ideas.

MS-LS1-8

Students who demonstrate understanding can: Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.

Assessment Boundary: Assessment does not include mechanisms for the transmission of this information.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Obtaining, Evaluating, and Communicating Information • Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence.	**LS1.D: Information Processing** • Each sense receptor responds to different inputs (electromagnetic, mechanical, chemical), transmitting them as signals that travel along nerve cells to the brain. The signals are then processed in the brain, resulting in immediate behaviors or memories.	**Cause and Effect** • Cause and effect relationships may be used to predict phenomena in natural systems.

MS. Matter and Energy in Organisms and Ecosystems

Students who demonstrate understanding can:

MS-LS1-6.

Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms. [Clarification Statement: Emphasis is on tracing the role of vegetation in movement of matter and flow of energy. Alaskan examples include: caribou eating lichen through the winter, forests and other ecosystems thriving with contribution of decaying salmon, and phytoplankton and seaweed in marine food chain.] [*Assessment Boundary: Assessment does not include the biochemical mechanisms of photosynthesis*.]

MS-LS1-7.

Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism. [Clarification Statement: Emphasis is on describing that molecules are broken apart and put back together and that in this process, energy is released.] [*Assessment Boundary: Assessment does not include details of the chemical reactions for photosynthesis or respiration*.]

MS-LS2-1.

Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem. [Clarification Statement: Emphasis is on cause and effect relationships between resources and growth of individual organisms and the numbers of organisms in ecosystems during periods of abundant and scarce resources. This emphasis should include local ecosystem processes and traditional native ways of knowing.]

MS-LS2-3.

Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. [Clarification Statement: Emphasis is on describing the conservation of matter and flow of energy into and out of various ecosystems, and on defining the boundaries of the system. Examples should include: food web, energy pyramid, cycles of water, oxygen, nitrogen, and carbon. Alaska references could include animal droppings contributing nutrients to tundra and other ecosystems.] [*Assessment Boundary: Assessment does not include the use of chemical reactions to describe the processes*.]

MS-LS2-4.

Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations. [Clarification Statement: Emphasis is on recognizing patterns in data, evaluating the validity of and analyzing the evidence, and making logical inferences that explain or predict changes in population based on physical or biological changes.]

MS-LS1-6

Students who demonstrate understanding can: Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.

Clarification Statement: Emphasis is on tracing the role of vegetation in movement of matter and flow of energy. Alaskan examples include: caribou eating lichen through the winter, forests and other ecosystems thriving with contribution of decaying salmon, and phytoplankton and seaweed in marine food chain.

Assessment Boundary: Assessment does not include the biochemical mechanisms of photosynthesis.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions • Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. **Connections to Nature of Science** **Scientific Knowledge is Based on Empirical Evidence** • Science knowledge is based upon logical connections between evidence and explanations.	**LS1.C: Organization for Matter and Energy Flow in Organisms** • Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use. **PS3.D: Energy in Chemical Processes and Everyday Life** • The chemical reaction by which plants produce complex food molecules (sugars) requires an energy input (i.e., from sunlight) to occur. In this reaction, carbon dioxide and water combine to form carbon-based organic molecules and release oxygen. (*Secondary*)	**Energy and Matter** • Within a natural system, the transfer of energy drives the motion and/or cycling of matter.

MS-LS1-7

Students who demonstrate understanding can: Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism.

Clarification Statement: Emphasis is on describing that molecules are broken apart and put back together and that in this process, energy is released.

Assessment Boundary: Assessment does not include details of the chemical reactions for photosynthesis or respiration.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Develop a model to describe unobservable mechanisms.	**LS1.C: Organization for Matter and Energy Flow in Organisms** • Within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, to support growth, or to release energy. **PS3.D: Energy in Chemical Processes and Everyday Life** • Cellular respiration in plants and animals involve chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials. (*Secondary*)	**Energy and Matter** • Matter is conserved because atoms are conserved in physical and chemical processes.

MS-LS2-1

Students that demonstrate understanding can: Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.

Clarification Statement: Emphasis is on cause and effect relationships between resources and growth of individual organisms and the numbers of organisms in ecosystems during periods of abundant and scarce resources. This emphasis should include local ecosystem processes and traditional native ways of knowing.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data • Analyze and interpret data to provide evidence for phenomena.	**LS2.A: Interdependent Relationships in Ecosystems** • Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors. • In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction. • Growth of organisms and population increases are limited by access to resources.	**Cause and Effect** • Cause and effect relationships may be used to predict phenomena in natural or designed systems.

MS-LS2-3

Students who demonstrate understanding can: Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.

Clarification Statement: Emphasis is on describing the conservation of matter and flow of energy into and out of various ecosystems, and on defining the boundaries of the system. Examples should include: food web, energy pyramid, cycles of water, oxygen, nitrogen, and carbon. Alaska references could include animal droppings contributing nutrients to tundra and other ecosystems.

Assessment Boundary: Assessment does not include the use of chemical reactions to describe the processes.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Develop a model to describe phenomena.	**LS2.B: Cycle of Matter and Energy Transfer in Ecosystems** • Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem.	**Energy and Matter** • The transfer of energy can be tracked as energy flows through a natural system. **Connections to Nature of Science** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.

MS-LS2-4

Students who demonstrate understanding can: Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

Clarification Statement: Emphasis is on recognizing patterns in data, evaluating the validity of and analyzing the evidence, and making logical inferences that explain or predict changes in population based on physical or biological changes.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence • Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. **Connections to Nature of Science** **Scientific Knowledge is Based on Empirical Evidence** • Science disciplines share common rules of obtaining and evaluating empirical evidence.	**LS2.C: Ecosystem Dynamics, Functioning, and Resilience** • Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations.	**Stability and Change** • Small changes in one part of a system might cause large changes in another part.

MS. Interdependent Relationships in Ecosystems

Students who demonstrate understanding can:

MS-LS2-2.

Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems. [Clarification Statement: Emphasis is on predicting consistent patterns of interactions in different ecosystems in terms of the relationships among and between organisms and abiotic components of ecosystems. Examples of types of interactions could include competitive, predatory, and mutually beneficial.]

MS-LS2-5.

Evaluate competing design solutions for maintaining biodiversity and ecosystem services.* [Clarification Statement: Examples of ecosystem services could include water purification, nutrient recycling, and prevention of soil erosion. Examples of design solution constraints could include scientific, economic, and social considerations.]

MS-LS2-2

Students who demonstrate understanding can: Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.

Clarification Statement: Emphasis is on predicting consistent patterns of interactions in different ecosystems in terms of the relationships among and between organisms and abiotic components of ecosystems. Examples of types of interactions could include competitive, predatory, and mutually beneficial.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions • Construct an explanation that includes qualitative or quantitative relationships between variables that predict phenomena.	**LS2.A: Interdependent Relationships in Ecosystems** • Similarly, predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. Mutually beneficial interactions, in contrast, may become so interdependent that each organism requires the other for survival. Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and nonliving, are shared.	**Patterns** • Patterns can be used to identify cause and effect relationships.

MS-LS2-5

Students who demonstrate understanding can: Evaluate competing design solutions for maintaining biodiversity and ecosystem services.*

Clarification Statement: Examples of ecosystem services could include water purification, nutrient recycling, and prevention of soil erosion. Examples of design solution constraints could include scientific, economic, and social considerations.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence • Evaluate competing design solutions based on jointly developed and agreed-upon design criteria.	**LS2.C: Ecosystem Dynamics, Functioning, and Resilience** • Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health. **LS4.D Biodiversity and Humans** • Changes in biodiversity can influence humans' resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on—for example, water purification and recycling. (*Secondary*) **ETS1.B: Developing Possible Solutions** • There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (*Secondary*)	**Stability and Change** • Small changes in one part of a system might cause large changes in another part. **Connections to Engineering, Technology, and Applications of Science** **Influence of Science, Engineering, and Technology on Society and the Natural World** • The use of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time. ≽

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
		Connections to Nature of Science **Science Addresses Questions About the Natural and Material World** • Scientific knowledge can describes consequence of actions but does not make the decisions that society takes.

MS. Growth, Development, and Reproduction of Organisms

Students who demonstrate understanding can:

MS-LS1-4.

Use an evidence-based argument to support an explanation for how characteristic behaviors and/or structures of organisms affect the probability of their successful reproduction. [Clarification Statement: Examples of behaviors that affect the probability of animal reproduction could include nest building and burrowing to protect young from cold, herding of animals to protect young from predators, and vocalization of animals and colorful plumage to attract mates for breeding. Examples of animal behaviors that affect the probability of plant reproduction could include transferring pollen or seeds, and creating conditions for seed germination and growth. Examples of plant structures could include bright flowers attracting butterflies that transfer pollen, flower nectar and odors that attract pollinators, and hard shells on nuts that squirrels bury.]

MS-LS1-5.

Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms. [Clarification Statement: Examples of local environmental conditions could include availability of food, light, space, and water. Examples of genetic factors could include large breed cattle and species of grass affecting growth of organisms. Examples of evidence could include drought decreasing plant growth, fertilizer increasing plant growth, different varieties of plant seeds growing at different rates in different conditions, and fish growing larger in large ponds than they do in small ponds. Alaskan examples include fish sizes/population in fresh vs. salt water or of varying water temperatures, deer size and color (Sitka blacktail deer), bear size and color.] [*Assessment Boundary: Assessment does not include genetic mechanisms, gene regulation, or biochemical processes.*]

MS-LS3-1.

Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism. [Clarification Statement: Emphasis is on conceptual understanding that changes in genetic material may result in making different proteins and that the changes can have far-reaching effects.] [*Assessment Boundary: Assessment does not include specific changes at the molecular level, mechanisms for protein synthesis, or specific types of mutations*.]

MS-LS3-2.

Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation. [Clarification Statement: Emphasis is on using models such as Punnett squares, diagrams, and simulations to describe the cause and effect relationship of gene transmission from parent(s) to offspring and resulting genetic variation.]

MS-LS4-5.

Gather and synthesize information about technologies that have changed the way humans influence the inheritance of desired traits in organisms. [Clarification Statement: Emphasis is on synthesizing information from reliable sources about the influence of humans on genetic outcomes in artificial selection (such as genetic modification, animal husbandry, gene therapy); and, on the impacts these technologies have on society as well as the technologies leading to these scientific discoveries.]

MS-LS1-4

Students who demonstrate understanding can: Use an evidence-based argument to support an explanation for how characteristic behaviors and/or structures of organisms affect the probability of their successful reproduction.

Clarification Statement: Examples of behaviors that affect the probability of animal reproduction could include nest building and burrowing to protect young from cold, herding of animals to protect young from predators, and vocalization of animals and colorful plumage to attract mates for breeding. Examples of animal behaviors that affect the probability of plant reproduction could include transferring pollen or seeds, and creating conditions for seed germination and growth. Examples of plant structures could include bright flowers attracting butterflies that transfer pollen, flower nectar and odors that attract pollinators, and hard shells on nuts that squirrels bury.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence • Use an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.	**LS1.B: Growth and Development of Organisms** • Animals engage in characteristic behaviors that increase the odds of reproduction. • Plants reproduce in a variety of ways, sometimes depending on animal behavior and specialized features for reproduction.	**Cause and Effect** • Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.

MS-LS1-5

Students who demonstrate understanding can: Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.

Clarification Statement: Examples of local environmental conditions could include availability of food, light, space, and water. Examples of genetic factors could include large breed cattle and species of grass affecting growth of organisms. Examples of evidence could include drought decreasing plant growth, fertilizer increasing plant growth, different varieties of plant seeds growing at different rates in different conditions, and fish growing larger in large ponds than they do in small ponds. Alaskan examples include fish sizes/population in fresh vs. salt water or of varying water temperatures, deer size and color (Sitka blacktail deer), bear size and color.

Assessment Boundary: Assessment does not include genetic mechanisms, gene regulation, or biochemical processes.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions • Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.	**LS1.B: Growth and Development of Organisms** • Genetic factors as well as local conditions affect the growth of the adult plant.	**Cause and Effect** • Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.

MS-LS3-1

Students who demonstrate understanding can: Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism.

Clarification Statement: Emphasis is on conceptual understanding that changes in genetic material may result in making different proteins and that the changes can have far-reaching effects.

Assessment Boundary: Assessment does not include specific changes at the molecular level, mechanisms for protein synthesis, or specific types of mutations.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Develop and use a model to describe phenomena.	**LS3.A: Inheritance of Traits** • Genes are located in the chromosomes of cells, with each chromosome pair containing two variants of each of many distinct genes. Each distinct gene chiefly controls the production of specific proteins, which in turn affects the traits of the individual. Changes (mutations) to genes can result in changes to proteins, which can affect the structures and functions of the organism and thereby change traits. **LS3.B: Variation of Traits** • In addition to variations that arise from sexual reproduction, genetic information can be altered because of mutations. Though rare, mutations may result in changes to the structure and function of proteins. Some changes are beneficial, others harmful, and some neutral to the organism.	**Structure and Function** • Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts, therefore complex natural and designed structures/systems can be analyzed to determine how they function.

MS-LS3-2

Students who demonstrate understanding can: Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation. [

Clarification Statement: Emphasis is on using models such as Punnett squares, diagrams, and simulations to describe the cause and effect relationship of gene transmission from parent(s) to offspring and resulting genetic variation.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Develop and use a model to describe phenomena.	**LS1.B: Growth and Development of Organisms** • Organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring. (*Secondary*) **LS3.A: Inheritance of Traits** • Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited. **LS3.B: Variation of Traits** • In sexually reproducing organisms, each parent contributes half of the genes acquired (at random) by the offspring. Individuals have two of each chromosome and hence two alleles of each gene, one acquired from each parent. These versions may be identical or may differ from each other.	**Cause and Effect** • Cause and effect relationships may be used to predict phenomena in natural systems.

MS-LS4-5

Students who demonstrate understanding can: Gather and synthesize information about technologies that have changed the way humans influence the inheritance of desired traits in organisms.

Clarification Statement: Emphasis is on synthesizing information from reliable sources about the influence of humans on genetic outcomes in artificial selection (such as genetic modification, animal husbandry, gene therapy); and, on the impacts these technologies have on society as well as the technologies leading to these scientific discoveries.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Obtaining, Evaluating, and Communicating Information • Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence.	**LS4.B: Natural Selection** • In artificial selection, humans have the capacity to influence certain characteristics of organisms by selective breeding. One can choose desired parental traits determined by genes, which are then passed on to offspring.	**Cause and Effect** • Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability. **Connections to Engineering, Technology, and Applications of Science** **Interdependence of Science, Engineering, and Technology** • Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems. **Connections to Nature of Science** **Science Addresses Questions About the Natural and Material World** • Scientific knowledge can describe consequences of actions but does not make the decisions that society takes.

MS. Natural Selection and Adaptations

Students who demonstrate understanding can:

MS-LS4-1.

Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past. [Clarification Statement: Emphasis is on finding patterns of changes in the level of complexity of anatomical structures in organisms and the chronological order of fossil appearance in the rock layers.] [*Assessment Boundary: Assessment does not include the names of individual species or geological eras in the fossil record*.]

MS-LS4-2.

Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships. [Clarification Statement: Emphasis is on comparing anatomical differences, such as field experiences using dichotomous and other types of keys, in order to explain evolutionary relationships among organisms in terms of similarity or differences of the gross appearance of anatomical structures.]

MS-LS4-3.

Analyze displays of pictorial data to compare patterns of similarities in the embryological development across multiple species to identify relationships not evident in the fully formed anatomy. [Clarification Statement: Emphasis is on inferring general patterns of relatedness among embryos of different organisms by comparing the macroscopic appearance of diagrams or pictures.] [*Assessment Boundary: Assessment of comparisons is limited to gross appearance of anatomical structures in embryological development*.]

MS-LS4-4.

Construct and present an evidence-based explanation of how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment. [Clarification Statement: Emphasis is on using simple probability statements and proportional reasoning to construct explanations.]

MS-LS4-6.

Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time. [Clarification Statement: Emphasis is on using mathematical models, probability statements, and proportional reasoning to support explanations of trends in changes to populations over time.] [*Assessment Boundary: Assessment does not include Hardy Weinberg calculations*.]

MS-LS4-1

Students who demonstrate understanding can: Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past.

Clarification Statement: Emphasis is on finding patterns of changes in the level of complexity of anatomical structures in organisms and the chronological order of fossil appearance in the rock layers.

Assessment Boundary: Assessment does not include the names of individual species or geological eras in the fossil record.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data • Analyze and interpret data to determine similarities and differences in findings. **Connections to Nature of Science** **Scientific Knowledge is Based on Empirical Evidence** • Science knowledge is based upon logical and conceptual connections between evidence and explanations.	**4.A: Evidence of Common Ancestry and Diversity** • The collection of fossils and their placement in chronological order (e.g., through the location of the sedimentary layers in which they are found or through radioactive dating) is known as the fossil record. It documents the existence, diversity, extinction, and change of many life forms throughout the history of life on Earth.	**Patterns** • Graphs, charts, and images can be used to identify patterns in data. **Connections to Nature of Science** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.

MS-LS4-2

Students who demonstrate understanding can: Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships.

Clarification Statement: Emphasis is on comparing anatomical differences, such as field experiences using dichotomous and other types of keys, in order to explain evolutionary relationships among organisms in terms of similarity or differences of the gross appearance of anatomical structures.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions • Apply scientific ideas to construct an explanation for real-world phenomena, examples, or events.	**LS4.A: Evidence of Common Ancestry and Diversity** • Anatomical similarities and differences between various organisms living today and between them and organisms in the fossil record, enable the reconstruction of evolutionary history and the inference of lines of evolutionary descent.	**Patterns** • Patterns can be used to identify cause and effect relationships. **Connections to Nature of Science** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.

MS-LS4-3

Students who demonstrate understanding can: Analyze displays of pictorial data to compare patterns of similarities in the embryological development across multiple species to identify relationships not evident in the fully formed anatomy.

Clarification Statement: Emphasis is on inferring general patterns of relatedness among embryos of different organisms by comparing the macroscopic appearance of diagrams or pictures.

Assessment Boundary: Assessment of comparisons is limited to gross appearance of anatomical structures in embryological development.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data • Analyze displays of data to identify linear and nonlinear relationships.	**LS4.A: Evidence of Common Ancestry and Diversity** • Comparison of the embryological development of different species also reveals similarities that show relationships not evident in the fully-formed anatomy.	**Patterns** • Graphs, charts, and images can be used to identify patterns in data.

MS-LS4-4

Students who demonstrate understanding can: Construct and present an evidence-based explanation of how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.

Clarification Statement: Emphasis is on using simple probability statements and proportional reasoning to construct explanations.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions • Construct an explanation that includes qualitative or quantitative relationships between variables that describe phenomena.	**LS4.B: Natural Selection** • Natural selection leads to the predominance of certain traits in a population, and the suppression of others.	**Cause and Effect** • Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.

MS-LS4-6

Students who demonstrate understanding can: Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time.

Clarification Statement: Emphasis is on using mathematical models, probability statements, and proportional reasoning to support explanations of trends in changes to populations over time.

Assessment Boundary: Assessment does not include Hardy Weinberg calculations.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematics and Computational Thinking • Use mathematical representations to support scientific conclusions and design solutions.	**LS4.C: Adaptation** • Adaptation by natural selection acting over generations is one important process by which species change over time in response to changes in environmental conditions. Traits that support successful survival and reproduction in the new environment become more common; those that do not become less common. Thus, the distribution of traits in a population changes.	**Cause and Effect** • Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.

MIDDLE SCHOOL EARTH AND SPACE SCIENCES

Students in middle school develop understanding of a wide range of topics in Earth and space science (ESS) that build upon science concepts from elementary school through more advanced content, practice, and crosscutting themes. There are six ESS standard topics in middle school: Space Systems, History of Earth, Earth's Interior Systems, Earth's Surface Systems, Weather and Climate, and Human Impacts. The content of the performance expectations are based on current community-based geoscience literacy efforts such as the Earth Science Literacy Principles (Wysession et al., 2012), and is presented with a greater emphasis on an Earth Systems Science approach. The performance expectations strongly reflect the many societally relevant aspects of ESS (resources, hazards, environmental impacts) as well as related connections to engineering and technology.

Space Systems: Middle school students can examine the Earth's place in relation to the solar system, Milky Way galaxy, and universe. There is a strong emphasis on a systems approach, using models of the solar system to explain astronomical and other observations of the cyclic patterns of eclipses, tides, and seasons. There is also a strong connection to engineering through the instruments and technologies that have allowed us to explore the objects in our solar system and obtain the data that support the theories that explain the formation and evolution of the universe.

History of Earth: Students can examine geoscience data in order to understand the processes and events in Earth's history. Important concepts in this topic are "Scale, Proportion, and Quantity" and "Stability and Change," in relation to the different ways geologic processes operate over the long expanse of geologic time. An important aspect of the history of Earth is that geologic events and conditions have affected the evolution of life, but different life forms have also played important roles in altering Earth's systems.

Earth's Systems: Students understand how Earth's geosystems operate by modeling the flow of energy and cycling of matter within and among different systems. Students can investigate the controlling properties of important materials and construct explanations based on the analysis of real geoscience data. Of special importance in both topics are the ways that geoscience processes provide resources needed by society but also cause natural hazards that present risks to society; both involve technological challenges, for the identification and development of resources and for the mitigation of hazards.

Weather and Climate: Students can analyze data, including maps, and construct and use models to develop understanding of the factors that control weather and climate. A systems approach is also important here, examining the feedbacks between systems as energy from the sun is transferred between systems and circulates though the ocean and atmosphere.

Human Impacts: Students understand the ways that human activities impacts Earth's other systems. Students can use many different practices to understand the significant and complex issues surrounding human uses of land, energy, mineral, and water resources and the resulting impacts of their development.

MS. Space Systems

Students who demonstrate understanding can:

MS-ESS1-1a

Develop and use a model to explain how the positions of the Earth-Sun-Moon in a system and the cyclic patterns of each cause lunar phases and eclipses of the sun and moon. [Clarification Statement: Examples of models can be physical, graphical, or conceptual.]

MS-ESS1-1b

Develop and use a model to explain how the seasons occur. [Clarification statement: Reference Alaskan community latitudes and how position on the Earth affects the severity of the seasons for the different regions of AK. Compare and describe the seasons of the northern hemisphere and the southern hemisphere.] [*Assessment Boundary: Assessment limited to qualitative and spatial explanations for seasons*.]

MS-ESS1-2

Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system. [Clarification Statement: Emphasis for the model is on gravity as the force that holds together the solar system and Milky Way galaxy and controls orbital motions within them. Examples of models can be physical (such as the analogy of distance along a football field or computer visualizations of elliptical orbits) or conceptual (such as mathematical proportions relative to the size of familiar objects such as students' school or state.)] [*Assessment Boundary: Assessment does not include Kepler's Laws of orbital motion or the apparent retrograde motion of the planets as viewed from Earth*.]

MS-ESS1-3

Analyze data to determine scale properties of objects in the solar system. [Clarification Statement: Emphasis is on the analysis of data from Earth-based instruments, space-based telescopes, and spacecraft to determine similarities and differences among solar system objects. Examples of scale properties include the sizes of an object's layers (such as crust and atmosphere), surface features (such as volcanoes), and orbital radius. Examples of data include statistical information, drawings and photographs, and models.] [*Assessment Boundary: Assessment does not include recalling facts about properties of the planets and other solar system bodies*.]

MS-ESS1-1a

Students who demonstrate understanding can: Develop and use a model to explain how the positions of the Earth-Sun-Moon in a system and the cyclic patterns of each cause lunar phases and eclipses of the sun and moon.

Clarification Statement: Examples of models can be physical, graphical, or conceptual.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Develop and use a model to describe phenomena.	**ESS1.A The Universe and its Stars** • Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models. **ESS1.B: Earth and the Solar System** • This model of the solar system can explain eclipses of the sun and the moon. Earth's spin axis is fixed in direction over the short- term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year.	**Patterns** • Patterns can be used to identify cause and effect relationships. **Connections to Nature of Science** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.

MS-ESS1-1b

Students who demonstrate understanding can: Develop and use a model to explain how the seasons occur.

Clarification statement: Reference Alaskan community latitudes and how position on the Earth affects the severity of the seasons for the different regions of AK. Compare and describe the seasons of the northern hemisphere and the southern hemisphere.

Assessment Boundary: Assessment limited to qualitative and spatial explanations for seasons.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Develop and use a model to describe phenomena.	**ESS1.A The Universe and its Stars** • Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models. **ESS1.B: Earth and the Solar System** • This model of the solar system can explain eclipses of the sun and the moon. Earth's spin axis is fixed in direction over the short- term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year.	**Patterns** • Patterns can be used to identify cause and effect relationships. **Connections to Nature of Science** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.

MS-ESS1-2

Students who demonstrate understanding can: Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system.

Clarification Statement: Emphasis for the model is on gravity as the force that holds together the solar system and Milky Way galaxy and controls orbital motions within them. Examples of models can be physical (such as the analogy of distance along a football field or computer visualizations of elliptical orbits) or conceptual (such as mathematical proportions relative to the size of familiar objects such as students' school or state.)

Assessment Boundary: Assessment does not include Kepler's Laws of orbital motion or the apparent retrograde motion of the planets as viewed from Earth.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Develop and use a model to describe phenomena.	**ESS1.A The Universe and its Stars** • Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe. **ESS1.B: Earth and the Solar System** • The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them. • The solar system appears to have formed from a disk of dust and gas, drawn together by gravity.	**Systems and System Models** • Models can be used to represent systems and their interactions. **Connections to Nature of Science** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.

MS-ESS1-3

Students who demonstrate understanding can: Analyze data to determine scale properties of objects in the solar system.

Clarification Statement: Emphasis is on the analysis of data from Earth-based instruments, space-based telescopes, and spacecraft to determine similarities and differences among solar system objects. Examples of scale properties include the sizes of an object's layers (such as crust and atmosphere), surface features (such as volcanoes), and orbital radius. Examples of data include statistical information, drawings and photographs, and models.

Assessment Boundary: Assessment does not include recalling facts about properties of the planets and other solar system bodies.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data • Analyze and interpret data to determine similarities and differences in findings.	**ESS1.B: Earth and the Solar System** • The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them.	**Scale, Proportion, and Quantity** • Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. **Connections to Engineering, Technology, and Applications of Science** **Interdependence of Science, Engineering, and Technology** • Engineering advances have led to important discoveries in virtually every field of science and scientific discoveries have led to the development of entire industries and engineered systems.

MS. History of Earth

Students who demonstrate understanding can:

MS-ESS1-4

Construct and explain, using evidence from rock strata, how the geologic time scale is used to organize Earth's 4.6-billion-year-old history. [Clarification Statement: Emphasis is on how analyses of rock formations and the fossils they contain are used to establish relative ages of major events in Earth's history. Examples of Earth's major events could range from being very recent (such as the last Ice Age or the earliest fossils of homo sapiens) to very old (such as the formation of Earth or the earliest evidence of life). Examples can include the formation of mountain chains and ocean basins, the evolution or extinction of particular living organisms, or significant volcanic eruptions.] [*Assessment Boundary: Assessment does not include recalling the names of specific periods or epochs and events within them*.]

MS-ESS2-2

Construct and present an evidence-based explanation of how geoscience processes have changed Earth's surface at varying time and spatial scales. [Clarification Statement: Emphasis is on how processes change Earth's surface at time and spatial scales that can be large (such as slow plate motions or the uplift of large mountain ranges) or small (such as rapid landslides or microscopic geochemical reactions), and how many geoscience processes (such as earthquakes, volcanoes, and meteor impacts) usually behave gradually but are punctuated by catastrophic events. Examples of geoscience processes include surface weathering and deposition by the movements of water, ice, and wind. Emphasis is on geoscience processes that shape local geographic features, where appropriate. Alaskan examples should include locally significant landforms including coastal or ocean sea floor structures.]

MS-ESS2-3

Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions. [Clarification Statement: Examples of data include similarities of rock and fossil types on different continents, the shapes of the continents (including continental shelves), and the locations of ocean structures (such as ridges, fracture zones, and trenches).] [*Assessment Boundary: Paleomagnetic anomalies in oceanic and continental crust are not assessed*.]

MS-ESS1-4

Students who demonstrate understanding can: Construct and explain, using evidence from rock strata, how the geologic time scale is used to organize Earth's 4.6-billion-year-old history.

Clarification Statement: Emphasis is on how analyses of rock formations and the fossils they contain are used to establish relative ages of major events in Earth's history. Examples of Earth's major events could range from being very recent (such as the last Ice Age or the earliest fossils of homo sapiens) to very old (such as the formation of Earth or the earliest evidence of life). Examples can include the formation of mountain chains and ocean basins, the evolution or extinction of particular living organisms, or significant volcanic eruptions.

Assessment Boundary: Assessment does not include recalling the names of specific periods or epochs and events within them.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions • Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.	**ESS1.C: The History of Planet Earth** • The geologic time scale interpreted from rock strata provides a way to organize Earth's history. Analyses of rock strata and the fossil record provide only relative dates, not an absolute scale.	**Scale Proportion and Quantity** • Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.

MS-ESS2-2

Students who demonstrate understanding can: Construct and present an evidence-based explanation of how geoscience processes have changed Earth's surface at varying time and spatial scales.

Clarification Statement: Emphasis is on how processes change Earth's surface at time and spatial scales that can be large (such as slow plate motions or the uplift of large mountain ranges) or small (such as rapid landslides or microscopic geochemical reactions), and how many geoscience processes (such as earthquakes, volcanoes, and meteor impacts) usually behave gradually but are punctuated by catastrophic events. Examples of geoscience processes include surface weathering and deposition by the movements of water, ice, and wind. Emphasis is on geoscience processes that shape local geographic features, where appropriate. Alaskan examples should include locally significant landforms including coastal or ocean sea floor structures.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions • Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.	**ESS2.A: Earth's Materials and Systems** • The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future **ESS2.C: The Roles of Water in Earth's Surface Processes** • Water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface features and create underground formations.	**Scale Proportion and Quantity** • Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.

MS-ESS2-3

Students who demonstrate understanding can: Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions.

Clarification Statement: Examples of data include similarities of rock and fossil types on different continents, the shapes of the continents (including continental shelves), and the locations of ocean structures (such as ridges, fracture zones, and trenches).

Assessment Boundary: Paleomagnetic anomalies in oceanic and continental crust are not assessed.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data • Analyze and interpret data to provide evidence for phenomena. **Connections to Nature of Science** **Scientific Knowledge is Open to Revision in Light of New Evidence** • Science findings are frequently revised and/or reinterpreted based on new evidence.	**ESS1.C: The History of Planet Earth** • Tectonic processes continually generate new ocean sea floor at ridges and destroy old sea floor at trenches. (*Secondary*) **ESS2.B: Plate Tectonics and Large-Scale System Interactions** • Maps of ancient land and water patterns, based on investigations of rocks and fossils, make clear how Earth's plates have moved great distances, collided, and spread apart.	**Patterns** • Patterns in rates of change and other numerical relationships can provide information about natural and human designed systems.

MS. Earth's Systems

Students who demonstrate understanding can:

MS-ESS2-1

Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process. [Clarification Statement: Emphasis is on the processes of melting, crystallization, weathering, deformation, and sedimentation, which act together to form minerals and rocks through the cycling of Earth's materials.] [*Assessment Boundary: Assessment does not include the identification and naming of minerals*.]

MS-ESS2-4

Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity. [Clarification Statement: Emphasis is on the ways water changes its state as it moves through the multiple pathways of the hydrologic cycle. Examples of models can be conceptual or physical.] [*Assessment Boundary: A quantitative understanding of the latent heats of vaporization and fusion is not assessed*.]

MS-ESS3-1

Construct an evidence-based explanation for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes. [Clarification Statement: Emphasis is on how these resources are limited and typically non-renewable, and how their distributions are significantly changing as a result of removal by humans. Examples of uneven distributions of resources as a result of past processes include but are not limited to petroleum (locations of the burial of organic marine sediments and subsequent geologic traps), metal ores (locations of past volcanic and hydrothermal activity associated with subduction zones), and soil (locations of active weathering and/or deposition of rock).]

MS-ESS2-1

Students who demonstrate understanding can: Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.

Clarification Statement: Emphasis is on the processes of melting, crystallization, weathering, deformation, and sedimentation, which act together to form minerals and rocks through the cycling of Earth's materials.

Assessment Boundary: Assessment does not include the identification and naming of minerals.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Develop and use a model to describe phenomena.	**ESS2.A: Earth's Materials and Systems** • All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms.	**Stability and Change** • Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and processes at different scales, including the atomic scale.

MS-ESS2-4

Students who demonstrate understanding can: Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.

Clarification Statement: Emphasis is on the ways water changes its state as it moves through the multiple pathways of the hydrologic cycle. Examples of models can be conceptual or physical.

Assessment Boundary: A quantitative understanding of the latent heats of vaporization and fusion is not assessed.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Develop a model to describe unobservable mechanisms.	**ESS2.C: The Roles of Water in Earth's Surface Processes** • Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land. • Global movements of water and its changes in form are propelled by sunlight and gravity.	**Energy and Matter** • Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter.

MS-ESS3-1

Students who demonstrate understanding can: Construct an evidence-based explanation for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes.

Clarification Statement: Emphasis is on how these resources are limited and typically non-renewable, and how their distributions are significantly changing as a result of removal by humans. Examples of uneven distributions of resources as a result of past processes include but are not limited to petroleum (locations of the burial of organic marine sediments and subsequent geologic traps), metal ores (locations of past volcanic and hydrothermal activity associated with subduction zones), and soil (locations of active weathering and/or deposition of rock).

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions • Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.	**ESS3.A: Natural Resources** • Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes.	**Cause and Effect** • Cause and effect relationships may be used to predict phenomena in natural or designed systems. **Connections to Engineering, Technology, and Applications of Science** **Influence of Science, Engineering, and Technology on Society and the Natural World** • All human activity draws on natural resources and has both short and long-term consequences, positive as well a negative, for the health of people and the natural environment.

MS. Weather and Climate

Students who demonstrate understanding can:

MS-ESS2-5

Collect data to provide evidence for how the motions and complex interactions of air masses result in changes in weather conditions. [Clarification Statement: Emphasis is on how air masses flow from regions of high pressure to low pressure, causing weather (defined by temperature, pressure, humidity, precipitation, and wind) at a fixed location to change over time, and how sudden changes in weather can result when different air masses collide. Emphasis is on how weather can be predicted within probabilistic ranges. Examples of data can be provided to students (such as weather maps, diagrams, and visualizations) or obtained through laboratory experiments (such as with condensation).] [*Assessment Boundary: Assessment does not include recalling the names of cloud types or weather symbols used on weather maps or the reported diagrams from weather stations*.]

MS-ESS2-6

Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates. [Clarification Statement: Emphasis is on how patterns vary by latitude, altitude, and geographic land distribution. Emphasis of atmospheric circulation is on the sunlight-driven latitudinal banding, the Coriolis effect, and resulting prevailing winds; emphasis of ocean circulation is on the transfer of heat by the global ocean convection cycle, which is constrained by the Coriolis effect and the outlines of continents. Examples of models can be diagrams, maps and globes, or digital representations.] [*Assessment Boundary: Assessment does not include the dynamics of the Coriolis effect*.]

MS-ESS3-5

Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century. [Clarification Statement: Examples of factors include human activities (such as fossil fuel combustion, cement production, and agricultural activity) and natural processes (such as changes in incoming solar radiation or volcanic activity). Examples of evidence can include tables, graphs, and maps of global and regional temperatures and chemistry (both ocean and land surface), sea ice cover, permafrost, glacial change, atmospheric levels of gases such as carbon dioxide and methane, food availability locally and worldwide, and the rates of human activities. Emphasis is on the major role that human activities play in causing the rise in global temperatures.]

MS-ESS2-5

Students who demonstrate understanding can: Collect data to provide evidence for how the motions and complex interactions of air masses result in changes in weather conditions.

Clarification Statement: Emphasis is on how air masses flow from regions of high pressure to low pressure, causing weather (defined by temperature, pressure, humidity, precipitation, and wind) at a fixed location to change over time, and how sudden changes in weather can result when different air masses collide. Emphasis is on how weather can be predicted within probabilistic ranges. Examples of data can be provided to students (such as weather maps, diagrams, and visualizations) or obtained through laboratory experiments (such as with condensation)..

Assessment Boundary: Assessment does not include recalling the names of cloud types or weather symbols used on weather maps or the reported diagrams from weather stations.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations • Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions.	**ESS2.C: The Roles of Water in Earth's Surface Processes** • The complex patterns of the changes and the movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns. **ESS2.D: Weather and Climate** • Because these patterns are so complex, weather can only be predicted probabilistically.	**Cause and Effect** • Cause and effect relationships may be used to predict phenomena in natural systems.

MS-ESS2-6

Students who demonstrate understanding can: Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.

Clarification Statement: Emphasis is on how patterns vary by latitude, altitude, and geographic land distribution. Emphasis of atmospheric circulation is on the sunlight-driven latitudinal banding, the Coriolis effect, and resulting prevailing winds; emphasis of ocean circulation is on the transfer of heat by the global ocean convection cycle, which is constrained by the Coriolis effect and the outlines of continents. Examples of models can be diagrams, maps and globes, or digital representations.

Assessment Boundary: Assessment does not include the dynamics of the Coriolis effect.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Develop and use a model to describe phenomena.	**ESS2.C: The Roles of Water in Earth's Surface Processes** • Variations in density due to variations in temperature and salinity drive a global pattern of interconnected ocean currents. **ESS2.D: Weather and Climate** • Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns. • The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents.	**Systems and System Models** • Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems.

MS-ESS3-5

Students who demonstrate understanding can: Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.

Clarification Statement: Examples of factors include human activities (such as fossil fuel combustion, cement production, and agricultural activity) and natural processes (such as changes in incoming solar radiation or volcanic activity). Examples of evidence can include tables, graphs, and maps of global and regional temperatures and chemistry (both ocean and land surface), sea ice cover, permafrost, glacial change, atmospheric levels of gases such as carbon dioxide and methane, food availability locally and worldwide, and the rates of human activities. Emphasis is on the major role that human activities play in causing the rise in global temperatures.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Asking Questions and Defining Problems • Ask questions to identify and clarify evidence of an argument.	**ESS3.D: Global Climate Change** • Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature (global warming). Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior and on applying that knowledge wisely in decisions and activities.	**Stability and Change** • Stability might be disturbed either by sudden events or gradual changes that accumulate over time.

MS. Human Impacts

Students who demonstrate understanding can:

MS-ESS3-2

Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects. [Clarification Statement: Emphasis is on how some natural hazards, such as volcanic eruptions and severe weather, are preceded by phenomena that allow for reliable predictions, but others, such as earthquakes, occur suddenly and with no notice, and thus are not yet predictable. Examples of natural hazards can be taken from interior processes (such as earthquakes and volcanic eruptions), surface processes (such as mass wasting and tsunamis), or severe weather events (such as hurricanes, tornadoes, and floods). Examples of data can include the locations, magnitudes, and frequencies of the natural hazards. Examples of technologies can be global (such as satellite systems to monitor hurricanes or forest fires) or local (such as building basements in tornado-prone regions or reservoirs to mitigate droughts). Alaskan examples should include but are not limited to tsunamis, storm surges, landslides, and earthquakes.]

MS-ESS3-3

Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.* [Clarification Statement: Examples of the design process include examining human environmental impacts, assessing the kinds of solutions that are feasible, and designing and evaluating solutions that could reduce that impact. Examples of human impacts can include water usage (such as the withdrawal of water from streams and aquifers or the construction of dams and levees), land usage (such as urban development, agriculture, or the removal of wetlands), and pollution (such as of the air, water, or land).]

MS-ESS3-4

Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems. [Clarification Statement: Examples of evidence include grade-appropriate databases on human populations and the rates of consumption of food and natural resources (such as freshwater, mineral, and energy). Examples of impacts can include changes to the appearance, composition, and structure of Earth’s systems as well as the rates at which they change. The consequences of increases in human populations and consumption of natural resources are described by science, but science does not make the decisions for the actions society takes.]

MS-ESS3-2

Students who demonstrate understanding can: Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.

Clarification Statement: Emphasis is on how some natural hazards, such as volcanic eruptions and severe weather, are preceded by phenomena that allow for reliable predictions, but others, such as earthquakes, occur suddenly and with no notice, and thus are not yet predictable. Examples of natural hazards can be taken from interior processes (such as earthquakes and volcanic eruptions), surface processes (such as mass wasting and tsunamis), or severe weather events (such as hurricanes, tornadoes, and floods). Examples of data can include the locations, magnitudes, and frequencies of the natural hazards. Examples of technologies can be global (such as satellite systems to monitor hurricanes or forest fires) or local (such as building basements in tornado-prone regions or reservoirs to mitigate droughts). Alaskan examples should include but are not limited to tsunamis, storm surges, landslides, and earthquakes.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data • Analyze and interpret data to determine similarities and differences in findings.	**ESS3.B: Natural Hazards** • Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces can help forecast the locations and likelihoods of future events.	**Patterns** • Graphs, charts, and images can be used to identify patterns in data. **Connections to Engineering, Technology, and Applications of Science** **Influence of Science, Engineering, and Technology on Society and the Natural World** • The uses of technologies and limitations on their use are driven by people's needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time.

MS-ESS3-3

Students who demonstrate understanding can: Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.*

Clarification Statement: Examples of the design process include examining human environmental impacts, assessing the kinds of solutions that are feasible, and designing and evaluating solutions that could reduce that impact. Examples of human impacts can include water usage (such as the withdrawal of water from streams and aquifers or the construction of dams and levees), land usage (such as urban development, agriculture, or the removal of wetlands), and pollution (such as of the air, water, or land).

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions • Apply scientific principles to design an object, tool, process or system.	**ESS3.C: Human Impacts on Earth Systems** • Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things. • Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.	**Cause and Effect** • Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation. **Connections to Engineering, Technology, and Applications of Science** **Influence of Science, Engineering, and Technology on Society and the Natural World** • The uses of technologies and limitations on their use are driven by people's needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time.

MS-ESS3-4

Students who demonstrate understanding can: Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.

Clarification Statement: Examples of evidence include grade-appropriate databases on human populations and the rates of consumption of food and natural resources (such as freshwater, mineral, and energy). Examples of impacts can include changes to the appearance, composition, and structure of Earth's systems as well as the rates at which they change. The consequences of increases in human populations and consumption of natural resources are described by science, but science does not make the decisions for the actions society takes.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence • Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.	**ESS3.C: Human Impacts on Earth Systems** • Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.	**Cause and Effect** • Cause and effect relationships may be used to predict phenomena in natural or designed systems. **Connections to Engineering, Technology, and Applications of Science** **Influence of Science, Engineering, and Technology on Society and the Natural World** • All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
		Connections to Nature of Science **Science Addresses Questions About the Natural and Material World** • Science knowledge can describe consequences of actions but does not make the decisions that society takes.

MS. Engineering Design

Students who demonstrate understanding can:

MS-ETS1-1

Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

MS-ETS1-2

Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

MS-ETS1-3

Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

MS-ETS1-4

Develop a model to generate data for repetitive testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

MS-ETS1-1

Students who demonstrate understanding can: Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Asking Questions and Defining Problems • Define a design problem that can be solved through the development of an object, tool, process, or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions.	**ETS1.A: Defining and Delimiting Engineering Problems** • The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge likely to limit possible solutions.	**Influence of Engineering, Technology, and Science on Society and the Natural World** • All human activity draws on natural resources and has both short- and long-term consequences, positive as well as negative, for the health of people and the natural environment. • The use of technologies and limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions.

MS-ETS1-2

Students who demonstrate understanding can: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence • Evaluate competing design solutions based on jointly developed and agreed-upon design criteria.	**ETS1.B: Developing Possible Solutions** • There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem.	

MS-ETS1-3

Students who demonstrate understanding can: Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data • Analyze and interpret data to determine similarities and differences in findings.	**ETS1.B: Developing Possible Solutions** • There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. • Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. **ETS1.C: Optimizing the Design Solution** • Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design.	

MS-ETS1-4

Students who demonstrate understanding can: Develop a model to generate data for repetitive testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Develop a model to generate data to test ideas about designed system, including those representing inputs and outputs.	**ETS1.B: Developing Possible Solutions** • A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. • Models of all kinds are important for testing solutions. **ETS1.C: Optimizing the Design Solution** • The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution.	

HIGH SCHOOL PHYSICAL SCIENCES

Students in high school continue to develop their understanding of the four core ideas in the physical sciences. These ideas include the most fundamental concepts from chemistry and physics, but are intended to leave room for expanded study in upper-level high school courses. The high school performance expectations in Physical Science build on the middle school ideas and skills and allow high school students to explain more in-depth phenomena central not only to the physical sciences, but to life and earth and space sciences as well. These performance expectations blend the core ideas with scientific and engineering practices and crosscutting concepts to support students in developing useable knowledge to explain ideas across the science disciplines. In the physical science performance expectations at the high school level, there is a focus on several scientific practices. These include developing and using models, planning and conducting investigations, analyzing and interpreting data, using mathematical and computational thinking, and constructing explanations; and to use these practices to demonstrate understanding of the core ideas. Students are also expected to demonstrate understanding of several engineering practices, including design and evaluation.

The performance expectations in the topic **Structure and Properties of Matter** help students formulate an answer to the question, “How can one explain the structure and properties of matter?” Two sub-ideas from the *NRC Framework* are addressed in these performance expectations: the structure and properties of matter, and nuclear processes. Students are expected to develop understanding of the substructure of atoms and provide more mechanistic explanations of the properties of substances. Students are able to use the periodic table as a tool to explain and predict the properties of elements. Phenomena involving nuclei are also important to understand, as they explain the formation and abundance of the elements, radioactivity, the release of energy from the sun and other stars, and the generation of nuclear power. The crosscutting concepts of patterns, energy and matter, and structure and function are called out as organizing concepts for these disciplinary core ideas. In these performance expectations, students are expected to demonstrate proficiency in developing and using models, planning and conducting investigations, and communicating scientific and technical information; and to use these practices to demonstrate understanding of the core ideas.

The performance expectations in the topic **Chemical Reactions** help students formulate an answer to the questions: “How do substances combine or change (react) to make new substances? How does one characterize and explain these reactions and make predictions about them?” Chemical reactions, including rates of reactions and energy changes, can be understood by students at this level in terms of the collisions of molecules and the rearrangements of atoms. Using this expanded knowledge of chemical reactions, students are able to explain important biological and geophysical phenomena. Students are also able to apply an understanding of the process of optimization in engineering design to chemical reaction systems. The crosscutting concepts of patterns, energy and matter, and stability and change are called out as organizing concepts for these disciplinary core ideas. In these performance expectations, students are expected to demonstrate proficiency in developing and using models, using mathematical thinking, constructing explanations, and designing solutions; and to use these practices to demonstrate understanding of the core ideas.

The Performance Expectations associated with the topic **Forces and Interactions** supports students' understanding of ideas related to why some objects will keep moving, why objects fall to the ground, and why some materials are attracted to each other while others are not. Students should be able to answer the question, "How can one explain and predict interactions between objects and within systems of objects?" The disciplinary core idea expressed in the Framework for PS2 is broken down into the sub ideas of Forces and Motion and Types of Interactions. The performance expectations in PS2 focus on students building understanding of forces and interactions and Newton's Second Law. Students also develop understanding that the total momentum of a system of objects is conserved when there is no net force on the system. Students are able to use Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects. Students are able to apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision. The crosscutting concepts of patterns, cause and effect, and systems and system models are called out as organizing concepts for these disciplinary core ideas. In the PS2 performance expectations, students are expected to demonstrate proficiency in planning and conducting investigations, analyzing data and using math to support claims, and applying scientific ideas to solve design problems; and to use these practices to demonstrate understanding of the core ideas.

The Performance Expectations associated with the topic **Energy** help students formulate an answer to the question, "How is energy transferred and conserved?" The disciplinary core idea expressed in the Framework for PS3 is broken down into four sub-core ideas: Definitions of Energy, Conservation of Energy and Energy Transfer, the Relationship between Energy and Forces, and Energy in Chemical Process and Everyday Life. Energy is understood as quantitative property of a system that depends on the motion and interactions of matter and radiation within that system, and the total change of energy in any system is always equal to the total energy transferred into or out of the system. Students develop an understanding that energy at both the macroscopic and the atomic scale can be accounted for as either motions of particles or energy associated with the configuration (relative positions) of particles. In some cases, the energy associated with the configuration of particles can be thought of as stored in fields. Students also demonstrate their understanding of engineering principles when they design, build, and refine devices associated with the conversion of energy. The crosscutting concepts of cause and effect; systems and system models; energy and matter; and the influence of science, engineering, and technology on society and the natural world are further developed in the performance expectations associated with PS3. In these performance expectations, students are expected to demonstrate proficiency in developing and using models, planning and carry out investigations, using computational thinking, and designing solutions; and to use these practices to demonstrate understanding of the core ideas.

The Performance Expectations associated with the topic **Waves and Electromagnetic Radiation** are critical to understand how many new technologies work. As such, this disciplinary core idea helps students answer the question, "How are waves used to transfer energy and send and store information?" The disciplinary core idea in PS4 is broken down into Wave Properties, Electromagnetic Radiation, and Information

Technologies and Instrumentation. Students are able to apply understanding of how wave properties and the interactions of electromagnetic radiation with matter can transfer information across long distances, store information, and investigate nature on many scales. Models of electromagnetic radiation as either a wave of changing electric and magnetic fields or as particles are developed and used. Students understand that combining waves of different frequencies can make a wide variety of patterns and thereby encode and transmit information. Students also demonstrate their understanding of engineering ideas by presenting information about how technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy. The crosscutting concepts of cause and effect; systems and system models; stability and change; interdependence of science, engineering, and technology; and the influence of engineering, technology, and science on society and the natural world are highlighted as organizing concepts for these disciplinary core ideas. In the PS3 performance expectations, students are expected to demonstrate proficiency in asking questions, using mathematical thinking, engaging in argument from evidence, and obtaining, evaluating and communicating information; and to use these practices to demonstrate understanding of the core ideas.

HS. Structure and Properties of Matter

Students who demonstrate understanding can:

HS-PS1-1.

Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms (valence electrons). [Clarification Statement: Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.] [*Assessment Boundary: Assessment is limited to main group elements. Assessment does not include quantitative understanding of ionization energy beyond relative trends*.]

HS-PS1-3.

Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. [Clarification Statement: Emphasis is on understanding the strengths of forces between particles, not on naming specific intermolecular forces (such as dipole-dipole). Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite). Examples of bulk properties of substances could include the melting point and boiling point, vapor pressure, and surface tension.] [*Assessment Boundary: Assessment does not include Raoult's law calculations of vapor pressure.*]

HS-PS1-8.

Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay. [Clarification Statement: Emphasis is on simple qualitative models, such as pictures or diagrams, and on the scale of energy released in nuclear processes relative to other kinds of transformations. Example applications include dating of rocks, carbon dating of artifacts, paleoclimate studies, medical imaging, tracking animal migrations via diet, age dating meteorites, tracking ground water flow.] [*Assessment Boundary: Assessment does not include quantitative calculation of energy released. Assessment is limited to alpha, beta, and gamma radioactive decays*.]

HS-PS2-6.

Communicate scientific and technical information about why the molecular-level structure is important in the functioning of natural and designed materials. [Clarification Statement: Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.] [*Assessment Boundary: Assessment is limited to provided molecular structures of specific designed materials*.]

HS-PS1-1

Students who demonstrate understanding can: Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms (valence electrons).

Clarification Statement: Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.

Assessment Boundary: Assessment is limited to main group elements. Assessment does not include quantitative understanding of ionization energy beyond relative trends.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Use a model to predict the relationships between systems or between components of a system.	**PS1.A: Structure and Properties of Matter** • Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. • The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. **PS2.B: Types of Interactions** • Attraction and repulsion between electrical charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. (*Secondary*)	**Patterns** • Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

HS-PS1-3

Students who demonstrate understanding can: Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

Clarification Statement: Emphasis is on understanding the strengths of forces between particles, not on naming specific intermolecular forces (such as dipole-dipole). Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite). Examples of bulk properties of substances could include the melting point and boiling point, vapor pressure, and surface tension.

Assessment Boundary: Assessment does not include Raoult's law calculations of vapor pressure.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations • Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.	**PS1.A: Structure and Properties of Matter** • The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. **PS2.B: Types of Interactions** • Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. (*Secondary*)	**Patterns** • Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

HS-PS1-8

Students who demonstrate understanding can: Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.

Clarification Statement: Emphasis is on simple qualitative models, such as pictures or diagrams, and on the scale of energy released in nuclear processes relative to other kinds of transformations. Example applications include dating of rocks, carbon dating of artifacts, paleoclimate studies, medical imaging, tracking animal migrations via diet, age dating meteorites, tracking ground water flow.

Assessment Boundary: Assessment does not include quantitative calculation of energy released. Assessment is limited to alpha, beta, and gamma radioactive decays.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Use a model to predict the relationships between systems or between components of a system.	**PS1.C: Nuclear Processes** • Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy. The total number of neutrons plus protons does not change in any nuclear process.	**Energy and Matter** • In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.

HS-PS2-6

Students who demonstrate understanding can: Communicate scientific and technical information about why the molecular-level structure is important in the functioning of natural and designed materials.

Clarification Statement: Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.

Assessment Boundary: Assessment is limited to provided molecular structures of specific designed materials.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Obtaining, Evaluating, and Communicating Information • Communicate scientific and technical information (e.g. about the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	**PS2.B: Types of Interactions** • Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects.	**Structure and Function** • Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.

HS. Chemical Reactions

Students who demonstrate understanding can:

HS-PS1-2.

Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. [Clarification Statement: Examples of chemical reactions could include the reaction of sodium and chlorine, of carbon and oxygen, or of carbon and hydrogen.] [*Assessment Boundary: Assessment is limited to chemical reactions involving main group elements and combustion reactions.*]

HS-PS1-4.

Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy. [Clarification Statement: Emphasis is on the idea that a chemical reaction is a system that affects the energy change. Examples of models could include molecular-level drawings and diagrams of reactions, graphs showing the relative energies of reactants and products, and representations showing energy is conserved.] [*Assessment Boundary: Assessment does not include calculating the total bond energy changes during a chemical reaction from the bond energies of reactants and products*.]

HS-PS1-5.

Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs. [Clarification Statement: Emphasis is on student reasoning that focuses on the number and energy of collisions between molecules.] [*Assessment Boundary: Assessment is limited to simple reactions in which there are only two reactants; evidence from temperature, concentration, and rate data; and qualitative relationships between rate and temperature*.]

HS-PS1-6.

Make arguments based on kinetic molecular theory to explain how altering conditions affects the forward and reverse rates of a reaction at equilibrium. [Clarification Statement: Emphasis is on the application of Le Chatelier's Principle and on refining designs of chemical reaction systems, including descriptions of the connection between changes made at the macroscopic level and what happens at the molecular level. Examples of designs could include different ways to increase product formation including adding reactants or removing products.] [*Assessment Boundary: Assessment is limited to specifying the change in only one variable at a time. Assessment does not include calculating equilibrium constants and concentrations*.]

HS-PS1-7.

Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. [Clarification Statement: Emphasis is on using mathematical ideas to communicate the proportional relationships between masses of atoms in the reactants and the products, and the translation of these relationships to the macroscopic scale using the mole as the conversion from the atomic to the macroscopic scale. Emphasis is on assessing students’ use of mathematical thinking and not on memorization and rote application of problem-solving techniques.] [*Assessment Boundary: Assessment does not include complex chemical reactions*.]

HS-PS1-2

Students who demonstrate understanding can: Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.

Clarification Statement: Examples of chemical reactions could include the reaction of sodium and chlorine, of carbon and oxygen, or of carbon and hydrogen.

Assessment Boundary: Assessment is limited to chemical reactions involving main group elements and combustion reactions.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Construction Explanations and Designing Solutions • Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.	**PS1.A: Structure and Properties of Matter** • The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. **PS1.B: Chemical Reactions** • The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions.	**Patterns** • Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

HS-PS1-4

Students who demonstrate understanding can: Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.

Clarification Statement: Emphasis is on the idea that a chemical reaction is a system that affects the energy change. Examples of models could include molecular-level drawings and diagrams of reactions, graphs showing the relative energies of reactants and products, and representations showing energy is conserved.

Assessment Boundary: Assessment does not include calculating the total bond energy changes during a chemical reaction from the bond energies of reactants and products.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Develop a model based on evidence to illustrate the relationships between systems or between components of a system.	**PS1.A: Structure and Properties of Matter** • A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart. **PS1.B: Chemical Reactions** • Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy.	**Energy and Matter** • Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.

HS-PS1-5

Students who demonstrate understanding can: Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

Clarification Statement: Emphasis is on student reasoning that focuses on the number and energy of collisions between molecules.

Assessment Boundary: Assessment is limited to simple reactions in which there are only two reactants; evidence from temperature, concentration, and rate data; and qualitative relationships between rate and temperature.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions • Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.	**PS1.B: Chemical Reactions** • Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy.	**Patterns** • Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

HS-PS1-6

Students who demonstrate understanding can: Make arguments based on kinetic molecular theory to explain how altering conditions affects the forward and reverse rates of a reaction at equilibrium.

Clarification Statement: Emphasis is on the application of Le Chatelier's Principle and on refining designs of chemical reaction systems, including descriptions of the connection between changes made at the macroscopic level and what happens at the molecular level. Examples of designs could include different ways to increase product formation including adding reactants or removing products.

Assessment Boundary: Assessment is limited to specifying the change in only one variable at a time. Assessment does not include calculating equilibrium constants and concentrations.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions • Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	**PS1.B: Chemical Reactions** • In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present. **ETS1.C: Optimizing the Design Solution** • Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. (*Secondary*)	**Stability and Change** • Much of science deals with constructing explanations of how things change and how they remain stable.

HS-PS1-7

Students who demonstrate understanding can: Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

Clarification Statement: Emphasis is on using mathematical ideas to communicate the proportional relationships between masses of atoms in the reactants and the products, and the translation of these relationships to the macroscopic scale using the mole as the conversion from the atomic to the macroscopic scale. Emphasis is on assessing students' use of mathematical thinking and not on memorization and rote application of problem-solving techniques.

Assessment Boundary: Assessment does not include complex chemical reactions.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematics and Computational Thinking • Use mathematical representations of phenomena to support claims.	**PS1.B: Chemical Reactions** • The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions.	**Energy and Matter** • The total amount of energy and matter in closed systems is conserved. **Connections to Nature of Science** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Science assumes the universe is a vast single system in which basic laws are consistent.

HS. Forces and Interactions

Students who demonstrate understanding can:

HS-PS2-1.

Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration. [Clarification Statement: Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object sliding down a ramp, or a moving object being pulled by a constant force.] [*Assessment Boundary: Assessment is limited to one-dimensional motion and to macroscopic objects moving at non-relativistic speeds*.]

HS-PS2-2.

Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system. [Clarification Statement: Emphasis is on the quantitative conservation of momentum in interactions and the qualitative meaning of this principle.] [*Assessment Boundary: Assessment is limited to systems of two macroscopic bodies moving in one dimension*.]

HS-PS2-3.

Apply science and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.* [Clarification Statement: Examples of evaluation and refinement could include determining the success of the device at protecting an object from damage and modifying the design to improve it. Examples of a device could include a football helmet or a parachute.] [*Assessment Boundary: Assessment is limited to qualitative evaluations and/or algebraic manipulations*.]

HS-PS2-4.

Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects. [Clarification Statement: Emphasis is on both quantitative and conceptual descriptions of gravitational and electric fields.] [*Assessment Boundary: Assessment is limited to systems with two objects*.]

HS-PS2-5.

Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current. [*Assessment Boundary: Assessment is limited to designing and conducting investigations with provided materials and tools.*]

HS-PS2-1

Students who demonstrate understanding can: Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

Clarification Statement: Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object sliding down a ramp, or a moving object being pulled by a constant force.

Assessment Boundary: Assessment is limited to one-dimensional motion and to macroscopic objects moving at non-relativistic speeds.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. **Connections to Nature of Science** **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** • Theories and laws provide explanations in science. • Laws are statements or descriptions of the relationships among observable phenomena.	**PS2.A: Forces and Motion** • Newton's second law accurately predicts changes in the motion of macroscopic objects.	**Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

HS-PS2-2

Students who demonstrate understanding can: Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.

Clarification Statement: Emphasis is on the quantitative conservation of momentum in interactions and the qualitative meaning of this principle.

Assessment Boundary: Assessment is limited to systems of two macroscopic bodies moving in one dimension.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematics and Computational Thinking • Use mathematical representations of phenomena to describe explanations.	**PS2.A: Forces and Motion** • Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. • If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system.	**Systems and System Models** • When investigating or describing a system, the boundaries and initial conditions of the system need to be defined.

HS-PS2-3

Students who demonstrate understanding can: Apply science and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.

Clarification Statement: Examples of evaluation and refinement could include determining the success of the device at protecting an object from damage and modifying the design to improve it. Examples of a device could include a football helmet or a parachute.

Assessment Boundary: Assessment is limited to qualitative evaluations and/or algebraic manipulations.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions • Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects.	**PS2.A: Forces and Motion** • If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system. **ETS1.A: Defining and Delimiting an Engineering Problem** • Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (*Secondary*) **ETS1.C: Optimizing the Design Solution** • Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. (*Secondary*)	**Cause and Effect** • Systems can be designed to cause a desired effect.

HS-PS2-4

Students who demonstrate understanding can: Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.

Clarification Statement: Emphasis is on both quantitative and conceptual descriptions of gravitational and electric fields.

Assessment Boundary: Assessment is limited to systems with two objects.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematics and Computational Thinking • Use mathematical representations of phenomena to describe explanations.	**PS2.B: Types of Interactions** • Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. • Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields.	**Patterns** • Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

HS-PS2-5

Students who demonstrate understanding can: Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.

Assessment Boundary: Assessment is limited to designing and conducting investigations with provided materials and tools.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations • Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.	**PS2.B: Types of Interactions** • Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. **PS3.A: Definitions of Energy** • "Electrical energy" may mean energy stored in a battery or energy transmitted by electric currents. (*Secondary*)	**Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

HS. Energy

Students who demonstrate understanding can:

HS-PS3-1

Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known. [Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model. Examples of models could include different insulation types or windows.] [*Assessment Boundary: Assessment is limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields*.]

HS-PS3-2

Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motion of particles (objects) and energy associated with the relative positions of particles (objects). [Clarification Statement: Examples of phenomena at the macroscopic scale could include the conversion of kinetic energy to thermal energy, the energy stored due to position of an object above the earth, and the energy stored between two electrically-charged plates. Examples of models could include diagrams, drawings, descriptions, and computer simulations.]

HS-PS3-3

Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.* [Clarification Statement: Emphasis is on both qualitative and quantitative evaluations of devices. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators. Examples of constraints could include use of renewable energy forms and efficiency.] [*Assessment Boundary: Assessment for quantitative evaluations is limited to total output for a given input. Assessment is limited to devices constructed with materials provided to students*.]

HS-PS3-4

Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics). [Clarification Statement: Emphasis is on analyzing data from student investigations and using mathematical thinking to describe the energy changes both quantitatively and conceptually. Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water.] [*Assessment Boundary: Assessment is limited to investigations based on materials and tools provided to students*.]

HS-PS3-5

Develop and use a model of two objects interacting through electrical or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction (Coulomb's Law). [Clarification Statement: Examples of models could include drawings, diagrams, and texts, such as drawings of what happens when two charges of opposite polarity are near each other.] [*Assessment Boundary: Assessment is limited to systems containing two objects*.]

HS-PS3-1

Students who demonstrate understanding can: Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.

Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.

Assessment Boundary: Assessment is limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematics and Computational Thinking • Create a computational model or simulation of a phenomenon, designed device, process, or system.	**PS3.A: Definitions of Energy** • Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. **PS3.B: Conservation of Energy and Energy Transfer** • Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. • Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.	**Systems and System Models** • Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. **Connections to Nature of Science** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Science assumes the universe is a vast single system in which basic laws are consistent.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
	• Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. • The availability of energy limits what can occur in any system.	

HS-PS3-2

Students who demonstrate understanding can: Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motion of particles (objects) and energy associated with the relative positions of particles (objects).

Clarification Statement: Examples of phenomena at the macroscopic scale could include the conversion of kinetic energy to thermal energy, the energy stored due to position of an object above the earth, and the energy stored between two electrically-charged plates. Examples of models could include diagrams, drawings, descriptions, and computer simulations.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system.	**PS3.A: Definitions of Energy** • Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. • At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. • These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration ≫	**Energy and Matter** • Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
	(relative position of the particles). In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space.	

HS-PS3-3

Students who demonstrate understanding can: Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.*

Clarification Statement: Emphasis is on both qualitative and quantitative evaluations of devices. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators. Examples of constraints could include use of renewable energy forms and efficiency.

Assessment Boundary: Assessment for quantitative evaluations is limited to total output for a given input. Assessment is limited to devices constructed with materials provided to students.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions • Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	**PS3.A: Definitions of Energy** • At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. **PS3.D: Energy in Chemical Processes** • Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment. **ETS1.A: Defining and Delimiting Engineering Problems** • Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (*Secondary*)	**Energy and Matter** • Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. **Connections to Engineering, Technology, and Applications of Science** **Influence of Science, Engineering, and Technology on Society and the Natural World** • Modern civilization depends on major technological systems. Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks.

HS-PS3-4

Students who demonstrate understanding can: Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).

Clarification Statement: Emphasis is on analyzing data from student investigations and using mathematical thinking to describe the energy changes both quantitatively and conceptually. Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water.

Assessment Boundary: Assessment is limited to investigations based on materials and tools provided to students.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations • Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.	**PS3.B: Conservation of Energy and Energy Transfer** • Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. • Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down). **PS3.D: Energy in Chemical Processes** • Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment.	**Systems and System Models** • When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models.

HS-PS3-5

Students who demonstrate understanding can: Develop and use a model of two objects interacting through electrical or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction (Coulomb's Law).

Clarification Statement: Examples of models could include drawings, diagrams, and texts, such as drawings of what happens when two charges of opposite polarity are near each other.

Assessment Boundary: Assessment is limited to systems containing two objects.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system.	**PS3.C: Relationship Between Energy and Forces** • When two objects interacting through a field change relative position, the energy stored in the field is changed.	**Cause and Effect** • Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system.

HS. Waves and Electromagnetic Radiation

Students who demonstrate understanding can:

HS-PS4-1.

Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media. [Clarification Statement: Examples of data could include electromagnetic radiation traveling in a vacuum and glass, sound waves traveling through air and water, and seismic waves traveling through the Earth.] [*Assessment Boundary: Assessment is limited to algebraic relationships and describing those relationships qualitatively*.]

HS-PS4-2.

Evaluate questions about the advantages and disadvantages of using digital transmission and storage of information with respect to that of forms other than digital, including analog. [Clarification Statement: Examples of advantages could include that digital information is stable because it can be stored reliably in computer memory, transferred easily, and copied and shared rapidly. Disadvantages could include issues of easy deletion, security, and theft.]

HS-PS4-3.

Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other. [Clarification Statement: Emphasis is on how the experimental evidence supports the claim and how a theory is generally modified in light of new evidence. Examples of a phenomenon could include resonance, interference, diffraction, and photoelectric effect.] [As*sessment Boundary: Assessment does not include using quantum theory.*]

HS-PS4-4.

Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter. [Clarification Statement: Emphasis is on the idea that photons associated with different frequencies of light have different energies, and the damage to living tissue from electromagnetic radiation depends on the energy of the radiation. Examples of published materials could include trade books, magazines, web resources, videos, and other passages that may reflect bias.] [*Assessment Boundary: Assessment is limited to qualitative descriptions*.]

HS-PS4-5.

Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.* [Clarification Statement: Examples could include solar cells capturing light and converting it to electricity; medical imaging; and communications technology.] [*Assessment Boundary: Assessments are limited to qualitative information. Assessments do not include band theory*.]

HS-PS4-1

Students who demonstrate understanding can: Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.

Clarification Statement: Examples of data could include electromagnetic radiation traveling in a vacuum and glass, sound waves traveling through air and water, and seismic waves traveling through the Earth.

Assessment Boundary: Assessment is limited to algebraic relationships and describing those relationships qualitatively.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematics and Computational Thinking • Use mathematical representations of phenomena or design solutions to describe and/or support claims and/or explanations.	**PS4.A: Wave Properties** • The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing.	**Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

HS-PS4-2

Students who demonstrate understanding can: Evaluate questions about the advantages and disadvantages of using digital transmission and storage of information with respect to that of forms other than digital, including analog.

Clarification Statement: Examples of advantages could include that digital information is stable because it can be stored reliably in computer memory, transferred easily, and copied and shared rapidly. Disadvantages could include issues of easy deletion, security, and theft.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Asking Questions and Defining Problems • Evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design.	**PS4.A: Wave Properties** • Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses.	**Stability and Change** • Systems can be designed for greater or lesser stability. **Connections to Engineering, Technology, and Application of Science** **Influence of Science, Engineering, and Technology on Society and the Natural World** • Modern civilization depends on major technological systems. • Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks.

HS-PS4-3

Students who demonstrate understanding can: Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.

Clarification Statement: Emphasis is on how the experimental evidence supports the claim and how a theory is generally modified in light of new evidence. Examples of a phenomenon could include resonance, interference, diffraction, and photoelectric effect.

Assessment Boundary: Assessment does not include using quantum theory.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence • Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments. **Connections to Nature of Science** **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** • A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed though observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that a theory does not accommodate, the theory is generally modified in light of this new evidence.	**PS4.A: Wave Properties** • [From the 3–5 grade band endpoints] Waves can add or cancel one another as they cross, depending on their relative phase (i.e., relative position of peaks and troughs of the waves), but they emerge unaffected by each other. (Boundary: The discussion at this grade level is qualitative only; it can be based on the fact that two different sounds can pass a location in different directions without getting mixed up.) **PS4.B: Electromagnetic Radiation** • Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features.	**Systems and System Models** • Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales.

HS-PS4-4

Students who demonstrate understanding can: Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.

Clarification Statement: Emphasis is on the idea that photons associated with different frequencies of light have different energies, and the damage to living tissue from electromagnetic radiation depends on the energy of the radiation. Examples of published materials could include trade books, magazines, web resources, videos, and other passages that may reflect bias.

Assessment Boundary: Assessment is limited to qualitative descriptions.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Obtaining, Evaluating, and Communicating Information • Evaluate the validity and reliability of multiple claims that appear in scientific and technical texts or media reports, verifying the data when possible.	**PS4.B: Electromagnetic Radiation** • When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells.	**Cause and Effect** • Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system.

HS-PS4-5

Students who demonstrate understanding can: Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.*

Clarification Statement: Examples could include solar cells capturing light and converting it to electricity; medical imaging; and communications technology.

Assessment Boundary: Assessments are limited to qualitative information. Assessments do not include band theory.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Obtaining, Evaluating, and Communicating Information • Communicate technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	**PS3.D: Energy in Chemical Processes** • Solar cells are human-made devices that likewise capture the sun's energy and produce electrical energy. (secondary) **PS4.A: Wave Properties** • Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses. **PS4.B: Electromagnetic Radiation** • Photoelectric materials emit electrons when they absorb light of a high-enough frequency. **PS4.C: Information Technologies and Instrumentation** • Multiple technologies based on the understanding of waves and their interactions with matter are part of	**Cause and Effect** • Systems can be designed to cause a desired effect. **Connections to Engineering, Technology, and Application of Science** **Interdependence of Science, Engineering, and Technology** • Science and engineering complement each other in the cycle known as research and development (R&D). **Influence of Science, Engineering, and Technology on Society and the Natural World** • Modern civilization depends on major technological systems.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
	everyday experiences in the modern world (e.g., medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them.	

HIGH SCHOOL LIFE SCIENCES

Students in high school develop understanding of key concepts that help them make sense of life science. The ideas are building upon students' science understanding of disciplinary core ideas, science and engineering practices, and crosscutting concepts from earlier grades. There are five life science topics in high school: *1) Structure and Function, 2) Inheritance and Variation of Traits, 3) Matter and Energy in Organisms and Ecosystems, 4) Interdependent Relationships in Ecosystems, and 5) Natural Selection and Evolution*. The performance expectations for high school life science blend core ideas with scientific and engineering practices and crosscutting concepts to support students in developing useable knowledge that can be applied across the science disciplines. While the performance expectations in high school life science couple particular practices with specific disciplinary core ideas, instructional decisions should include use of many practices underlying the performance expectations. The performance expectations are based on the grade-band endpoints described in *A Framework for K-12 Science Education* (NRC, 2012).

The performance expectations in the topic **Structure and Function** help students formulate an answer to the question: "How do the structures of organisms enable life's functions?" High school students are able to investigate explanations for the structure and function of cells as the basic units of life, the hierarchical systems of organisms, and the role of specialized cells for maintenance and growth. Students demonstrate understanding of how systems of cells function together to support the life processes. Students demonstrate their understanding through critical reading, using models, and conducting investigations. The crosscutting concepts of structure and function, matter and energy, and systems and system models in organisms are called out as organizing concepts.

The performance expectations in the topic **Inheritance and Variation of Traits** help students in pursuing an answer to the question: "How are the characteristics from one generation related to the previous generation?" High school students demonstrate understanding of the relationship of DNA and chromosomes in the processes of cellular division that pass traits from one generation to the next. Students can determine why individuals of the same species vary in how they look, function, and behave. Students can develop conceptual models for the role of DNA in the unity of life on Earth and use statistical models to explain the importance of variation within populations for the survival and evolution of species. Ethical issues related to genetic modification of organisms and the nature of science can be described. Students can explain the mechanisms of genetic inheritance and describe the environmental and genetic causes of gene mutation and the alteration of gene expression. Crosscutting concepts of structure and function, patterns, and cause and effect developed in this topic help students to generalize understanding of inheritance of traits to other applications in science.

The performance expectations in the topic **Matter and Energy in Organisms and Ecosystems** help students answer the questions: "How do organisms obtain and use energy they need to live and grow? How do matter and energy move through ecosystems?" High school students can construct explanations for the role of energy in the cycling of matter in organisms and ecosystems. They can apply mathematical concepts to develop evidence to support explanations of the interactions of photosynthesis and cellular respiration and develop models to communicate these explanations. They can relate the nature of science to how explanations may change in light of new evidence and the implications for our understanding of the tentative nature of science. Students understand organisms' interactions with each other and their physical environment, how organisms obtain resources, change the environment, and how these changes affect both organisms and ecosystems. In addition, students can utilize the crosscutting concepts of matter and energy and Systems and system models to make sense of ecosystem dynamics.

The performance expectations in the topic **Interdependent Relationships in Ecosystems** help students answer the question, "How do organisms interact with the living and non-living environment to obtain matter and energy?" This topic builds on the other topics as high school students demonstrate an ability to investigate the role of biodiversity in ecosystems and the role of animal behavior on survival of individuals and species. Students have increased understanding of interactions among organisms and how those interactions influence the dynamics of ecosystems. Students can generate mathematical comparisons, conduct investigations, use models, and apply scientific reasoning to link evidence to explanations about interactions and changes within ecosystems.

The performance expectations in the topic **Natural Selection and Evolution** help students answer the questions: "How can there be so many similarities among organisms yet so many different plants, animals, and microorganisms? How does biodiversity affect humans?" High school students can investigate patterns to find the relationship between the environment and natural selection. Students demonstrate understanding of the factors causing natural selection and the process of evolution of species over time. They demonstrate understanding of how multiple lines of evidence contribute to the strength of scientific theories of natural selection and evolution. Students can demonstrate an understanding of the processes that change the distribution of traits in a population over time and describe extensive scientific evidence ranging from the fossil record to genetic relationships among species that support the theory of biological evolution. Students can use models, apply statistics, analyze data, and produce scientific communications about evolution. Understanding of the crosscutting concepts of patterns, scale, structure and function, and cause and effect supports the development of a deeper understanding of this topic.

HS. Structure and Function

Students who demonstrate understanding can:

HS-LS1-1.

Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins, which carry out the essential functions of life through systems of specialized cells. [*Assessment Boundary: Assessment does not include identification of specific cell or tissue types, whole body systems, specific protein structures and functions, or the biochemistry of protein synthesis.*]

HS-LS1-2.

Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. [Clarification Statement: Emphasis is on functions at the organism system level such as nutrient uptake, water delivery, and organism movement in response to neural stimuli. An example of an interacting system could be an artery depending on the proper function of elastic tissue and smooth muscle to regulate and deliver the proper amount of blood within the circulatory system.] [*Assessment Boundary: Assessment does not include interactions and functions at the molecular or chemical reaction level.*]

HS-LS1-3.

Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis. [Clarification Statement: Examples of investigations could include heart rate response to exercise, stomate response to moisture and temperature, and root development in response to water levels.] [*Assessment Boundary: Assessment does not include the cellular processes involved in the feedback mechanism*.]

HS-LS1-1

Students who demonstrate understanding can: Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins, which carry out the essential functions of life through systems of specialized cells.

Assessment Boundary: Assessment does not include identification of specific cell or tissue types, whole body systems, specific protein structures and functions, or the biochemistry of protein synthesis.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions • Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.	**LS1.A: Structure and Function** • Systems of specialized cells within organisms help them perform the essential functions of life. • All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells.	**Structure and Function** • Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.

HS-LS1-2

Students who demonstrate understanding can: Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.

Clarification Statement: Emphasis is on functions at the organism system level such as nutrient uptake, water delivery, and organism movement in response to neural stimuli. An example of an interacting system could be an artery depending on the proper function of elastic tissue and smooth muscle to regulate and deliver the proper amount of blood within the circulatory system.

Assessment Boundary: Assessment does not include interactions and functions at the molecular or chemical reaction level.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system.	**LS1.A: Structure and Function** • Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level.	**Systems and System Models** • Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales.

HS-LS1-3

Students who demonstrate understanding can: Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.

Clarification Statement: Emphasis is on functions at the organism system level such as nutrient uptake, water delivery, and organism movement in response to neural stimuli. An example of an interacting system could be an artery depending on the proper function of elastic tissue and smooth muscle to regulate and deliver the proper amount of blood within the circulatory system.

Assessment Boundary: Assessment does not include interactions and functions at the molecular or chemical reaction level.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations • Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. **Connections to Nature of Science** **Scientific Investigations Use a Variety of Methods** • Scientific inquiry is characterized by a common set of values that include: logical thinking, precision, open-mindedness, objectivity, skepticism, replicability of results, and honest and ethical reporting of findings.	**LS1.A: Structure and Function** • Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system.	**Stability and Change** • Feedback (negative or positive) can stabilize or destabilize a system.

HS. Matter and Energy in Organisms and Ecosystems

Students who demonstrate understanding can:

HS-LS1-5.

Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy. [Clarification Statement: Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and conceptual models.] [*Assessment Boundary: Assessment does not include specific biochemical steps*.]

HS-LS1-6.

Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules. [Clarification Statement: Emphasis is on using evidence from models and simulations to support explanations.] [*Assessment Boundary: Assessment does not include the details of the specific chemical reactions or identification of macromolecules*.]

HS-LS1-7.

Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed, resulting in a net transfer of energy. [Clarification Statement: Emphasis is on the conceptual understanding of the inputs and outputs of the process of cellular respiration.] [*Assessment Boundary: Assessment should not include identification of the steps or specific processes involved in cellular respiration*.]

HS-LS2-3.

Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions. [Clarification Statement: Emphasis is on conceptual understanding of the role of aerobic and anaerobic respiration in different environments.] [*Assessment Boundary: Assessment does not include the specific chemical processes of either aerobic or anaerobic respiration.*]

HS-LS2-4.

Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem. [Clarification Statement: Emphasis is on using a mathematical model of stored energy in biomass to describe the transfer of energy from one trophic level to another and that matter and energy are conserved as matter cycles and energy flows through ecosystems. Emphasis is on atoms and molecules such as carbon, oxygen, hydrogen and nitrogen being conserved as they move through an ecosystem.] [*Assessment Boundary: Assessment is limited to proportional reasoning to describe the cycling of matter and flow of energy*.]

HS-LS2-5.

Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere. [Clarification Statement: Examples of models could include simulations and mathematical models.] [*Assessment Boundary: Assessment does not include the specific chemical steps of photosynthesis and respiration*.]

HS-LS1-5

Students who demonstrate understanding can: Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.

Clarification Statement: Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and conceptual models.

Assessment Boundary: Assessment does not include specific biochemical steps.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Use a model based on evidence to illustrate the relationships between systems or between components of a system.	**LS1.C: Organization for Matter and Energy Flow in Organisms** • The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen.	**Energy and Matter** • Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.

HS-LS1-6

Students who demonstrate understanding can: Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules.

Clarification Statement: Emphasis is on using evidence from models and simulations to support explanations.

Assessment Boundary: Assessment does not include the details of the specific chemical reactions or identification of macromolecules.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions • Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.	**LS1.C: Organization for Matter and Energy Flow in Organisms** • The sugar molecules thus formed contain carbon, hydrogen, and oxygen: their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), used for example to form new cells. • As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products.	**Energy and Matter** • Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.

HS-LS1-7

Students who demonstrate understanding can: Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed, resulting in a net transfer of energy.

Clarification Statement: Emphasis is on the conceptual understanding of the inputs and outputs of the process of cellular respiration.

Assessment Boundary: Assessment should not include identification of the steps or specific processes involved in cellular respiration.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Use a model based on evidence to illustrate the relationships between systems or between components of a system.	**LS1.C: Organization for Matter and Energy Flow in Organisms** • As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. • As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment.	**Energy and Matter** • Energy cannot be created or destroyed—it only moves between one place and another place, between objects and/or fields, or between systems.

HS-LS2-3

Students who demonstrate understanding can: Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.

Clarification Statement: Emphasis is on conceptual understanding of the role of aerobic and anaerobic respiration in different environments.

Assessment Boundary: Assessment does not include the specific chemical processes of either aerobic or anaerobic respiration.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions • Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. **Connections to Nature of Science** **Scientific Knowledge is Open to Revision in Light of New Evidence** • Most scientific knowledge is quite durable, but is, in principle, subject to change based on new evidence and/or reinterpretation of existing evidence.	**LS2.B: Cycles of Matter and Energy Transfer in Ecosystems** • Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes.	**Energy and Matter** • Energy drives the cycling of matter within and between systems.

HS-LS2-4

Students who demonstrate understanding can: Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.

Clarification Statement: Emphasis is on using a mathematical model of stored energy in biomass to describe the transfer of energy from one trophic level to another and that matter and energy are conserved as matter cycles and energy flows through ecosystems. Emphasis is on atoms and molecules such as carbon, oxygen, hydrogen and nitrogen being conserved as they move through an ecosystem.

Assessment Boundary: Assessment is limited to proportional reasoning to describe the cycling of matter and flow of energy.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematics and Computational Thinking • Use mathematical representations of phenomena or design solutions to support claims.	**LS2.B: Cycles of Matter and Energy Transfer in Ecosystems** • Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved.	**Energy and Matter** • Energy cannot be created or destroyed—it only moves between one place and another place, between objects and/or fields, or between systems.

HS-LS2-5

Students who demonstrate understanding can: Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.

Clarification Statement: Examples of models could include simulations and mathematical models.

Assessment Boundary: Assessment does not include the specific chemical steps of photosynthesis and respiration.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Develop a model based on evidence to illustrate the relationships between systems or components of a system.	**LS2.B: Cycles of Matter and Energy Transfer in Ecosystems** • Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes. **PS3.D: Energy in Chemical Processes** • The main way that solar energy is captured and stored on Earth is through the complex chemical process known as photosynthesis. (*Secondary*)	**Systems and System Models** • Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales.

HS. Interdependent Relationships in Ecosystems

Students who demonstrate understanding can:

HS-LS2-1.

Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales. [Clarification Statement: Emphasis is on quantitative analysis and comparison of the relationships among interdependent factors including boundaries, resources, climate, and competition. Examples of mathematical comparisons could include graphs, charts, histograms, and population changes gathered from simulations or historical data sets.] [*Assessment Boundary: Assessment does not include deriving mathematical equations to make comparisons*.]

HS-LS2-2.

Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales. [Clarification Statement: Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data.] [*Assessment Boundary: Assessment is limited to provided data*.]

HS-LS2-6.

Evaluate claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem. [Clarification Statement: Examples of changes in ecosystem conditions could include hunting and fishing harvests, predation, flooding, sea ice variation, erosion, volcanic eruptions, land level changes due to earthquakes, tsunamis, changes in ocean current patterns or ocean chemistry, or sea-level rise.]

HS-LS2-7.

Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.* [Clarification Statement: Examples of human activities can include urbanization, pollution, building dams and roads, and dissemination of invasive species. Example lessons can include applications of Tragedy of the Commons.]

HS-LS2-8.

Evaluate evidence for the role of group behavior on individual and species' chances to survive and reproduce. [Clarification Statement: Emphasis is on: (1) distinguishing between group and individual behavior, (2) identifying evidence supporting the outcomes of group behavior, and (3) developing logical and reasonable arguments based on evidence. Examples of group behaviors could include flocking, schooling, herding, and cooperative behaviors such as hunting, migrating, and swarming.]

HS-LS4-6.

Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.* [Clarification Statement: Emphasis is on testing solutions for a proposed problem related to threatened or endangered species, or to genetic variation of organisms for multiple species.]

HS-LS2-1

Students who demonstrate understanding can: Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.

Clarification Statement: Emphasis is on quantitative analysis and comparison of the relationships among interdependent factors including boundaries, resources, climate, and competition. Examples of mathematical comparisons could include graphs, charts, histograms, and population changes gathered from simulations or historical data sets.

Assessment Boundary: Assessment does not include deriving mathematical equations to make comparisons.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematics and Computational Thinking • Use mathematical and/or computational representations of phenomena or design solutions to support explanations.	**LS2.A: Interdependent Relationships in Ecosystems** • Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem.	**Scale, Proportion, and Quantity** • The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.

HS-LS2-2

Students who demonstrate understanding can: Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.

Clarification Statement: Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data.

Assessment Boundary: Assessment is limited to provided data.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematics and Computational Thinking • Use mathematical representations of phenomena or design solutions to support and revise explanations. **Connections to Nature of Science** **Scientific Knowledge is Open to Revision in Light of New Evidence** • Most scientific knowledge is quite durable, but is, in principle, subject to change based on new evidence and/or reinterpretation of existing evidence.	**LS2.A: Interdependent Relationships in Ecosystems** • Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem. **LS2.C: Ecosystem Dynamics, Functioning, and Resilience** • A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant	**Scale, Proportion, and Quantity** • Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
	over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability.	

HS-LS2-6

Students who demonstrate understanding can: Evaluate claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.

Clarification Statement: Examples of changes in ecosystem conditions could include hunting and fishing harvests, predation, flooding, sea ice variation, erosion, volcanic eruptions, land level changes due to earthquakes, tsunamis, changes in ocean current patterns or ocean chemistry, or sea-level rise.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence • Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments. **Connections to Nature of Science** **Scientific Knowledge is Open to Revision in Light of New Evidence** • Scientific argumentation is a mode of logical discourse used to clarify the strength of relationships between ideas and evidence that may result in revision of an explanation.	**LS2.C: Ecosystem Dynamics, Functioning, and Resilience** • A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability.	**Stability and Change** • Much of science deals with constructing explanations of how things change and how they remain stable.

HS-LS2-7

Students who demonstrate understanding can: Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.*

Clarification Statement: Examples of human activities can include urbanization, pollution, building dams and roads, and dissemination of invasive species. Example lessons can include applications of Tragedy of the Commons.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions • Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	**LS2.C: Ecosystem Dynamics, Functioning, and Resilience** • Moreover, anthropogenic changes (induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species. **LS4.D: Biodiversity and Humans** • Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). (*Secondary*) • Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ≫	**Stability and Change** • Much of science deals with constructing explanations of how things change and how they remain stable.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
	ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. (*Secondary*) **ETS1.B: Developing Possible Solutions** • When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (*Secondary*)	

HS-LS2-8

Students who demonstrate understanding can: Evaluate evidence for the role of group behavior on individual and species' chances to survive and reproduce.

Clarification Statement: Emphasis is on: (1) distinguishing between group and individual behavior, (2) identifying evidence supporting the outcomes of group behavior, and (3) developing logical and reasonable arguments based on evidence. Examples of group behaviors could include flocking, schooling, herding, and cooperative behaviors such as hunting, migrating, and swarming.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence • Evaluate the evidence behind currently accepted explanations or solutions to determine the merits of arguments. **Connections to Nature of Science** **Scientific Knowledge is Open to Revision in Light of New Evidence** • Scientific argumentation is a mode of logical discourse used to clarify the strength of relationships between ideas and evidence that may result in revision of an explanation.	**LS2.D: Social Interactions and Group Behavior** • Group behavior has evolved because membership can increase the chances of survival for individuals and their genetic relatives.	**Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

HS-LS4-6

Students who demonstrate understanding can: Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.*

Clarification Statement: Emphasis is on testing solutions for a proposed problem related to threatened or endangered species, or to genetic variation of organisms for multiple species.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematics and Computational Thinking • Create or revise a simulation of a phenomenon, designed device, process, or system.	**LS4.C: Adaptation** • Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline–and sometimes the extinction–of some species. **LS4.D: Biodiversity and Humans** • Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by	**Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
	preserving landscapes of recreational or inspirational value. **ETS1.B: Developing Possible Solutions** • When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. • Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs.	

HS. Inheritance and Variation of Traits

Students who demonstrate understanding can:

HS-LS1-4.

Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms. [*Assessment Boundary: Assessment does not include specific gene control mechanisms or rote memorization of the steps of mitosis*.]

HS-LS3-1.

Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring. [*Assessment Boundary: Assessment does not include the phases of meiosis or the biochemical mechanism of specific steps in the process*.]

HS-LS3-2.

Make and defend a claim based on evidence that inheritable genetic variations may result from (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors. [Clarification Statement: Emphasis is on using data to support arguments for the way variation occurs.] [*Assessment Boundary: Assessment does not include the phases of meiosis or the biochemical mechanism of specific steps in the process*.]

HS-LS3-3.

Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population. [Clarification Statement: Emphasis is on the use of mathematics to describe the probability of traits as it relates to genetic and environmental factors in the expression of traits.] [*Assessment Boundary: Assessment does not include Hardy-Weinberg calculations*.]

HS-LS1-4

Students who demonstrate understanding can: Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.

Assessment Boundary: Assessment does not include specific gene control mechanisms or rote memorization of the steps of mitosis.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Use a model based on evidence to illustrate the relationships between systems or between components of a system.	**LS1.B: Growth and Development of Organisms** • In multicellular organisms individual cells grow and then divide via a process called mitosis, thereby allowing the organism to grow. The organism begins as a single cell (fertilized egg) that divides successively to produce many cells, with each parent cell passing identical genetic material (two variants of each chromosome pair) to both daughter cells. Cellular division and differentiation produce and maintain a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism.	**Systems and System Models** • Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales.

HS-LS3-1

Students who demonstrate understanding can: Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.

Assessment Boundary: Assessment does not include the phases of meiosis or the biochemical mechanism of specific steps in the process.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Asking Questions and Defining Problems • Ask questions that arise from examining models or a theory to clarify relationships.	**LS1.A: Structure and Function** • All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins. (*Secondary*) **LS3.A: Inheritance of Traits** • Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The instructions for forming species' characteristics are carried in DNA. All cells in an organism have the same genetic content, but the genes used (expressed) by the cell may be regulated in different ways. Not all DNA codes for a protein; some segments of DNA are involved in regulatory or structural functions, and some have no as-yet known function.	**Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

HS-LS3-2

Students who demonstrate understanding can: Make and defend a claim based on evidence that inheritable genetic variations may result from (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.

Clarification Statement: Emphasis is on using data to support arguments for the way variation occurs.

Assessment Boundary: Assessment does not include the phases of meiosis or the biochemical mechanism of specific steps in the process.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence • Make and defend a claim based on evidence about the natural world that reflects scientific knowledge, and student-generated evidence.	**LS3.B: Variation of Traits** • In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation. Environmental factors can also cause mutations in genes, and viable mutations are inherited. • Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus the variation and distribution of traits observed depends on both genetic and environmental factors.	**Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

HS-LS3-3

Students who demonstrate understanding can: Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.

Clarification Statement: Emphasis is on the use of mathematics to describe the probability of traits as it relates to genetic and environmental factors in the expression of traits.

Assessment Boundary: Assessment does not include Hardy-Weinberg calculations.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data • Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible.	**LS3.B: Variation of Traits** • Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus the variation and distribution of traits observed depends on both genetic and environmental factors.	**Scale, Proportion, and Quantity** • Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth). **Connections to Nature of Science** **Science is a Human Endeavor** • Technological advances have influenced the progress of science and science has influenced advances in technology. • Science and engineering are influenced by society and society is influenced by science and engineering.

HS. Natural Selection and Evolution

Students who demonstrate understanding can:

HS-LS4-1.

Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence. [Clarification Statement: Emphasis is on a conceptual understanding of the role each line of evidence has relating to common ancestry and biological evolution. Examples of evidence could include similarities in DNA sequences, anatomical structures, and order of appearance of structures in embryological development.]

HS-LS4-2.

Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment. [Clarification Statement: Emphasis is on using evidence to explain the influence each of the four factors has on number of organisms, behaviors, morphology, or physiology in terms of ability to compete for limited resources and subsequent survival of individuals and adaptation of species. Examples of evidence could include mathematical models such as simple distribution graphs and proportional reasoning.] [*Assessment Boundary: Assessment does not include other mechanisms of evolution, such as genetic drift, gene flow through migration, and co-evolution*.]

HS-LS4-3.

Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait. [Clarification Statement: Emphasis is on analyzing shifts in numerical distribution of traits and using these shifts as evidence to support explanations.] [*Assessment Boundary: Assessment is limited to basic statistical and graphical analysis. Assessment does not include allele frequency calculations*.]

HS-LS4-4.

Construct an explanation based on evidence for how natural selection leads to adaptation of populations. [Clarification Statement: Emphasis is on using data to provide evidence for how specific biotic and abiotic differences in ecosystems (such as ranges of seasonal temperature, long-term climate change, acidity, light, geographic barriers, or evolution of other organisms) contribute to a change in gene frequency over time, leading to adaptation of populations.]

HS-LS4-5.

Evaluate the evidence supporting claims that changes in environmental conditions may result in (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species. [Clarification Statement: Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, fishing, pollution, erosion, permafrost thawing, changes in sea ice, invasive species, land level changes due to earthquakes, changes in ocean chemistry, sea level change, volcanic eruptions, drought, flood and the rate of change of the environment affect the distribution or disappearance of traits in species.

HS-LS4-1

Students who demonstrate understanding can: Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.

Clarification Statement: Emphasis is on a conceptual understanding of the role each line of evidence has relating to common ancestry and biological evolution. Examples of evidence could include similarities in DNA sequences, anatomical structures, and order of appearance of structures in embryological development.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Obtaining, Evaluating, and Communicating Information • Communicate scientific information (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). **Connections to Nature of Science** **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** • A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence.	**LS4.A: Evidence of Common Ancestry and Diversity** • Genetic information, like the fossil record, provides evidence of evolution. DNA sequences vary among species, but there are many overlaps; in fact, the ongoing branching that produces multiple lines of descent can be inferred by comparing the DNA sequences of different organisms. Such information is also derivable from the similarities and differences in amino acid sequences and from anatomical and embryological evidence.	**Patterns** • Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. **Connections to Nature of Science** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future.

HS-LS4-2

Students who demonstrate understanding can: Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.

Clarification Statement: Emphasis is on using evidence to explain the influence each of the four factors has on number of organisms, behaviors, morphology, or physiology in terms of ability to compete for limited resources and subsequent survival of individuals and adaptation of species. Examples of evidence could include mathematical models such as simple distribution graphs and proportional reasoning.

Assessment Boundary: Assessment does not include other mechanisms of evolution, such as genetic drift, gene flow through migration, and co-evolution.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions • Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.	**LS4.B: Natural Selection** • Natural selection occurs only if there is both (1) variation in the genetic information between organisms in a population and (2) variation in the expression of that genetic information—that is, trait variation—that leads to differences in performance among individuals. **LS4.C: Adaptation** • Evolution is a consequence of the interaction of four factors: (1) the potential for a species to increase in number, (2) the genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for an environment's limited supply of the resources that individuals need in	**Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
	order to survive and reproduce, and (4) the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment.	

HS-LS4-3

Students who demonstrate understanding can: Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.

Clarification Statement: Emphasis is on analyzing shifts in numerical distribution of traits and using these shifts as evidence to support explanations.

Assessment Boundary: Assessment is limited to basic statistical and graphical analysis. Assessment does not include allele frequency calculations.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data • Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible.	**LS4.B: Natural Selection** • Natural selection occurs only if there is both (1) variation in the genetic information between organisms in a population and (2) variation in the expression of that genetic information—that is, trait variation—that leads to differences in performance among individuals. • The traits that positively affect survival are more likely to be reproduced, and thus are more common in the population. **LS4.C: Adaptation** • Natural selection leads to adaptation, that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction	**Patterns** • Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
	of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not. • Adaptation also means that the distribution of traits in a population can change when conditions change.	

HS-LS4-4

Students who demonstrate understanding can: Construct an explanation based on evidence for how natural selection leads to adaptation of populations.

Clarification Statement: Emphasis is on using data to provide evidence for how specific biotic and abiotic differences in ecosystems (such as ranges of seasonal temperature, long-term climate change, acidity, light, geographic barriers, or evolution of other organisms) contribute to a change in gene frequency over time, leading to adaptation of populations.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions • Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.	**LS4.C: Adaptation** • Natural selection leads to adaptation, that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not.	**Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. **Connections to Nature of Science** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future.

HS-LS4-5

Students who demonstrate understanding can: Evaluate the evidence supporting claims that changes in environmental conditions may result in (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.

Clarification Statement: Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, fishing, pollution, erosion, permafrost thawing, changes in sea ice, invasive species, land level changes due to earthquakes, changes in ocean chemistry, sea level change, volcanic eruptions, drought, flood and the rate of change of the environment affect the distribution or disappearance of traits in species.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence • Evaluate the evidence behind currently accepted explanations or solutions to determine the merits of arguments.	**LS4.C: Adaptation** • Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline–and sometimes the extinction–of some species. • Species become extinct because they can no longer survive and reproduce in their altered environment. If members cannot adjust to change that is too fast or drastic, the opportunity for the species' evolution is lost.	**Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

HIGH SCHOOL EARTH AND SPACE SCIENCES

Students in high school develop understanding of a wide range of topics in Earth and space science (ESS) that build upon science concepts from middle school through more advanced content, practice, and crosscutting themes. There are five ESS standard topics in middle school: Space Systems, History of Earth, Earth's Systems, Weather and Climate, and Human Sustainability. The content of the performance expectations are based on current community-based geoscience literacy efforts such as the Earth Science Literacy Principles (Wysession et al., 2012), and is presented with a greater emphasis on an Earth Systems Science approach. There are strong connections to mathematical practices of analyzing and interpreting data. The performance expectations strongly reflect the many societally relevant aspects of ESS (resources, hazards, environmental impacts) with an emphasis on using engineering and technology concepts to design solutions to challenges facing human society.

Space Systems: High school students can examine the processes governing the formation, evolution, and workings of the solar system and universe. Some concepts studied are fundamental to science, such as understanding how the matter of our world formed during the Big Bang and within the cores of stars. Others concepts are practical, such as understanding how short-term changes in the behavior of our sun directly affect humans. Engineering and technology play a large role here in obtaining and analyzing the data that support the theories of the formation of the solar system and universe.

History of Earth: Students can construct explanations for the scales of time over which Earth processes operate. An important aspect of Earth and space science involves making inferences about events in Earth's history based on a data record that is increasingly incomplete that farther you go back in time. A mathematical analysis of radiometric dating is used to comprehend how absolute ages are obtained for the geologic record. A key to Earth's history is the coevolution of the biosphere with Earth's other systems, not only in the ways that climate and environmental changes have shaped the course of evolution but also in how emerging life forms have been responsible for changing Earth.

Earth's Systems: Students can develop models and explanations for the ways that feedbacks between different Earth systems control the appearance of Earth's surface. Central to this is the tension between internal systems, which are largely responsible for creating land at Earth's surface (e.g., volcanism and mountain building), and the sun- driven surface systems that tear down the land through weathering and erosion. Students understand the role that water plays in affecting weather. Students understand chemical cycles such as the carbon cycle. Students can examine the ways that human activities cause feedbacks that create changes to other systems.

Weather and Climate: Students understand the system interactions that control weather and climate, with a major emphasis on the mechanisms and implications of climate change. Students understand the analysis and interpretation of different kinds of geoscience data allow students to construct explanations for the many factors that drive climate change over a wide range of time scales.

Human Impacts: Students understand the complex and significant interdependencies between humans and the rest of Earth's systems through the impacts of natural hazards, our dependencies on natural resources, and the environmental impacts of human activities.

HS. Space Systems

Students who demonstrate understanding can:

HS-ESS1-1.

Develop a model based on evidence to illustrate that the life span of the Sun is a function of nuclear fusion in its core, and that stars, through nuclear fusion over their life cycle, produce elements and release energy that eventually reaches Earth in the form of radiation. [Clarification Statement: Emphasis is on the way nucleosynthesis, and therefore the different elements created, varies as a function of the mass of a star and the stage of its lifetime. Emphasis is on the energy transfer mechanisms that allow energy from nuclear fusion in the sun's core to reach Earth. Example applications include solar flares, auroras, the 11-year sunspot cycle and non-cyclic variations over centuries.] [*Assessment Boundary: Assessment does not include details of the atomic and sub-atomic processes involved with nuclear fusion, or details of the many different nucleosynthesis pathways for stars of differing masses*.]

HS-ESS1-2.

Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe. [Clarification Statement: Emphasis is on the astronomical evidence of the red shift of light from galaxies as an indication that the universe is currently expanding, the cosmic microwave background as the remnant radiation from the Big Bang, and the observed composition of ordinary matter of the universe, primarily found in stars and interstellar gases (from the spectra of electromagnetic radiation from stars), which matches that predicted by the Big Bang theory (3/4 hydrogen and 1/4 helium).]

HS-ESS1-4.

Use mathematical or computational representations to predict the motion of orbiting objects in the solar system. [Clarification Statement: Emphasis is on Newtonian gravitational laws governing orbital motions, which apply to human-made satellites as well as planets and moons.] [*Assessment Boundary: Mathematical representations for the gravitational attraction of bodies and Kepler's Laws of orbital motions should not deal with more than two bodies, nor involve calculus*.]

HS-ESS1-1

Students who demonstrate understanding can: Develop a model based on evidence to illustrate that the life span of the Sun is a function of nuclear fusion in its core, and that stars, through nuclear fusion over their life cycle, produce elements and release energy that eventually reaches Earth in the form of radiation.

Clarification Statement: Emphasis is on the way nucleosynthesis, and therefore the different elements created, varies as a function of the mass of a star and the stage of its lifetime. Emphasis is on the energy transfer mechanisms that allow energy from nuclear fusion in the sun's core to reach Earth. Example applications include solar flares, auroras, the 11-year sunspot cycle and non-cyclic variations over centuries.

Assessment Boundary: Assessment does not include details of the atomic and sub-atomic processes involved with nuclear fusion, or details of the many different nucleosynthesis pathways for stars of differing masses.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Develop a model based on evidence to illustrate the relationships between systems or components of a system.	**ESS1.A: The Universe and Its Stars** • The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years. **PS3.D: Energy in Chemical Processes and Everyday Life** • Nuclear Fusion processes in the center of the sun release the energy that ultimately reaches Earth as radiation. (*Secondary*)	**Scale, Proportion, and Quantity** • The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.

HS-ESS1-2

Students who demonstrate understanding can: Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe.

Clarification Statement: Emphasis is on the astronomical evidence of the red shift of light from galaxies as an indication that the universe is currently expanding, the cosmic microwave background as the remnant radiation from the Big Bang, and the observed composition of ordinary matter of the universe, primarily found in stars and interstellar gases (from the spectra of electromagnetic radiation from stars), which matches that predicted by the Big Bang theory (3/4 hydrogen and 1/4 helium).

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions • Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. **Connections to Nature of Science** **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** • A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each ⩔	**ESS1.A: The Universe and Its Stars** • The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. • The Big Bang theory is supported by observations of distant galaxies receding from our own, of the measured composition of stars and non-stellar gases, and of the maps of spectra of the primordial radiation (cosmic microwave background) that still fills the universe. • Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode. ⩔	**Energy and Matter** • Energy cannot be created or destroyed–only moved between one place and another place, between objects and/or fields, or between systems. **Connection to Engineering, Technology, and Applications of Science** **Interdependence of Science, Engineering, and Technology** • Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise. ⩔

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence.	**PS4.B Electromagnetic Radiation** • Atoms of each element emit and absorb characteristic frequencies of light. These characteristics allow identification of the presence of an element, even in microscopic quantities. (*Secondary*)	**Connection to Nature of Science** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future. • Science assumes the universe is a vast single system in which basic laws are consistent.

HS-ESS1-4

Students who demonstrate understanding can: Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.

Clarification Statement: Emphasis is on Newtonian gravitational laws governing orbital motions, which apply to human-made satellites as well as planets and moons.

Assessment Boundary: Mathematical representations for the gravitational attraction of bodies and Kepler's Laws of orbital motions should not deal with more than two bodies, nor involve calculus.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematical and Computational Thinking • Use mathematical or computational representations of phenomena to describe explanations.	**ESS1.B: Earth and the Solar System** • Kepler's laws describe common features of the motions of orbiting objects, including their elliptical paths around the sun. Orbits may change due to the gravitational effects from, or collisions with, other objects in the solar system.	**Scale, Proportion, and Quantity** • Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth). **Connection to Engineering, Technology, and Applications of Science** **Interdependence of Science, Engineering, and Technology** • Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise.

HS. History of Earth

Students who demonstrate understanding can:

HS-ESS1-5.

Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks. [Clarification Statement: Emphasis is on the ability of plate tectonics to explain the ages of crustal rocks. Examples include evidence of the ages oceanic crust increasing with distance from mid-ocean ridges (a result of plate spreading) and the ages of North American continental crust decreasing with distance away from a central ancient core of the continental plate (a result of past plate interactions).]

HS-ESS1-6.

Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history. [Clarification Statement: Emphasis is on using available evidence within the solar system to reconstruct the early history of Earth, which formed along with the rest of the solar system 4.6 billion years ago. Examples of evidence include the absolute ages of ancient materials (obtained by radiometric dating of meteorites, moon rocks, and Earth's oldest minerals), the sizes and compositions of solar system objects, and the impact cratering record of planetary surfaces.]

HS-ESS2-1.

Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features. [Clarification Statement: Emphasis is on how the appearance of land features (such as mountains, valleys, and plateaus) and sea-floor features (such as trenches, ridges, and seamounts) are a result of both constructive forces (such as volcanism, tectonic uplift, and orogeny) and destructive mechanisms (such as weathering, mass wasting, and coastal erosion).] [*Assessment Boundary: Assessment does not include memorization of the details of the formation of specific geographic features of Earth's surface*.]

HS-ESS1-5

Students who demonstrate understanding can: Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks.

Clarification Statement: Emphasis is on the ability of plate tectonics to explain the ages of crustal rocks. Examples include evidence of the ages oceanic crust increasing with distance from mid-ocean ridges (a result of plate spreading) and the ages of North American continental crust decreasing with distance away from a central ancient core of the continental plate (a result of past plate interactions).

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence • Evaluate evidence behind currently accepted explanations or solutions to determine the merits of arguments.	**ESS1.C: The History of Planet Earth** • Continental rocks, which can be older than 4 billion years, are generally much older than the rocks of the ocean floor, which are less than 200 million years old . **ESS2.B: Plate Tectonics and Large-Scale System Interactions** • Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. (*Secondary*) **PS1.C: Nuclear Processes** • Spontaneous radioactive decays follow a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials. (*Secondary*)	**Patterns** • Empirical evidence is needed to identify patterns.

HS-ESS1-6

Students who demonstrate understanding can: Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history.

Clarification Statement: Emphasis is on using available evidence within the solar system to reconstruct the early history of Earth, which formed along with the rest of the solar system 4.6 billion years ago. Examples of evidence include the absolute ages of ancient materials (obtained by radiometric dating of meteorites, moon rocks, and Earth's oldest minerals), the sizes and compositions of solar system objects, and the impact cratering record of planetary surfaces.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions • Apply scientific reasoning to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. **Connections to Nature of Science** **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** • A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence.	**ESS1.C: The History of Planet Earth** • Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history. **PS1.C: Nuclear Processes** • Spontaneous radioactive decays follow a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials. (*Secondary*)	**Stability and Change** • Much of science deals with constructing explanations of how things change and how they remain stable.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
• Models, mechanisms, and explanations collectively serve as tools in the development of a scientific theory.		

HS-ESS2-1

Students who demonstrate understanding can: Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features.

Clarification Statement: Emphasis is on how the appearance of land features (such as mountains, valleys, and plateaus) and sea-floor features (such as trenches, ridges, and seamounts) are a result of both constructive forces (such as volcanism, tectonic uplift, and orogeny) and destructive mechanisms (such as weathering, mass wasting, and coastal erosion).

Assessment Boundary: Assessment does not include memorization of the details of the formation of specific geographic features of Earth's surface.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Develop a model based on evidence to illustrate the relationships between systems or between components of a system.	**ESS2.A: Earth Materials and Systems** • Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. **ESS2.B: Plate Tectonics and Large-Scale System Interactions** • Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. • Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust.	**Stability and Change** • Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.

HS. Earth's Systems

Students who demonstrate understanding can:

HS-ESS2-2.

Analyze geoscience data to evaluate claims that one change to Earth's surface creates feedbacks that cause changes to other Earth systems. [Clarification Statement: Examples should include climate feedbacks, such as how an increase in greenhouse gases causes a rise in global temperature that melts glacial and sea ice, which reduces the amount of sunlight reflected from Earth's surface, increasing surface temperatures and further reducing the amount of ice. Examples could also be taken from other system interactions, such as feedbacks due to the effects of permafrost thawing; how the loss of ground vegetation causes an increase in water runoff and soil erosion; how dammed rivers increase groundwater recharge and decrease sediment transport, and how the loss of wetlands causes a decrease in local humidity that further reduces wetland extent.]

HS-ESS2-3.

Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection. [Clarification Statement: Emphasis is on both a one-dimensional model of Earth, with radial layers determined by density, and a three-dimensional model, which is controlled by mantle convection and the resulting plate tectonics. Examples of evidence include maps of Earth's three-dimensional structure obtained from seismic waves, records of the rate of change of Earth's magnetic field (as constraints on convection in the outer core), and identification of the composition of Earth's layers from high-pressure laboratory experiments.]

HS-ESS2-5.

Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. [Clarification Statement: Emphasis is on mechanical and chemical investigations with water and a variety of solid materials to provide evidence for the connections between the hydrologic cycle and system interactions commonly known as the rock cycle. Examples of mechanical investigations include stream transportation and deposition using a stream table, beach erosion and deposition patterns in relation to substrate type and size, erosion using variations in soil moisture content, and frost wedging by the expansion of water as it freezes. Examples of chemical investigations include chemical weathering, and recrystallization (by testing the solubility of different materials) or melt generation (by examining how water lowers the melting temperature of most solids).]

HS-ESS2-6.

Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. [Clarification Statement: Emphasis is on modeling biogeochemical cycles that include the cycling of carbon through the ocean, atmosphere, soil, permafrost, and biosphere (including humans), providing the foundation for living organisms.]

HS-ESS2-7.

Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth. [Clarification Statement: Emphasis is on the dynamic causes, effects, and feedbacks between the biosphere and Earth's other systems, whereby geoscience factors control the evolution of life, which in turn continuously alters Earth's surface. Examples include how photosynthetic life altered the atmosphere through the production of oxygen, which in turn increased weathering rates and allowed for the evolution of animal life; how microbial life on land increased the formation of soil, which in turn allowed for the evolution of land plants; or how the evolution of corals created reefs that altered patterns of erosion and deposition along coastlines and provided habitats for the evolution of new life forms.] [*Assessment Boundary: Assessment does not include a comprehensive understanding of the mechanisms of how the biosphere interacts with all of Earth's other systems*.]

HS-ESS2-2

Students who demonstrate understanding can: Analyze geoscience data to evaluate claims that one change to Earth's surface creates feedbacks that cause changes to other Earth systems.

Clarification Statement: Examples should include climate feedbacks, such as how an increase in greenhouse gases causes a rise in global temperature that melts glacial and sea ice, which reduces the amount of sunlight reflected from Earth's surface, increasing surface temperatures and further reducing the amount of ice. Examples could also be taken from other system interactions, such as feedbacks due to the effects of permafrost thawing; how the loss of ground vegetation causes an increase in water runoff and soil erosion; how dammed rivers increase groundwater recharge and decrease sediment transport, and how the loss of wetlands causes a decrease in local humidity that further reduces wetland extent.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.	**ESS2.A: Earth Materials and Systems** • Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes.	**Stability and Change** • Feedback (negative or positive) can stabilize or destabilize a system. **Connections to Engineering, Technology and Applications of Science** **Influence of Engineering, Technology, and Science on Society and the Natural World** • New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.

HS-ESS2-3

Students who demonstrate understanding can: Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.

Clarification Statement: Emphasis is on both a one-dimensional model of Earth, with radial layers determined by density, and a three-dimensional model, which is controlled by mantle convection and the resulting plate tectonics. Examples of evidence include maps of Earth's three-dimensional structure obtained from seismic waves, records of the rate of change of Earth's magnetic field (as constraints on convection in the outer core), and identification of the composition of Earth's layers from high-pressure laboratory experiments.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Develop a model based on evidence to illustrate the relationships between systems or between components of a system. **Connections to Nature of Science** **Scientific Knowledge is Based on Empirical Evidence** • Science knowledge is based on empirical evidence. • Science disciplines share common rules of evidence used to evaluate explanations about natural systems. • Science includes the process of coordinating patterns of evidence with current theory.	**ESS2.A: Earth Materials and Systems** • Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth's surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and gravitational movement of denser materials toward the interior. **ESS2.B: Plate Tectonics and Large-Scale System Interactions** • The radioactive decay of unstable isotopes continually generates new energy within Earth's crust and mantle, providing the primary source of the	**Energy and Matter** • Energy drives the cycling of matter within and between systems. **Connections to Engineering, Technology and Applications of Science** **Interdependence of Science, Engineering, and Technology** • Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
	heat that drives mantle convection. Plate tectonics can be viewed as the surface expression of mantle convection. **PS4.A: Wave Properties** • Geologists use seismic waves and their reflection at interfaces between layers to probe structures deep in the planet. (*Secondary*)	

HS-ESS2-5

Students who demonstrate understanding can: Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.

Clarification Statement: Emphasis is on mechanical and chemical investigations with water and a variety of solid materials to provide evidence for the connections between the hydrologic cycle and system interactions commonly known as the rock cycle. Examples of mechanical investigations include stream transportation and deposition using a stream table, beach erosion and deposition patterns in relation to substrate type and size, erosion using variations in soil moisture content, and frost wedging by the expansion of water as it freezes. Examples of chemical investigations include chemical weathering, and recrystallization (by testing the solubility of different materials) or melt generation (by examining how water lowers the melting temperature of most solids).

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations • Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.	**ESS2.C: The Roles of Water in Earth's Surface Processes** • The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks.	**Structure and Function** • The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials.

HS-ESS2-6

Students who demonstrate understanding can: Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.

Clarification Statement: Emphasis is on modeling biogeochemical cycles that include the cycling of carbon through the ocean, atmosphere, soil, permafrost, and biosphere (including humans), providing the foundation for living organisms.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Develop a model based on evidence to illustrate the relationships between systems or between components of a system.	**ESS2.D: Weather and Climate** • Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. • Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate.	**Energy and Matter** • The total amount of energy and matter in closed systems is conserved.

HS-ESS2-7

Students who demonstrate understanding can: Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth.

Clarification Statement: Emphasis is on the dynamic causes, effects, and feedbacks between the biosphere and Earth's other systems, whereby geoscience factors control the evolution of life, which in turn continuously alters Earth's surface. Examples include how photosynthetic life altered the atmosphere through the production of oxygen, which in turn increased weathering rates and allowed for the evolution of animal life; how microbial life on land increased the formation of soil, which in turn allowed for the evolution of land plants; or how the evolution of corals created reefs that altered patterns of erosion and deposition along coastlines and provided habitats for the evolution of new life forms.

Assessment Boundary: Assessment does not include a comprehensive understanding of the mechanisms of how the biosphere interacts with all of Earth's other systems.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence • Construct an oral and written argument or counter- arguments based on data and evidence.	**ESS2.D: Weather and Climate** • Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. **ESS2.E: Biogeology** • The many dynamic and delicate feedbacks between the biosphere and other Earth systems cause a continual co-evolution of Earth's surface and the life that exists on it.	**Stability and Change** • Much of science deals with constructing explanations of how things change and how they remain stable.

HS. Weather and Climate

Students who demonstrate understanding can:

HS-ESS2-4.

Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate. [Clarification Statement: Examples of the causes of climate change differ by timescale, over 1-10 years: large volcanic eruption, ocean circulation; 10-100s of years: changes in human activity, ocean circulation, solar output; 10-100s of thousands of years: changes to Earth's orbit and the orientation of its axis; and 10-100s of millions of years: long-term changes in atmospheric composition.] [*Assessment Boundary: Assessment of the results of changes in climate is limited to changes in surface temperatures, precipitation patterns, glacial ice volumes, sea levels, and biosphere distribution*.]

HS-ESS3-5.

Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth's systems. [Clarification Statement: Examples of evidence, for both data and climate model outputs, are for climate changes (such as precipitation and temperature) and their associated impacts (such as on sea level, glacial ice volumes, and physical and chemical characteristics of atmosphere and ocean.] [*Assessment Boundary: Assessment is limited to one example of a climate change and its associated impacts*.]

HS-ESS2-4

Students who demonstrate understanding can: Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.

Clarification Statement: Examples of the causes of climate change differ by timescale, over 1-10 years: large volcanic eruption, ocean circulation; 10-100s of years: changes in human activity, ocean circulation, solar output; 10-100s of thousands of years: changes to Earth's orbit and the orientation of its axis; and 10-100s of millions of years: long-term changes in atmospheric composition.

Assessment Boundary: Assessment of the results of changes in climate is limited to changes in surface temperatures, precipitation patterns, glacial ice volumes, sea levels, and biosphere distribution.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Use a model to provide mechanistic accounts of phenomena. **Connections to Nature of Science** **Scientific Knowledge is Based on Empirical Evidence** • Science arguments are strengthened by multiple lines of evidence supporting a single explanation.	**ESS1.B: Earth and the Solar System** • Cyclical changes in the shape of Earth's orbit around the sun, together with changes in the tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the earth. These phenomena cause a cycle of ice ages and other gradual climate changes. (*Secondary*) **ESS2.A: Earth Materials and Systems** • The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to ⮟	**Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
	intermediate (ice ages) to very long-term tectonic cycles. **ESS2.D: Weather and Climate** • The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. • Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate.	

HS-ESS3-5

Students who demonstrate understanding can: Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth's systems.

Clarification Statement: Examples of evidence, for both data and climate model outputs, are for climate changes (such as precipitation and temperature) and their associated impacts (such as on sea level, glacial ice volumes, and physical and chemical characteristics of atmosphere and ocean.

Assessment Boundary: Assessment is limited to one example of a climate change and its associated impacts.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data • Analyze data using computational models in order to make valid and reliable scientific claims. **Connections to Nature of Science** **Scientific Investigations Use a Variety of Methods** • Science investigations use diverse methods and do not always use the same set of procedures to obtain data. • New technologies advance scientific knowledge. **Scientific Knowledge is Based on Empirical Evidence** • Science knowledge is based on empirical evidence. • Science arguments are strengthened by multiple lines of evidence supporting a single explanation.	**ESS3.D: Global Climate Change** • Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts.	**Stability and Change** • Change and rates of change can be quantified and modeled over very short or very long period of time. Some system changes are irreversible.

HS. Human Sustainability

Students who demonstrate understanding can:

HS-ESS3-1.

Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity. [Clarification Statement: Examples of key natural resources include access to fresh water (such as rivers, lakes and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals, wildlife, fish, trees, and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting, and soil erosion), and severe weather (such as hurricanes, floods, storm surge, lightning strike fires, and droughts). Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, changes in stream or ocean water temperatures and/or chemistry, and the types of food that can be raised, hunted, fished, harvested, or gathered.]

HS-ESS3-2.

Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.* [Clarification Statement: Emphasis is on the conservation, recycling and reuse of resources (such as minerals and metals) where possible and on minimizing impacts where it is not. Examples include developing best practices for agricultural soil use, all types of mining, extracting of fossil fuels, and collecting renewable resources. Scientific knowledge indicates what can happen in natural systems--not what should happen.]

HS-ESS3-3.

Create a computational simulation to illustrate the relationships among the management of natural resources, the sustainability of human populations, and biodiversity. [Clarification Statement: Examples of factors that affect the management of natural resources include costs of resource extraction and waste management, per-capita consumption, and the development of new technologies. Examples of factors that affect human sustainability include agricultural efficiency, levels of conservation, and urban planning.] [*Assessment Boundary: Assessment for computational simulations is limited to using provided multi-parameter programs or constructing simplified spreadsheet calculations*.]

HS-ESS3-4.

Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.* [Clarification Statement: Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean).]

HS-ESS3-6.

Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity. [Clarification Statement: Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. An example of the far-reaching impacts from a human activity is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on land and an increase in ocean acidification, with resulting impacts on sea organism health and marine populations.] [*Assessment Boundary: Assessment does not include running computational representations but is limited to using the published results of scientific computational models*.]

HS-ESS3-1

Students who demonstrate understanding can: Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.

Clarification Statement: Examples of key natural resources include access to fresh water (such as rivers, lakes and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals, wildlife, fish, trees, and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting, and soil erosion), and severe weather (such as hurricanes, floods, storm surge, lightning strike fires, and droughts). Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, changes in stream or ocean water temperatures and/or chemistry, and the types of food that can be raised, hunted, fished, harvested, or gathered.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions • Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.	**ESS3.A: Natural Resources** • Resource availability has guided the development of human society. **ESS3.B: Natural Hazards** • Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations.	**Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. **Connections to Engineering, Technology, and Applications of Science** **Influence of Engineering, Technology, and Science on Society and the Natural World** • Modern civilization depends on major technological systems.

HS-ESS3-2

Students who demonstrate understanding can: Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.*

Clarification Statement: Emphasis is on the conservation, recycling and reuse of resources (such as minerals and metals) where possible and on minimizing impacts where it is not. Examples include developing best practices for agricultural soil use, all types of mining, extracting of fossil fuels, and collecting renewable resources. Scientific knowledge indicates what can happen in natural systems--not what should happen.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence • Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations).	**ESS3.A: Natural Resources** • All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. **ETS1.B. Designing Solutions to Engineering Problems** • When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (*Secondary*)	**Connections to Engineering, Technology, and Applications of Science** **Influence of Engineering, Technology, and Science on Society and the Natural World** • Engineers continuously modify these systems to increase benefits while decreasing costs and risks. • Analysis of costs and benefits is a critical aspect of decisions about technology. **Connections to Nature of Science** **Science Addresses Questions About the Natural and Material World** • Science and technology may raise ethical issues for which science, by itself, does not provide answers and solutions. • Science knowledge indicates what can happen in natural systems—not what should happen. The latter involves ethics, values, and human decisions about the use of knowledge.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
		• Many decisions are not made using science alone, but rely on social and cultural contexts to resolve issues.

HS-ESS3-3

Students who demonstrate understanding can: Create a computational simulation to illustrate the relationships among the management of natural resources, the sustainability of human populations, and biodiversity.

Clarification Statement: Examples of factors that affect the management of natural resources include costs of resource extraction and waste management, per-capita consumption, and the development of new technologies. Examples of factors that affect human sustainability include agricultural efficiency, levels of conservation, and urban planning.

Assessment Boundary: Assessment for computational simulations is limited to using provided multi-parameter programs or constructing simplified spreadsheet calculations.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematics and Computational Thinking • Create a computational model or simulation of a phenomenon, designed device, process, or system.	**ESS3.C: Human Impacts on Earth Systems** • The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources.	**Stability and Change** • Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. **Connections to Engineering, Technology, and Applications of Science** **Influence of Engineering, Technology, and Science on Society and the Natural World** • Modern civilization depends on major technological systems. • New technologies can have deep impacts on society and the environment, including some that were not anticipated.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
		Connections to Nature of Science **Science is a Human Endeavor** • Scientific knowledge is a result of human endeavors, imagination, and creativity.

HS-ESS3-4

Students who demonstrate understanding can: Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.*

Clarification Statement: Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean).

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions • Design or refine a solution to a complex real-world problem, based on scientific knowledge, student- generated sources of evidence, prioritized criteria, and tradeoff considerations.	**ESS3.C: Human Impacts on Earth Systems** • Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation. **ETS1.B. Designing Solutions to Engineering Problems** • When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (*Secondary*)	**Stability and Change** • Feedback (negative or positive) can stabilize or destabilize a system. **Connections to Engineering, Technology, and Applications of Science** **Influence of Engineering, Technology, and Science on Society and the Natural World** • Engineers continuously modify these systems to increase benefits while decreasing costs and risks.

HS-ESS3-6

Students who demonstrate understanding can: Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.

Clarification Statement: Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. An example of the far-reaching impacts from a human activity is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on land and an increase in ocean acidification, with resulting impacts on sea organism health and marine populations.

Assessment Boundary: Assessment does not include running computational representations but is limited to using the published results of scientific computational models.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematics and Computational Thinking • Use a computational representation of phenomena or design solutions to describe and/or support claims and/or explanations.	**ESS2.D: Weather and Climate** • Current models predict that, although future regional climate changes will be complex and varied, average global temperatures will continue to rise. The outcomes predicted by global climate models strongly depend on the amounts of human-generated greenhouse gases added to the atmosphere each year and by the ways in which these gases are absorbed by the ocean and biosphere. (*Secondary*) **ESS3.D: Global Climate Change** • Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities.	**Systems and System Models** • When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models.

HS. Engineering Design

Students who demonstrate understanding can:

HS-ETS1-1.

Analyze major global challenges to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

HS-ETS1-2.

Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

HS-ETS1-3.

Evaluate a solution to a complex real-world problem based on prioritized criteria and tradeoffs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

HS-ETS1-4.

Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

HS-ETS1-1

Students who demonstrate understanding can: Analyze major global challenges to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Asking Questions and Defining Problems • Analyze complex real-world problems by specifying criteria and constraints for successful solutions.	**ETS1.A: Defining and Delimiting Engineering Problems** • Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. • Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities.	**Connections to Engineering, Technology, and Application of Science** **Influence of Science, Engineering, and Technology on Society and the Natural World** • New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.

HS-ETS1-2

Students who demonstrate understanding can: Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions • Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	**ETS1.C: Optimizing the Design Solution** • Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (tradeoffs) may be needed.	

HS-ETS1-3

Students who demonstrate understanding can: Evaluate a solution to a complex real-world problem based on prioritized criteria and tradeoffs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions • Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	**ETS1.B: Developing Possible Solutions** • When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.	**Connections to Engineering, Technology, and Application of Science** **Influence of Science, Engineering, and Technology on Society and the Natural World** • New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.

HS-ETS1-4

Students who demonstrate understanding can: Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematics and Computational Thinking • Use mathematical models and/or computer simulations to predict the effects of a design solution on system and/or the interactions between systems.	**ETS1.B: Developing Possible Solutions** • Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical, and in making a persuasive presentation to a client about how a given design will meet his or her needs.	**Systems and System Models** • Models (e.g. physical, mathematical, computer) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales.

U.S. Department
of Transportation

**Federal Aviation
Administration**

FAA-S-ACS-6B
(with Change 1)

Private Pilot – Airplane

Airman Certification Standards

June 2018

Flight Standards Service
Washington, DC 20591

Acknowledgments

The U.S. Department of Transportation, Federal Aviation Administration (FAA), Office of Safety Standards, Regulatory Support Division, Airman Testing Branch, P.O. Box 25082, Oklahoma City, OK 73125 developed this Airman Certification Standards (ACS) document with the assistance of the aviation community. The FAA gratefully acknowledges the valuable support from the many individuals and organizations who contributed their time and expertise to assist in this endeavor.

Availability

This ACS is available for download from www.faa.gov. Please send comments regarding this document using the following link to the Airman Testing Branch Mailbox.

Material in FAA-S-ACS-6B will be effective June 11, 2018. All previous editions of the Private Pilot – Airplane Airman Certification Standards will be obsolete as of this date for airplane applicants.

Foreword

The Federal Aviation Administration (FAA) has published the Private Pilot – Airplane Airman Certification Standards (ACS) document to communicate the aeronautical knowledge, risk management, and flight proficiency standards for the private pilot certification in the airplane category, single-engine land and sea; and multiengine land and sea classes. This ACS incorporates and supersedes FAA-S-ACS-6A, Private Pilot – Airplane Airman Certification Standards, Change 1.

The FAA views the ACS as the foundation of its transition to a more integrated and systematic approach to airman certification. The ACS is part of the safety management system (SMS) framework that the FAA uses to mitigate risks associated with airman certification training and testing. Specifically, the ACS, associated guidance, and test question components of the airman certification system are constructed around the four functional components of an SMS:

- Safety Policy that defines and describes aeronautical knowledge, flight proficiency, and risk management as integrated components of the airman certification system;
- Safety Risk Management processes through which both internal and external stakeholders identify changes in regulations, safety recommendations, or other factors. These changes are then evaluated to determine whether they require modification of airman testing and training materials;
- Safety Assurance processes to ensure the prompt and appropriate incorporation of changes arising from new regulations and safety recommendations; and
- Safety Promotion in the form of ongoing engagement with both external stakeholders (e.g., the aviation training industry) and FAA policy divisions.

The FAA has developed this ACS and its associated guidance in collaboration with a diverse group of aviation training experts. The goal is to drive a systematic approach to all components of the airman certification system, including knowledge test question development and conduct of the practical test. The FAA acknowledges and appreciates the many hours that these aviation experts have contributed toward this goal. This level of collaboration, a hallmark of a robust safety culture, strengthens and enhances aviation safety at every level of the airman certification system.

John S. Duncan
Executive Director, Flight Standards Service

Revision History

Document #	Description	Revision Date
FAA-S-8081-14B	Private Pilot Practical Test Standards for Airplane, (Changes 1-6)	November 2011
FAA-S-ACS-6	Private Pilot – Airplane Airman Certification Standards	June 1, 2016
FAA-S-ACS-6	Private Pilot – Airplane Airman Certification Standards (Change 1)	June 15, 2016
FAA-S-ACS-6A	Private Pilot – Airplane Airman Certification Standards (Change 1)	June 12, 2017
FAA-S-ACS-6B	Private Pilot – Airplane Airman Certification Standards	June 11, 2018
FAA-S-ACS-6B	Private Pilot – Airplane Airman Certification Standards (with Change 1)	June 6, 2019

Record of Changes

Change 1 (June 6, 2019)

- Revised the following sections of the Introduction:
  - Airman Certification Standards Concept (page 1)
  - Using the ACS (pages 1 and 2)
- Added FAA-H-8083-25 to list of References for Area of Operation VII, Task A. Maneuvering During Slow Flight (page 41).
- Revised Task elements corresponding to the following ACS codes to make their wording consistent with the other ACSs, as applicable:

PA.I.A.K1	PA.IV.B.S8	PA.IV.J.S6	PA.VII.D.R6
PA.I.C.K1	PA.IV.C.R4	PA.IV.K.R4	PA.VIII.A.R4
PA.I.C.K2	PA.IV.C.R6	PA.IV.K.R6	PA.VIII.B.R4
PA.I.C.K3j	PA.IV.C.S5	PA.IV.K.S5	PA.VIII.B.S2
PA.I.C.K3l	PA.IV.D.R4	PA.IV.K.S6	PA.VIII.C.R4
PA.I.C.S1	PA.IV.D.R6	PA.IV.K.S9	PA.VIII.C.S2
PA.I.C.S2	PA.IV.D.S5	PA.IV.L.R4	PA.VIII.D.R4
PA.I.C.S3	PA.IV.D.S7	PA.IV.L.R6	PA.VIII.D.S1
PA.I.E.S1	PA.IV.D.S8	PA.IV.L.S5	PA.VIII.E.R4
PA.I.E.S3	PA.IV.E.R4	PA.IV.L.S8	PA.VII.E.R7
PA.I.F.S2	PA.IV.E.R6	PA.IV.M.R2e	PA.IX.A.K1
PA.I.G.K1	PA.IV.E.S5	PA.IV.M.R3	PA.IX.A.R4
PA.I.G.S1	PA.IV.E.S11	PA.IV.M.R3a	PA.IX.A.S3
PA.I.H.K1	PA.IV.F.R4	PA.IV.M.R3b	PA.IX.B.R6
PA.I.H.K1a	PA.IV.F.R6	PA.IV.M.R4	PA.IX.C.R2
PA.I.H.K1f	PA.IV.F.S5	PA.IV.M.R6	PA.IX.E.R3
PA.I.H.R3	PA.IV.F.S7	PA.IV.N.R5	PA.IX.F.R5
PA.I.H.S1	PA.IV.F.S8	PA.IV.N.R7	PA.IX.G.K4
PA.I.I.K1	PA.IV.G.R4	PA.V.A.R2	PA.IX.G.R5
PA.II.B.S3	PA.IV.G.R6	PA.V.A.R4	PA.IX.G.S1
PA.II.D.K1	PA.IV.G.S5	PA.V.A.S2	PA.IX.G.S2
PA.II.D.S3	PA.IV.G.S9	PA.V.B.R4	PA.IX.G.S9
PA.II.E.K6b	PA.IV.G.S12	PA.VI.A.R2	PA.X.A.S7
PA.II.E.S6	PA.IV.H.R4	PA.VI.A.S4	PA.X.B.R3
PA.II.F.R4	PA.IV.H.R6	PA.VI.B.R2	PA.X.B.S6
PA.II.F.S3	PA.IV.H.S5	PA.VI.C.K2	PA.X.C.R4
PA.III.B.R2	PA.IV.H.S7	PA.VI.C.R2	PA.X.C.S11
PA.III.B.R3	PA.IV.H.S8	PA.VI.C.R4	PA.X.D.R2
PA.III.B.S1	PA.IV.I.K1	PA.VI.C.S1	PA.X.D.R3
PA.IV.A.R4	PA.IV.I.R4	PA.VI.C.S5	PA.X.D.R4
PA.IV.A.S8	PA.IV.I.R6	PA.VI.D.R2	PA.X.D.R5
PA.IV.B Objective	PA.IV.I.S7	PA.VI.D.S4	PA.X.D.R6
PA.IV.B.R1	PA.IV.I.S10	PA.VII.A.R6	PA.X.D.S1
PA.IV.B.R4	PA.IV.J.R4	PA.VII.B.R8	PA.X.D.S2
PA.IV.B.R6	PA.IV.J.R6	PA.VII.C.R8	PA.XI.A.R2
PA.IV.B.S5	PA.IV.J.S4	PA.VII.C.S4	PA.XII.A.S1

- Revised the "Knowledge Test Requirements" section of Appendix 1: The Knowledge Test Eligibility, Prerequisites, and Testing Centers (page A-2).
- Revised the "FAA Knowledge Test Question Coding" section of Appendix 3: Airman Knowledge Test Report (page A-5).

- Revised the following sections of Appendix 5: Practical Test Roles, Responsibilities, and Outcomes:
  - — Evaluator Responsibilities (page A-8)
  - — Possible Outcomes of the Test (page A-9)
  - — Satisfactory Performance (page A-9)
  - — Testing after Discontinuance or Unsatisfactory Performance (page A-10)
  - — Addition of an Airplane Single-Engine Land Rating to an existing Private Pilot Certificate (page A-12)
  - — Addition of an Airplane Single-Engine Sea Rating to an existing Private Pilot Certificate (page A-13)
  - — Addition of an Airplane Multiengine Land Rating to an existing Private Pilot Certificate (page A-14)
  - — Addition of an Airplane Multiengine Sea Rating to an existing Private Pilot Certificate (page A-15)
- Revised the "Multiengine Considerations" section of Appendix 6: Safety of Flight (page A-18).
- Revised the "Equipment Requirements & Limitations" section of Appendix 7: Aircraft, Equipment, and Operational Requirements & Limitations (page A-19).
- Revised Appendix 10: Abbreviations and Acronyms (pages A-25 and A-26).

Major Enhancements to Version FAA-S-ACS-6B

- Revised Introduction and appendices to account for FAA reorganization.
- Replaced numerous prescriptive references to airplane configuration with more general references.
- Revised numerous Tasks in all Areas of Operation to include more consistent element descriptions.
- Added language to account for Part 68 BasicMed.
- Included SFRA and SATR, if applicable, in Area of Operation I, Task E.
- Distinguished different types of hypoxia in Area of Operation I, Task H.
- Broadened scope of engine starting conditions knowledge element in Area of Operation II, Task C.
- Revised Area of Operation III, Task A to include runway lighting systems.
- Revised Area of Operation IV to require touch down a proper pitch attitude.
- Restored distance tolerance in Area of Operation IV, Task B.
- Added airspeed tolerance to Area of Operation IX, Task A.
- Revised Area of Operation X, Tasks C and D to match the Instrument Rating Airman Certification Standards.
- Correlated knowledge elements of multiengine airplane engine inoperative flight to zero sideslip.
- Revised language regarding reduction of drag with one engine inoperative in terms of the manufacturer's recommendation or appropriate use of flight controls.
- Added CFIT to low altitude maneuvering risk elements.
- Added a reference to Task Objectives and enhanced *Appendix 7: Aircraft, Equipment, and Operational Requirements & Limitations*, regarding flight solely by reference to instruments.
- Updated the following Appendices:
  - Appendix 1: The Knowledge Test Eligibility, Prerequisites, and Testing Centers
  - Appendix 5: Practical Test Roles, Responsibilities, and Outcomes
  - Appendix 6: Safety of Flight
  - Appendix 7: Aircraft, Equipment, and Operational Requirements & Limitations
  - Appendix 9: References
  - Appendix 10: Abbreviations and Acronyms

Table of Contents

Introduction

Airman Certification Standards Concept

The goal of the airman certification process is to ensure the applicant possesses the knowledge, ability to manage risks, and skill consistent with the privileges of the certificate or rating being exercised, in order to act as Pilot-in-command (PIC).

In fulfilling its responsibilities for the airman certification process, the Federal Aviation Administration (FAA) Flight Standards Service (AFS) plans, develops, and maintains materials related to airman certification training and testing. These materials include several components. The FAA knowledge test measures mastery of the aeronautical knowledge areas listed in Title 14 of the Code of Federal Regulations (14 CFR) part 61. Other materials, such as handbooks in the FAA-H-8083 series, provide guidance to applicants on aeronautical knowledge, risk management, and flight proficiency.

Safe operations in today's National Airspace System (NAS) require integration of aeronautical knowledge, risk management, and flight proficiency standards. To accomplish these goals, the FAA drew upon the expertise of organizations and individuals across the aviation and training community to develop the Airman Certification Standards (ACS). The ACS integrates the elements of knowledge, risk management, and skill listed in 14 CFR part 61 for each airman certificate or rating. It thus forms a more comprehensive standard for what an applicant must know, consider, and do for the safe conduct and successful completion of each Task to be tested on both the qualifying FAA knowledge test and the oral and flight portions of the practical test.

During the ground and flight portion of the practical test, the FAA expects evaluators to assess the applicant's mastery of the topic in accordance with the level of learning most appropriate for the specified Task. The oral questioning will continue throughout the entire practical test. For some topics, the evaluator will ask the applicant to describe or explain. For other items, the evaluator will assess the applicant's understanding by providing a scenario that requires the applicant to appropriately apply and/or correlate knowledge, experience, and information to the circumstances of the given scenario. The flight portion of the practical test requires the applicant to demonstrate knowledge, risk management, flight proficiency, and operational skill in accordance with the ACS.

Note: *As used in the ACS, an* evaluator *is any person authorized to conduct airman testing (e.g., an FAA Aviation Safety Inspector (ASI), Designated Pilot Examiner (DPE), or other individual authorized to conduct test for a certificate or rating).*

Using the ACS

The ACS consists of ***Areas of Operation*** arranged in a logical sequence, beginning with Preflight Preparation and ending with Postflight Procedures. Each Area of Operation includes ***Tasks*** appropriate to that Area of Operation. Each Task begins with an ***Objective*** stating what the applicant should know, consider, and/or do. The ACS then lists the aeronautical knowledge, risk management, and skill elements relevant to the specific Task, along with the conditions and standards for acceptable performance. The ACS uses ***Notes*** to emphasize special considerations. The ACS uses the terms "will" and "must" to convey directive (mandatory) information. The term "may" denotes items that are recommended but not required. The ***References*** for each Task indicate the source material for Task elements. For example, in Tasks such as "Weather products required for preflight planning, current and forecast weather for departure, en route, and arrival phases of flight." (PA.I.C.K2), the applicant should be prepared for questions on any weather product presented in the references for that Task.

The abbreviation(s) within parentheses immediately following a Task refer to the category and/or class airplane appropriate to that Task. The meaning of each abbreviation is as follows:

ASEL: Airplane – Single-Engine Land
ASES: Airplane – Single-Engine Sea
AMEL: Airplane – Multiengine Land
AMES: Airplane – Multiengine Sea

Note: *When administering a test, the Tasks appropriate to the class airplane (ASEL, ASES, AMEL, or AMES) used for the test must be included in the plan of action. The absence of a class indicates the Task is for all classes.*

Each Task in the ACS is coded according to a scheme that includes four elements. For example:

PA.XI.A.K1:

- **PA** = Applicable ACS (Private Pilot – Airplane)
- **XI** = Area of Operation (Night Operations)
- **A** = Task (Night Preparation)
- **K1** = Task element Knowledge 1 (Physiological aspects of vision related to night flying.)

Knowledge test questions correspond to the ACS codes, which will ultimately replace the system of Learning Statement Codes (LSC). After this transition occurs, the Airman Knowledge Test Report (AKTR) will list an ACS code that correlates to a specific Task element for a given Area of Operation and Task. Remedial instruction and re-testing will be specific, targeted, and based on specified learning criteria. Similarly, a Notice of Disapproval for the practical test will use the ACS codes to identify the deficient Task elements. Applicants and evaluators should interpret the AKTR codes using the ACS revision in effect on the date of the knowledge test.

However, for knowledge tests taken before this system comes on line, only the LSC code (e.g., “PLT058”) will be displayed on the AKTR. The LSC codes link to references and broad subject areas. By contrast, each ACS code represents a unique Task element in the ACS. Because of this fundamental difference, there is no one-to-one correlation between Learning Statement (PLT) codes and ACS codes.

Because all active knowledge test questions for the Private Pilot Airplane (PAR) Knowledge Test now align with the corresponding ACS, evaluators can use LSC codes in conjunction with this ACS for targeting retesting of missed knowledge subject areas. The evaluator should look up the LSC code(s) on the applicant’s AKTR in the Learning Statement Reference Guide available using the following link: Learning Statement Reference Guide. After noting the subject area(s), the evaluator can use the corresponding Area(s) of Operation/Task(s) in the ACS to narrow the scope of material for retesting, and to evaluate the applicant’s understanding of that material in the context of the appropriate ACS Area(s) of Operation and Task(s).

Applicants for a combined Private Pilot Certificate with Instrument Rating, in accordance with 14 CFR part 61, section 61.65 (a) and (g), must pass all areas designated in the Private Pilot – Airplane ACS and the Instrument Rating – Airplane ACS. Evaluators need not duplicate Tasks. For example, only one preflight demonstration would be required; however, the Preflight Task from the Instrument Rating – Airplane ACS would be more extensive than the Preflight Task from the Private Pilot – Airplane ACS to ensure readiness for Instrument Flight Rules (IFR) flight.

A combined certificate and rating evaluation should be treated as one practical test, requiring only one application and resulting in only one temporary certificate, disapproval notice, or letter of discontinuance, as applicable. Failure of any Task will result in a failure of the entire test and application. Therefore, even if the deficient maneuver was instrument related and the performance of all visual flight rules (VFR) Tasks was determined to be satisfactory, the applicant will receive a notice of disapproval.

The applicant must pass the Private Pilot Airplane (PAR) Knowledge Test before taking the private pilot practical test. The practical test is conducted in accordance with the ACS and FAA regulations that are current as of the date of the test. Further, the applicant must pass the ground portion of the practical test before beginning the flight portion.

The ground portion of the practical test allows the evaluator to determine whether the applicant is sufficiently prepared to advance to the flight portion of the practical test. The oral questioning will continue throughout the entire practical test.

Evaluators conduct the practical test in accordance with the current ACS and FAA regulations, and the FAA encourages applicants and instructors to use the ACS when preparing for knowledge tests and practical tests. The FAA will revise the ACS as circumstances require. However, if an applicant is entitled to credit for Areas of Operation previously passed as indicated on a Notice of Disapproval or Letter of Discontinuance, evaluators should continue using the ACS effective on the test cycle start date.

I. Preflight Preparation

Task	***A. Pilot Qualifications***
References	14 CFR parts 61, 68, 91; FAA-H-8083-2, FAA-H-8083-25; AC 68-1
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with airman and medical certificates including privileges, limitations, currency, and operating as pilot-in-command (PIC) as a private pilot.
Knowledge	The applicant demonstrates understanding of:
PA.I.A.K1	Certification requirements, recent flight experience, and recordkeeping.
PA.I.A.K2	Privileges and limitations.
PA.I.A.K3	Medical certificates: class, expiration, privileges, temporary disqualifications.
PA.I.A.K4	Documents required to exercise private pilot privileges.
PA.I.A.K5	Part 68 BasicMed privileges and limitations.
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.I.A.R1	Failure to distinguish proficiency versus currency.
PA.I.A.R2	Flying unfamiliar airplanes, or operating with unfamiliar flight display systems, and avionics.
Skills	The applicant demonstrates the ability to:
PA.I.A.S1	Apply requirements to act as PIC under Visual Flight Rules (VFR) in a scenario given by the evaluator.

I. Preflight Preparation

Task	***B. Airworthiness Requirements***
References	14 CFR parts 39, 43, 91; FAA-H-8083-2, FAA-H-8083-25
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with airworthiness requirements, including airplane certificates.
Knowledge	The applicant demonstrates understanding of:
PA.I.B.K1	General airworthiness requirements and compliance for airplanes, including:
PA.I.B.K1a	a. Certificate location and expiration dates
PA.I.B.K1b	b. Required inspections and airplane logbook documentation
PA.I.B.K1c	c. Airworthiness Directives and Special Airworthiness Information Bulletins
PA.I.B.K1d	d. Purpose and procedure for obtaining a special flight permit
PA.I.B.K2	Pilot-performed preventive maintenance.
PA.I.B.K3	Equipment requirements for day and night VFR flight, to include:
PA.I.B.K3a	a. Flying with inoperative equipment
PA.I.B.K3b	b. Using an approved Minimum Equipment List (MEL)
PA.I.B.K3c	c. Kinds of Operation Equipment List (KOEL)
PA.I.B.K3d	d. Required discrepancy records or placards
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.I.B.R1	Inoperative equipment discovered prior to flight.
Skills	The applicant demonstrates the ability to:
PA.I.B.S1	Locate and describe airplane airworthiness and registration information.
PA.I.B.S2	Determine the airplane is airworthy in a scenario given by the evaluator.
PA.I.B.S3	Apply appropriate procedures for operating with inoperative equipment in a scenario given by the evaluator.

I. Preflight Preparation

Task	*C. Weather Information*
References	14 CFR part 91; FAA-H-8083-25; AC 00-6, AC 00-45, AC 00-54; AIM
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with weather information for a flight under VFR.
Knowledge	The applicant demonstrates understanding of:
PA.I.C.K1	Sources of weather data (e.g., National Weather Service, Flight Service) for flight planning purposes.
PA.I.C.K2	Acceptable weather products and resources required for preflight planning, current and forecast weather for departure, en route, and arrival phases of flight.
PA.I.C.K3	Meteorology applicable to the departure, en route, alternate, and destination under VFR in Visual Meteorological Conditions (VMC) to include expected climate and hazardous conditions such as:
PA.I.C.K3a	a. Atmospheric composition and stability
PA.I.C.K3b	b. Wind (e.g., crosswind, tailwind, windshear, mountain wave, etc.)
PA.I.C.K3c	c. Temperature
PA.I.C.K3d	d. Moisture/precipitation
PA.I.C.K3e	e. Weather system formation, including air masses and fronts
PA.I.C.K3f	f. Clouds
PA.I.C.K3g	g. Turbulence
PA.I.C.K3h	h. Thunderstorms and microbursts
PA.I.C.K3i	i. Icing and freezing level information
PA.I.C.K3j	j. Fog/mist
PA.I.C.K3k	k. Frost
PA.I.C.K3l	l. Obstructions to visibility (e.g., smoke, haze, volcanic ash, etc.)
PA.I.C.K4	Flight deck displays of digital weather and aeronautical information.
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.I.C.R1	Factors involved in making the go/no-go and continue/divert decisions, to include:
PA.I.C.R1a	a. Circumstances that would make diversion prudent
PA.I.C.R1b	b. Personal weather minimums
PA.I.C.R1c	c. Hazardous weather conditions to include known or forecast icing or turbulence aloft
PA.I.C.R2	Limitations of:
PA.I.C.R2a	a. Onboard weather equipment
PA.I.C.R2b	b. Aviation weather reports and forecasts
PA.I.C.R2c	c. Inflight weather resources
Skills	The applicant demonstrates the ability to:
PA.I.C.S1	Use available aviation weather resources to obtain an adequate weather briefing.
PA.I.C.S2	Analyze the implications of at least three of the conditions listed in K3a through K3l above, using actual weather or weather conditions in a scenario provided by the evaluator.
PA.I.C.S3	Correlate weather information to make a competent go/no-go decision.

I. Preflight Preparation

Task	*D. Cross-Country Flight Planning*
References	14 CFR part 91; FAA-H-8083-2, FAA-H-8083-25; Navigation Charts; Chart Supplements; AIM; NOTAMs
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with cross-country flights and VFR flight planning.
Knowledge	The applicant demonstrates understanding of:
PA.I.D.K1	Route planning, including consideration of different classes and special use airspace (SUA) and selection of appropriate and available navigation/communication systems and facilities.
PA.I.D.K2	Altitude selection accounting for terrain and obstacles, glide distance of the airplane, VFR cruising altitudes, and the effect of wind.
PA.I.D.K3	Calculating:
PA.I.D.K3a	a. Time, climb and descent rates, course, distance, heading, true airspeed, and groundspeed
PA.I.D.K3b	b. Estimated time of arrival to include conversion to universal coordinated time (UTC)
PA.I.D.K3c	c. Fuel requirements, to include reserve
PA.I.D.K4	Elements of a VFR flight plan.
PA.I.D.K5	Procedures for activating and closing a VFR flight plan.
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.I.D.R1	Pilot.
PA.I.D.R2	Aircraft.
PA.I.D.R3	Environment (e.g., weather, airports, airspace, terrain, obstacles).
PA.I.D.R4	External pressures.
PA.I.D.R5	Limitations of air traffic control (ATC) services.
PA.I.D.R6	Improper fuel planning.
Skills	The applicant demonstrates the ability to:
PA.I.D.S1	Prepare, present, and explain a cross-country flight plan assigned by the evaluator including a risk analysis based on real-time weather, to the first fuel stop.
PA.I.D.S2	Apply pertinent information from appropriate and current aeronautical charts, Chart Supplements; NOTAMs relative to airport, runway and taxiway closures; and other flight publications.
PA.I.D.S3	Create a navigation plan and simulate filing a VFR flight plan.
PA.I.D.S4	Recalculate fuel reserves based on a scenario provided by the evaluator.

I. Preflight Preparation

Task	*E. National Airspace System*
References	14 CFR parts 71, 91, 93; FAA-H-8083-2; Navigation Charts; AIM
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with the National Airspace System (NAS) operating under VFR as a private pilot.
Knowledge	The applicant demonstrates understanding of:
PA.I.E.K1	Types of airspace/airspace classes and associated requirements and limitations.
PA.I.E.K2	Charting symbology.
PA.I.E.K3	Special use airspace (SUA), special flight rules areas (SFRA), temporary flight restrictions (TFR), and other airspace areas.
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.I.E.R1	Various classes and types of airspace.
Skills	The applicant demonstrates the ability to:
PA.I.E.S1	Identify and comply with the requirements for basic VFR weather minimums and flying in particular classes of airspace.
PA.I.E.S2	Correctly identify airspace and operate in accordance with associated communication and equipment requirements.
PA.I.E.S3	Identify the requirements for operating in SUA or within a TFR. Identify and comply with SATR and SFRA operations, if applicable.

Task	***F. Performance and Limitations***
References	FAA-H-8083-1, FAA-H-8083-2, FAA-H-8083-3, FAA-H-8083-25; POH/AFM
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with operating an airplane safely within the parameters of its performance capabilities and limitations.
Knowledge	The applicant demonstrates understanding of:
PA.I.F.K1	Elements related to performance and limitations by explaining the use of charts, tables, and data to determine performance.
PA.I.F.K2	Factors affecting performance, to include:
PA.I.F.K2a	a. Atmospheric conditions
PA.I.F.K2b	b. Pilot technique
PA.I.F.K2c	c. Airplane configuration
PA.I.F.K2d	d. Airport environment
PA.I.F.K2e	e. Loading (e.g., center of gravity)
PA.I.F.K2f	f. Weight and balance
PA.I.F.K3	Aerodynamics.
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.I.F.R1	Inaccurate use of manufacturer's performance charts, tables, and data.
PA.I.F.R2	Exceeding airplane limitations.
PA.I.F.R3	Possible differences between calculated performance and actual performance.
Skills	The applicant demonstrates the ability to:
PA.I.F.S1	Compute the weight and balance, correct out-of-center of gravity (CG) loading errors and determine if the weight and balance remains within limits during all phases of flight.
PA.I.F.S2	Utilize the appropriate airplane manufacturer's approved performance charts, tables, and data.

I. Preflight Preparation

Task	***G. Operation of Systems***
References	FAA-H-8083-2, FAA-H-8083-3, FAA-H-8083-23, FAA-H-8083-25; POH/AFM.
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with the safe operation of systems on the airplane provided for the flight test.
Knowledge	The applicant demonstrates understanding of:
PA.I.G.K1	Airplane systems, to include: **Note:** *If K1 is selected, the evaluator must assess the applicant's knowledge of at least three of the following sub-elements.*
PA.I.G.K1a	a. Primary flight controls
PA.I.G.K1b	b. Secondary flight controls
PA.I.G.K1c	c. Powerplant and propeller
PA.I.G.K1d	d. Landing gear
PA.I.G.K1e	e. Fuel, oil, and hydraulic
PA.I.G.K1f	f. Electrical
PA.I.G.K1g	g. Avionics
PA.I.G.K1h	h. Pitot-static, vacuum/pressure, and associated flight instruments
PA.I.G.K1i	i. Environmental
PA.I.G.K1j	j. Deicing and anti-icing
PA.I.G.K1k	k. Water rudders (ASES, AMES)
PA.I.G.K1l	l. Oxygen system
PA.I.G.K2	Indications of and procedures for managing system abnormalities or failures.
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.I.G.R1	Failure to detect system malfunctions or failures.
PA.I.G.R2	Improper management of a system failure.
PA.I.G.R3	Failure to monitor and manage automated systems.
Skills	The applicant demonstrates the ability to:
PA.I.G.S1	Operate at least three of the systems listed in K1a through K1l above appropriately.
PA.I.G.S2	Use appropriate checklists properly.

I. Preflight Preparation

Task	***H. Human Factors***
References	FAA-H-8083-2, FAA-H-8083-25; AIM
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with personal health, flight physiology, aeromedical and human factors, as it relates to safety of flight. ***Note:*** *See Appendix 6: Safety of Flight.*
Knowledge	The applicant demonstrates understanding of:
PA.I.H.K1	The symptoms (as applicable), recognition, causes, effects, and corrective actions associated with aeromedical and physiological issues including:
PA.I.H.K1a	a. Hypoxia
PA.I.H.K1b	b. Hyperventilation
PA.I.H.K1c	c. Middle ear and sinus problems
PA.I.H.K1d	d. Spatial disorientation
PA.I.H.K1e	e. Motion sickness
PA.I.H.K1f	f. Carbon monoxide poisoning
PA.I.H.K1g	g. Stress
PA.I.H.K1h	h. Fatigue
PA.I.H.K1i	i. Dehydration and nutrition
PA.I.H.K1j	j. Hypothermia
PA.I.H.K1k	k. Optical illusions
PA.I.H.K1l	l. Dissolved nitrogen in the bloodstream after scuba dives
PA.I.H.K2	Regulations regarding use of alcohol and drugs.
PA.I.H.K3	Effects of alcohol, drugs, and over-the-counter medications.
PA.I.H.K4	Aeronautical Decision-Making (ADM).
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks encompassing:
PA.I.H.R1	Aeromedical and physiological issues.
PA.I.H.R2	Hazardous attitudes.
PA.I.H.R3	Distractions, loss of situational awareness, or improper task management.
Skills	The applicant demonstrates the ability to:
PA.I.H.S1	Associate the symptoms and effects for at least three of the conditions listed in K1a through K1l above with the cause(s) and corrective action(s).
PA.I.H.S2	Perform self-assessment, including fitness for flight and personal minimums, for actual flight or a scenario given by the evaluator.

I. Preflight Preparation

Task	***I. Water and Seaplane Characteristics, Seaplane Bases, Maritime Rules, and Aids to Marine Navigation (ASES, AMES)***
References	FAA-H-8083-2, FAA-H-8083-23; AIM; USCG Navigation Rules, International-Inland; POH/AFM; Chart Supplements
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with water and seaplane characteristics, seaplane bases, maritime rules, and aids to marine navigation.
Knowledge	The applicant demonstrates understanding of:
PA.I.I.K1	The characteristics of a water surface as affected by features, such as:
PA.I.I.K1a	a. Size and location
PA.I.I.K1b	b. Protected and unprotected areas
PA.I.I.K1c	c. Surface wind
PA.I.I.K1d	d. Direction and strength of water current
PA.I.I.K1e	e. Floating and partially submerged debris
PA.I.I.K1f	f. Sandbars, islands, and shoals
PA.I.I.K1g	g. Vessel traffic and wakes
PA.I.I.K1h	h. Other characteristics specific to the area
PA.I.I.K2	Float and hull construction, and its effect on seaplane performance.
PA.I.I.K3	Causes of porpoising and skipping, and the pilot action needed to prevent or correct these occurrences.
PA.I.I.K4	How to locate and identify seaplane bases on charts or in directories.
PA.I.I.K5	Operating restrictions at various bases.
PA.I.I.K6	Right-of-way, steering, and sailing rules pertinent to seaplane operation.
PA.I.I.K7	Marine navigation aids, such as buoys, beacons, lights, sound signals, and range markers.
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.I.I.R1	Local conditions.
PA.I.I.R2	Impact of marine traffic.
Skills	The applicant demonstrates the ability to:
PA.I.I.S1	Assess the water surface characteristics for the proposed flight.
PA.I.I.S2	Identify restrictions at local seaplane bases.
PA.I.I.S3	Identify marine navigation aids.
PA.I.I.S4	Perform correct right-of-way, steering, and sailing operations.

II. Preflight Procedures

Task	***A. Preflight Assessment***
References	FAA-H-8083-2, FAA-H-8083-3, FAA-H-8083-23; POH/AFM; AC 00-6
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with preparing for safe flight.
Knowledge	The applicant demonstrates understanding of:
PA.II.A.K1	Pilot self-assessment.
PA.II.A.K2	Determining that the airplane to be used is appropriate and airworthy.
PA.II.A.K3	Airplane preflight inspection including:
PA.II.A.K3a	a. Which items must be inspected
PA.II.A.K3b	b. The reasons for checking each item
PA.II.A.K3c	c. How to detect possible defects
PA.II.A.K3d	d. The associated regulations
PA.II.A.K4	Environmental factors including weather, terrain, route selection, and obstructions.
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.II.A.R1	Pilot.
PA.II.A.R2	Aircraft.
PA.II.A.R3	Environment (e.g., weather, airports, airspace, terrain, obstacles).
PA.II.A.R4	External pressures.
PA.II.A.R5	Aviation security concerns.
Skills	The applicant demonstrates the ability to:
PA.II.A.S1	Inspect the airplane with reference to an appropriate checklist.
PA.II.A.S2	Verify the airplane is in condition for safe flight and conforms to its type design.

II. Preflight Procedures

Task	***B. Flight Deck Management***
References	FAA-H-8083-2, FAA-H-8083-3; AC 120-71; POH/AFM
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with safe flight deck management practices.
Knowledge	The applicant demonstrates understanding of:
PA.II.B.K1	Passenger briefing requirements, to include operation and required use of safety restraint systems.
PA.II.B.K2	Use of appropriate checklists.
PA.II.B.K3	Requirements for current and appropriate navigation data.
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.II.B.R1	Improper use of systems or equipment, to include automation and portable electronic devices.
PA.II.B.R2	Flying with unresolved discrepancies.
Skills	The applicant demonstrates the ability to:
PA.II.B.S1	Secure all items in the flight deck and cabin.
PA.II.B.S2	Conduct an appropriate pre-takeoff briefing, to include identifying the PIC, use of safety belts, shoulder harnesses, doors, sterile flight deck, and emergency procedures.
PA.II.B.S3	Program and manage the airplane’s automation properly.

II. Preflight Procedures

Task	*C. Engine Starting*
References	FAA-H-8083-2, FAA-H-8083-3, FAA-H-8083-25; POH/AFM
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with recommended engine starting procedures.
Knowledge	The applicant demonstrates understanding of:
PA.II.C.K1	Starting under various conditions.
PA.II.C.K2	Starting the engine(s) by use of external power.
PA.II.C.K3	Engine limitations as they relate to starting.
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.II.C.R1	Propeller safety.
Skills	The applicant demonstrates the ability to:
PA.II.C.S1	Position the airplane properly considering structures, other aircraft, wind, and the safety of nearby persons and property.
PA.II.C.S2	Complete the appropriate checklist.

II. Preflight Procedures

Task	***D. Taxiing (ASEL, AMEL)***
References	FAA-H-8083-2, FAA-H-8083-3, FAA-H-8083-25; POH/AFM; AC 91-73; Chart Supplements; AIM
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with safe taxi operations, including runway incursion avoidance.
Knowledge	The applicant demonstrates understanding of:
PA.II.D.K1	Current airport aeronautical references and information resources such as the Chart Supplement, airport diagram, and NOTAMS.
PA.II.D.K2	Taxi instructions/clearances.
PA.II.D.K3	Airport markings, signs, and lights.
PA.II.D.K4	Visual indicators for wind.
PA.II.D.K5	Aircraft lighting.
PA.II.D.K6	Procedures for:
PA.II.D.K6a	a. Appropriate flight deck activities prior to taxi, including route planning and identifying the location of Hot Spots
PA.II.D.K6b	b. Radio communications at towered and nontowered airports
PA.II.D.K6c	c. Entering or crossing runways
PA.II.D.K6d	d. Night taxi operations
PA.II.D.K6e	e. Low visibility taxi operations
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.II.D.R1	Inappropriate activities and distractions.
PA.II.D.R2	Confirmation or expectation bias as related to taxi instructions.
PA.II.D.R3	A taxi route or departure runway change.
Skills	The applicant demonstrates the ability to:
PA.II.D.S1	Receive and correctly read back clearances/instructions, if applicable.
PA.II.D.S2	Use an airport diagram or taxi chart during taxi, if published, and maintain situational awareness.
PA.II.D.S3	Position the flight controls for the existing wind.
PA.II.D.S4	Complete the appropriate checklist.
PA.II.D.S5	Perform a brake check immediately after the airplane begins moving.
PA.II.D.S6	Maintain positive control of the airplane during ground operations by controlling direction and speed without excessive use of brakes.
PA.II.D.S7	Comply with airport/taxiway markings, signals, and ATC clearances and instructions.
PA.II.D.S8	Position the airplane properly relative to hold lines.

Task	***E. Taxiing and Sailing (ASES, AMES)***
References	FAA-H-8083-2, FAA-H-8083-23, FAA-H-8083-25; POH/AFM; AC 91-73; Chart Supplements; AIM
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with safe taxiing and sailing operations, including runway incursion avoidance.
Knowledge	The applicant demonstrates understanding of:
PA.II.E.K1	Airport information resources including Chart Supplements, airport diagram, and appropriate references.
PA.II.E.K2	Taxi instructions/clearances.
PA.II.E.K3	Airport/seaplane base markings, signs, and lights.
PA.II.E.K4	Visual indicators for wind.
PA.II.E.K5	Airplane lighting.
PA.II.E.K6	Procedures for:
PA.II.E.K6a	a. Appropriate flight deck activities during taxiing or sailing
PA.II.E.K6b	b. Radio communications at towered and nontowered seaplane bases
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.II.E.R1	Inappropriate activities and distractions.
PA.II.E.R2	Porpoising and skipping.
PA.II.E.R3	Low visibility taxi and sailing operations.
PA.II.E.R4	Other aircraft, vessels, and hazards.
Skills	The applicant demonstrates the ability to:
PA.II.E.S1	Receive and correctly read back clearances/instructions, if applicable.
PA.II.E.S2	Use an appropriate diagram or chart during taxi, if published.
PA.II.E.S3	Comply with seaplane base/airport/taxiway markings, signals, and signs.
PA.II.E.S4	Depart the dock/mooring buoy or beach/ramp in a safe manner, considering wind, current, traffic, and hazards.
PA.II.E.S5	Complete the appropriate checklist.
PA.II.E.S6	Position the flight controls, flaps, doors, water rudders, and power correctly for the existing conditions to follow the desired course while sailing and to prevent or correct for porpoising and skipping during step taxi.
PA.II.E.S7	Exhibit procedures for steering and maneuvering while maintaining proper situational awareness and desired orientation, path, and position while taxiing using idle, plow, or step taxi technique, as appropriate.
PA.II.E.S8	Plan and follow the most favorable taxi or sailing course for current conditions.
PA.II.E.S9	Abide by right-of-way rules, maintain positive airplane control, proper speed, and separation between other aircraft, vessels, and persons.
PA.II.E.S10	Comply with applicable taxi elements in Task D if the practical test *is conducted* in an amphibious airplane.

II. Preflight Procedures

Task	***F. Before Takeoff Check***
References	FAA-H-8083-2, FAA-H-8083-3, FAA-H-8083-23; POH/AFM
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with the before takeoff check.
Knowledge	The applicant demonstrates understanding of:
PA.II.F.K1	Purpose of pre-takeoff checklist items including:
PA.II.F.K1a	a. Reasons for checking each item
PA.II.F.K1b	b. Detecting malfunctions
PA.II.F.K1c	c. Ensuring the airplane is in safe operating condition as recommended by the manufacturer
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.II.F.R1	Division of attention while conducting pre-flight checks.
PA.II.F.R2	Unexpected runway changes by ATC.
PA.II.F.R3	Wake turbulence.
PA.II.F.R4	A powerplant failure during takeoff or other malfunction considering operational factors such as airplane characteristics, runway/takeoff path length, surface conditions, environmental conditions, and obstructions.
Skills	The applicant demonstrates the ability to:
PA.II.F.S1	Review takeoff performance.
PA.II.F.S2	Complete the appropriate checklist.
PA.II.F.S3	Position the airplane appropriately considering other aircraft, vessels, and wind.
PA.II.F.S4	Divide attention inside and outside the flight deck.
PA.II.F.S5	Verify that engine parameters and airplane configuration are suitable.

III. Airport and Seaplane Base Operations

Task	***A. Communications, Light Signals, and Runway Lighting Systems***
References	14 CFR part 91; FAA-H-8083-2, FAA-H-8083-25; AIM
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with normal and emergency radio communications, ATC light signals, and runway lighting systems to conduct safe airport operations.
Knowledge	The applicant demonstrates understanding of:
PA.III.A.K1	How to obtain proper radio frequencies.
PA.III.A.K2	Proper radio communication procedures and ATC phraseology.
PA.III.A.K3	ATC light signal recognition.
PA.III.A.K4	Appropriate use of transponders.
PA.III.A.K5	Lost communication procedures.
PA.III.A.K6	Equipment issues that could cause loss of communication.
PA.III.A.K7	Radar assistance.
PA.III.A.K8	National Transportation Safety Board (NTSB) accident/incident reporting.
PA.III.A.K9	Runway Status Lighting Systems.
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.III.A.R1	Poor communication.
PA.III.A.R2	Failure to recognize and declare an emergency.
PA.III.A.R3	Confirmation or expectation bias.
Skills	The applicant demonstrates the ability to:
PA.III.A.S1	Select appropriate frequencies.
PA.III.A.S2	Transmit using phraseology and procedures as specified in the AIM.
PA.III.A.S3	Acknowledge radio communications and comply with instructions.

III. Airport and Seaplane Base Operations

Task	***B. Traffic Patterns***
References	14 CFR part 91; FAA-H-8083-2, FAA-H-8083-25; AIM
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with traffic patterns.
Knowledge	The applicant demonstrates understanding of:
PA.III.B.K1	Towered and nontowered airport operations.
PA.III.B.K2	Runway selection for the current conditions.
PA.III.B.K3	Right-of-way rules.
PA.III.B.K4	Use of automated weather and airport information.
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.III.B.R1	Collision hazards, to include aircraft, terrain, obstacles, and wires.
PA.III.B.R2	Distractions, loss of situational awareness, or improper task management.
PA.III.B.R3	Wake turbulence or windshear.
Skills	The applicant demonstrates the ability to:
PA.III.B.S1	Identify and interpret airport/seaplane base runways, taxiways, markings, signs, and lighting.
PA.III.B.S2	Comply with recommended traffic pattern procedures.
PA.III.B.S3	Correct for wind drift to maintain the proper ground track.
PA.III.B.S4	Maintain orientation with the runway/landing area in use.
PA.III.B.S5	Maintain traffic pattern altitude, ±100 feet, and the appropriate airspeed, ±10 knots.
PA.III.B.S6	Maintain situational awareness and proper spacing from other aircraft in the traffic pattern.

IV. Takeoffs, Landings, and Go-Arounds

Task	***A. Normal Takeoff and Climb***
References	FAA-H-8083-2, FAA-H-8083-3, FAA-H-8083-23; POH/AFM; AIM
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with a normal takeoff, climb operations, and rejected takeoff procedures. ***Note:*** *If a crosswind condition does not exist, the applicant's knowledge of crosswind elements must be evaluated through oral testing.*
Knowledge	The applicant demonstrates understanding of:
PA.IV.A.K1	Effects of atmospheric conditions, including wind, on takeoff and climb performance.
PA.IV.A.K2	V_X and V_Y.
PA.IV.A.K3	Appropriate airplane configuration.
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.IV.A.R1	Selection of runway based on pilot capability, airplane performance and limitations, available distance, and wind.
PA.IV.A.R2	Effects of:
PA.IV.A.R2a	a. Crosswind
PA.IV.A.R2b	b. Windshear
PA.IV.A.R2c	c. Tailwind
PA.IV.A.R2d	d. Wake turbulence
PA.IV.A.R2e	e. Runway surface/condition
PA.IV.A.R3	Abnormal operations, to include planning for:
PA.IV.A.R3a	a. Rejected takeoff
PA.IV.A.R3b	b. Engine failure in takeoff/climb phase of flight
PA.IV.A.R4	Collision hazards, to include aircraft, terrain, obstacles, wires, vehicles, vessels, persons, and wildlife.
PA.IV.A.R5	Low altitude maneuvering including stall, spin, or CFIT.
PA.IV.A.R6	Distractions, loss of situational awareness, or improper task management.
Skills	The applicant demonstrates the ability to:
PA.IV.A.S1	Complete the appropriate checklist.
PA.IV.A.S2	Make radio calls as appropriate.
PA.IV.A.S3	Verify assigned/correct runway.
PA.IV.A.S4	Ascertain wind direction with or without visible wind direction indicators.
PA.IV.A.S5	Position the flight controls for the existing wind.
PA.IV.A.S6	Clear the area; taxi into takeoff position and align the airplane on the runway centerline (ASEL, AMEL) or takeoff path (ASES, AMES).
PA.IV.A.S7	Confirm takeoff power and proper engine and flight instrument indications prior to rotation (ASEL, AMEL).
PA.IV.A.S8	Avoid excessive water spray on the propeller(s) (ASES, AMES).
PA.IV.A.S9	Rotate and lift off at the recommended airspeed and accelerate to V_Y.
PA.IV.A.S10	Retract the water rudders, as appropriate, establish and maintain the most efficient planing/liftoff attitude, and correct for porpoising and skipping (ASES, AMES).
PA.IV.A.S11	Establish a pitch attitude to maintain the manufacturer's recommended speed or V_Y, +10/-5 knots.
PA.IV.A.S12	Configure the airplane in accordance with manufacturer's guidance.
PA.IV.A.S13	Maintain V_Y +10/-5 knots to a safe maneuvering altitude.
PA.IV.A.S14	Maintain directional control and proper wind-drift correction throughout takeoff and climb.
PA.IV.A.S15	Comply with noise abatement procedures.

IV. Takeoffs, Landings, and Go-Arounds

Task	*B. Normal Approach and Landing*
References	FAA-H-8083-2, FAA-H-8083-3, FAA-H-8083-23; POH/AFM; AIM
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with a normal approach and landing with emphasis on proper use of flight controls. ***Note:*** *If a crosswind condition does not exist, the applicant's knowledge of crosswind elements must be evaluated through oral testing.*
Knowledge	The applicant demonstrates understanding of:
PA.IV.B.K1	A stabilized approach, to include energy management concepts.
PA.IV.B.K2	Effects of atmospheric conditions, including wind, on approach and landing performance.
PA.IV.B.K3	Wind correction techniques on approach and landing.
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.IV.B.R1	Selection of runway or approach path and touchdown area based on pilot capability, airplane performance and limitations, available distance, and wind.
PA.IV.B.R2	Effects of:
PA.IV.B.R2a	a. Crosswind
PA.IV.B.R2b	b. Windshear
PA.IV.B.R2c	c. Tailwind
PA.IV.B.R2d	d. Wake turbulence
PA.IV.B.R2e	e. Runway surface/condition
PA.IV.B.R3	Planning for:
PA.IV.B.R3a	a. Go-around and rejected landing
PA.IV.B.R3b	b. Land and hold short operations (LAHSO)
PA.IV.B.R4	Collision hazards, to include aircraft, terrain, obstacles, wires, vehicles, vessels, persons, and wildlife.
PA.IV.B.R5	Low altitude maneuvering including stall, spin, or CFIT.
PA.IV.B.R6	Distractions, loss of situational awareness, incorrect airport surface approach and landing, or improper task management.
Skills	The applicant demonstrates the ability to:
PA.IV.B.S1	Complete the appropriate checklist.
PA.IV.B.S2	Make radio calls as appropriate.
PA.IV.B.S3	Ensure the airplane is aligned with the correct/assigned runway or landing surface.
PA.IV.B.S4	Scan runway or landing surface and the adjoining area for traffic and obstructions.
PA.IV.B.S5	Select and aim for a suitable touchdown point considering the wind, landing surface, and obstructions.
PA.IV.B.S6	Establish the recommended approach and landing configuration and airspeed, and adjust pitch attitude and power as required to maintain a stabilized approach.
PA.IV.B.S7	Maintain manufacturer's published approach airspeed or in its absence not more than 1.3 V_{SO}, +10/-5 knots with gust factor applied.
PA.IV.B.S8	Maintain directional control and appropriate crosswind correction throughout the approach and landing.
PA.IV.B.S9	Make smooth, timely, and correct control application during round out and touchdown.
PA.IV.B.S10	Touch down at a proper pitch attitude, within 400 feet beyond or on the specified point, with no side drift, and with the airplane's longitudinal axis aligned with and over the runway center/landing path.
PA.IV.B.S11	Execute a timely go-around if the approach cannot be made within the tolerances specified above or for any other condition that may result in an unsafe approach or landing.
PA.IV.B.S12	Utilize runway incursion avoidance procedures.

IV. Takeoffs, Landings, and Go-Arounds

IV. Takeoffs, Landings, and Go-Arounds

Task	***C. Soft-Field Takeoff and Climb (ASEL)***
References	FAA-H-8083-2, FAA-H-8083-3; POH/AFM; AIM
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with a soft-field takeoff, climb operations, and rejected takeoff procedures.
Knowledge	The applicant demonstrates understanding of:
PA.IV.C.K1	Effects of atmospheric conditions, including wind, on takeoff and climb performance.
PA.IV.C.K2	V_X and V_Y.
PA.IV.C.K3	Appropriate airplane configuration.
PA.IV.C.K4	Ground effect.
PA.IV.C.K5	Importance of weight transfer from wheels to wings.
PA.IV.C.K6	Left turning tendencies.
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.IV.C.R1	Selection of runway based on pilot capability, airplane performance and limitations, available distance, and wind.
PA.IV.C.R2	Effects of:
PA.IV.C.R2a	a. Crosswind
PA.IV.C.R2b	b. Windshear
PA.IV.C.R2c	c. Tailwind
PA.IV.C.R2d	d. Wake turbulence
PA.IV.C.R2e	e. Runway surface/condition
PA.IV.C.R3	Abnormal operations, to include planning for:
PA.IV.C.R3a	a. Rejected takeoff
PA.IV.C.R3b	b. Engine failure in takeoff/climb phase of flight
PA.IV.C.R4	Collision hazards, to include aircraft, terrain, obstacles, wires, vehicles, persons, and wildlife.
PA.IV.C.R5	Low altitude maneuvering including stall, spin, or CFIT.
PA.IV.C.R6	Distractions, loss of situational awareness, or improper task management.
Skills	The applicant demonstrates the ability to:
PA.IV.C.S1	Complete the appropriate checklist.
PA.IV.C.S2	Make radio calls as appropriate.
PA.IV.C.S3	Verify assigned/correct runway.
PA.IV.C.S4	Ascertain wind direction with or without visible wind direction indicators.
PA.IV.C.S5	Position the flight controls for the existing wind.
PA.IV.C.S6	Clear the area, maintain necessary flight control inputs, taxi into takeoff position and align the airplane on the runway centerline without stopping, while advancing the throttle smoothly to takeoff power.
PA.IV.C.S7	Confirm takeoff power and proper engine and flight instrument indications.
PA.IV.C.S8	Establish and maintain a pitch attitude that will transfer the weight of the airplane from the wheels to the wings as rapidly as possible.
PA.IV.C.S9	Lift off at the lowest possible airspeed and remain in ground effect while accelerating to V_X or V_Y, as appropriate.
PA.IV.C.S10	Establish a pitch attitude for V_X or V_Y, as appropriate, and maintain selected airspeed +10/-5 knots during the climb.
PA.IV.C.S11	Configure the airplane after a positive rate of climb has been verified or in accordance with airplane manufacturer's instructions.
PA.IV.C.S12	Maintain V_X or V_Y, as appropriate, +10/-5 knots to a safe maneuvering altitude.
PA.IV.C.S13	Maintain directional control and proper wind-drift correction throughout takeoff and climb.
PA.IV.C.S14	Comply with noise abatement procedures.

IV. Takeoffs, Landings, and Go-Arounds

Task	***D. Soft-Field Approach and Landing (ASEL)***
References	FAA-H-8083-2, FAA-H-8083-3; POH/AFM; AIM
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with a soft-field approach and landing with emphasis on proper use and coordination of flight controls.
Knowledge	The applicant demonstrates understanding of:
PA.IV.D.K1	A stabilized approach, to include energy management concepts.
PA.IV.D.K2	Effects of atmospheric conditions, including wind, on approach and landing performance.
PA.IV.D.K3	Wind correction techniques on approach and landing.
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.IV.D.R1	Selection of runway based on pilot capability, airplane performance and limitations, available distance, and wind.
PA.IV.D.R2	Effects of:
PA.IV.D.R2a	a. Crosswind
PA.IV.D.R2b	b. Windshear
PA.IV.D.R2c	c. Tailwind
PA.IV.D.R2d	d. Wake turbulence
PA.IV.D.R2e	e. Runway surface/condition
PA.IV.D.R3	Planning for:
PA.IV.D.R3a	a. Go-around and rejected landing
PA.IV.D.R3b	b. Land and hold short operations (LAHSO)
PA.IV.D.R4	Collision hazards, to include aircraft, terrain, obstacles, wires, vehicles, persons, and wildlife.
PA.IV.D.R5	Low altitude maneuvering including stall, spin, or CFIT.
PA.IV.D.R6	Distractions, loss of situational awareness, or improper task management.
Skills	The applicant demonstrates the ability to:
PA.IV.D.S1	Complete the appropriate checklist.
PA.IV.D.S2	Make radio calls as appropriate.
PA.IV.D.S3	Ensure the airplane is aligned with the correct/assigned runway.
PA.IV.D.S4	Scan the landing runway and adjoining area for traffic and obstructions.
PA.IV.D.S5	Select and aim for a suitable touchdown point considering the wind, landing surface, and obstructions.
PA.IV.D.S6	Establish the recommended approach and landing configuration and airspeed, and adjust pitch attitude and power as required to maintain a stabilized approach.
PA.IV.D.S7	Maintain manufacturer's published approach airspeed or in its absence not more than 1.3 V_{SO}, +10/-5 knots with gust factor applied.
PA.IV.D.S8	Maintain directional control and appropriate crosswind correction throughout the approach and landing.
PA.IV.D.S9	Make smooth, timely, and correct control inputs during the round out and touchdown, and, for tricycle gear airplanes, keep the nose wheel off the surface until loss of elevator effectiveness.
PA.IV.D.S10	Touch down at a proper pitch attitude with minimum sink rate, no side drift, and with the airplane's longitudinal axis aligned with the center of the runway.
PA.IV.D.S11	Maintain elevator as recommended by manufacturer during rollout and exit the "soft" area at a speed that would preclude sinking into the surface.
PA.IV.D.S12	Execute a timely go-around if the approach cannot be made within the tolerances specified above or for any other condition that may result in an unsafe approach or landing.
PA.IV.D.S13	Maintain proper position of the flight controls and sufficient speed to taxi while on the soft surface.

Task	***E. Short-Field Takeoff and Maximum Performance Climb (ASEL, AMEL)***
References	FAA-H-8083-2, FAA-H-8083-3; POH/AFM; AIM
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with a short-field takeoff, maximum performance climb operations, and rejected takeoff procedures.
Knowledge	The applicant demonstrates understanding of:
PA.IV.E.K1	Effects of atmospheric conditions, including wind, on takeoff and climb performance.
PA.IV.E.K2	V_X and V_Y.
PA.IV.E.K3	Appropriate airplane configuration.
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.IV.E.R1	Selection of runway based on pilot capability, airplane performance and limitations, available distance, and wind.
PA.IV.E.R2	Effects of:
PA.IV.E.R2a	a. Crosswind
PA.IV.E.R2b	b. Windshear
PA.IV.E.R2c	c. Tailwind
PA.IV.E.R2d	d. Wake turbulence
PA.IV.E.R2e	e. Runway surface/condition
PA.IV.E.R3	Abnormal operations, to include planning for:
PA.IV.E.R3a	a. Rejected takeoff
PA.IV.E.R3b	b. Engine failure in takeoff/climb phase of flight
PA.IV.E.R4	Collision hazards, to include aircraft, terrain, obstacles, wires, vehicles, persons, and wildlife.
PA.IV.E.R5	Low altitude maneuvering including stall, spin, or CFIT.
PA.IV.E.R6	Distractions, loss of situational awareness, or improper task management.
Skills	The applicant demonstrates the ability to:
PA.IV.E.S1	Complete the appropriate checklist.
PA.IV.E.S2	Make radio calls as appropriate.
PA.IV.E.S3	Verify assigned/correct runway.
PA.IV.E.S4	Ascertain wind direction with or without visible wind direction indicators.
PA.IV.E.S5	Position the flight controls for the existing wind.
PA.IV.E.S6	Clear the area, taxi into takeoff position and align the airplane on the runway centerline utilizing maximum available takeoff area.
PA.IV.E.S7	Apply brakes while setting engine power to achieve maximum performance.
PA.IV.E.S8	Confirm takeoff power prior to brake release and verify proper engine and flight instrument indications prior to rotation.
PA.IV.E.S9	Rotate and lift off at the recommended airspeed and accelerate to the recommended obstacle clearance airspeed or V_X, +10/-5 knots.
PA.IV.E.S10	Establish a pitch attitude that will maintain the recommended obstacle clearance airspeed or V_X, +10/-5 knots until clearing the obstacle or until the airplane is 50 feet above the surface.
PA.IV.E.S11	Establish a pitch attitude for V_Y and accelerate to V_Y+10/-5 knots after clearing the obstacle or at 50 feet AGL if simulating an obstacle.
PA.IV.E.S12	Configure the airplane in accordance with the manufacturer's guidance after a positive rate of climb has been verified.
PA.IV.E.S13	Maintain V_Y +10/-5 knots to a safe maneuvering altitude.
PA.IV.E.S14	Maintain directional control and proper wind-drift correction throughout takeoff and climb.
PA.IV.E.S15	Comply with noise abatement procedures.

Task	***F. Short-Field Approach and Landing (ASEL, AMEL)***
References	FAA-H-8083-2, FAA-H-8083-3; POH/AFM; AIM
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with a short-field approach and landing with emphasis on proper use and coordination of flight controls.
Knowledge	The applicant demonstrates understanding of:
PA.IV.F.K1	A stabilized approach, to include energy management concepts.
PA.IV.F.K2	Effects of atmospheric conditions, including wind, on approach and landing performance.
PA.IV.F.K3	Wind correction techniques on approach and landing.
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.IV.F.R1	Selection of runway based on pilot capability, airplane performance and limitations, available distance, and wind.
PA.IV.F.R2	Effects of:
PA.IV.F.R2a	a. Crosswind
PA.IV.F.R2b	b. Windshear
PA.IV.F.R2c	c. Tailwind
PA.IV.F.R2d	d. Wake turbulence
PA.IV.F.R2e	e. Runway surface/condition
PA.IV.F.R3	Planning for:
PA.IV.F.R3a	a. Go-around and rejected landing
PA.IV.F.R3b	b. Land and hold short operations (LAHSO)
PA.IV.F.R4	Collision hazards, to include aircraft, terrain, obstacles, wires, vehicles, persons, and wildlife.
PA.IV.F.R5	Low altitude maneuvering including stall, spin, or CFIT.
PA.IV.F.R6	Distractions, loss of situational awareness, or improper task management.
Skills	The applicant demonstrates the ability to:
PA.IV.F.S1	Complete the appropriate checklist.
PA.IV.F.S2	Make radio calls as appropriate.
PA.IV.F.S3	Ensure the airplane is aligned with the correct/assigned runway.
PA.IV.F.S4	Scan the landing runway and adjoining area for traffic and obstructions.
PA.IV.F.S5	Select and aim for a suitable touchdown point considering the wind, landing surface, and obstructions.
PA.IV.F.S6	Establish the recommended approach and landing configuration and airspeed, and adjust pitch attitude and power as required to maintain a stabilized approach.
PA.IV.F.S7	Maintain manufacturer's published approach airspeed or in its absence not more than 1.3 V_{SO}, +10/-5 knots with gust factor applied.
PA.IV.F.S8	Maintain directional control and appropriate crosswind correction throughout the approach and landing.
PA.IV.F.S9	Make smooth, timely, and correct control application during the round out and touchdown.
PA.IV.F.S10	Touch down at a proper pitch attitude within 200 feet beyond or on the specified point, threshold markings, or runway numbers, with no side drift, minimum float, and with the airplane's longitudinal axis aligned with and over runway centerline.
PA.IV.F.S11	Use manufacturer's recommended procedures for airplane configuration and braking.
PA.IV.F.S12	Execute a timely go-around if the approach cannot be made within the tolerances specified above or for any other condition that may result in an unsafe approach or landing.
PA.IV.F.S13	Utilize runway incursion avoidance procedures.

Task	*G. Confined Area Takeoff and Maximum Performance Climb (ASES, AMES)*
References	FAA-H-8083-2, FAA-H-8083-3, FAA-H-8083-23; POH/AFM; AIM
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with a confined area takeoff, and maximum performance climb operations.
Knowledge	The applicant demonstrates understanding of:
PA.IV.G.K1	Effects of atmospheric conditions, including wind, on takeoff and climb performance.
PA.IV.G.K2	V_X and V_Y.
PA.IV.G.K3	Appropriate airplane configuration.
PA.IV.G.K4	Effects of water surface.
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.IV.G.R1	Selection of takeoff path based on pilot capability, airplane performance and limitations, available distance, and wind.
PA.IV.G.R2	Effects of:
PA.IV.G.R2a	a. Crosswind
PA.IV.G.R2b	b. Windshear
PA.IV.G.R2c	c. Tailwind
PA.IV.G.R2d	d. Wake turbulence
PA.IV.G.R2e	e. Water surface/condition
PA.IV.G.R3	Abnormal operations, to include planning for:
PA.IV.G.R3a	a. Rejected takeoff
PA.IV.G.R3b	b. Engine failure in takeoff/climb phase of flight
PA.IV.G.R4	Collision hazards, to include aircraft, terrain, obstacles, wires, vessels, persons, and wildlife.
PA.IV.G.R5	Low altitude maneuvering including stall, spin, or CFIT.
PA.IV.G.R6	Distractions, loss of situational awareness, or improper task management.
Skills	The applicant demonstrates the ability to:
PA.IV.G.S1	Complete the appropriate checklist.
PA.IV.G.S2	Make radio calls as appropriate.
PA.IV.G.S3	Verify assigned/correct takeoff path.
PA.IV.G.S4	Ascertain wind direction with or without visible wind direction indicators.
PA.IV.G.S5	Position the flight controls for the existing wind.
PA.IV.G.S6	Clear the area, taxi into takeoff position utilizing maximum available takeoff area and align the airplane on the takeoff path.
PA.IV.G.S7	Confirm takeoff power and proper engine and flight instrument indications prior to rotation.
PA.IV.G.S8	Establish a pitch attitude that maintains the most efficient planing/liftoff attitude and correct for porpoising and skipping.
PA.IV.G.S9	Avoid excessive water spray on the propeller(s).
PA.IV.G.S10	Rotate and liftoff at the recommended airspeed, and accelerate to the recommended obstacle clearance airspeed or V_X.
PA.IV.G.S11	Establish a pitch attitude that will maintain the recommended obstacle clearance airspeed or V_X, +10/-5 knots until the obstacle is cleared or until the airplane is 50 feet above the surface.
PA.IV.G.S12	Establish a pitch attitude for V_Y and accelerate to V_Y +10/-5 knots after clearing the obstacle or at 50 feet AGL if simulating an obstacle.
PA.IV.G.S13	Retract flaps, if extended, after a positive rate of climb has been verified or in accordance with airplane manufacturer’s guidance.
PA.IV.G.S14	Maintain V_Y +10/-5 knots to a safe maneuvering altitude.
PA.IV.G.S15	Maintain directional control and proper wind-drift correction throughout takeoff and climb.
PA.IV.G.S16	Comply with noise abatement procedures.

Task	***H. Confined Area Approach and Landing (ASES, AMES)***
References	FAA-H-8083-2, FAA-H-8083-3, FAA-H-8083-23; POH/AFM; AIM
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with a confined area approach and landing.
Knowledge	The applicant demonstrates understanding of:
PA.IV.H.K1	A stabilized approach, to include energy management concepts.
PA.IV.H.K2	Effects of atmospheric conditions, including wind, on approach and landing performance.
PA.IV.H.K3	Wind correction techniques on approach and landing.
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.IV.H.R1	Selection of approach path and touchdown area based on pilot capability, airplane performance and limitations, available distance, and wind.
PA.IV.H.R2	Effects of:
PA.IV.H.R2a	a. Crosswind
PA.IV.H.R2b	b. Windshear
PA.IV.H.R2c	c. Tailwind
PA.IV.H.R2d	d. Wake turbulence
PA.IV.H.R2e	e. Water surface/condition
PA.IV.H.R3	Planning for a go-around and rejected landing.
PA.IV.H.R4	Collision hazards, to include aircraft, terrain, obstacles, wires, vessels, persons, and wildlife.
PA.IV.H.R5	Low altitude maneuvering including stall, spin, or CFIT.
PA.IV.H.R6	Distractions, loss of situational awareness, or improper task management.
Skills	The applicant demonstrates the ability to:
PA.IV.H.S1	Complete the appropriate checklist.
PA.IV.H.S2	Make radio calls as appropriate.
PA.IV.H.S3	Ensure the airplane is aligned for an approach to the correct/assigned landing surface.
PA.IV.H.S4	Scan the landing area for traffic and obstructions.
PA.IV.H.S5	Select and aim for a suitable touchdown point considering the wind, landing surface, and obstructions.
PA.IV.H.S6	Establish the recommended approach and landing configuration and airspeed, and adjust pitch attitude and power as required to maintain a stabilized approach.
PA.IV.H.S7	Maintain manufacturer's published approach airspeed or in its absence not more than 1.3 V_{SO}, +10/-5 knots with gust factor applied.
PA.IV.H.S8	Maintain directional control and appropriate crosswind correction throughout the approach and landing, as required.
PA.IV.H.S9	Make smooth, timely, and correct control application during the round out and touchdown.
PA.IV.H.S10	Contact the water at the recommended airspeed with a proper pitch attitude for the surface conditions.
PA.IV.H.S11	Touch down at a proper pitch attitude, within 200 feet beyond or on the specified point, with no side drift, minimum float, and with the airplane's longitudinal axis aligned with the projected landing path.
PA.IV.H.S12	Execute a timely go-around if the approach cannot be made within the tolerances specified above or for any other condition that may result in an unsafe approach or landing.
PA.IV.H.S13	Apply elevator control as necessary to stop in the shortest distance consistent with safety.

IV. Takeoffs, Landings, and Go-Arounds

Task	***I. Glassy Water Takeoff and Climb (ASES, AMES)***
References	FAA-H-8083-2, FAA-H-8083-23; POH/AFM; AIM
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with a glassy water takeoff and climb. ***Note:*** *If a glassy water condition does not exist, the applicant must be evaluated by simulating the Task.*
Knowledge	The applicant demonstrates understanding of:
PA.IV.I.K1	Effects of atmospheric conditions, including wind, on takeoff and climb performance.
PA.IV.I.K2	V_X and V_Y.
PA.IV.I.K3	Appropriate airplane configuration.
PA.IV.I.K4	Appropriate use of glassy water takeoff and climb technique.
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.IV.I.R1	Selection of takeoff path based on pilot capability, airplane performance and limitations, and available distance.
PA.IV.I.R2	Water surface/condition.
PA.IV.I.R3	Abnormal operations, to include planning for:
PA.IV.I.R3a	a. Rejected takeoff
PA.IV.I.R3b	b. Engine failure in takeoff/climb phase of flight
PA.IV.I.R4	Collision hazards, to include aircraft, terrain, obstacles, wires, vessels, persons, and wildlife.
PA.IV.I.R5	Low altitude maneuvering including stall, spin, or CFIT.
PA.IV.I.R6	Distractions, loss of situational awareness, or improper task management.
PA.IV.I.R7	Failure to confirm gear position in an amphibious airplane.
Skills	The applicant demonstrates the ability to:
PA.IV.I.S1	Complete the appropriate checklist.
PA.IV.I.S2	Make radio calls as appropriate.
PA.IV.I.S3	Position flight controls and flaps for the existing conditions.
PA.IV.I.S4	Clear the area; select appropriate takeoff path considering surface hazards or vessels and surface conditions.
PA.IV.I.S5	Retract the water rudders as appropriate; advance the throttle smoothly to takeoff power.
PA.IV.I.S6	Establish and maintain an appropriate planing attitude, directional control, and correct for porpoising, skipping, and increase in water drag.
PA.IV.I.S7	Avoid excessive water spray on the propeller(s).
PA.IV.I.S8	Utilize appropriate techniques to lift seaplane from the water considering surface conditions.
PA.IV.I.S9	Establish proper attitude/airspeed and accelerate to V_Y +10/-5 knots during the climb.
PA.IV.I.S10	Configure the airplane after a positive rate of climb has been verified or in accordance with airplane manufacturer's instructions.
PA.IV.I.S11	Maintain V_Y +10/-5 knots to a safe maneuvering altitude.
PA.IV.I.S12	Maintain directional control throughout takeoff and climb.

IV. Takeoffs, Landings, and Go-Arounds

Task	***J. Glassy Water Approach and Landing (ASES, AMES)***
References	FAA-H-8083-2, FAA-H-8083-23; POH/AFM; AIM
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with a glassy water approach and landing. ***Note:*** *If a glassy water condition does not exist, the applicant must be evaluated by simulating the Task.*
Knowledge	The applicant demonstrates understanding of:
PA.IV.J.K1	A stabilized approach, to include energy management concepts.
PA.IV.J.K2	Effects of atmospheric conditions on approach and landing performance.
PA.IV.J.K3	When and why glassy water techniques are used.
PA.IV.J.K4	How a glassy water approach and landing is executed.
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.IV.J.R1	Selection of approach path and touchdown area based on pilot capability, airplane performance and limitations, and available distance.
PA.IV.J.R2	Water surface/condition.
PA.IV.J.R3	Planning for go-around and rejected landing.
PA.IV.J.R4	Collision hazards, to include aircraft, terrain, obstacles, wires, vessels, persons, and wildlife.
PA.IV.J.R5	Low altitude maneuvering including stall, spin, or CFIT.
PA.IV.J.R6	Distractions, loss of situational awareness, or improper task management.
PA.IV.J.R7	Failure to confirm gear position in an amphibious airplane.
Skills	The applicant demonstrates the ability to:
PA.IV.J.S1	Complete the appropriate checklist.
PA.IV.J.S2	Make radio calls as appropriate.
PA.IV.J.S3	Scan the landing area for traffic and obstructions.
PA.IV.J.S4	Select a proper approach and landing path considering the landing surface, visual attitude references, water depth, and collision hazards.
PA.IV.J.S5	Establish the recommended approach and landing configuration and airspeed, and adjust pitch attitude and power as required to maintain a stabilized approach.
PA.IV.J.S6	Maintain manufacturer's published approach airspeed or in its absence not more than 1.3 V_{SO}, +10/-5 knots.
PA.IV.J.S7	Make smooth, timely, and correct power and control adjustments to maintain proper pitch attitude and rate of descent to touchdown.
PA.IV.J.S8	Contact the water in a proper pitch attitude, and slow to idle taxi speed.
PA.IV.J.S9	Maintain directional control throughout the approach and landing.

Task	***K. Rough Water Takeoff and Climb (ASES, AMES)***
References	FAA-H-8083-2, FAA-H-8083-23; POH/AFM; AIM
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with a rough water takeoff and climb. ***Note:*** *If a rough water condition does not exist, the applicant must be evaluated by simulating the Task.*
Knowledge	The applicant demonstrates understanding of:
PA.IV.K.K1	Effects of atmospheric conditions, including wind, on takeoff and climb performance.
PA.IV.K.K2	V_X and V_Y.
PA.IV.K.K3	Appropriate airplane configuration.
PA.IV.K.K4	Appropriate use of rough water takeoff and climb technique.
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.IV.K.R1	Selection of takeoff path based on pilot capability, airplane performance and limitations, available distance, and wind.
PA.IV.K.R2	Effects of:
PA.IV.K.R2a	a. Crosswind
PA.IV.K.R2b	b. Windshear
PA.IV.K.R2c	c. Tailwind
PA.IV.K.R2d	d. Wake turbulence
PA.IV.K.R2e	e. Water surface/condition
PA.IV.K.R3	Abnormal operations, to include planning for:
PA.IV.K.R3a	a. Rejected takeoff
PA.IV.K.R3b	b. Engine failure in takeoff/climb phase of flight
PA.IV.K.R4	Collision hazards, to include aircraft, terrain, obstacles, wires, vessels, persons, and wildlife.
PA.IV.K.R5	Low altitude maneuvering including stall, spin, or CFIT.
PA.IV.K.R6	Distractions, loss of situational awareness, or improper task management.
PA.IV.K.R7	Failure to confirm gear position in an amphibious airplane.
Skills	The applicant demonstrates the ability to:
PA.IV.K.S1	Complete the appropriate checklist.
PA.IV.K.S2	Make radio calls as appropriate.
PA.IV.K.S3	Verify assigned/correct takeoff path.
PA.IV.K.S4	Ascertain wind direction with or without visible wind direction indicators.
PA.IV.K.S5	Position flight controls and configure the airplane for the existing conditions.
PA.IV.K.S6	Clear the area, select an appropriate takeoff path considering wind, swells, surface hazards, or vessels.
PA.IV.K.S7	Retract the water rudders as appropriate; advance the throttle smoothly to takeoff power.
PA.IV.K.S8	Establish and maintain an appropriate planing attitude, directional control, and correct for porpoising, skipping, and increase in water drag.
PA.IV.K.S9	Avoid excessive water spray on the propeller(s).
PA.IV.K.S10	Lift off at minimum airspeed and accelerate to V_Y +10/- 5 knots before leaving ground effect.
PA.IV.K.S11	Configure the airplane after a positive rate of climb has been verified or in accordance with airplane manufacturer's instructions.
PA.IV.K.S12	Maintain V_Y +10/-5 knots to a safe maneuvering altitude.
PA.IV.K.S13	Maintain directional control and proper wind-drift correction throughout takeoff and climb.

IV. Takeoffs, Landings, and Go-Arounds

Task	***L. Rough Water Approach and Landing (ASES, AMES)***
References	FAA-H-8083-2, FAA-H-8083-23; POH/AFM; AIM
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with a rough water approach and landing. ***Note:*** *If a rough water condition does not exist, the applicant must be evaluated by simulating the Task.*
Knowledge	The applicant demonstrates understanding of:
PA.IV.L.K1	A stabilized approach, to include energy management concepts.
PA.IV.L.K2	Effects of atmospheric conditions, including wind, on approach and landing performance.
PA.IV.L.K3	Wind correction techniques on approach and landing.
PA.IV.L.K4	When and why rough water techniques are used.
PA.IV.L.K5	How a rough water approach and landing is executed.
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.IV.L.R1	Selection of approach path and touchdown area based on pilot capability, airplane performance and limitations, available distance, and wind.
PA.IV.L.R2	Effects of:
PA.IV.L.R2a	a. Crosswind
PA.IV.L.R2b	b. Windshear
PA.IV.L.R2c	c. Tailwind
PA.IV.L.R2d	d. Wake turbulence
PA.IV.L.R2e	e. Water surface/condition
PA.IV.L.R3	Planning for go-around and rejected landing.
PA.IV.L.R4	Collision hazards, to include aircraft, terrain, obstacles, wires, vessels, persons, and wildlife.
PA.IV.L.R5	Low altitude maneuvering including stall, spin, or CFIT.
PA.IV.L.R6	Distractions, loss of situational awareness, or improper task management.
PA.IV.L.R7	Failure to confirm gear position in an amphibious airplane.
Skills	The applicant demonstrates the ability to:
PA.IV.L.S1	Complete the appropriate checklist.
PA.IV.L.S2	Make radio calls as appropriate.
PA.IV.L.S3	Ensure the airplane is aligned with the correct/assigned waterway.
PA.IV.L.S4	Scan the landing area for traffic and obstructions.
PA.IV.L.S5	Select and aim for a suitable touchdown point considering the wind, landing surface, and obstructions.
PA.IV.L.S6	Establish the recommended approach and landing configuration and airspeed, and adjust pitch attitude and power as required to maintain a stabilized approach.
PA.IV.L.S7	Maintain manufacturer's published approach airspeed or in its absence not more than 1.3 V_{SO}, +10/-5 knots with gust factor applied.
PA.IV.L.S8	Maintain directional control and appropriate crosswind correction throughout the approach and landing.
PA.IV.L.S9	Make smooth, timely, and correct power and control adjustments to maintain proper pitch attitude and rate of descent to touchdown.
PA.IV.L.S10	Contact the water in a proper pitch attitude, considering the type of rough water.

Task	***M. Forward Slip to a Landing (ASEL, ASES)***
References	FAA-H-8083-2, FAA-H-8083-3; POH/AFM; AIM
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with a forward slip to a landing.
Knowledge	The applicant demonstrates understanding of:
PA.IV.M.K1	Concepts of energy management during a forward slip approach.
PA.IV.M.K2	Effects of atmospheric conditions, including wind, on approach and landing performance.
PA.IV.M.K3	Wind correction techniques during forward slip.
PA.IV.M.K4	When and why a forward slip approach is used during an approach.
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.IV.M.R1	Selection of runway or approach path and touchdown area based on pilot capability, airplane performance and limitations, available distance, and wind.
PA.IV.M.R2	Effects of:
PA.IV.M.R2a	a. Crosswind
PA.IV.M.R2b	b. Windshear
PA.IV.M.R2c	c. Tailwind
PA.IV.M.R2d	d. Wake turbulence
PA.IV.M.R2e	e. Landing surface/condition
PA.IV.M.R3	Planning for:
PA.IV.M.R3a	a. Go-around and rejected landing
PA.IV.M.R3b	b. Land and hold short operations (LAHSO)
PA.IV.M.R4	Collision hazards, to include aircraft, terrain, obstacles, wires, vehicles, vessels, persons, and wildlife.
PA.IV.M.R5	Low altitude maneuvering including stall, spin, or CFIT.
PA.IV.M.R6	Distractions, loss of situational awareness, or improper task management.
PA.IV.M.R7	Forward slip operations, including fuel flowage, tail stalls with flaps, and lack of airspeed control.
PA.IV.M.R8	Surface contact with the airplane's longitudinal axis misaligned.
PA.IV.M.R9	Unstable approach.
Skills	The applicant demonstrates the ability to:
PA.IV.M.S1	Complete the appropriate checklist.
PA.IV.M.S2	Make radio calls as appropriate.
PA.IV.M.S3	Plan and follow a flightpath to the selected landing area considering altitude, wind, terrain, and obstructions.
PA.IV.M.S4	Select the most suitable touchdown point based on wind, landing surface, obstructions, and airplane limitations.
PA.IV.M.S5	Position airplane on downwind leg, parallel to landing runway.
PA.IV.M.S6	Configure the airplane correctly.
PA.IV.M.S7	As necessary, correlate crosswind with direction of forward slip and transition to sideslip before touchdown.
PA.IV.M.S8	Touch down at a proper pitch attitude, within 400 feet beyond or on the specified point, with no side drift, and with the airplane's longitudinal axis aligned with and over the runway center/landing path.
PA.IV.M.S9	Maintain a ground track aligned with the runway center/landing path.

IV. Takeoffs, Landings, and Go-Arounds

Task	***N. Go-Around/Rejected Landing***
References	FAA-H-8083-3, FAA-H-8083-23; POH/AFM; AIM
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with a go-around/rejected landing with emphasis on factors that contribute to landing conditions that may require a go-around.
Knowledge	The applicant demonstrates understanding of:
PA.IV.N.K1	A stabilized approach, to include energy management concepts.
PA.IV.N.K2	Effects of atmospheric conditions, including wind and density altitude on a go-around or rejected landing.
PA.IV.N.K3	Wind correction techniques on takeoff/departure and approach/landing.
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.IV.N.R1	Delayed recognition of the need for a go-around/rejected landing.
PA.IV.N.R2	Delayed performance of a go-around at low altitude.
PA.IV.N.R3	Improper application of power.
PA.IV.N.R4	Improper airplane configuration.
PA.IV.N.R5	Collision hazards, to include aircraft, terrain, obstacles, wires, vehicles, vessels, persons, and wildlife.
PA.IV.N.R6	Low altitude maneuvering including stall, spin, or CFIT.
PA.IV.N.R7	Distractions, loss of situational awareness, or improper task management.
Skills	The applicant demonstrates the ability to:
PA.IV.N.S1	Complete the appropriate checklist.
PA.IV.N.S2	Make radio calls as appropriate.
PA.IV.N.S3	Make a timely decision to discontinue the approach to landing.
PA.IV.N.S4	Apply takeoff power immediately and transition to climb pitch attitude for V_X or V_Y as appropriate +10/-5 knots.
PA.IV.N.S5	Configure the airplane after a positive rate of climb has been verified or in accordance with airplane manufacturer's instructions.
PA.IV.N.S6	Maneuver to the side of the runway/landing area when necessary to clear and avoid conflicting traffic.
PA.IV.N.S7	Maintain V_Y +10/-5 knots to a safe maneuvering altitude.
PA.IV.N.S8	Maintain directional control and proper wind-drift correction throughout the climb.

V. Performance and Ground Reference Maneuvers

Task	*A. Steep Turns*
References	FAA-H-8083-2, FAA-H-8083-3; POH/AFM
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with steep turns. ***Note:*** *See Appendix 7: Aircraft, Equipment, and Operational Requirements & Limitations.*
Knowledge	The applicant demonstrates understanding of:
PA.V.A.K1	Purpose of steep turns.
PA.V.A.K2	Aerodynamics associated with steep turns, to include:
PA.V.A.K2a	a. Coordinated and uncoordinated flight
PA.V.A.K2b	b. Overbanking tendencies
PA.V.A.K2c	c. Maneuvering speed, including the impact of weight changes
PA.V.A.K2d	d. Load factor and accelerated stalls
PA.V.A.K2e	e. Rate and radius of turn
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.V.A.R1	Failure to divide attention between airplane control and orientation.
PA.V.A.R2	Collision hazards, to include aircraft and terrain.
PA.V.A.R3	Low altitude maneuvering including stall, spin, or CFIT.
PA.V.A.R4	Distractions, improper task management, loss of situational awareness, or disorientation.
PA.V.A.R5	Failure to maintain coordinated flight.
Skills	The applicant demonstrates the ability to:
PA.V.A.S1	Clear the area.
PA.V.A.S2	Establish the manufacturer’s recommended airspeed; or if one is not available, an airspeed not to exceed V_A.
PA.V.A.S3	Roll into a coordinated 360° steep turn with approximately a 45° bank.
PA.V.A.S4	Perform the Task in the opposite direction, as specified by evaluator.
PA.V.A.S5	Maintain the entry altitude ±100 feet, airspeed ±10 knots, bank ±5°, and roll out on the entry heading ±10°.

V. Performance and Ground Reference Maneuvers

Task	***B. Ground Reference Maneuvers***
References	14 CFR part 61; FAA-H-8083-2, FAA-H-8083-3
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with ground reference maneuvering which may include a rectangular course, S-turns, and turns around a point. ***Note:*** *See Appendix 7: Aircraft, Equipment, and Operational Requirements & Limitations.*
Knowledge	The applicant demonstrates understanding of:
PA.V.B.K1	Purpose of ground reference maneuvers.
PA.V.B.K2	Effects of wind on ground track and relation to a ground reference point.
PA.V.B.K3	Effects of bank angle and groundspeed on rate and radius of turn.
PA.V.B.K4	Relationship of rectangular course to airport traffic pattern.
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.V.B.R1	Failure to divide attention between airplane control and orientation.
PA.V.B.R2	Collision hazards, to include aircraft, terrain, obstacles, and wires.
PA.V.B.R3	Low altitude maneuvering including stall, spin, or CFIT.
PA.V.B.R4	Distractions, loss of situational awareness, or improper task management.
PA.V.B.R5	Failure to maintain coordinated flight.
Skills	The applicant demonstrates the ability to:
PA.V.B.S1	Clear the area.
PA.V.B.S2	Select a suitable ground reference area, line, or point as appropriate.
PA.V.B.S3	Plan the maneuver: ***Note:*** *The evaluator must select at least one maneuver for the applicant to demonstrate.*
PA.V.B.S3a	a. Rectangular course: enter a left or right pattern, 600 to 1,000 feet above ground level (AGL) at an appropriate distance from the selected reference area, 45° to the downwind leg
PA.V.B.S3b	b. S-turns: enter perpendicular to the selected reference line, 600 to 1,000 feet AGL at an appropriate distance from the selected reference area
PA.V.B.S3c	c. Turns around a point: enter at an appropriate distance from the reference point, 600 to 1,000 feet AGL at an appropriate distance from the selected reference area
PA.V.B.S4	Apply adequate wind-drift correction during straight and turning flight to maintain a constant ground track around a rectangular reference area, or to maintain a constant radius turn on each side of a selected reference line or point.
PA.V.B.S5	If performing S-Turns, reverse the turn directly over the selected reference line; if performing turns around a point, complete turns in either direction, as specified by the evaluator.
PA.V.B.S6	Divide attention between airplane control, traffic avoidance and the ground track while maintaining coordinated flight.
PA.V.B.S7	Maintain altitude ±100 feet; maintain airspeed ±10 knots.

VI. Navigation

Task	***A. Pilotage and Dead Reckoning***
References	14 CFR part 61; FAA-H-8083-2, FAA-H-8083-25; Navigation Charts
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with pilotage and dead reckoning.
Knowledge	The applicant demonstrates understanding of:
PA.VI.A.K1	Pilotage and dead reckoning.
PA.VI.A.K2	Magnetic compass errors.
PA.VI.A.K3	Topography.
PA.VI.A.K4	Selection of appropriate:
PA.VI.A.K4a	a. Route
PA.VI.A.K4b	b. Altitude(s)
PA.VI.A.K4c	c. Checkpoints
PA.VI.A.K5	Plotting a course, to include:
PA.VI.A.K5a	a. Determining heading, speed, and course
PA.VI.A.K5b	b. Wind correction angle
PA.VI.A.K5c	c. Estimating time, speed, and distance
PA.VI.A.K5d	d. True airspeed and density altitude
PA.VI.A.K6	Power setting selection.
PA.VI.A.K7	Planned versus actual flight plan calculations and required corrections.
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.VI.A.R1	Collision hazards, to include aircraft, terrain, obstacles, and wires.
PA.VI.A.R2	Distractions, loss of situational awareness, or improper task management.
Skills	The applicant demonstrates the ability to:
PA.VI.A.S1	Prepare and use a flight log.
PA.VI.A.S2	Navigate by pilotage.
PA.VI.A.S3	Navigate by means of pre-computed headings, groundspeeds, and elapsed time.
PA.VI.A.S4	Use the magnetic direction indicator in navigation, to include turns to headings.
PA.VI.A.S5	Verify position within three nautical miles of the flight-planned route.
PA.VI.A.S6	Arrive at the en route checkpoints within five minutes of the initial or revised estimated time of arrival (ETA) and provide a destination estimate.
PA.VI.A.S7	Maintain the appropriate altitude ±200 feet and heading ±15°.

VI. Navigation

Task	***B. Navigation Systems and Radar Services***
References	FAA-H-8083-2, FAA-H-8083-3, FAA-H-8083-6, FAA-H-8083-25; AIM ***Note:*** *The evaluator should reference the manufacturer's equipment supplement(s) as necessary.*
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with navigation systems and radar services.
Knowledge	The applicant demonstrates understanding of:
PA.VI.B.K1	Ground-based navigation (orientation, course determination, equipment, tests, and regulations).
PA.VI.B.K2	Satellite-based navigation (e.g., equipment, regulations, database considerations, and limitations of satellite navigation).
PA.VI.B.K3	Radar assistance to VFR aircraft (e.g., operations, equipment, available services, traffic advisories).
PA.VI.B.K4	Transponder (Mode(s) A, C, and S).
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.VI.B.R1	Failure to manage automated navigation and autoflight systems.
PA.VI.B.R2	Distractions, loss of situational awareness, or improper task management.
PA.VI.B.R3	Limitations of the navigation system in use.
PA.VI.B.R4	Loss of a navigation signal.
Skills	The applicant demonstrates the ability to:
PA.VI.B.S1	Use an airborne electronic navigation system.
PA.VI.B.S2	Determine the airplane's position using the navigation system.
PA.VI.B.S3	Intercept and track a given course, radial, or bearing, as appropriate.
PA.VI.B.S4	Recognize and describe the indication of station or waypoint passage, if appropriate.
PA.VI.B.S5	Recognize signal loss or interference and take appropriate action, if applicable.
PA.VI.B.S6	Use proper communication procedures when utilizing radar services.
PA.VI.B.S7	Maintain the appropriate altitude ±200 feet and heading ±15°.

VI. Navigation

Task	***C. Diversion***
References	FAA-H-8083-2, FAA-H-8083-25; AIM; Navigation Charts
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with diversion.
Knowledge	The applicant demonstrates understanding of:
PA.VI.C.K1	Selecting an alternate destination.
PA.VI.C.K2	Situations that require deviations from flight plan or ATC instructions.
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.VI.C.R1	Collision hazards, to include aircraft, terrain, obstacles, and wires.
PA.VI.C.R2	Distractions, loss of situational awareness, or improper task management.
PA.VI.C.R3	Failure to make a timely decision to divert.
PA.VI.C.R4	Failure to select an appropriate airport or seaplane base.
PA.VI.C.R5	Failure to utilize all available resources (e.g., automation, ATC, and flight deck planning aids).
Skills	The applicant demonstrates the ability to:
PA.VI.C.S1	Select a suitable destination and route for diversion.
PA.VI.C.S2	Make a reasonable estimate of heading, groundspeed, arrival time, and fuel consumption to the divert airport.
PA.VI.C.S3	Maintain the appropriate altitude ±200 feet and heading ±15°.
PA.VI.C.S4	Update/interpret weather in flight.
PA.VI.C.S5	Utilize flight deck displays of digital weather and aeronautical information, as applicable.

VI. Navigation

Task	***D. Lost Procedures***
References	FAA-H-8083-2, FAA-H-8083-25; AIM; Navigation Charts
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with lost procedures and taking appropriate steps to achieve a satisfactory outcome if lost.
Knowledge	The applicant demonstrates understanding of:
PA.VI.D.K1	Methods to determine position.
PA.VI.D.K2	Assistance available if lost (e.g., radar services, communication procedures).
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.VI.D.R1	Collision hazards, to include aircraft, terrain, obstacles, and wires.
PA.VI.D.R2	Distractions, loss of situational awareness, or improper task management.
PA.VI.D.R3	Failure to record times over waypoints.
PA.VI.D.R4	Failure to seek assistance or declare an emergency in a deteriorating situation.
Skills	The applicant demonstrates the ability to:
PA.VI.D.S1	Use an appropriate method to determine position.
PA.VI.D.S2	Maintain an appropriate heading and climb as necessary.
PA.VI.D.S3	Identify prominent landmarks.
PA.VI.D.S4	Use navigation systems/facilities or contact an ATC facility for assistance.

VII. Slow Flight and Stalls

Task	***A. Maneuvering During Slow Flight***
References	FAA-H-8083-2, FAA-H-8083-3, FAA-H-8083-25; POH/AFM
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with maneuvering during slow flight. ***Note:*** *See Appendix 6: Safety of Flight and Appendix 7: Aircraft, Equipment, and Operational Requirements & Limitations.*
Knowledge	The applicant demonstrates understanding of:
PA.VII.A.K1	Aerodynamics associated with slow flight in various airplane configurations, to include the relationship between angle of attack, airspeed, load factor, power setting, airplane weight and center of gravity, airplane attitude, and yaw effects.
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.VII.A.R1	Inadvertent slow flight and flight with a stall warning, which could lead to loss of control.
PA.VII.A.R2	Range and limitations of stall warning indicators (e.g., airplane buffet, stall horn, etc.).
PA.VII.A.R3	Failure to maintain coordinated flight.
PA.VII.A.R4	Effect of environmental elements on airplane performance (e.g., turbulence, microbursts, and high-density altitude).
PA.VII.A.R5	Collision hazards, to include aircraft, terrain, obstacles, and wires.
PA.VII.A.R6	Distractions, loss of situational awareness, or improper task management.
Skills	The applicant demonstrates the ability to:
PA.VII.A.S1	Clear the area.
PA.VII.A.S2	Select an entry altitude that will allow the Task to be completed no lower than 1,500 feet AGL (ASEL, ASES) or 3,000 feet AGL (AMEL, AMES).
PA.VII.A.S3	Establish and maintain an airspeed at which any further increase in angle of attack, increase in load factor, or reduction in power, would result in a stall warning (e.g., airplane buffet, stall horn, etc.).
PA.VII.A.S4	Accomplish coordinated straight-and-level flight, turns, climbs, and descents with the airplane configured as specified by the evaluator without a stall warning (e.g., airplane buffet, stall horn, etc.).
PA.VII.A.S5	Maintain the specified altitude, ±100 feet; specified heading, ±10°; airspeed, +10/-0 knots; and specified angle of bank, ±10°.

VII. Slow Flight and Stalls

Task	***B. Power-Off Stalls***
References	FAA-H-8083-2, FAA-H-8083-3; AC 61-67; POH/AFM
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with power-off stalls. ***Note:*** *See Appendix 7: Aircraft, Equipment, and Operational Requirements & Limitations.*
Knowledge	The applicant demonstrates understanding of:
PA.VII.B.K1	Aerodynamics associated with stalls in various airplane configurations, to include the relationship between angle of attack, airspeed, load factor, power setting, airplane weight and center of gravity, airplane attitude, and yaw effects.
PA.VII.B.K2	Stall characteristics (i.e., airplane design) and impending stall and full stall indications (i.e., how to recognize by sight, sound, or feel).
PA.VII.B.K3	Factors and situations that can lead to a power-off stall and actions that can be taken to prevent it.
PA.VII.B.K4	Fundamentals of stall recovery.
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.VII.B.R1	Factors and situations that could lead to an inadvertent power-off stall, spin, and loss of control.
PA.VII.B.R2	Range and limitations of stall warning indicators (e.g., airplane buffet, stall horn, etc.).
PA.VII.B.R3	Failure to recognize and recover at the stall warning during normal operations.
PA.VII.B.R4	Improper stall recovery procedure.
PA.VII.B.R5	Secondary stalls, accelerated stalls, and cross-control stalls.
PA.VII.B.R6	Effect of environmental elements on airplane performance related to power-off stalls (e.g., turbulence, microbursts, and high-density altitude).
PA.VII.B.R7	Collision hazards, to include aircraft, terrain, obstacles, and wires.
PA.VII.B.R8	Distractions, improper task management, loss of situational awareness, or disorientation.
Skills	The applicant demonstrates the ability to:
PA.VII.B.S1	Clear the area.
PA.VII.B.S2	Select an entry altitude that will allow the Task to be completed no lower than 1,500 feet AGL (ASEL, ASES) or 3,000 feet AGL (AMEL, AMES).
PA.VII.B.S3	Configure the airplane in the approach or landing configuration, as specified by the evaluator, and maintain coordinated flight throughout the maneuver.
PA.VII.B.S4	Establish a stabilized descent.
PA.VII.B.S5	Transition smoothly from the approach or landing attitude to a pitch attitude that will induce a stall.
PA.VII.B.S6	Maintain a specified heading ±10° if in straight flight; maintain a specified angle of bank not to exceed 20°, ±10° if in turning flight, while inducing the stall.
PA.VII.B.S7	Acknowledge cues of the impending stall and then recover promptly after a full stall occurs.
PA.VII.B.S8	Execute a stall recovery in accordance with procedures set forth in the POH/AFM.
PA.VII.B.S9	Configure the airplane as recommended by the manufacturer, and accelerate to V_X or V_Y.
PA.VII.B.S10	Return to the altitude, heading, and airspeed specified by the evaluator.

Task	*C. Power-On Stalls*
References	FAA-H-8083-2, FAA-H-8083-3; AC 61-67; POH/AFM
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with power-on stalls. ***Note:*** *See Appendix 6: Safety of Flight and Appendix 7: Aircraft, Equipment, and Operational Requirements & Limitations.*
Knowledge	The applicant demonstrates understanding of:
PA.VII.C.K1	Aerodynamics associated with stalls in various airplane configurations, to include the relationship between angle of attack, airspeed, load factor, power setting, airplane weight and center of gravity, airplane attitude, and yaw effects.
PA.VII.C.K2	Stall characteristics (i.e., airplane design) and impending stall and full stall indications (i.e., how to recognize by sight, sound, or feel).
PA.VII.C.K3	Factors and situations that can lead to a power-on stall and actions that can be taken to prevent it.
PA.VII.C.K4	Fundamentals of stall recovery.
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.VII.C.R1	Factors and situations that could lead to an inadvertent power-on stall, spin, and loss of control.
PA.VII.C.R2	Range and limitations of stall warning indicators (e.g., airplane buffet, stall horn, etc.).
PA.VII.C.R3	Failure to recognize and recover at the stall warning during normal operations.
PA.VII.C.R4	Improper stall recovery procedure.
PA.VII.C.R5	Secondary stalls, accelerated stalls, elevator trim stalls, and cross-control stalls.
PA.VII.C.R6	Effect of environmental elements on airplane performance related to power-on stalls (e.g., turbulence, microbursts, and high-density altitude).
PA.VII.C.R7	Collision hazards, to include aircraft, terrain, obstacles, and wires.
PA.VII.C.R8	Distractions, improper task management, loss of situational awareness, or disorientation.
Skills	The applicant demonstrates the ability to:
PA.VII.C.S1	Clear the area.
PA.VII.C.S2	Select an entry altitude that will allow the Task to be completed no lower than 1,500 feet AGL (ASEL, ASES) or 3,000 feet AGL (AMEL, AMES).
PA.VII.C.S3	Establish the takeoff, departure, or cruise configuration, as specified by the evaluator, and maintain coordinated flight throughout the maneuver.
PA.VII.C.S4	Set power (as assigned by the evaluator) to no less than 65 percent power.
PA.VII.C.S5	Transition smoothly from the takeoff or departure attitude to the pitch attitude that will induce a stall.
PA.VII.C.S6	Maintain a specified heading ±10° if in straight flight; maintain a specified angle of bank not to exceed 20°, ±10° if in turning flight, while inducing the stall.
PA.VII.C.S7	Acknowledge cues of the impending stall and then recover promptly after a full stall occurs.
PA.VII.C.S8	Execute a stall recovery in accordance with procedures set forth in the POH/AFM.
PA.VII.C.S9	Configure the airplane as recommended by the manufacturer, and accelerate to V_X or V_Y.
PA.VII.C.S10	Return to the altitude, heading, and airspeed specified by the evaluator.

VII. Slow Flight and Stalls

Task	***D. Spin Awareness***
References	FAA-H-8083-2, FAA-H-8083-3; AC 61-67; POH/AFM
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with spins, flight situations where unintentional spins may occur and procedures for recovery from unintentional spins.
Knowledge	The applicant demonstrates understanding of:
PA.VII.D.K1	Aerodynamics associated with spins in various airplane configurations, to include the relationship between angle of attack, airspeed, load factor, power setting, airplane weight and center of gravity, airplane attitude, and yaw effects.
PA.VII.D.K2	What causes a spin and how to identify the entry, incipient, and developed phases of a spin.
PA.VII.D.K3	Spin recovery procedure.
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.VII.D.R1	Factors and situations that could lead to inadvertent spin and loss of control.
PA.VII.D.R2	Range and limitations of stall warning indicators (e.g., airplane buffet, stall horn, etc.).
PA.VII.D.R3	Improper spin recovery procedure.
PA.VII.D.R4	Effect of environmental elements on airplane performance related to spins (e.g., turbulence, microbursts, and high-density altitude).
PA.VII.D.R5	Collision hazards, to include aircraft, terrain, obstacles, and wires.
PA.VII.D.R6	Distractions, improper task management, loss of situational awareness, or disorientation.
Skills	[Intentionally left blank]

VIII. Basic Instrument Maneuvers

Task	***A. Straight-and-Level Flight***
References	FAA-H-8083-2, FAA-H-8083-3, FAA-H-8083-15
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with flying during straight-and-level flight solely by reference to instruments.
Knowledge	The applicant demonstrates understanding of:
PA.VIII.A.K1	Flight instruments as related to:
PA.VIII.A.K1a	a. Sensitivity, limitations, and potential errors in unusual attitudes
PA.VIII.A.K1b	b. Correlation (pitch instruments/bank instruments)
PA.VIII.A.K1c	c. Function and operation
PA.VIII.A.K1d	d. Proper instrument cross-check techniques
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.VIII.A.R1	Instrument flying hazards to include failure to maintain VFR, spatial disorientation, loss of control, fatigue, stress, and emergency off airport landings.
PA.VIII.A.R2	Failure to seek assistance or declare an emergency in a deteriorating situation.
PA.VIII.A.R3	Collision hazards, to include aircraft, terrain, obstacles, and wires.
PA.VIII.A.R4	Distractions, loss of situational awareness, or improper task management.
Skills	The applicant demonstrates the ability to:
PA.VIII.A.S1	Maintain straight-and-level flight using proper instrument cross-check and interpretation, and coordinated control application.
PA.VIII.A.S2	Maintain altitude ±200 feet, heading ±20°, and airspeed ±10 knots.

Task	***B. Constant Airspeed Climbs***
References	FAA-H-8083-2, FAA-H-8083-3, FAA-H-8083-15
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with attitude instrument flying during constant airspeed climbs solely by reference to instruments.
Knowledge	The applicant demonstrates understanding of:
PA.VIII.B.K1	Flight instruments as related to:
PA.VIII.B.K1a	a. Sensitivity, limitations, and potential errors in unusual attitudes
PA.VIII.B.K1b	b. Correlation (pitch instruments/bank instruments)
PA.VIII.B.K1c	c. Function and operation
PA.VIII.B.K1d	d. Proper instrument cross-check techniques
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.VIII.B.R1	Instrument flying hazards to include failure to maintain VFR, spatial disorientation, loss of control, fatigue, stress, and emergency off airport landings.
PA.VIII.B.R2	Failure to seek assistance or declare an emergency in a deteriorating situation.
PA.VIII.B.R3	Collision hazards, to include aircraft, terrain, obstacles, and wires.
PA.VIII.B.R4	Distractions, loss of situational awareness, or improper task management.
Skills	The applicant demonstrates the ability to:
PA.VIII.B.S1	Transition to the climb pitch attitude and power setting on an assigned heading using proper instrument cross-check and interpretation, and coordinated flight control application.
PA.VIII.B.S2	Climb at a constant airspeed to specific altitudes in straight flight and turns.
PA.VIII.B.S3	Level off at the assigned altitude and maintain altitude ±200 feet, heading ±20°, and airspeed ±10 knots.

VIII. Basic Instrument Maneuvers

Task	*C. Constant Airspeed Descents*
References	FAA-H-8083-2, FAA-H-8083-3, FAA-H-8083-15
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with attitude instrument flying during constant airspeed descents solely by reference to instruments.
Knowledge	The applicant demonstrates understanding of:
PA.VIII.C.K1	Flight instruments as related to:
PA.VIII.C.K1a	a. Sensitivity, limitations, and potential errors in unusual attitudes
PA.VIII.C.K1b	b. Correlation (pitch instruments/bank instruments)
PA.VIII.C.K1c	c. Function and operation
PA.VIII.C.K1d	d. Proper instrument cross-check techniques
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.VIII.C.R1	Instrument flying hazards to include failure to maintain VFR, spatial disorientation, loss of control, fatigue, stress, and emergency off airport landings.
PA.VIII.C.R2	Failure to seek assistance or declare an emergency in a deteriorating situation.
PA.VIII.C.R3	Collision hazards, to include aircraft, terrain, obstacles, and wires.
PA.VIII.C.R4	Distractions, loss of situational awareness, or improper task management.
Skills	The applicant demonstrates the ability to:
PA.VIII.C.S1	Transition to the descent pitch attitude and power setting on an assigned heading using proper instrument cross-check and interpretation, and coordinated flight control application.
PA.VIII.C.S2	Descend at a constant airspeed to specific altitudes in straight flight and turns.
PA.VIII.C.S3	Level off at the assigned altitude and maintain altitude ±200 feet, heading ±20°, and airspeed ±10 knots.

Task	*D. Turns to Headings*
References	FAA-H-8083-2, FAA-H-8083-3, FAA-H-8083-15
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with attitude instrument flying during turns to headings solely by reference to instruments.
Knowledge	The applicant demonstrates understanding of:
PA.VIII.D.K1	Flight instruments as related to:
PA.VIII.D.K1a	a. Sensitivity, limitations, and potential errors in unusual attitudes
PA.VIII.D.K1b	b. Correlation (pitch instruments/bank instruments)
PA.VIII.D.K1c	c. Function and operation
PA.VIII.D.K1d	d. Proper instrument cross-check techniques
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.VIII.D.R1	Instrument flying hazards to include failure to maintain VFR, spatial disorientation, loss of control, fatigue, stress, and emergency off airport landings.
PA.VIII.D.R2	Failure to seek assistance or declare an emergency in a deteriorating situation.
PA.VIII.D.R3	Collision hazards, to include aircraft, terrain, obstacles, and wires.
PA.VIII.D.R4	Distractions, loss of situational awareness, or improper task management.
Skills	The applicant demonstrates the ability to:
PA.VIII.D.S1	Turn to headings, maintain altitude ±200 feet, maintain a standard rate turn, roll out on the assigned heading ±10°, and maintain airspeed ±10 knots.

Task	*E. Recovery from Unusual Flight Attitudes*
References	FAA-H-8083-2, FAA-H-8083-3, FAA-H-8083-15
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with attitude instrument flying while recovering from unusual attitudes solely by reference to instruments.
Knowledge	The applicant demonstrates understanding of:
PA.VIII.E.K1	Flight instruments as related to:
PA.VIII.E.K1a	a. Sensitivity, limitations, and potential errors in unusual attitudes
PA.VIII.E.K1b	b. Correlation (pitch instruments/bank instruments)
PA.VIII.E.K1c	c. Function and operation
PA.VIII.E.K1d	d. Proper instrument cross-check techniques
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.VIII.E.R1	Instrument flying hazards to include failure to maintain VFR, spatial disorientation, loss of control, fatigue, stress, and emergency off airport landings.
PA.VIII.E.R2	Failure to seek assistance or declare an emergency in a deteriorating situation.
PA.VIII.E.R3	Collision hazards, to include aircraft, terrain, obstacles, and wires.
PA.VIII.E.R4	Distractions, loss of situational awareness, or improper task management.
PA.VIII.E.R5	Failure to interpret flight instruments.
PA.VIII.E.R6	Failure to unload the wings in recovering from high G situations.
PA.VII.E.R7	Exceeding the operating envelope during the recovery.
Skills	The applicant demonstrates the ability to:
PA.VIII.E.S1	Recognize unusual flight attitudes; perform the correct, coordinated, and smooth flight control application to resolve unusual pitch and bank attitudes while staying within the airplane’s limitations and flight parameters.

Task	*F. Radio Communications, Navigation Systems/Facilities, and Radar Services*
References	FAA-H-8083-2, FAA-H-8083-3, FAA-H-8083-15, FAA-H-8083-25
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with radio communications, navigation systems/facilities, and radar services available for use during flight solely by reference to instruments.
Knowledge	The applicant demonstrates understanding of:
PA.VIII.F.K1	Operating communications equipment to include identifying and selecting radio frequencies, requesting and following ATC instructions.
PA.VIII.F.K2	Operating navigation equipment to include functions and displays, and following bearings, radials, or courses.
PA.VIII.F.K3	Air traffic control facilities and services.
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.VIII.F.R1	Failure to seek assistance or declare an emergency in a deteriorating situation.
PA.VIII.F.R2	Failure to utilize all available resources (e.g., automation, ATC, and flight deck planning aids).
Skills	The applicant demonstrates the ability to:
PA.VIII.F.S1	Maintain airplane control while selecting proper communications frequencies, identifying the appropriate facility, and managing navigation equipment.
PA.VIII.F.S2	Comply with ATC instructions.
PA.VIII.F.S3	Maintain altitude ±200 feet, heading ±20°, and airspeed ±10 knots.

IX. Emergency Operations

Task	***A. Emergency Descent***
References	FAA-H-8083-2, FAA-H-8083-3; POH/AFM
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with an emergency descent. ***Note:*** *See Appendix 6: Safety of Flight.*
Knowledge	The applicant demonstrates understanding of:
PA.IX.A.K1	Situations that would require an emergency descent (e.g., depressurization, smoke, or engine fire).
PA.IX.A.K2	Immediate action items and emergency procedures.
PA.IX.A.K3	Airspeed, to include airspeed limitations.
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.IX.A.R1	Failure to consider altitude, wind, terrain, obstructions, and available glide distance.
PA.IX.A.R2	Collision hazards, to include aircraft, terrain, obstacles, and wires.
PA.IX.A.R3	Improper airplane configuration.
PA.IX.A.R4	Distractions, loss of situational awareness, or improper task management.
Skills	The applicant demonstrates the ability to:
PA.IX.A.S1	Clear the area.
PA.IX.A.S2	Establish and maintain the appropriate airspeed and configuration appropriate to the scenario specified by the evaluator and as covered in POH/AFM for the emergency descent.
PA.IX.A.S3	Maintain orientation, divide attention appropriately, and plan and execute a smooth recovery.
PA.IX.A.S4	Use bank angle between 30° and 45° to maintain positive load factors during the descent.
PA.IX.A.S5	Maintain appropriate airspeed +0/-10 knots, and level off at a specified altitude ±100 feet.
PA.IX.A.S6	Complete the appropriate checklist.

IX. Emergency Operations

Task	*B. Emergency Approach and Landing (Simulated) (ASEL, ASES)*
References	FAA-H-8083-2, FAA-H-8083-3; POH/AFM
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with emergency approach and landing procedures. ***Note:*** *See Appendix 6: Safety of Flight.*
Knowledge	The applicant demonstrates understanding of:
PA.IX.B.K1	Immediate action items and emergency procedures.
PA.IX.B.K2	Airspeed, to include:
PA.IX.B.K2a	a. Importance of best glide speed and its relationship to distance
PA.IX.B.K2b	b. Difference between best glide speed and minimum sink speed
PA.IX.B.K2c	c. Effects of wind on glide distance
PA.IX.B.K3	Effects of atmospheric conditions on emergency approach and landing.
PA.IX.B.K4	A stabilized approach, to include energy management concepts.
PA.IX.B.K5	ELTs and other emergency locating devices.
PA.IX.B.K6	ATC services to aircraft in distress.
Risk Management	The applicant demonstrates the ability to identify, assess, and mitigate risks, encompassing:
PA.IX.B.R1	Failure to consider altitude, wind, terrain, obstructions, gliding distance, and available landing distance.
PA.IX.B.R2	Failure to plan and follow a flightpath to the selected landing area.
PA.IX.B.R3	Collision hazards, to include aircraft, terrain, obstacles, and wires.
PA.IX.B.R4	Improper airplane configuration.
PA.IX.B.R5	Low altitude maneuvering including stall, spin, or CFIT.
PA.IX.B.R6	Distractions, loss of situational awareness, or improper task management.
Skills	The applicant demonstrates the ability to:
PA.IX.B.S1	Establish and maintain the recommended best glide airspeed, ±10 knots.
PA.IX.B.S2	Configure the airplane in accordance with the POH/AFM and existing conditions.
PA.IX.B.S3	Select a suitable landing area considering altitude, wind, terrain, obstructions, and available glide distance.
PA.IX.B.S4	Plan and follow a flightpath to the selected landing area considering altitude, wind, terrain, and obstructions.
PA.IX.B.S5	Prepare for landing as specified by the evaluator.
PA.IX.B.S6	Complete the appropriate checklist.

IX. Emergency Operations

Task	*C. Systems and Equipment Malfunctions*
References	FAA-H-8083-2, FAA-H-8083-3; POH/AFM
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with system and equipment malfunctions appropriate to the airplane provided for the practical test and analyzing the situation and take appropriate action for simulated emergencies.
Knowledge	The applicant demonstrates understanding of:
PA.IX.C.K1	Partial or complete power loss related to the specific powerplant, including:
PA.IX.C.K1a	a. Engine roughness or overheat
PA.IX.C.K1b	b. Carburetor or induction icing
PA.IX.C.K1c	c. Loss of oil pressure
PA.IX.C.K1d	d. Fuel starvation
PA.IX.C.K2	System and equipment malfunctions specific to the airplane, including:
PA.IX.C.K2a	a. Electrical malfunction
PA.IX.C.K2b	b. Vacuum/pressure and associated flight instrument malfunctions
PA.IX.C.K2c	c. Pitot/static system malfunction
PA.IX.C.K2d	d. Electronic flight deck display malfunction
PA.IX.C.K2e	e. Landing gear or flap malfunction
PA.IX.C.K2f	f. Inoperative trim
PA.IX.C.K3	Smoke/fire/engine compartment fire.
PA.IX.C.K4	Any other system specific to the airplane (e.g., supplemental oxygen, deicing).
PA.IX.C.K5	Inadvertent door or window opening.
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.IX.C.R1	Failure to use the proper checklist for a system or equipment malfunction.
PA.IX.C.R2	Distractions, loss of situational awareness, or improper task management.
Skills	The applicant demonstrates the ability to:
PA.IX.C.S1	Describe appropriate action for simulated emergencies specified by the evaluator, from at least three of the elements or sub-elements listed in K1 through K5 above.
PA.IX.C.S2	Complete the appropriate checklist.

IX. Emergency Operations

Task	***D. Emergency Equipment and Survival Gear***
References	FAA-H-8083-2, FAA-H-8083-3; POH/AFM
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with emergency equipment, and survival gear appropriate to the airplane and environment encountered during flight and identifying appropriate equipment that should be onboard the airplane.
Knowledge	The applicant demonstrates understanding of:
PA.IX.D.K1	Emergency Locator Transmitter (ELT) operations, limitations, and testing requirements.
PA.IX.D.K2	Fire extinguisher operations and limitations.
PA.IX.D.K3	Emergency equipment and survival gear needed for:
PA.IX.D.K3a	a. Climate extremes (hot/cold)
PA.IX.D.K3b	b. Mountainous terrain
PA.IX.D.K3c	c. Overwater operations
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.IX.D.R1	Failure to plan for basic needs (water, clothing, shelter) for 48 to 72 hours.
Skills	The applicant demonstrates the ability to:
PA.IX.D.S1	Identify appropriate equipment and personal gear.
PA.IX.D.S2	Brief passengers on proper use of on-board emergency equipment and survival gear.

IX. Emergency Operations

Task	*E. Engine Failure During Takeoff Before V_{MC} (Simulated) (AMEL, AMES)*
References	FAA-H-8083-2, FAA-H-8083-3; FAA-P-8740-66; POH/AFM
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with an engine failure during takeoff before V_{MC}. ***Note:*** *See Appendix 6: Safety of Flight and Appendix 7: Aircraft, Equipment, and Operational Requirements & Limitations.*
Knowledge	The applicant demonstrates understanding of:
PA.IX.E.K1	Factors affecting V_{MC}.
PA.IX.E.K2	V_{MC} (red line) and V_{YSE} (blue line).
PA.IX.E.K3	Accelerate/stop distance.
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.IX.E.R1	Failure to plan for engine failure during takeoff.
PA.IX.E.R2	Improper airplane configuration.
PA.IX.E.R3	Distractions, loss of situational awareness, or improper task management.
Skills	The applicant demonstrates the ability to:
PA.IX.E.S1	Close the throttles smoothly and promptly when a simulated engine failure occurs.
PA.IX.E.S2	Maintain directional control and apply brakes (AMEL), or flight controls (AMES), as necessary.

IX. Emergency Operations

Task	*F. Engine Failure After Liftoff (Simulated) (AMEL, AMES)*
References	FAA-H-8083-2, FAA-H-8083-3; FAA-P-8740-66; POH/AFM
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with an engine failure after liftoff. ***Note:*** *See Appendix 6: Safety of Flight and Appendix 7: Aircraft, Equipment, and Operational Requirements & Limitations.*
Knowledge	The applicant demonstrates understanding of:
PA.IX.F.K1	Factors affecting V_{MC}.
PA.IX.F.K2	V_{MC} (red line), V_{YSE} (blue line), and V_{SSE} (safe single-engine speed).
PA.IX.F.K3	Accelerate/stop and accelerate/go distances.
PA.IX.F.K4	How to identify, verify, feather, and secure an inoperative engine.
PA.IX.F.K5	Importance of drag reduction, to include propeller feathering, gear and flap retraction, the manufacturer's recommended control input and its relation to zero sideslip.
PA.IX.F.K6	Simulated propeller feathering and the evaluator's zero-thrust procedures and responsibilities.
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.IX.F.R1	Failure to plan for engine failure after liftoff.
PA.IX.F.R2	Collision hazards, to include aircraft, terrain, obstacles, and wires.
PA.IX.F.R3	Improper airplane configuration.
PA.IX.F.R4	Low altitude maneuvering including stall, spin, or CFIT.
PA.IX.F.R5	Distractions, loss of situational awareness, or improper task management.
Skills	The applicant demonstrates the ability to:
PA.IX.F.S1	Promptly recognize an engine failure, maintain control, and utilize appropriate emergency procedures.
PA.IX.F.S2	Establish V_{YSE}; if obstructions are present, establish V_{XSE} or V_{MC} +5 knots, whichever is greater, until obstructions are cleared. Then transition to V_{YSE}.
PA.IX.F.S3	Reduce drag by retracting landing gear and flaps in accordance with the manufacturer's guidance.
PA.IX.F.S4	Simulate feathering the propeller on the inoperative engine (evaluator should then establish zero thrust on the inoperative engine).
PA.IX.F.S5	Use flight controls in the proper combination as recommended by the manufacturer, or as required to maintain best performance, and trim as required.
PA.IX.F.S6	Monitor the operating engine and make adjustments as necessary.
PA.IX.F.S7	Recognize the airplane's performance capabilities. If a climb is not possible at V_{YSE}, maintain V_{YSE} and return to the departure airport for landing, or initiate an approach to the most suitable landing area available.
PA.IX.F.S8	Simulate securing the inoperative engine.
PA.IX.F.S9	Maintain heading ±10° and airspeed ±5 knots.
PA.IX.F.S10	Complete the appropriate checklist.

Task	*G. Approach and Landing with an Inoperative Engine (Simulated) (AMEL, AMES)*
References	FAA-H-8083-2, FAA-H-8083-3; FAA-P-8740-66; POH/AFM
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with an approach and landing with an engine inoperative, including engine failure on final approach. ***Note:*** *See Appendix 6: Safety of Flight and Appendix 7: Aircraft, Equipment, and Operational Requirements & Limitations.*
Knowledge	The applicant demonstrates understanding of:
PA.IX.G.K1	Factors affecting V_{MC}.
PA.IX.G.K2	V_{MC} (red line) and V_{YSE} (blue line).
PA.IX.G.K3	How to identify, verify, feather, and secure an inoperative engine.
PA.IX.G.K4	Importance of drag reduction, to include propeller feathering, gear and flap retraction, and the manufacturer's recommended flight control input and its relation to zero sideslip.
PA.IX.G.K5	Applicant responsibilities during simulated feathering.
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.IX.G.R1	Failure to plan for engine failure inflight or during an approach.
PA.IX.G.R2	Collision hazards, to include aircraft, terrain, obstacles, and wires.
PA.IX.G.R3	Improper airplane configuration.
PA.IX.G.R4	Low altitude maneuvering including stall, spin, or CFIT.
PA.IX.G.R5	Distractions, loss of situational awareness, or improper task management.
PA.IX.G.R6	Possible single-engine go-around.
Skills	The applicant demonstrates the ability to:
PA.IX.G.S1	Promptly recognize an engine failure and maintain positive airplane control.
PA.IX.G.S2	Set the engine controls, reduce drag, identify and verify the inoperative engine, and simulate feathering of the propeller on the inoperative engine. (Evaluator should then establish zero thrust on the inoperative engine).
PA.IX.G.S3	Use flight controls in the proper combination as recommended by the manufacturer or as required to maintain best performance, and trim as required.
PA.IX.G.S4	Follow the manufacturer's recommended emergency procedures.
PA.IX.G.S5	Monitor the operating engine and make adjustments as necessary.
PA.IX.G.S6	Maintain the manufacturer's recommended approach airspeed +10/-5 knots, in the landing configuration with a stabilized approach, until landing is assured.
PA.IX.G.S7	Make smooth, timely, and correct control application during round out and touchdown.
PA.IX.G.S8	Touch down on the first one-third of available runway/landing surface, with no drift, and the airplane's longitudinal axis aligned with and over the runway center or landing path.
PA.IX.G.S9	Maintain directional control and appropriate crosswind correction throughout the approach and landing.
PA.IX.G.S10	Complete the appropriate checklist.

X. Multiengine Operations

Task	***A. Maneuvering with One Engine Inoperative (AMEL, AMES)***
References	FAA-H-8083-2, FAA-H-8083-3; FAA-P-8740-66; POH/AFM
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with maneuvering with one engine inoperative. ***Note:*** *See Appendix 6: Safety of Flight and Appendix 7: Aircraft, Equipment, and Operational Requirements & Limitations.*
Knowledge	The applicant demonstrates understanding of:
PA.X.A.K1	Factors affecting V_{MC}.
PA.X.A.K2	V_{MC} (red line) and V_{YSE} (blue line).
PA.X.A.K3	How to identify, verify, feather, and secure an inoperative engine.
PA.X.A.K4	Importance of drag reduction, to include propeller feathering, gear and flap retraction, the manufacturer's recommended flight control input and its relation to zero sideslip.
PA.X.A.K5	Feathering, securing, unfeathering, and restarting.
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.X.A.R1	Failure to plan for engine failure during flight.
PA.X.A.R2	Collision hazards, to include aircraft, terrain, obstacles, and wires.
PA.X.A.R3	Improper airplane configuration.
PA.X.A.R4	Low altitude maneuvering including stall, spin, or CFIT.
PA.X.A.R5	Distractions, loss of situational awareness, or improper task management.
Skills	The applicant demonstrates the ability to:
PA.X.A.S1	Recognize an engine failure, maintain control, use manufacturer's memory item procedures, and utilize appropriate emergency procedures.
PA.X.A.S2	Set the engine controls, identify and verify the inoperative engine, and feather the appropriate propeller.
PA.X.A.S3	Use flight controls in the proper combination as recommended by the manufacturer, or as required to maintain best performance, and trim as required.
PA.X.A.S4	Attempt to determine and resolve the reason for the engine failure.
PA.X.A.S5	Secure the inoperative engine and monitor the operating engine and make necessary adjustments.
PA.X.A.S6	Restart the inoperative engine using manufacturer's restart procedures.
PA.X.A.S7	Maintain altitude ±100 feet or a minimum sink rate if applicable, airspeed ±10 knots, and headings ±10°.
PA.X.A.S8	Complete the appropriate checklist.

X. Multiengine Operations

Task	*B. V_{MC} Demonstration (AMEL, AMES)*
References	FAA-H-8083-2, FAA-H-8083-3; FAA-P-8740-66; POH/AFM
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with a V_{MC} demonstration. ***Note:*** *See Appendix 6: Safety of Flight and Appendix 7: Aircraft, Equipment, and Operational Requirements & Limitations.*
Knowledge	The applicant demonstrates understanding of:
PA.X.B.K1	Factors affecting V_{MC} and how V_{MC} differs from stall speed (V_S).
PA.X.B.K2	V_{MC} (red line), V_{YSE} (blue line), and V_{SSE} (safe single-engine speed).
PA.X.B.K3	Cause of loss of directional control at airspeeds below V_{MC}.
PA.X.B.K4	Proper procedures for maneuver entry and safe recovery.
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.X.B.R1	Improper airplane configuration.
PA.X.B.R2	Maneuvering with one engine inoperative.
PA.X.B.R3	Distractions, loss of situational awareness, or improper task management.
Skills	The applicant demonstrates the ability to:
PA.X.B.S1	Configure the airplane in accordance with the manufacturer's recommendations, in the absence of the manufacturer's recommendations, then at V_{SSE}/V_{YSE}, as appropriate, and:
PA.X.B.S1a	a. Landing gear retracted
PA.X.B.S1b	b. Flaps set for takeoff
PA.X.B.S1c	c. Cowl flaps set for takeoff
PA.X.B.S1d	d. Trim set for takeoff
PA.X.B.S1e	e. Propellers set for high RPM
PA.X.B.S1f	f. Power on critical engine reduced to idle and propeller windmilling
PA.X.B.S1g	g. Power on operating engine set to takeoff or maximum available power
PA.X.B.S2	Establish a single-engine climb attitude with the airspeed at approximately 10 knots above V_{SSE}.
PA.X.B.S3	Establish a bank angle not to exceed 5° toward the operating engine, as required for best performance and controllability.
PA.X.B.S4	Increase the pitch attitude slowly to reduce the airspeed at approximately 1 knot per second while applying rudder pressure to maintain directional control until full rudder is applied.
PA.X.B.S5	Recognize indications of loss of directional control, stall warning, or buffet.
PA.X.B.S6	Recover promptly by simultaneously reducing power sufficiently on the operating engine, decreasing the angle of attack as necessary to regain airspeed and directional control, and without adding power on the simulated failed engine.
PA.X.B.S7	Recover within 20° of entry heading.
PA.X.B.S8	Advance power smoothly on the operating engine and accelerate to V_{SSE}/V_{YSE}, as appropriate, +10/-5 knots during recovery.

X. Multiengine Operations

Task	***C. One Engine Inoperative (Simulated) (solely by Reference to Instruments) During Straight-and-Level Flight and Turns (AMEL, AMES)***
References	FAA-H-8083-2, FAA-H-8083-3; FAA-P-8740-66; POH/AFM
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with flight solely by reference to instruments with one engine inoperative. ***Note:*** *See Appendix 6: Safety of Flight and Appendix 7: Aircraft, Equipment, and Operational Requirements & Limitations.*
Knowledge	The applicant demonstrates understanding of:
PA.X.C.K1	Procedures used if engine failure occurs during straight-and-level flight and turns while on instruments.
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.X.C.R1	Failure to identify the inoperative engine.
PA.X.C.R2	Inability to climb or maintain altitude with an inoperative engine.
PA.X.C.R3	Low altitude maneuvering including stall, spin, or CFIT.
PA.X.C.R4	Distractions, loss of situational awareness, or improper task management.
PA.X.C.R5	Fuel management during single-engine operation.
Skills	The applicant demonstrates the ability to:
PA.X.C.S1	Promptly recognize an engine failure and maintain positive airplane control.
PA.X.C.S2	Set the engine controls, reduce drag, identify and verify the inoperative engine, and simulate feathering of the propeller on the inoperative engine. (Evaluator should then establish zero thrust on the inoperative engine.)
PA.X.C.S3	Establish the best engine-inoperative airspeed and trim the airplane.
PA.X.C.S4	Use flight controls in the proper combination as recommended by the manufacturer, or as required to maintain best performance, and trim as required.
PA.X.C.S5	Verify the prescribed checklist procedures normally used for securing the inoperative engine.
PA.X.C.S6	Attempt to determine and resolve the reason for the engine failure.
PA.X.C.S7	Monitor engine functions and make necessary adjustments.
PA.X.C.S8	Maintain the specified altitude ±100 feet or minimum sink rate if applicable, airspeed ±10 knots, and the specified heading ±10°.
PA.X.C.S9	Assess the airplane's performance capability and decide an appropriate action to ensure a safe landing.
PA.X.C.S10	Avoid loss of airplane control or attempted flight contrary to the engine-inoperative operating limitations of the airplane.
PA.X.C.S11	Utilize SRM.

X. Multiengine Operations

Task	***D. Instrument Approach and Landing with an Inoperative Engine (Simulated) (solely by Reference to Instruments) (AMEL, AMES)***
References	FAA-H-8083-2, FAA-H-8083-3; FAA-P-8740-66; POH/AFM
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with executing a published instrument approach solely by reference to instruments with one engine inoperative. ***Note:*** *See Appendix 6: Safety of Flight and Appendix 7: Aircraft, Equipment, and Operational Requirements & Limitations.*
Knowledge	The applicant demonstrates understanding of:
PA.X.D.K1	Instrument approach procedures with one engine inoperative.
Risk Management	The applicant demonstrates the ability to identify, assess, and mitigate risks, encompassing:
PA.X.D.R1	Failure to plan for engine failure during approach and landing.
PA.X.D.R2	Collision hazards, to include aircraft, terrain, obstacles, wires, vehicles, vessels, persons, and wildlife.
PA.X.D.R3	Improper airplane configuration.
PA.X.D.R4	Low altitude maneuvering including stall, spin, or CFIT.
PA.X.D.R5	Distractions, loss of situational awareness, or improper task management.
PA.X.D.R6	Performing a go-around/rejected landing with an engine failure.
Skills	The applicant demonstrates the ability to:
PA.X.D.S1	Promptly recognize engine failure and maintain positive airplane control.
PA.X.D.S2	Set the engine controls, reduce drag, identify and verify the inoperative engine, and simulate feathering of the propeller on the inoperative engine. (Evaluator should then establish zero thrust on the inoperative engine).
PA.X.D.S3	Use flight controls in the proper combination as recommended by the manufacturer, or as required to maintain best performance, and trim as required.
PA.X.D.S4	Follow the manufacturer's recommended emergency procedures.
PA.X.D.S5	Monitor the operating engine and make adjustments as necessary.
PA.X.D.S6	Request and follow an actual or a simulated ATC clearance for an instrument approach.
PA.X.D.S7	Maintain altitude ±100 feet or minimum sink rate if applicable, airspeed ±10 knots, and selected heading ±10°.
PA.X.D.S8	Establish a rate of descent that will ensure arrival at the MDA or DA/DH with the airplane in a position from which a descent to a landing on the intended runway can be made, either straight in or circling as appropriate.
PA.X.D.S9	On final approach segment, maintain vertical (as applicable) and lateral guidance within ¾-scale deflection.
PA.X.D.S10	Avoid loss of airplane control, or attempted flight contrary to the operating limitations of the airplane.
PA.X.D.S11	Comply with the published criteria for the aircraft approach category if circling.
PA.X.D.S12	Execute a normal landing.
PA.X.D.S13	Complete the appropriate checklist.

XI. Night Operations

Task	***A. Night Preparation***
References	FAA-H-8083-2, FAA-H-8083-3, FAA-H-8083-25; AIM; POH/AFM
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with night operations.
Knowledge	The applicant demonstrates understanding of:
PA.XI.A.K1	Physiological aspects of vision related to night flying.
PA.XI.A.K2	Lighting systems identifying airports, runways, taxiways and obstructions, as well as pilot controlled lighting.
PA.XI.A.K3	Airplane equipment and lighting requirements for night operations.
PA.XI.A.K4	Personal equipment essential for night flight.
PA.XI.A.K5	Night orientation, navigation, and chart reading techniques.
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.XI.A.R1	Collision hazards, to include aircraft, terrain, obstacles, and wires.
PA.XI.A.R2	Distractions, loss of situational awareness, or improper task management.
PA.XI.A.R3	Hazards specific to night flying.
Skills	*N/A* ***Note:*** *Not generally evaluated in flight. If the practical test is conducted at night, all ACS Tasks are evaluated in that environment, thus there is no need for explicit Task elements to exist here.*

XII. Postflight Procedures

Task	***A. After Landing, Parking and Securing (ASEL, AMEL)***
References	FAA-H-8083-2, FAA-H-8083-3; POH/AFM
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with after landing, parking, and securing procedures.
Knowledge	The applicant demonstrates understanding of:
PA.XII.A.K1	Airplane shutdown, securing, and postflight inspection.
PA.XII.A.K2	Documenting in-flight/postflight discrepancies.
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.XII.A.R1	Inappropriate activities and distractions.
PA.XII.A.R2	Confirmation or expectation bias as related to taxi instructions.
PA.XII.A.R3	Airport specific security procedures.
PA.XII.A.R4	Disembarking passengers.
Skills	The applicant demonstrates the ability to:
PA.XII.A.S1	Utilize runway incursion avoidance procedures.
PA.XII.A.S2	Park in an appropriate area, considering the safety of nearby persons and property.
PA.XII.A.S3	Complete the appropriate checklist.
PA.XII.A.S4	Conduct a postflight inspection and document discrepancies and servicing requirements, if any.
PA.XII.A.S5	Secure the airplane.

XII. Postflight Procedures

Task	*B. Seaplane Post-Landing Procedures (ASES, AMES)*
References	FAA-H-8083-2, FAA-H-8083-23; POH/AFM
Objective	To determine that the applicant exhibits satisfactory knowledge, risk management, and skills associated with anchoring, docking, mooring, and ramping/beaching. ***Note:*** *The evaluator must select at least one after-landing procedure (anchoring, docking and mooring, or ramping/beaching).*
Knowledge	The applicant demonstrates understanding of:
PA.XII.B.K1	Mooring.
PA.XII.B.K2	Docking.
PA.XII.B.K3	Anchoring.
PA.XII.B.K4	Beaching/ramping.
PA.XII.B.K5	Postflight inspection, recording of in-flight/postflight discrepancies.
Risk Management	The applicant demonstrates the ability to identify, assess and mitigate risks, encompassing:
PA.XII.B.R1	Inappropriate activities and distractions.
PA.XII.B.R2	Confirmation or expectation bias as related to taxi instructions.
PA.XII.B.R3	Seaplane base specific security procedures, if applicable.
PA.XII.B.R4	Disembarking passengers.
Skills	The applicant demonstrates the ability to:
PA.XII.B.S1	If anchoring, select a suitable area considering seaplane movement, water depth, tide, wind, and weather changes. Use an adequate number of anchors and lines of sufficient strength and length to ensure the seaplane's security.
PA.XII.B.S2	If not anchoring, approach the dock/mooring buoy or beach/ramp in the proper direction and at a safe speed, considering water depth, tide, current, and wind.
PA.XII.B.S3	Complete the appropriate checklist.
PA.XII.B.S4	Conduct a postflight inspection and document discrepancies and servicing requirements, if any.
PA.XII.B.S5	Secure the seaplane considering the effect of wind, waves, and changes in water level, or comply with applicable after landing, parking and securing if operating an amphibious airplane on land.

Appendix Table of Contents

Appendix 1: The Knowledge Test Eligibility, Prerequisites, and Testing Centers

Knowledge Test Description

The knowledge test is an important part of the airman certification process. Applicants must pass the knowledge test before taking the practical test.

The knowledge test consists of objective, multiple-choice questions. There is a single correct response for each test question. Each test question is independent of other questions. A correct response to one question does not depend upon, or influence, the correct response to another.

Knowledge Test Table

Test Code	Test Name	Number of Questions	Age	Allotted Time	Passing Score
PAR	Private Pilot Airplane	60	15	2.5	70
PAT	Private Pilot Airplane/Recreational Pilot - Transition	30	15	1.5	70
PBG	Private Pilot Balloon - Gas	60	14	2.5	70
PBH	Private Pilot Balloon - Hot Air	60	14	2.5	70
PCH	Private Pilot Helicopter ***Canadian Conversion***	40	16	2.0	70
PCP	Private Pilot – Airplane ***Canadian Conversion***	40	16	2.0	70
PGL	Private Pilot Glider	60	14	2.5	70
PGT	Private Pilot Gyroplane/Recreational Pilot - Transition	30	15	1.5	70
PHT	Private Pilot Helicopter/Recreational Pilot - Transition	30	15	1.5	70
PLA	Private Pilot Airship	60	15	2.5	70
PPP	Private Pilot Powered Parachute	60	15	2.5	70
PRG	Private Pilot Gyroplane	60	15	2.5	70
PRH	Private Pilot Helicopter	60	15	2.5	70
PWS	Private Pilot Weight-Shift-Control	60	15	2.5	70

Knowledge Test Blueprint

PAR Knowledge Areas Required by 14 CFR part 61, section 61.105 to be on the Knowledge Test	Percent of Questions Per Test
Regulations	5 – 15%
Accident Reporting	5 – 10%
Performance Charts	5 – 10%
Radio Communications	5 – 10%
Weather	5 – 10%
Safe and Efficient Operations	5 – 15%
Density Altitude Performance	5 – 10%
Weight and Balance	5 – 10%
Aerodynamics, Powerplants, and Aircraft Systems	5 – 10%
Stalls and Spins	5 – 10%
Aeronautical Decision-Making (ADM)	5 – 10%
Preflight actions	5 – 10%
Total Number of Questions	**60**

English Language Standard

In accordance with the requirements of 14 CFR part 61, section 61.13(c) the applicant must demonstrate the ability to read, write, speak, and understand the English language throughout the application and testing process. English language proficiency is required to communicate effectively with Air Traffic Control (ATC), to comply with ATC instructions, and to ensure clear and effective crew communication and coordination. Normal restatement of questions as would be done for a native English speaker is permitted, and does not constitute grounds for disqualification. The FAA Aviation English Language Standard (AELS) is the FAA evaluator's benchmark. It requires the applicant to demonstrate at least the International Civil Aviation Organization (ICAO) level 4 standard.

Knowledge Test Requirements

In order to take the Private Pilot Knowledge Test, you must provide proper identification. To verify your eligibility to take the test, you must also provide one of the following in accordance with the requirements of 14 CFR part 61:

- 14 CFR part 61, section 61.35 lists the prerequisites for taking the knowledge test, to include the minimum age an applicant must be to take the test.
  - Received an endorsement, if required by this part, from an authorized instructor certifying that the applicant accomplished the appropriate ground-training or a home-study course required by this part for the certificate or rating sought and is prepared for the knowledge test;
  - Proper identification at the time of application that contains the applicant's—
    - (i) Photograph;
    - (ii) Signature;
    - (iii) Date of birth; and
    - (iv) Physical, residential address.
- 14 CFR part 61, section 61.49 acceptable forms of retest authorization for **all** Private Pilot tests:
  - An applicant retesting **after failure** is required to submit the applicable Airman Knowledge Test Report indicating failure, along with an endorsement from an authorized instructor who gave the applicant the required additional training. The endorsement must certify that the applicant is competent to pass the test. The test proctor must retain the original failed Airman Knowledge Test Report presented as authorization and attach it to the applicable sign-in/out log.

    Note: *If the applicant no longer possesses the original Airman Knowledge Test Report, he or she may request a duplicate replacement issued by the Airmen Certification Branch.*
- Acceptable forms of authorization for Private Pilot Canadian Conversion (PCP) only:
  - Confirmation of Verification Letter issued by the Office of Foundational Business, Civil Aviation Division, Airmen Certification Branch (Knowledge Testing Authorization Requirements Matrix).
  - Requires **no** instructor endorsement or other form of written authorization.

Knowledge Test Centers

The FAA authorizes hundreds of knowledge testing center locations that offer a full range of airman knowledge tests. For information on authorized testing centers and to register for the knowledge test, contact one of the providers listed at www.faa.gov.

Knowledge Test Registration

When you contact a knowledge testing center to register for a test, please be prepared to select a test date, choose a testing center, and make financial arrangements for test payment when you call. You may register for test(s) several weeks in advance, and you may cancel in accordance with the testing center's cancellation policy.

Appendix 2: Knowledge Test Procedures and Tips

Before starting the actual test, the testing center will provide an opportunity to practice navigating through the test. This practice or tutorial session may include sample questions to familiarize the applicant with the look and feel of the software. (e.g., selecting an answer, marking a question for later review, monitoring time remaining for the test, and other features of the testing software.)

Acceptable Materials

The applicant may use the following aids, reference materials, and test materials, as long as the material does not include actual test questions or answers:

Acceptable Materials	Unacceptable Materials	Notes
Supplement book provided by proctor	Written materials that are handwritten, printed, or electronic	Testing centers may provide calculators and/or deny the use of personal calculators
All models of aviation-oriented calculators or small electronic calculators that perform only arithmetic functions	Electronic calculators incorporating permanent or continuous type memory circuits without erasure capability	Unit Member (proctor) may prohibit the use of your calculator if he or she is unable to determine the calculator's erasure capability
Calculators with simple programmable memories, which allow addition to, subtraction from, or retrieval of one number from the memory; or simple functions, such as square root and percentages	Magnetic Cards, magnetic tapes, modules, computer chips, or any other device upon which pre-written programs or information related to the test can be stored and retrieved	Printouts of data must be surrendered at the completion of the test if the calculator incorporates this design feature
Scales, straightedges, protractors, plotters, navigation computers, blank log sheets, holding pattern entry aids, and electronic or mechanical calculators that are directly related to the test	Dictionaries	Before, and upon completion of the test, while in the presence of the Unit Member, actuate the ON/OFF switch or RESET button, and perform any other function that ensures erasure of any data stored in memory circuits
Manufacturer's permanently inscribed instructions on the front and back of such aids, e.g., formulas, conversions, regulations, signals, weather data, holding pattern diagrams, frequencies, weight and balance formulas, and air traffic control procedures	Any booklet or manual containing instructions related to use of test aids	Unit Member makes the final determination regarding aids, reference materials, and test materials

Test Tips

When taking a knowledge test, please keep the following points in mind:

- Carefully read the instructions provided with the test.
- Answer each question in accordance with the latest regulations and guidance publications.
- Read each question carefully before looking at the answer options. You should clearly understand the problem before trying to solve it.
- After formulating a response, determine which answer option corresponds with your answer. The answer you choose should completely solve the problem.
- Remember that only one answer is complete and correct. The other possible answers are either incomplete or erroneous.

- If a certain question is difficult for you, mark it for review and return to it after you have answered the less difficult questions. This procedure will enable you to use the available time to maximum advantage.
- When solving a calculation problem, be sure to read all the associated notes.
- For questions involving use of a graph, you may request a printed copy that you can mark in computing your answer. This copy and all other notes and paperwork must be given to the testing center upon completion of the test.

Cheating or Other Unauthorized Conduct

To avoid test compromise, computer testing centers must follow strict security procedures established by the FAA and described in FAA Order 8080.6 (as amended), Conduct of Airman Knowledge Tests. The FAA has directed testing centers to terminate a test at any time a test unit member suspects that a cheating incident has occurred.

The FAA will investigate and, if the agency determines that cheating or unauthorized conduct has occurred, any airman certificate or rating you hold may be revoked. You will also be prohibited from applying for or taking any test for a certificate or rating under 14 CFR part 61 for a period of 1 year.

Testing Procedures for Applicants Requesting Special Accommodations

An applicant with learning or reading disability may request approval from the Airman Testing Branch through the local Flight Standards District Office (FSDO) or International Field Office/International Field Unit (IFO/IFU) to take airman knowledge test using one of the three options listed below, in preferential order:

Option 1: Use current testing facilities and procedures whenever possible.

Option 2: Use a self-contained, electronic device, which pronounces and displays typed-in words (e.g., the Franklin Speaking Wordmaster®) to facilitate the testing process.

Note: *The device should consist of an electronic thesaurus that audibly pronounces typed-in words and presents them on a display screen. The device should also have a built-in headphone jack in order to avoid disturbing others during testing.*

Option 3: Request the proctor's assistance in reading specific words or terms from the test questions and/or supplement book. To prevent compromising the testing process, the proctor must be an individual with no aviation background or expertise. The proctor may provide reading assistance only (i.e., no explanation of words or terms). When an applicant requests this option, the FSDO or IFO/IFU inspector must contact the Airman Testing Branch for assistance in selecting the test site and assisting the proctor. Before approving any option, the FSDO or IFO/IFU inspector must advise the applicant of the regulatory certification requirement to be able to read, write, speak, and understand the English language.

Appendix 3: Airman Knowledge Test Report

Immediately upon completion of the knowledge test, the applicant receives a printed Airman Knowledge Test Report (AKTR) documenting the score with the testing center's raised, embossed seal. The applicant must retain the original AKTR. The instructor must provide instruction in each area of deficiency and provide a logbook endorsement certifying that the applicant has demonstrated satisfactory knowledge in each area. When taking the practical test, the applicant must present the original AKTR to the evaluator, who is required to assess the noted areas of deficiency during the ground portion of the practical test.

An AKTR expires 24 calendar months after the month the applicant completes the knowledge test. If the AKTR expires before completion of the practical test, the applicant must retake the knowledge test.

To obtain a duplicate AKTR due to loss or destruction of the original, the applicant can send a signed request accompanied by a check or money order for $12.00 (U.S. funds), payable to the FAA to the following address:

Federal Aviation Administration
Airmen Certification Branch
P.O. Box 25082
Oklahoma City, OK 73125

To obtain a copy of the application form or a list of the information required, please see the Airmen Certification Branch webpage.

FAA Knowledge Test Question Coding

Each Task in the ACS includes an ACS code. This ACS code will ultimately be displayed on the AKTR to indicate what Task element was proven deficient on the knowledge test. Instructors can then provide remedial training in the deficient areas, and evaluators can re-test this element during the practical test.

The ACS coding consists of four elements. For example, this code is interpreted as follows:

PA.XI.A.K1:

PA = Applicable ACS (Private Pilot – Airplane)
XI = Area of Operation (Night Operations)
A = Task (Night Preparation)
K1 = Task element Knowledge 1 (Physiological aspects of vision related to night flying.)

Knowledge test questions correspond to the ACS codes, which will ultimately replace the system of Learning Statement Codes (LSC). After this transition occurs, the AKTR will list an ACS code that correlates to a specific Task element for a given Area of Operation and Task. Remedial instruction and re-testing will be specific, targeted, and based on specified learning criteria. Similarly, a Notice of Disapproval for the practical test will use the ACS codes to identify the deficient Task elements. Applicants and evaluators should interpret the codes using the ACS revision in effect on the date of the knowledge test

However, for knowledge tests taken before this system comes on line, only the LSC code (e.g., "PLT058") will be displayed on the AKTR. The LSC codes link to references and broad subject areas. By contrast, each ACS code represents a unique Task element in the ACS. Because of this fundamental difference, there is no one-to-one correlation between Learning Statement (PLT) codes and ACS codes.

Because all active knowledge test questions for the Private Pilot Airplane Knowledge Test (PAR) now align with this ACS, evaluators can use LSC codes in conjunction with this ACS for targeted retesting of missed knowledge subject areas. The evaluator should look up the LSC code(s) on the applicant's AKTR in the Learning Statement Reference Guide. After noting the subject area(s), the evaluator can use the corresponding Area(s) of Operation/Task(s) in the ACS to narrow the scope of material for retesting to the appropriate ACS Area(s) of Operation and Task(s). Evaluators must verify the applicant has sufficient knowledge in those areas associated with incorrect responses on the knowledge test.

Applicant Name Considerations for the Airman Knowledge Test Report (AKTR) and the Practical Test Application Form

The applicant uses his or her full legal name on the Airman Certificate and/or Rating Application, FAA Form 8710-1, using up to 50 characters (including spaces). The applicant may exclude some middle names as necessary to meet the 50-character limit. The AKTR may not reflect the applicant's full legal name and may differ slightly from the name presented for the practical test.

If the 8710-1 shows a middle name, the AKTR may show that middle name, the correct middle initial, or no entry. The application will process correctly using the Integrated Airman Certificate and Rating Application (IACRA) system, and the Airmen Certification Branch will accept it. If an incorrect middle initial, spelling variant or different middle name is on the AKTR, or if the AKTR has a first name variation of any kind, the evaluator must attach an explanation and a scan or copy of the applicant's photo identification and attach it to the IACRA or paper application. If the last name on the AKTR has a different spelling or suffix, an IACRA application is not possible. The applicant must use a paper application, and the evaluator must include an explanation and copy of the applicant's photo identification to avoid a correction notice.

Appendix 4: The Practical Test – Eligibility and Prerequisites

The prerequisite requirements and general eligibility for a practical test and the specific requirements for the original issuance of a Private Pilot Certificate in the airplane category can be found in 14 CFR part 61, sections 61.39(a) (1) through (7) and 61.103.

Appendix 5: Practical Test Roles, Responsibilities, and Outcomes

Applicant Responsibilities

The applicant is responsible for mastering the established standards for knowledge, skill, and risk management elements in all Tasks appropriate to the certificate and rating sought. The applicant should use this ACS, its references, and the Practical Test Checklist in this Appendix in preparation to take the practical test.

Instructor Responsibilities

The instructor is responsible for training the applicant to meet the established standards for knowledge, skill, and risk management elements in all Tasks appropriate to the certificate and rating sought. The instructor should use this ACS and its references as part of preparing the applicant to take the practical test and, if necessary, in retraining the applicant to proficiency in all subject(s) missed on the knowledge test.

Evaluator Responsibilities

An evaluator is:

- Aviation Safety Inspector (ASI);
- Pilot examiner (other than administrative pilot examiners);
- Training center evaluator (TCE);
- Chief instructor, assistant chief instructor or check instructor of pilot school holding examining authority; or
- Instrument Flight Instructor (CFII) conducting an instrument proficiency check (IPC).

The evaluator who conducts the practical test is responsible for determining that the applicant meets the established standards of aeronautical knowledge, skills (flight proficiency), and risk management for the Tasks in the appropriate ACS. This responsibility also includes verifying the experience requirements specified for a certificate or rating.

Prior to beginning the practical test, the evaluator must also determine that the applicant meets FAA Aviation English Language Proficiency Standard. An applicant for an FAA certificate or rating should be able to communicate in English in a discernible and understandable manner with ATC, pilots, and others involved in preparing an aircraft for flight and operating an aircraft in flight. This communication may or may not involve the use of the radio. An applicant for an FAA certificate issued in accordance with part 61, 63, 65, or 107 who cannot hear or speak due to a medical deficiency may be eligible for an FAA certificate with specific operational limitations. For additional guidance, reference AC 60-28, English Language Skill Standards required by 14 CFR parts 61, 63, 65, and 107, as amended.

The evaluator must develop a Plan of Action (POA), written in English, to conduct the practical test, and it must include all of the required Areas of Operation and Tasks. The POA must include a scenario that evaluates as many of the required Areas of Operation and Tasks as possible. As the scenario unfolds during the test, the evaluator will introduce problems and emergencies that the applicant must manage. The evaluator has the discretion to modify the POA in order to accommodate unexpected situations as they arise. For example, the evaluator may elect to suspend and later resume a scenario in order to assess certain Tasks.

In the integrated ACS framework, the Areas of Operation contain Tasks that include “knowledge” elements (such as K1), “risk management” elements (such as R1), and “skill” elements (such as S1). Knowledge and risk management elements are primarily evaluated during the knowledge testing phase of the airman certification process. The evaluator must assess the applicant on all skill elements for each Task included in each Area of Operation of the ACS, unless otherwise noted. The evaluator administering the practical test has the discretion to combine Tasks/elements as appropriate to testing scenarios.

The required minimum elements to include in the POA, unless otherwise noted, from each applicable Task are as follows:

- at least one knowledge element;
- at least one risk management element;
- all skill elements; and

- any Task elements in which the applicant was shown to be deficient on the knowledge test.

Note: *Task elements added to the POA on the basis of being listed on the AKTR may satisfy the other minimum Task element requirements. The missed items on the AKTR are not required to be added in addition to the minimum Task element requirements.*

There is no expectation for testing every knowledge and risk management element in a Task, but the evaluator has discretion to sample as needed to ensure the applicant's mastery of that Task.

Unless otherwise noted in the Task, the evaluator must test each item in the skills section by asking the applicant to perform each one. As safety of flight conditions permit, the evaluator should use questions during flight to test knowledge and risk management elements not evident in the demonstrated skills. To the greatest extent practicable, evaluators should test the applicant's ability to apply and correlate information, and use rote questions only when they are appropriate for the material being tested. If the Task includes an element with sub-elements, the evaluator may choose the primary element and select at least one sub-element to satisfy the requirement that at least one knowledge element be selected. For example, if the evaluator chooses PA.I.H.K1, he or she must select a sub-element like PA.I.H.K1e to satisfy the requirement to select one knowledge element.

Possible Outcomes of the Test

There are three possible outcomes of the practical test: (1) Temporary Airman Certificate (satisfactory), (2) Notice of Disapproval (unsatisfactory), or (3) Letter of Discontinuance.

If the evaluator determines that a Task is incomplete, or the outcome is uncertain, the evaluator must require the applicant to repeat that Task, or portions of that Task. This provision does not mean that instruction, practice, or the repetition of an unsatisfactory Task is permitted during the practical test.

If the outcome is unsatisfactory, the evaluator must issue a Notice of Disapproval.

Satisfactory Performance

In accordance with 14 CFR part 61, section 61.43, satisfactory performance requires that the applicant:

- Demonstrate the Tasks specified in the Areas of Operation for the certificate or rating sought within the established standards;
- Demonstrate mastery of the aircraft by performing each Task successfully;
- Demonstrate proficiency and competency in accordance with the approved standards;
- Demonstrate sound judgment and exercise aeronautical decision-making/risk management; and

The applicant is expected to demonstrate competence in resource management (CRM/SRM) appropriate to the aircraft and Tasks.

Satisfactory performance will result in the issuance of a temporary certificate.

Unsatisfactory Performance

Typical areas of unsatisfactory performance and grounds for disqualification include:

- Any action or lack of action by the applicant that requires corrective intervention by the evaluator to maintain safe flight.
- Failure to use proper and effective visual scanning techniques to clear the area before and while performing maneuvers.
- Consistently exceeding tolerances stated in the skill elements of the Task.
- Failure to take prompt corrective action when tolerances are exceeded.
- Failure to exercise risk management.

If, in the judgment of the evaluator, the applicant does not meet the standards for any Task, the applicant fails the Task and associated Area of Operation. The test is unsatisfactory, and the evaluator issues a Notice of Disapproval. The evaluator lists the Area(s) of Operation in which the applicant did not meet the standard, any Area(s) of Operation not tested, and the number of practical test failures. The evaluator should also list the Tasks failed or Tasks not tested within any unsatisfactory or partially completed Area(s) of Operation. If the applicant's inability to meet English language requirements contributed to the failure of a Task, the evaluator must note "English Proficiency" on the Notice of Disapproval.

The evaluator or the applicant may end the test if the applicant fails a Task. The evaluator may continue the test only with the consent of the applicant. The applicant is entitled to credit only for those Areas of Operation and the associated Tasks performed satisfactorily.

Discontinuance

When it is necessary to discontinue a practical test for reasons other than unsatisfactory performance (e.g., equipment failure, weather, illness), the evaluator must return all test paperwork to the applicant. The evaluator must prepare, sign, and issue a Letter of Discontinuance that lists those Areas of Operation the applicant successfully completed and the time period remaining to complete the test. The evaluator should advise the applicant to present the Letter of Discontinuance to the evaluator when the practical test resumes in order to receive credit for the items successfully completed. The Letter of Discontinuance becomes part of the applicant's certification file.

Testing after Discontinuance or Unsatisfactory Performance

In accordance with 14 CFR part 61, section 61.39(f), a discontinued or unsatisfactory practical test cycle completes within two calendar months after the month the applicant begins the test. In addition and in accordance with section 61.43(f), an applicant may receive credit for items passed, but only within a 60-day period after the date of a first failure or Letter of Discontinuance. When an applicant is entitled to credit for Areas of Operation previously passed as indicated on a Notice of Disapproval or Letter of Discontinuance, evaluators should continue using the PTS/ACS effective on the start date of the test cycle. The evaluator has discretion to reevaluate any Task(s) successfully completed within a failed or partially tested Area of Operation.

Practical Test Checklist (Applicant)
Appointment with Evaluator

Evaluator's Name: ____

Location: ____

Date/Time: ____

Acceptable Aircraft

- ☐ Aircraft Documents:
  - ☐ Airworthiness Certificate
  - ☐ Registration Certificate
  - ☐ Operating Limitations
- ☐ Aircraft Maintenance Records:
  - ☐ Logbook Record of Airworthiness Inspections and AD Compliance
- ☐ Pilot's Operating Handbook, FAA-Approved Aircraft Flight Manual

Personal Equipment

- ☐ View-Limiting Device
- ☐ Current Aeronautical Charts (printed or electronic)
- ☐ Computer and Plotter
- ☐ Flight Plan Form and Flight Logs (printed or electronic)
- ☐ Chart Supplements, Airport Diagrams, and appropriate publications
- ☐ Current AIM

Personal Records

- ☐ Identification—Photo/Signature ID
- ☐ Pilot Certificate
- ☐ Current Medical Certificate or BasicMed qualification (when applicable)
- ☐ Completed FAA Form 8710-1, Airman Certificate and/or Rating Application with Instructor's Signature or completed IACRA form
- ☐ Original Airman Knowledge Test Report
- ☐ Pilot Logbook with appropriate Instructor Endorsements
- ☐ FAA Form 8060-5, Notice of Disapproval (if applicable)
- ☐ Letter of Discontinuance (if applicable)
- ☐ Approved School Graduation Certificate (if applicable)
- ☐ Evaluator's Fee (if applicable)

Additional Rating Task Table

For an applicant who holds at least a Private Pilot Certificate and seeks an additional airplane category and/or class rating at the private pilot level, the evaluator must evaluate that applicant in the Areas of Operation and Tasks listed in the Additional Rating Task Table. Please note, however, that the evaluator has the discretion to evaluate the applicant's competence in the remaining Areas of Operation and Tasks.

If the applicant holds two or more category or class ratings at least at the private level, and the ratings table indicates differing required Tasks, the "least restrictive" entry applies. For example, if "All" and "None" are indicated for one Area of Operation, the "None" entry applies. If "B" and "B, C" are indicated, the "B" entry applies.

Addition of an Airplane Single-Engine Land Rating to an existing Private Pilot Certificate

Required Tasks are indicated by either the Task letter(s) that apply(s) or an indication that all or none of the Tasks must be tested based on the notes in each Area of Operation.

Private Pilot Rating(s) Held

Areas of Operation	ASES	AMEL	AMES	RH	RG	Glider	Balloon	Airship
I	F,G	F,G	F,G	F,G	F,G	F,G	F,G	F,G
II	A,B,D,F	A,B,F	A,B,D,F	A,B,C,D,F	A,B,C,D,F	A,B,C,D,F	A,B,C, D,F	A,B,C, D,F
III	B	None	B	B	B	B	B	B
IV	A,B,C, D,E,F	A,B,C, D,E,F,M	A,B,C, D,E,F,M	A,B,C,D, E,F,M,N	A,B,C,D, E,F,M,N	A,B,C,D, E,F,M,N	A,B,C,D, E,F,M,N	A,B,C,D, E,F,M,N
V	None	None	None	A,B	A	A,B	A,B	A,B
VI	None	None	None	None	None	A,B,C,D	A,B,C,D	None
VII	None	None	None	All	All	All	All	All
VIII	None	None	None	A,B,C, D,E,F	A,B,C, D,E,F	A,B,C, D,E,F	A,B,C, D,E,F	A,B,C, D,E,F
IX	A,B,C	A,B,C	A,B,C	A,B,C,D	A,B,C,D	A,B,C,D	A,B,C,D	A,B,C,D
X	None	None	None	None	None	None	None	None
XI	None	None	None	None	None	A	A	A
XII	A	None	A	A	A	A	A	A

Addition of an Airplane Single-Engine Sea Rating to an existing Private Pilot Certificate

Required Tasks are indicated by either the Task letter(s) that apply(s) or an indication that all or none of the Tasks must be tested based on the notes in each Area of Operation.

Private Pilot Rating(s) Held

Areas of Operation	ASEL	AMEL	AMES	RH	RG	Glider	Balloon	Airship
I	F,G,I	F,G,I	F,G	F,G,I	F,G,I	D,F,G,I	D,F,G,I	D,F,G,I
II	A,B,E,F	A,B,E,F	A,B,,F	A,B,C,E,F	A,B,C,E,F	A,B,C,E,F	A,B,C,E,F	A,B,C,E,F
III	B	B	None	B	B	B	B	B
IV	A,B,G,H,I, J,K,L	A,B,G,H I,J,K,L,M	A,B,M	A,B,G,H,I, J,K,L,M,N	A,B,G,H,I, J,K,L,M,N	A,B,G,H,I, J,K,L,M,N	A,B,G,H,I, J,K,L,M,N	A,B,G,H,I, J,K,L,M,N
V	None	None	None	All	A	All	All	All
VI	None	None	None	None	None	All	All	None
VII	None	None	None	All	All	All	All	All
VIII	None	None	None	All	All	All	All	All
IX	None	B,C	B,C	A,B,C	A,B,C	A,B,C	A,B,C	A,B,C
X	None	None	None	None	None	None	None	None
XI	None	None	None	None	None	All	All	All
XII	B	B	None	B	B	B	B	B

Addition of an Airplane Multiengine Land Rating to an existing Private Pilot Certificate

Required Tasks are indicated by either the Task letter(s) that apply(s) or an indication that all or none of the Tasks must be tested based on the notes in each Area of Operation.

Private Pilot Rating(s) Held

Areas of Operation	ASEL	ASES	AMES	RH	RG	Glider	Balloon	Airship
I	F,G	F,G	F,G	F,G	F,G	D,F,G	D,F,G	F,G
II	A,B,C, D,F	A,B,C, D,F	A,D	A,B,C, D,F	A,B,C, D,F	A,B,C, D,F	A,B,C, D,F	A,B,C, D,F
III	None	B	B	B	B	B	B	B
IV	A,B,E,F	A,B,E,F	A,B,E,F	A,B,E, F,N	A,B,E, F,N	A,B,E, F,N	A,B,E, F,N	A,B,E, F,N
V	A	A	None	All	A	All	All	All
VI	None	None	None	None	None	All	All	None
VII	All	All	None	All	All	All	All	All
VIII	None	None	None	All	All	All	All	All
IX	E,F,G	E,F,G	None	A,C, E,F,G	A,C, E,F,G	A,C, E,F,G	A,C, E,F,G	A,C, E,F,G
X*	All	All	None	All	All	All	All	All
XI	None	None	None	None	None	A	A	A
XII	None	A	A	A	A	A	A	A

* Tasks C and D are not required for applicants who are instrument-rated and who have previously demonstrated instrument proficiency in a multiengine airplane or for applicants who do not hold an instrument rating.

Addition of an Airplane Multiengine Sea Rating to an existing Private Pilot Certificate

Required Tasks are indicated by either the Task letter(s) that apply(s) or an indication that all or none of the Tasks must be tested based on the notes in each Area of Operation.

Private Pilot Rating(s) Held

Areas of Operation	ASEL	ASES	AMEL	RH	RG	Glider	Balloon	Airship
I	F,G,I	F,G	F,G,I	F,G,I	F,G,I	D,F,G,I	D,F,G,I	F,G,I
II	A,B,E,F	A,B,E,F	A,B,E,F	A,B,C,E,F	A,B,C,E,F	A,B,C,E,F	A,B,C,E,F	A,B,C,E,F
III	None	None	None	B	B	B	B	B
IV	A,B,G,H, I,J,K,L	A,B	A,B,G,H, I,J,K,L	A,B,G,H,I, J,K,L,N	A,B,G,H,I, J,K,L,N	A,B,G,H,I, J,K,L,N	A,B,G,H,I, J,K,L,N	A,B,G,H,I, J,K,L,N
V	A	A	None	All	A	All	All	All
VI	None	None	None	None	None	All	All	None
VII	All	All	None	All	All	All	All	All
VIII	None	None	None	All	All	All	All	All
IX	E,F,G	E,F,G	None	A,C,E,F,G	A,C,E,F,G	A,C,E,F,G	A,C,E,F,G	A,C,E,F,G
X*	All	All	None	All	All	All	All	All
XI	None	None	None	None	None	All	All	All
XII	B	None	B	B	B	B	B	B

Note: *An applicant who holds a Private Airplane Multiengine Land Rating (AMEL) without a center thrust limitation is not required to supply a seaplane with propeller feathering capability when testing to add a Private Airplane Multiengine Sea Rating (AMES).*

* Tasks C and D are not required for applicants who are instrument-rated and who have previously demonstrated instrument proficiency in a multiengine airplane or for applicants who do not hold an instrument rating.

Removal of the "Airplane Multiengine VFR Only" Limitation

The removal of the "Airplane Multiengine VFR Only" limitation, at the private pilot certificate level, requires an applicant to satisfactorily perform the following Area of Operation and Tasks from the Private Pilot – Airplane ACS in a multiengine airplane that has a manufacturer's published V_{MC} speed.

X.	**Multiengine Operations**	
	Task C:	Engine Failure During Flight (by Reference to Instruments) (AMEL, AMES)
	Task D:	Instrument Approach and Landing with an Inoperative Engine (Simulated) (by Reference to Instruments) (AMEL, AMES)

Removal of the "Limited to Center Thrust" Limitation

The "Limited to Center Thrust" limitation for the AMEL rating is issued to applicants who complete the practical test for the AMEL rating in an aircraft that does not have a manufacturer's published V_{MC}. When conducting a practical test for the purpose of removing the "Limited to Center Thrust" limitation from the AMEL rating, the applicant must be tested on the multiengine Tasks identified in the table below in a multiengine airplane that has a manufacturer's published V_{MC} speed. This speed would be found on the type certificate data sheet (TCDS) or in the AFM. If the limitation will be removed under parts 121, 135, or 142, it must be done in accordance with an approved curriculum or training program. An applicant who holds an airplane instrument rating and has not demonstrated instrument proficiency in a multiengine airplane with a published V_{MC} shall complete the additional Tasks listed under Removal of the "Airplane Multiengine VFR Only" Limitation section.

IX.	**Emergency Operations**	
	Task E:	Engine Failure During Takeoff Before V_{MC} (Simulated) (AMEL and AMES)
	Task F:	Engine Failure After Liftoff (Simulated) (AMEL, AMES)
	Task G:	Approach and Landing with an Inoperative Engine (Simulated) (AMEL, AMES)
X.	**Multiengine Operations**	
	Task A:	Maneuvering with One Engine Inoperative (AMEL, AMES)
	Task B:	V_{MC} Demonstration (AMEL and AMES)

Appendix 6: Safety of Flight

General

Safety of flight must be the prime consideration at all times. The evaluator, applicant, and crew must be constantly alert for other traffic. If performing aspects of a given maneuver, such as emergency procedures, would jeopardize safety, the evaluator will ask the applicant to simulate that portion of the maneuver. The evaluator will assess the applicant's use of visual scanning and collision avoidance procedures throughout the entire test.

Stall and Spin Awareness

During flight training and testing, the applicant and the instructor or evaluator must always recognize and avoid operations that could lead to an inadvertent stall or spin and inadvertent loss of control.

Use of Checklists

Throughout the practical test, the applicant is evaluated on the use of an appropriate checklist.

Assessing proper checklist use depends upon the specific Task. In all cases, the evaluator should determine whether the applicant appropriately divides attention and uses proper visual scanning. In some situations, reading the actual checklist may be impractical or unsafe. In such cases, the evaluator should assess the applicant's performance of published or recommended immediate action "memory" items along with his or her review of the appropriate checklist once conditions permit.

In a single-pilot airplane, the applicant should demonstrate the crew resource management (CRM) principles described as single-pilot resource management (SRM). Proper use is dependent on the specific Task being evaluated. The situation may be such that the use of the checklist while accomplishing elements of an Objective would be either unsafe or impractical in a single-pilot operation. In this case, a review of the checklist after the elements have been accomplished is appropriate.

Use of Distractions

Numerous studies indicate that many accidents have occurred when the pilot has been distracted during critical phases of flight. The evaluator should incorporate realistic distractions during the flight portion of the practical test to evaluate the pilot's situational awareness and ability to utilize proper control technique while dividing attention both inside and outside the cockpit.

Positive Exchange of Flight Controls

There must always be a clear understanding of who has control of the aircraft. Prior to flight, the pilots involved should conduct a briefing that includes reviewing the procedures for exchanging flight controls.

The FAA recommends a positive three-step process for exchanging flight controls between pilots:

- When one pilot seeks to have the other pilot take control of the aircraft, he or she will say, "You have the flight controls."
- The second pilot acknowledges immediately by saying, "I have the flight controls."
- The first pilot again says, "You have the flight controls," and visually confirms the exchange.

Pilots should follow this procedure during any exchange of flight controls, including any occurrence during the practical test. The FAA also recommends that both pilots use a visual check to verify that the exchange has occurred. There must never be any doubt as to who is flying the aircraft.

Aeronautical Decision-Making, Risk Management, Crew Resource Management and Single-Pilot Resource Management

Throughout the practical test, the evaluator must assess the applicant's ability to use sound aeronautical decision-making procedures in order to identify hazards and mitigate risk. The evaluator must accomplish this requirement by reference to the risk management elements of the given Task(s), and by developing scenarios that incorporate and combine Tasks appropriate to assessing the applicant's risk management in making safe aeronautical decisions. For example, the evaluator may develop a scenario that incorporates weather decisions and performance planning.

In assessing the applicant's performance, the evaluator should take note of the applicant's use of CRM and, if appropriate, SRM. CRM/SRM is the set of competencies that includes situational awareness, communication skills, teamwork, task allocation, and decision-making within a comprehensive framework of standard operating procedures (SOP). SRM specifically refers to the management of all resources onboard the aircraft as well as outside resources available to the single pilot.

Deficiencies in CRM/SRM almost always contribute to the unsatisfactory performance of a Task. While evaluation of CRM/SRM may appear to be somewhat subjective, the evaluator should use the risk management elements of the given Task(s) to determine whether the applicant's performance of the Task(s) demonstrates both understanding and application of the associated risk management elements.

Multiengine Considerations

On multiengine practical tests, where the failure of the most critical engine after liftoff is required, the evaluator must consider local atmospheric conditions, terrain, and type of aircraft used. The evaluator must not simulate failure of an engine until attaining at least V_{SSE}/V_{XSE}/V_{YSE} and an altitude not lower than 400 feet AGL.

The applicant must supply an airplane that does not prohibit the demonstration of feathering the propeller in flight. However, an applicant holding an unrestricted AMEL rating may take a practical test for the addition of an AMES rating in an AMES without propeller feathering capability. Practical tests conducted in a flight simulation training device (FSTD) can only be accomplished as part of an approved curriculum or training program. Any limitations or powerplant failure will be noted in that program.

For safety reasons, when the practical test is conducted in an airplane, the applicant must perform Tasks that require feathering or shutdown only under conditions and at a position and altitude where it is possible to make a safe landing on an established airport if there is difficulty in unfeathering the propeller or restarting the engine. The evaluator must select an entry altitude that will allow the single-engine demonstration Tasks to be completed no lower than 3,000 feet AGL or the manufacturer's recommended altitude (whichever is higher). If it is not possible to unfeather the propeller or restart the engine while airborne, the applicant and the evaluator should treat the situation as an emergency. At altitudes lower than 3,000 feet AGL, engine failure should be simulated by reducing throttle to idle and then establishing zero thrust.

Engine failure (simulated) during takeoff should be accomplished prior to reaching 50 percent of the calculated V_{MC}.

Single-Engine Considerations

For safety reasons, the evaluator will not request a simulated powerplant failure in a single-engine airplane unless it is possible to safely complete a landing.

High-Performance Airplane Considerations

In some high-performance airplanes, the power setting may have to be reduced below the ACS guidelines power setting to prevent excessively high pitch attitudes greater than 30° nose up.

Appendix 7: Aircraft, Equipment, and Operational Requirements & Limitations

Aircraft Requirements & Limitations

14 CFR part 61, section 61.45 prescribes the required aircraft and equipment for a practical test. The regulation states the minimum aircraft registration and airworthiness requirements as well as the minimum equipment requirements, to include the minimum required controls.

Multiengine practical tests require normal engine shutdowns and restarts in the air, to include propeller feathering and unfeathering. The Airplane Flight Manual (AFM) must not prohibit these procedures, but low power settings for cooling periods prior to the actual shutdown in accordance with the AFM are acceptable and encouraged. For a type rating in an airplane not certificated with inflight unfeathering capability, a simulated powerplant failure is acceptable.

If the multiengine airplane used for the practical test does not publish a V_{MC}, then the "Limited to Centerline Thrust" limitation will be added to the certificate issued from this check, unless the applicant has previously demonstrated competence in a multiengine airplane with a published V_{MC}.

If the aircraft presented for the practical test has inoperative instruments or equipment, it must be addressed in accordance with 14 CFR part 91, section 91.213. If the aircraft can be operated in accordance with 14 CFR part 91, section 91.213, then it must be determined if the inoperative instruments or equipment are required to complete the practical test.

Equipment Requirements & Limitations

The equipment examination should be administered before the flight portion of the practical test, but it must be closely coordinated and related to the flight portion.

The aircraft must meet the requirements as outlined in 14 CFR part 61, section 61.45.

To assist in management of the aircraft during the practical test, the applicant is expected to demonstrate automation management skills by utilizing installed, available, or airborne equipment such as autopilot, avionics and systems displays, and/or a flight management system (FMS). The evaluator is expected to test the applicant's knowledge of the systems that are available or installed and operative during both the ground and flight portions of the practical test. If the applicant has trained using a portable EFB to display charts and data, and wishes to use the EFB during the practical test, the applicant is expected to demonstrate appropriate knowledge, risk management, and skill.

If the practical test is conducted in an aircraft, the applicant is required by 14 CFR part 61, section 61.45(d)(2) to provide an appropriate view limiting device acceptable to the evaluator. The applicant and the evaluator should establish a procedure as to when and how this device should be donned and removed, and brief this procedure before the flight. The device must be used during all testing that requires flight "solely by reference to instruments" included as part of the Task objective. This device must prevent the applicant from having visual reference outside the aircraft, but it must not restrict the evaluator's ability to see and avoid other traffic. The use of the device does not apply to specific elements within a Task when there is a requirement for visual references.

Operational Requirements, Limitations, & Task Information

V. Performance and Ground Reference Maneuvers

Task B. Ground Reference Maneuvers

As noted in the skill elements, the evaluator must choose at least one maneuver for the applicant to demonstrate:

- Rectangular course
- S-Turns
- Turns around a point

VII. Slow Flight and Stalls

Task A. Maneuvering During Slow Flight

Evaluation criteria for this Task should recognize that environmental factors (e.g., turbulence) may result in a momentary activation of stall warning indicators such as the stall horn. If the applicant recognizes the stall warning indication and promptly makes an appropriate correction, a momentary activation does not constitute unsatisfactory performance on this Task. As with other Tasks, unsatisfactory performance would arise from an applicant's continual deviation from the standard, lack of correction, and/or lack of recognition.

Task B. Power-Off Stalls

Evaluation criteria for a recovery from an approach to stall should not mandate a predetermined value for altitude loss and should not mandate maintaining altitude during recovery. Proper evaluation criteria should consider the multitude of external and internal variables that affect the recovery altitude.

Task C. Power-On Stalls

In some high-performance airplanes, the power setting may have to be reduced below the ACS guidelines power setting to prevent excessively high pitch attitudes greater than 30° nose up. Evaluation criteria for a recovery from an approach to stall should not mandate a predetermined value for altitude loss and should not mandate maintaining altitude during recovery. Proper evaluation criteria should consider the multitude of external and internal variables that affect the recovery altitude.

IX. Emergency Operations

Task E. Engine Failure During Takeoff Before V_{MC} (Simulated) (AMEL, AMES)

Engine failure (simulated) during takeoff should be accomplished prior to reaching 50 percent of the calculated V_{MC}.

X. Multiengine Operations

Task B. V_{MC} Demonstration (AMEL, AMES)

Airplanes with normally aspirated engines will lose power as altitude increases because of the reduced density of the air entering the induction system of the engine. This loss of power will result in a V_{MC} lower than the stall speed at higher altitudes. Therefore, recovery should be made at the first indication of loss of directional control, stall warning, or buffet. Do not perform this maneuver by increasing the pitch attitude to a high angle with both engines operating and then reducing power on the critical engine. This technique is hazardous and may result in loss of airplane control.

Task C. Engine Failure During Flight (by Reference to Instruments) (AMEL, AMES)

This Task is not required if an instrument-rated applicant has previously demonstrated instrument proficiency in a multiengine airplane, or if the applicant does not hold an Instrument Airplane Rating. If an applicant holds both a single- and multiengine rating on a pilot certificate, but has not demonstrated instrument proficiency in a multiengine aircraft, that airman's certificate must bear a limitation indicating that multiengine flight is permitted in visual flight rules (VFR) conditions only.

Task D. Instrument Approach and Landing with an Inoperative Engine (Simulated) (by Reference to Instruments) (AMEL, AMES)

This Task is not required if an instrument-rated applicant has previously demonstrated instrument proficiency in a multiengine airplane, or if the applicant does not hold an Instrument Airplane Rating. If an applicant holds both a single- and multiengine rating on a pilot certificate, but has not demonstrated instrument proficiency in a multiengine aircraft, that airman's certificate must bear a limitation indicating that multiengine flight is permitted in visual flight rules (VFR) conditions only.

Appendix 8: Use of Flight Simulation Training Devices (FSTD) and Aviation Training Devices (ATD): Airplane Single-Engine, Multiengine Land and Sea

Use of Flight Simulator Training Devices

14 CFR part 61, section 61.4, *Qualification and approval of flight simulators and flight training devices*, states in paragraph (a) that each full flight simulator (FFS) and flight training device (FTD) used for training, and for which an airman is to receive credit to satisfy any training, testing, or checking requirement under this chapter, must be qualified and approved by the Administrator for—

> *(1) the training, testing, and checking for which it is used;*
>
> *(2) each particular maneuver, procedure, or crewmember function performed; and*
>
> *(3) the representation of the specific category and class of aircraft, type of aircraft, particular variation within the type of aircraft, or set of aircraft for certain flight training devices.*

14 CFR part 60 prescribes the rules governing the initial and continuing qualification and use of all Flight Simulator Training Devices (FSTD) used for meeting training, evaluation, or flight experience requirements for flight crewmember certification or qualification.

An FSTD is defined in 14 CFR part 60 as an FFS or FTD:

> ***Full Flight Simulator (FFS)****—a replica of a specific type, make, model, or series aircraft. It includes the equipment and computer programs necessary to represent aircraft operations in ground and flight conditions, a visual system providing an out-of-the-flight deck view, a system that provides cues at least equivalent to those of a three-degree-of-freedom motion system, and has the full range of capabilities of the systems installed in the device as described in part 60 of this chapter and the qualification performance standard (QPS) for a specific FFS qualification level. (part 1)*
>
> ***Flight Training Device (FTD)****—a replica of aircraft instruments, equipment, panels, and controls in an open flight deck area or an enclosed aircraft flight deck replica. It includes the equipment and computer programs necessary to represent aircraft (or set of aircraft) operations in ground and flight conditions having the full range of capabilities of the systems installed in the device as described in part 60 of this chapter and the QPS for a specific FTD qualification level (part 1).*

The FAA National Simulator Program (NSP) qualifies Level A-D FFSs and Level 4 – 7[1] FTDs. In addition, each operational rule part identifies additional requirements for the approval and use of FSTDs in a training program[2]. Use of an FSTD for the completion of the private pilot airplane practical test is permitted only when accomplished in accordance with an FAA approved curriculum or training program.

Use of Aviation Training Devices

14 CFR part 61, section 61.4(c) states the Administrator may approve a device other than an FFS or FTD for specific purposes. Under this authority, the FAA's General Aviation and Commercial Division provides approvals for aviation training devices (ATD).

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[1]The FSTD qualification standards in effect prior to part 60 defined a Level 7 FTD for airplanes (see Advisory Circular 120-45A, Airplane Flight Training Device Qualification, 1992). This device required high fidelity, airplane specific aerodynamic and flight control models similar to a Level D FFS, but did not require a motion cueing system or visual display system. In accordance with the "grandfather rights" of 14 CFR part 60, section 60.17, these previously qualified devices will retain their qualification basis as long as they continue to meet the standards under which they were originally qualified. There is only one airplane Level 7 FTD with grandfather rights that remains in the U.S. As a result of changes to part 60 that were published in the Federal Register in March 2016, the airplane Level 7 FTD was reinstated with updated evaluation standards. The new Level 7 FTD will require a visual display system for qualification. The minimum qualified Tasks for the Level 7 FTD are described in Table B1B of Appendix B of part 60.

[2] 14 CFR part 121, section 121.407; part 135, section 135.335; part 141, section 141.41; and part 142, section 142.59.

Advisory Circular (AC) 61-136A, *FAA Approval of Aviation Training Devices and Their Use for Training and Experience,* provides information and guidance for the required function, performance, and effective use of ATDs for pilot training and aeronautical experience (including instrument currency). FAA issues a letter of authorization (LOA) to an ATD manufacturer approving an ATD as a basic aviation training device (BATD) or an advanced aviation training device (AATD). LOAs are valid for a five-year period with a specific expiration date and include the amount of credit a pilot may take for training and experience requirements.

> ***Aviation Training Device (ATD)****—a training device, other than an FFS or FTD, that has been evaluated, qualified, and approved by the Administrator. In general, this includes a replica of aircraft instruments, equipment, panels, and controls in an open flight deck area or an enclosed aircraft cockpit. It includes the hardware and software necessary to represent a category and class of aircraft (or set of aircraft) operations in ground and flight conditions having the appropriate range of capabilities and systems installed in the device as described within AC 61-136 for the specific basic or advanced qualification level.*

> ***Basic Aviation Training Device (BATD)****—provides an adequate training platform for both procedural and operational performance Tasks specific to instrument experience and the ground and flight training requirements for the Private Pilot Certificate and Instrument Rating per 14 CFR parts 61 and 141.*

> ***Advanced Aviation Training Device (AATD)****—provides an adequate training platform for both procedural and operational performance Tasks specific to the ground and flight training requirements for the Private Pilot Certificate, Instrument Rating Certificate, Commercial Pilot Certificate, Airline Transport Pilot Certificate, and Flight Instructor Certificate per 14 CFR parts 61 and 141. It also provides an adequate platform for Tasks required for instrument experience and the instrument proficiency check.*

Note: *ATDs cannot be used for practical tests, aircraft type specific training, or for an aircraft type rating; therefore use of an ATD for the private pilot airplane practical test is not permitted.*

Credit for Time in an FSTD

14 CFR part 61, section 61.109 specifies the minimum aeronautical experience requirements for a person applying for a Private Pilot Certificate. Paragraphs (a) and (b) specify the time requirements for a Private Pilot Certificate in a single-engine airplane and a multiengine airplane, respectively[3]. These paragraphs include specific experience requirements that must be completed in an airplane. Paragraph (k) of this section specifies the amount of credit a pilot can take for time in an FFS or FTD. For those that received training in programs outside of 14 CFR part 142, section 61.109(k)(1)[4] applies. For those pilots that received training through a 14 CFR part 142 program, section 61.109(k)(2) applies.

Credit for Time in an ATD

14 CFR part 61, section 61.109 specifies the minimum aeronautical experience requirements for a person applying for a private pilot certificate Paragraphs (a) and (b) specify the time requirements for a private pilot certificate in a single-engine airplane and a multiengine airplane, respectively[5]. These paragraphs include specific experience requirements that must be completed in an airplane. Paragraph (k) of this section specifies the amount of credit a pilot can take towards the private pilot certificate aeronautical experience requirements.

In order to credit pilot time, an ATD must be FAA-approved and the time must be provided by an authorized instructor. AC 61-136A, states the LOA for each approved ATD will indicate the credit allowances for pilot training and experience, as provided under 14 CFR parts 61 and 141. Time with an instructor in a BATD and an AATD may be credited towards the aeronautical experience requirements for the private pilot certificate as specified in the LOA for the device used. It is recommended that applicants who intend to take credit for time in a BATD or an AATD towards the aeronautical experience requirements for the private pilot certificate obtain a copy of the LOA for each device used so they have a record for how much credit may be taken. For additional information on the logging of ATD time, reference AC 61-136A.

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[3] The minimum aeronautical experience requirements may be further reduced as permitted in 14 CFR part 61, section 61.109(k)(3).

[4] As part of program approval, 14 CFR part 141 training providers must also adhere to the requirements for permitted time in an FFS or FTD per Appendix B to 14 CFR part 141.

[5] The minimum aeronautical experience requirements may be further reduced as permitted in 14 CFR part 61, section 61.109(k)(3).

Use of an FSTD on a Practical Test

14 CFR part 61, section 61.45 specifies the required aircraft and equipment that must be provided for a practical test unless permitted to use an FFS or FTD for the flight portion. 14 CFR part, section 61.64 provides the criteria for using an FSTD for a practical test. Specifically, paragraph (a) states –

> *If an applicant for a certificate or rating uses a flight simulator or flight training device for training or any portion of the practical test, the flight simulator and flight training device—*
>
> *(1) Must represent the category, class, and type (if a type rating is applicable) for the rating sought; and*
>
> *(2) Must be qualified and approved by the Administrator and used in accordance with an approved course of training under 14 CFR part 141 or part 142 of this chapter; or under 14 CFR part 121 or part 135 of this chapter, provided the applicant is a pilot employee of that air carrier operator.*

Therefore, practical tests or portions thereof, when accomplished in an FSTD, may only be conducted by FAA aviation safety inspectors (ASI), aircrew program designees (APD) authorized to conduct such tests in FSTDs in 14 CFR parts 121 or 135, qualified personnel and designees authorized to conduct such tests in FSTDs for 14 CFR part 141 pilot school graduates, or appropriately authorized 14 CFR part 142 Training Center Evaluators (TCE).

In addition, 14 CFR part, 61 section 61.64(b) states if an airplane is not used during the practical test for a type rating for a turbojet airplane (except for preflight inspection), an applicant must accomplish the entire practical test in a Level C or higher FFS and the applicant must meet the specific experience criteria listed. If the experience criteria cannot be met, the applicant can either—

> *(f)(1) […] complete the following Tasks on the practical test in an aircraft appropriate to category, class, and type for the rating sought: Preflight inspection, normal takeoff, normal instrument landing system approach, missed approach, and normal landing; or*
>
> *(f)(2) The applicant's pilot certificate will be issued with a limitation that states: "The [name of the additional type rating] is subject to pilot-in-command limitations," and the applicant is restricted from serving as pilot-in-command in an aircraft of that type.*

When flight Tasks are accomplished in an airplane, certain Task elements may be accomplished through "simulated" actions in the interest of safety and practicality. However, when accomplished in an FFS or FTD, these same actions would not be "simulated." For example, when in an airplane, a simulated engine fire may be addressed by retarding the throttle to idle, simulating the shutdown of the engine, simulating the discharge of the fire suppression agent, if applicable, and simulating the disconnection of associated electrical, hydraulic, and pneumatics systems. However, when the same emergency condition is addressed in an FSTD, all Task elements must be accomplished as would be expected under actual circumstances.

Similarly, safety of flight precautions taken in the airplane for the accomplishment of a specific maneuver or procedure (such as limiting altitude in an approach to stall or setting maximum airspeed for an engine failure expected to result in a rejected takeoff) need not be taken when an FSTD is used. It is important to understand that, whether accomplished in an airplane or FSTD, all Tasks and elements for each maneuver or procedure must have the same performance standards applied equally for determination of overall satisfactory performance.

Appendix 9: References

This ACS is based on the following 14 CFR parts, FAA guidance documents, manufacturer's publications, and other documents.

Reference	Title
14 CFR part 39	Airworthiness Directives
14 CFR part 43	Maintenance, Preventive Maintenance, Rebuilding and Alteration
14 CFR part 61	Certification: Pilots, Flight Instructors, and Ground Instructors
14 CFR part 68	Requirements for Operating Certain Small Aircraft Without a Medical Certificate
14 CFR part 71	Designation of Class A, B, C, D and E Airspace Areas; Air Traffic Service Routes; and Reporting Points
14 CFR part 91	General Operating and Flight Rules
14 CFR part 93	Special Air Traffic Rules
AC 00-6	Aviation Weather
AC 00-45	Aviation Weather Services
AC 60-28	English Language Skill Standards Required by 14 CFR parts 61, 63, 65, and 107
AC 61-67	Stall and Spin Awareness Training
AC 91-73	Parts 91 and 135 Single Pilot, Flight School Procedures During Taxi Operations
AC 68-1	Alternative Pilot Physical Examination and Education Requirements
AC 91.21-1	Use of Portable Electronic Devices Aboard Aircraft
AIM	Aeronautical Information Manual
FAA-H-8083-1	Aircraft Weight and Balance Handbook
FAA-H-8083-2	Risk Management Handbook
FAA-H-8083-3	Airplane Flying Handbook
FAA-H-8083-6	Advanced Avionics Handbook
FAA-H-8083-15	Instrument Flying Handbook
FAA-H-8083-23	Seaplane, Skiplane, and Float/Ski Equipped Helicopter Operations Handbook
FAA-H-8083-25	Pilot's Handbook of Aeronautical Knowledge
FAA-P-8740-66	Flying Light Twins Safely Pamphlet
POH/AFM	Pilot's Operating Handbook/FAA-Approved Airplane Flight Manual
Other	Chart Supplements
	Navigation Charts
	Navigation Equipment Manual
	USCG Navigation Rules, International-Inland
	NOTAMs

Note: *Users should reference the current edition of the reference documents listed above. The current edition of all FAA publications can be found at www.faa.gov.*

Appendix 10: Abbreviations and Acronyms

The following abbreviations and acronyms are used in the ACS.

Abb./Acronym	Definition
14 CFR	Title 14 of the Code of Federal Regulations
AATD	Advanced Aviation Training Device
AC	Advisory Circular
ACS	Airman Certification Standards
AD	Airworthiness Directive
ADM	Aeronautical Decision-Making
AELS	Aviation English Language Standard
AFM	Airplane Flight Manual
AFS	Flight Standards Service
AGL	Above Ground Level
AIM	Aeronautical Information Manual
AKTR	Airman Knowledge Test Report
AMEL	Airplane Multiengine Land
AMES	Airplane Multiengine Sea
APD	Aircrew Program Designee
ASEL	Airplane Single-Engine Land
ASES	Airplane Single-Engine Sea
ASI	Aviation Safety Inspector
ATC	Air Traffic Control
ATD	Aviation Training Device
BATD	Basic Aviation Training Device
CFIT	Controlled Flight Into Terrain
CFR	Code of Federal Regulations
CG	Center of Gravity
CRM	Crew Resource Management
DA	Decision Altitude
DH	Decision Height
DPE	Designated Pilot Examiner
ELT	Emergency Locator Transmitter
ETA	Estimated Time of Arrival
FAA	Federal Aviation Administration
FFS	Full Flight Simulator
FMS	Flight Management System
FSDO	Flight Standards District Office
FSTD	Flight Simulation Training Device
FTD	Flight Training Device
ICAO	International Civil Aviation Organization
IFO	International Field Office
IFU	International Field Unit
IPC	Instrument Proficiency Check

Abb./Acronym	Definition
LAHSO	Land and Hold Short Operations
LOA	Letter of Authorization
LSC	Learning Statement Codes
MDA	Minimum Descent Altitude
MEL	Minimum Equipment List
NAS	National Airspace System
NOTAMs	Notices to Airmen
NSP	National Simulator Program
NTSB	National Transportation Safety Board
PA	Private Airplane
PAR	Private Pilot Airplane
PAT	Private Pilot Airplane/Recreational Pilot – Transition
PCP	Private Pilot Canadian Conversion
PIC	Pilot-in-Command
POA	Plan of Action
POH	Pilot's Operating Handbook
PTS	Practical Test Standards
QPS	Qualification Performance Standard
SATR	Special Air Traffic Rules
SFRA	Special Flight Rules Area
SMS	Safety Management System
SOP	Standard Operating Procedures
SRM	Single-Pilot Resource Management
SUA	Special Use Airspace
TCE	Training Center Evaluator
TFR	Temporary Flight Restrictions
TPP	Terminal Procedures Publications
UTC	Coordinated Universal Time
V_A	Maneuvering speed
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions
V_{MC}	Minimum Control Speed with the Critical Engine Inoperative
V_S	Stall Speed
V_X	Best Angle of Climb Speed
V_Y	Best Rate of Climb Speed
V_{SSE}	Safe, intentional one-engine-inoperative speed. Originally known as safe single-engine speed
V_{XSE}	Best angle of climb speed with one engine inoperative
V_{YSE}	Best rate of climb speed with one engine inoperative
V_{SO}	Stalling Speed or the Minimum Steady Flight Speed in the Landing Configuration

Federal Aviation Administration Regulations

To view the current FAA regulations, visit their website at
https://www.faa.gov/regulations_policies/faa_regulations

Fairbanks North Star Borough School District