“I Can¨ Earth and Space Science Mascoma High School Curriculum

I Have Good SCIENTIFIC SKILLS

☐ I can observe and ask questions about scientific topics.

☐ I can build and revise a simple model to represent events and design solutions.

☐ I can develop a model to describe or represent scientific phenomena.

☐ I can plan and carry out a scientific investigation to answer a question or solve a problem.

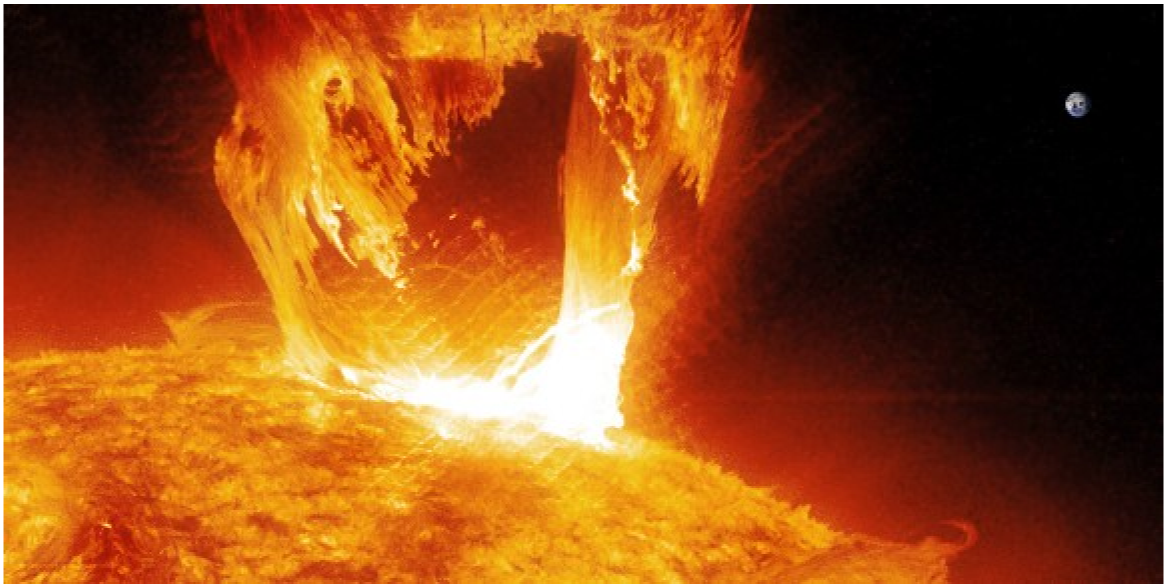
☐ I can produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials is considered.

☐ I can make observations and measurements to produce data to serve as the basis for evidence for the explanation of a phenomenon.

☐ I can measure and graph quantities such as weight and length to address scientific and engineering questions and problems.

☐ I can explain the results of a scientific investigation.

I know about Earth's Place in the Universe



☐ I can develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy that eventually reaches earth in the form of radiation (Emphasis is on the energy transfer mechanisms that allow energy from nuclear fusion in the sun's core to reach Earth. Examples of evidence for the model include observations of the masses and lifetimes of other stars, as well as the ways that the sun's radiation varies due to sudden solar flares, or space weather, the 11 year sunspot cycle, and non-cyclic variations over the centuries. Assessment does not include details of the atomic and sub-atomic processes involved with the sun's nuclear fusion).

☐ I 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. (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, found primarily in stars and interstellar gases, from the spectra of electromagnetic radiation from the stars, which matches that predicted by the Big Bang Theory- ¾ hydrogen and ¼ helium.).

☐ I can communicate scientific ideas about the way stars, over their life cycle, produce elements (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. Assessment: details of the many different nucleosynthesis pathways for stars of differing masses are not assessed).

☐ I can use mathematical or computational representations to predict the motion of orbiting objects in the solar system (Emphasis is on Newtonian gravitational laws governing orbital motions, which apply to human-made satellites as well as planets and moons. Assessment: Mathematical representations for the gravitational attraction and Kepler's Law of orbital motions should not deal with more than two bodies, nor involve calculus).

☐ I 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 (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, as a result of plate spreading, and the ages of North American continental crust increasing with distance away from a central ancient core, a result of past plate interactions.).

☐ I 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. (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.).

A little primer for my teacher: **Every student is responsible for the blue standards. Only juniors and seniors are responsible for the black standards.**

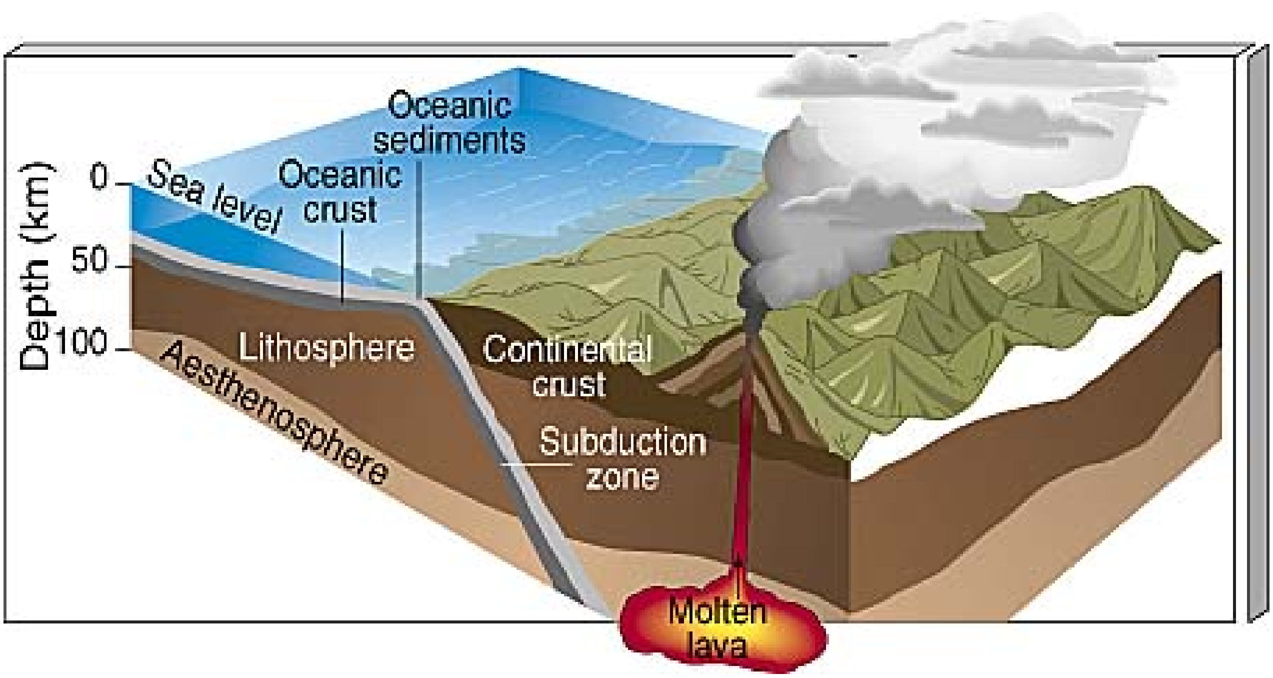
Mascoma Standards	RIST.11.1- Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.	RIST.11.8- Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
	WHST.9.1- Write arguments focused on *discipline-specific* content.	WHST.9.2- Write informative/ explanatory texts, including the narration of scientific procedures/ experiments, or technical processes.
	SL.11.4- 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.	MP.9.2- Reason abstractly and quantitatively
	MP.9.4- Model with mathematics	HSN.Q. A.9.1- 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.
	HSN.Q. A.9.2- Define appropriate quantities for the purpose of descriptive modeling.	HSN.Q. A.9.3- Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
	HSA.SSE. A.9.1- Interpret expressions that represent a quantity in terms of its context.	HSA.CED. A.9.2- Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.
	HSA.CED. A.9.4- Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.	HSF.IF. B.9.5- Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes.
	HSS.ID. B.9.6- Represent data on two quantitative variables on a scatter plot, and describe how those variables are related.	
Vocabulary	Nuclear Fusion, lifetime of stars, solar flare, space weather, sunspot cycle, Big Bang Theory, light spectra, motion of galaxies, composition of matter, red shift of light, cosmic microwave background, remnant radiation, interstellar gases, electromagnetic radiation spectra, nucleosynthesis, mass of a star, Newtonian Gravitational Laws, Kepler's Laws, orbital motion, gravitational attraction of bodies, continental crust, oceanic crust, plate tectonics, plate spreading, central ancient core, ancient Earth materials, meteorites, Earth's formation, radiometric dating, moon rocks, impact cratering record, supernova, elliptical orbit, geologic process, erosion, asteroids, radioactive decay, exponential decay law	
Disciplinary Core Ideas	The Universe and Its Stars • The star called the sun is changing and will burn out over a lifespan of approximately ten billion years. • The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distance 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 produces when certain massive stars achieve a supernova stage and explode. 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.	

	<u>The History of Planet Earth</u> • 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. • Although active geological 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. <u>Plate Tectonics and Large-Scale System Interactions</u> • 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. <u>Nuclear Processes</u> • Spontaneous radioactive decays follow a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages or rocks and other materials. <u>Energy in Chemical Processes and Everyday Life</u> • Nuclear Fusion processes in the center of the sun release the energy that ultimately reaches Earth as radiation. <u>Electromagnetic Radiation</u> • 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.
Cross-cutting Concepts	<u>Patterns</u> • Empirical evidence is needed to identify patterns. <u>Scale, Proportion, and Quantity</u> • The significance of a phenomenon is dependent on the scale, proportion and quantity at which it occurs. • 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) <u>Energy and Matter</u> • Energy cannot be created or destroyed, only moved between one place and another place, between objects and/or fields, or between systems. • In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. <u>Stability and Change</u> • Much of science deals with constructing explanations of how things change and how they remain stable. <u>Interdependence of Science, Engineering and Technology</u> • Science and engineering complement each other in the cycle known as Research and Development (R & D). Many R & D projects may involve scientists, engineers, with wide ranges of expertise. <u>Scientific Knowledge Assumes an Order and Consistency in Natural Systems</u> • Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and will continue to do so in the future. • Science assumes the universe is a vast single system in which basic laws are consistent

Science and Engineering Practice	• Develop a model based on evidence to illustrate the relationships between systems or between components of a system. • Use mathematical or computational representations of phenomena to describe explanations. • Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including student's own investigation, 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. • Apply scientific reasoning to link evidence to claims to assess the extent to which the reasoning and data support the explanation or conclusion. • Evaluate evidence behind currently accepted explanations or solutions to determine the merits of arguments. • Communicate scientific 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. • A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have 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. • Models, mechanisms, and explanations collectively serve as tools in the development of a scientific theory.

I know about Earth's Systems



☐ I 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. (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 forces- such as weathering, mass wasting, and coastal erosion. Assessment does not include memorization of the details of the formation of specific geographic features of Earth's surface.).

☐ I can analyze geoscience data to make a claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems. (Examples should include climate feedback, such as how an increase in greenhouse gases causes a rise in global temperatures that melts glacial 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 how the loss of ground vegetation causes an increase in water runoff and soil erosion; how dammed rivers increase groundwater recharge, decrease sediment transport, and increase coastal erosion; or how the loss of wetlands causes a decrease in local humidity that further reduces the wetland extent.).

☐ I can develop a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate. (Examples of the causes of climate change differ by timescale:

- Over 1-10 years- large volcanic eruption, ocean circulation
- Over 10-100s of years- change in human activity, ocean circulation, solar output
- Over 10-100,000s of years- changes to Earth's orbit and the orientation of its axis
- Over 10-100,000,000s of years- long term changes in atmospheric patterns

Assessment of the results of changes in climate is limited to changes in surface temperatures, precipitation patterns, glacial ice volumes, seal levels, and biosphere distribution).

☐ I can plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. (Emphasis is on mechanical and chemical investigations with water and a variety of solid materials to provide the evidence for 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, erosion using variation in soil moisture content, or 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 material, or melt generation, by examining how water lowers the melting temperature of most solids.).

☐ I can develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. (Emphasis is on modeling biogeochemical cycles that include cycling of carbon through the ocean, atmosphere, soil, and biosphere (including humans), providing the foundation for living organisms.).

☐ I can construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth (Emphasis is on the dynamic causes, effects, and feedbacks between the biosphere and Earth's of the systems, whereby geoscience factors control the evolution of life, which in turn continuously alters Earth's surface. Examples of 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 on new life forms. Assessment does not include a comprehensive understanding of the mechanisms of how the biosphere interacts with all of Earth's other systems).

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Mascoma Standards	RIST.11.1- 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.	RIST.11.2- Determine the central ideas or conclusions of a text; summarize complex concepts, process, or information presented in a text by paraphrasing them in simpler but still accurate terms.
	WHST.9.1- Write arguments focused on *discipline-specific* content.	WHST.9.7- Conduct short, as well as more sustained, research projects to answer a questions (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.
	SL.11.5- Make strategic use of digital media (textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning and evidence, and to add interest.	MP.9.2- Reason abstractly and quantitatively
	MP.9.4- Model with mathematics	HSN.Q. A.9.1- 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.
	HSN.Q. A.9.2- Define appropriate quantities for the purpose of descriptive modeling.	HSN.Q. A.9.3- Choose a level of accuracy appropriate to limitations on

		measurement when reporting quantities.
Vocabulary	Surface processes, temporal scale, spatial scale, continental features, ocean floor features, trenches, ridges, seamounts, constructive force, tectonic uplift, orogeny, destructive mechanisms, mass wasting, coastal erosion, geoscience, feedbacks, greenhouse gases, groundwater recharge, sediment transport, wetlands, biosphere distribution, hydrologic cycle, rock cycle, frost wedging, recrystallization, solubility, melt generation, biogeochemical cycles, coevolution, thermal convection, tectonic cycles, radioactive decay, unstable isotopes, unifying theory, viscosity, re-radiation, carbon dioxide concentrations, seismic waves	
Disciplinary Core Ideas	<u>Earth and the Solar System</u> • 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. <u>Earth Materials and Systems</u> • Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. • 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, and 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 gravitations movement of denser materials toward the interior. • The geological record show 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 intermediate (ice ages) to very long-term tectonic cycles. <u>Plate Tectonics and Large-Scale System Interactions</u> • The radioactive decay of unstable isotopes continually generates new energy within Earth's crust and mantle, providing the primary source of the heart that drives mantle convection. Plate tectonics can be viewed as the surface expression of mantle convection. • 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 geological 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. <u>The Roles of Water in Earth's Surface Processes</u> • 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. 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. • 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. 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. Wave Patterns • Geologists use seismic waves and their reflection at interfaces between layers to probe structures deep in the planet.
Cross-cutting Concepts	Cause and Effect • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. Energy and Matter • The total amount of energy and matter in closed systems is conserved. • Energy drives the cycling of matter within and between systems. 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. Stability and Change • Much of science deals with constructing explanations of how things change and how they remain stable. • Changes and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. • Feedback (negative or positive) can stabilize or destabilize a system. 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, with wide ranges of expertise. Scientific Knowledge Assumes an Order and Consistency in Natural Systems • 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.
Science and Engineering Practice	• Develop a model based on evidence to illustrate the relationships between systems or between components of a system. • Use a model to provide mechanist accounts of a phenomenon. • 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 the accuracy of data needed to produce reliable measurements and consider limitations on the precision of data (number of trials, cost, risk, time), and refine the design accordingly.

	• Analyze data using tools, technologies, and/or models (computational or mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. • Construct an oral and written argument or counter-argument based on data and evidence. • Scientific 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 patters of evidence with current theory. • Science arguments are strengthened by multiple lines of evidence supporting a single explanation.

I know about Earth and Human Activity

☐ I 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. (Emphasis of key natural resources include: access to fresh water-such as rivers, lakes and groundwater, regions of fertile soil, such as river deltas, and high concentrations of minerals 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 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, and the types of crops and livestock that can be raised.).

☐ I can evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios. (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, mining for coal, tar sands and oil shales, and pumping for petroleum and natural gas. Science knowledge indicates what can happen in natural systems- not what should happen).

☐ I can create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity (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 for computational simulations is limited to using provided multi-parameter programs or constructing simplified spreadsheet calculations.).

☐ I can evaluate of refine a technological solution that reduces impacts of human activities on natural systems (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 to large-scale geo-engineering design solutions such as altering global temperatures by making large changes to the atmosphere or ocean.).

☐ I can analyze geoscience data and the result 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 systems. (Examples of evidence, for both data and climate model outputs, are for climate changes, such as precipitation and temperature and their associated impacts on sea level, glacial ice volumes, or atmosphere and ocean composition. Assessment is limited to one example of a climate change and its associated impacts.).

☐ I can use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity. (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 does not include running computational representation but is limited to using the published results of scientific computational models.).

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	RIST.11.7- 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.	RIST.11.8- Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying data when possible and corroborating or challenging conclusions with other sources of information.
	WHST.9.2- Write informative/ explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.	MP.9.2- Reason abstractly and quantitatively
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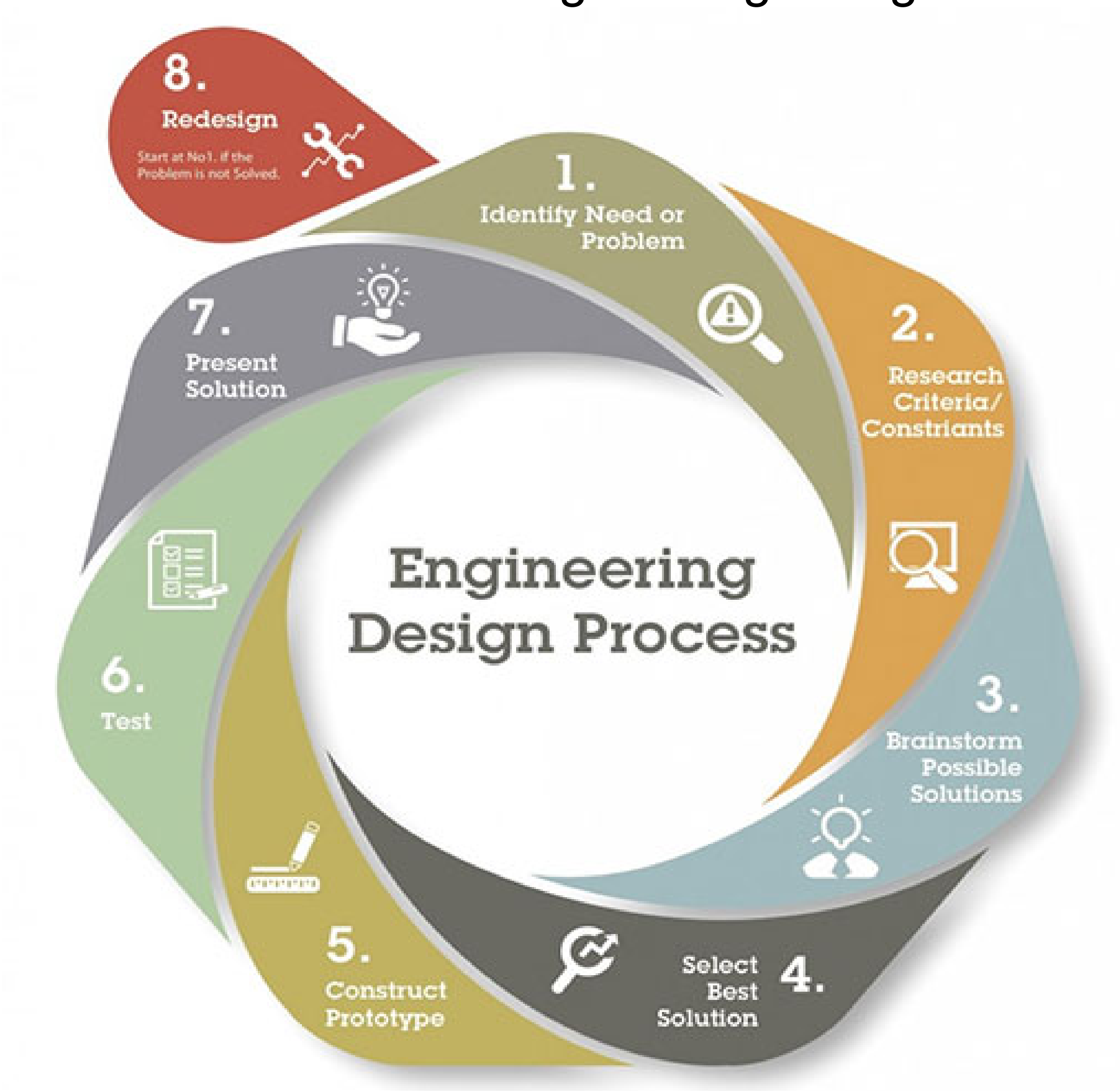
	HSN.Q. A.9.2- Define appropriate quantities for the purpose of descriptive modeling.	HSN.Q. A.9.3- Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
Vocabulary	Fossil fuels, interior processes, surface processes, cost-benefit ratio, minimizing impact, sustainability, biodiversity, resource extraction, per-capita consumption, biomass changes, species diversity, areal changes, land surface use, forecast,	

	geo-engineering, design solution, cryosphere, geopolitical, social regulations, human migration, ecosystem degradation, aesthetics
Disciplinary Core Ideas	<u>Weather and Climate</u> • 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. <u>Natural Resources</u> • Resource availability has guided the development of human society. • All forms of energy production and other resource extraction have associate economic, social, environmental and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. <u>Natural Hazards</u> • 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. <u>Human Impacts on Earth Systems</u> • The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. • Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation. <u>Global Climate Change</u> • 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. • 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. <u>Developing Possible Solutions</u> • 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.
Cross-cutting Concepts	<u>Cause and Effect</u> • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. <u>Systems and System Models</u> • When investigating or describing the system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. <u>Stability and Change</u> • Changes and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. • Feedback (negative or positive) can stabilize or destabilize a system. <u>Influence of Engineering, Technology and Science on Society and the Natural World</u> • 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. • 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. <u>Science is a Human Endeavor</u> • Science is a result of human endeavors, imagination and creativity. <u>Science Addresses Questions About the Natural and Material World</u> • 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. • Many decisions are made using science alone, but rely on social and cultural contexts to resolve issues.
Science and Engineering Practice	• Analyze data using computational models in order to make valid and reliable scientific claims. • Create a computational model or simulation of a phenomenon, designed device, process, or system. • Use a computational representation of phenomena or design solutions to describe and/or support claims and/or explanations. • Construct an explanation based on valid and reliable evidence obtained from a variety of sources including students' own investigations, models, theories, simulations, and peer reviews, 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 • Design or refine a solution to a complex, real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations. • Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and logical arguments regarding relevant factors (economic, societal, environmental, and ethical considerations. • 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 arguments are strengthened by multiple lines of evidence supporting a single explanation.

I know about Engineering Design



☐ I can analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

☐ I 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.

☐ I can evaluate a solution to a complex, real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible societal, cultural and environmental impacts.

☐ I 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.

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<table>
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<tr><td>Vocabulary</td><td colspan="2">Criteria, constraints, societal needs/wants, aesthetics, impact</td></tr>
<tr><td>Disciplinary Core Ideas</td><td colspan="2">Defining and Delimiting Engineering Problems
• Criteria and constraint 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.
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.
Optimizing the Design Solution</td></tr>
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	• 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 may be needed.
Cross-cutting Concepts	Systems and System Models • Models (physical, mathematical, and computer) can be used to simulate systems and interactions- including energy, matter, and information flows- within and between systems at different scales. 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.
Science and Engineering Practice	• Analyze complex, real-world problems by specifying criteria and constraints for successful solutions. • Use mathematical models and/or computer simulations to predict the effect of a design solution on systems and/or the interactions between systems. • Design a solution to a complex, real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations. • Evaluate a solution to a complex, real-world problem based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations.