TRUMBULL PUBLIC SCHOOLS

Trumbull, Connecticut

GRADE 9 INTEGRATED PHYSICAL SCIENCE

Science Department

2018

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Grade 9 Integrated Physical Science
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The Trumbull Board of Education will continue to take Affirmative Action to ensure that no persons are discriminated against in its employment.

CORE VALUES AND BELIEFS

The Trumbull School Community engages in an environment conducive to learning which believes that all students will **read** and **write effectively**, therefore communicating in an articulate and coherent manner. All students will participate in activities **that present problem-solving through critical thinking**. Students will use technology as a tool applying it to decision making. We believe that by fostering self-confidence, self-directed and student-centered activities, we will promote **independent thinkers and learners**. We believe **ethical conduct** to be paramount in sustaining the welcoming school climate that we presently enjoy.

Approved 8/26/2011

INTRODUCTION & PHILOSOPHY

Grade 9 Integrated Physical Science is consistent in the continued development of scientifically literate students. Authentic scientific and engineering experiences build on one another and increase in complexity throughout students' K-12 education. In 2015, the Connecticut State Board of Education adopted the Next-Generation Science Standards (NGSS), which embody the National Research Council's *Framework for K-12 Science Education* (2012). Both the *Framework* and the NGSS stress the importance of teaching classroom scientific inquiry as practiced by scientists and engineers. The *Framework* provides a vision for American science education in the 21st century, while the NGSS provide grade-level student performance expectations, disciplinary core ideas, and crosscutting concepts. The *Framework* and NGSS indicated a paradigm shift in science education, one in which teachers are to incorporate authentic learning experiences for students that reflect the nature of doing science and engineering.

The *Framework* and NGSS provide clarity to classroom scientific inquiry by stressing the importance of the eight practices of science and engineering. The practices were designed to help students understand how scientific knowledge develops, and to stimulate students' interest ing and continued study of science. Three-dimensional learning facilitates student engagement with Science and Engineering Practices and Crosscutting Concepts to deepen their understanding of Disciplinary Core Ideas in order to explain phenomena and solve problems. Three-dimensional learning promotes development of student skills in the following areas:

- Knowing, using, and interpreting scientific explanations of the natural world (Disciplinary Core Ideas, and Crosscutting Concepts)
- Generating and evaluating scientific evidence and explanations (Science and Engineering Practices)
- Participating productively in scientific practices and discourse (Science and Engineering Practices)
- Understanding the nature and development of scientific knowledge (Science and Engineering Practices, and Crosscutting Concepts)

The shift of science education reflects the interconnected nature of science as it is practiced in the real world and builds coherently across grades K-12. The NGSS focus on deeper understanding of content as well as application of content with an alignment to the Connecticut Core Standards. A deeper understanding and application of science and engineering practices prepare students for postsecondary success and citizenship in a world fueled by innovations in science and technology.

Most systems or processes depend at some level on physical and chemical subprocesses that occur within, whether the system in question is a star, Earth's atmosphere, a river, a bicycle, the human brain, or a living cell. Large-scale systems often have emergent properties that cannot be explained on the basis of atomic-scale processes; nevertheless, to understand the physical and chemical basis of a system, one must ultimately consider the structure of matter at the atomic and subatomic scales to discover how it influences the system's larger-scale structures, properties, and functions. Similarly, understanding a process at any scale requires awareness of the interactions occurring – in terms of the forces between objects, the related energy transfers, and their consequences. Earth and space sciences have much in common with the other branches of science, but they also include a unique set of scientific pursuits. Inquiries into the physical sciences (e.g., forces, energy, gravity, magnetism) have been pursued in part as a means of understanding the size, age, structure, composition, and behavior of Earth, the sun, and the moon.

Integrated Physical Science is offered at three separate course levels: Honors, Advanced College Preparatory (ACP), and College Preparatory (CP). All levels will explore each unit of study. The courses are differentiated by pacing of curriculum, rigor of exploration, depth of content knowledge, and the application of quantitative reasoning. The honors course will explore topics with the greatest depth, most rigorous exploration, deepest study of content, and furthest application of quantitative reasoning. More supports will be offered at the ACP course level, with the most supports offered at the CP course level.

COURSE GOALS

The course goals derive from the 2013 Next-Generation Science Standards, the 2010 Connecticut Core Standards, and the ISTE (International Society for Technology in Education) Technology Standards. Goals are listed specific to each unit in this curriculum guide, and developed through unit lessons using the 5-E learning model (engage, explore, explain, elaborate, evaluate) in order to encourage student engagement and foster metacognitive learning strategies through a reflective process. An important role of science education is not to teach "all the facts," but rather to prepare students with sufficient core knowledge so that they can later acquire additional information on their own.

COURSE ENDURING UNDERSTANDINGS

Students will understand that . . .

- The planet Earth is a tiny part of a vast universe that has developed over a huge expanse of time. The history of the universe, and of the structures and objects within it, can be deciphered using observations of their present condition together with knowledge of physics and chemistry. Similarly, the patterns of motion of the objects in the solar system can be described and predicted on the basis of observations and an understanding of gravity.

- Earth's surface is a complex and dynamic set of interconnected systems that interact over a wide range of temporal and spatial scales. All of Earth's processes are the result of energy flowing and matter cycling within and among the systems. For example, the motion of tectonic plates is part of the cycles of convection in Earth's mantle, driven by outflowing heat and the downward pull of gravity, which result in the formation and changes of many features of Earth's land and undersea surface. Water is essential to the dynamics of most earth systems, and it plays a significant role in shaping Earth's landscape.

- Earth's surface processes affect and are affected by human activities. Humans depend on all of the planet's systems for a variety of resources, some of which are renewable or replaceable and some of which are not. Natural hazards and other geological events can significantly alter human populations and activities.

- Matter can be understood in terms of the types of atoms present and the interactions both between and within them. Nuclear reactions involve changes in the types of atomic nuclei present and are key to the energy release from the sun and the balance of isotopes in matter.

- Interactions between any two objects can cause changes in one or both of them. An understanding of the forces between objects is important for describing how their motions change, as well as for predicting stability or instability in systems at any scale. All forces between objects arise from a few types of interactions: gravity, electromagnetism, and the strong and weak nuclear interactions.

- Interactions of objects can be explained and predicted using the concept of transfer of energy from one object or system of objects to another. The total energy within a defined system changes only by the transfer of energy into or out of the system.

- Waves are a repeating pattern of motion that transfers energy from place to place without overall displacement of matter. Light and sound are wavelike phenomena.

COURSE ESSENTIAL QUESTIONS

- What methods do scientists employ to explore and model the universe?
- How does energy flow and cycle within and between natural systems? How is energy conserved?
- What evidence-based models can explain and predict the motions and interactions of objects in a system?
- How do Earth's internal and surface processes, which operate at different spatial and temporal scales, result in the formation of characteristic terrestrial features?

- How do the availability of natural resources and the occurrence of natural hazards influence human activity?
- How can natural resources be used to efficiently generate electrical energy?

COURSE KNOWLEDGE & SKILLS

Students will understand . . .

- Patterns. Observed patterns of forms and events guide organization and classification, and they prompt questions about relationships and the factors that influence them.
- Cause and effect: Mechanism and explanation. Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts.
- Scale, proportion, and quantity. In considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system's structure or performance.
- Systems and system models. Defining the system under study – specifying its boundaries and making explicit a model of that system – provides tools for understanding and testing ideas that are applicable throughout science and engineering.
- Energy and matter: Flows, cycles, and conservation. Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems' possibilities and limitations.
- Structure and function. The way in which an object or living thing is shaped and its substructure determine many of its properties and functions.
- Stability and change. For natural and built systems alike, conditions of stability and determinants of rates of change or evolution of a system are critical elements of study.

Students will be able to . . .

- ask questions (for science) and define problems (for engineering).
- develop and use models.
- plan and carry out investigations.
- analyze and interpret data.

- use mathematics and computational thinking.
- construct explanations (for science) and design solutions (for engineering).
- engage in arguments from evidence.
- obtain, evaluate, and communicate information.

COURSE SYLLABUS

Course Name

Grade 9 Integrated Physical Science

Level

College-Preparatory , Advanced College-Preparatory , & Honors

Prerequisites

None

Materials Required

None

General Description of the Course

This course is aligned to the Next Generation Science Standards (NGSS) Disciplinary Core Ideas for Grade 9. Through the implementation of the Three Dimensions of NGSS (Disciplinary Core Ideas, Science and Engineering Practices and Cross Cutting Concepts), students will explore topics in earth and space science through physical science concepts. Students will engage in the Science and Engineering Practices throughout their studies in order to develop their ability to think critically, engage in analysis, effectively communicate and defend their understandings like a scientist or engineer. At the Honors level, algebraic reasoning and independent discovery are expected; the CP level mirrors the ACP level with additional guided inquiry.

Assured Assessments

Formative Assessments:
Formative assessments can include, but are not limited to:

- Simulation and analysis of a mathematical model (Unit 1)
- Laboratory investigation and modeling (Unit 2)
- Monitoring, observing, and defining using the Incorporated Institutions of Seismology (IRIS) Earthquake Browser (Unit 3)
- Construction and evaluation of the performance of an electromagnet (Unit 4)

Summative Assessments:

- End-of-unit assessment with multiple-choice questions and interpreting and analyzing data (Units 1, 3)
- Design, construction, and testing of device (Units 2, 4)

Core Texts

- Feather, Jr., Ralph M., Charles William McLaughlin, Marilyn Thompson, & Dinah Zike. *Physical Science with Earth Science*. Columbus: Glencoe, 2012. Print.
- Hendrik, Marc S., Gray Thompson, & Jon Turk. *Earth*. Stamford: Cengage, 2015. Print.

UNIT 1
Cosmic Evolution

Unit Goals

At the completion of this unit, students will:

NGSS.HS-ESS1-1	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.
NGSS.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~~.
NGSS.HS-PS4-1	Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media
NGSS.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.
NGSS.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.
NGSS.HS.ESS1-3	Communicate scientific ideas about the way stars, over their life cycle, produce elements.
CCS.ELA-Literacy.RST.9-10.1	Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.
CCS.ELA-Literacy.RST.9-10.7	Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.

CCS.ELA-Literacy.RST.9-10.8	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.
CCS.ELA-Literacy.WHST.9-10.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
CCS.ELA-Literacy.SL.9-10.4	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.
CCS.MP.2	Reason abstractly and quantitatively.
CCS.MP.4	Model with mathematics.
CCS.HSN-Q.A.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.
CCS.HSN-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling.
CCS.HSN-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
CCS.HSA-SSE.A.1	Interpret expressions that represent a quantity in terms of its context.
CCS.HSA-SSE.B.3	Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression.
CCS.HSA-CED.A.2	Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.
CCS.HSA-CED.A.4	Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.

CCS.HSF-IF.B.5	Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes.
CCS.HSS-ID.B.6	Represent data on two quantitative variables on a scatter plot, and describe how those variables are related.
ISTE Knowledge Constructor (Standard 3a)	Plan and employ effective research strategies to locate information and other resources for their intellectual or creative pursuits.
ISTE Knowledge Constructor (Standard 3c)	Curate information from digital resources using a variety of tools and methods to create collections of artifacts that demonstrate meaningful connections or conclusions.
ISTE Knowledge Constructor (Standard 3d)	Build knowledge by actively exploring real-world issues and problems, developing ideas and theories and pursuing answers and solutions.

Science & 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. (NGSS.HS-ESS1-1, NGSS.HS-PS1-8) Using Mathematics and Computational Thinking: • Use mathematical representations of phenomena or design solutions to describe and/or support claims and/or explanations. (NGSS.HS-PS4-1) Engaging in Argument from Evidence: • Evaluate the claims, evidence, and reasoning	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. (NGSS.HS-ESS1-1) • The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. (NGSS.HS-ESS1-2, NGSS.HS-ESS1-3) • 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	Energy and Matter: • In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. (NGSS.HS-PS1-8) • Energy cannot be created or destroyed – only moved between one place and another place, between objects and/or fields, or between systems. (NGSS.HS-ESS1-2) 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.

behind currently accepted explanations or solutions to determine the merits of arguments. (NGSS.HS-PS4-3) Constructing Explanations and Designing Solutions: • Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, 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. (NGSS.HS-ESS1-2) Obtaining, Evaluating, and Communicating Information: • 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). (NGSS.HS-ESS1-3) 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	background) that still fills the universe. (NGSS.HS-ESS1-2) • 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. (NGSS.HS-ESS1-2) 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. (NGSS.HS-PS1-8) 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 to NGSS.HS-ESS1-1) PS4.A: Wave Processes: • 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	(NGSS.HS-PS4-3) 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. (NGSS.HS-ESS1-2) Connections to Nature of Science: Scientific 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. (NGSS.HS-ESS1-2) • Science assumes the universe is a vast single system in which basic laws are consistent. (NGSS.HS-ESS1-2)

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. (NGSS.HS-ESS1-2, NGSS.HS-ESS1-6, NGSS.HS-PS4-3)	medium through which it is passing. (NGSS.HS-PS4-1) • 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. (NGSS.HS-PS4-3) 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. (NGSS.HS-PS4-3) • 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 to NGSS.HS-ESS1-2)	

Unit Essential Questions

- Given the enormous scale of the universe, how is it possible for scientists to study and develop models that explain it?
- What evidence exists to support the Big Bang as a model for the genesis of the universe?
- Where do the elements that make up the Earth, and all life on it, come from?
- How do stars produce energy?
- How does energy travel from the sun (a star) to the Earth?

- What are the properties of electromagnetic waves, and how are these properties related?
- What is the relationship between the wavelengths of light emitted from a star and its temperature?
- How does interaction with different mediums affect the behavior of waves?
- How can the distances to stars be determined to account for absolute brightness?
- How do the properties of stars lead us to understand cosmic and stellar evolution?

Scope and Sequence

1. Nuclear fusion and atomic structure
2. Electromagnetic energy
3. Stellar emission spectra
4. Stellar distance
5. Stellar evolution and nucleosynthesis

Assured Assessments

Formative Assessment:

- Students will investigate the properties of electromagnetic energy through a simulation; they will determine the relationship between frequency and wavelength through analysis of a mathematical model.

Summative Assessment:

- Students will participate in an assessment consisting of multiple-choice questions, and interpreting and analyzing data, related to cosmic and stellar evolution.

Resources

Core

- Feather, Jr., Ralph M., Charles William McLaughlin, Marilyn Thompson, & Dinah Zike. *Physical Science with Earth Science*. Columbus: Glencoe, 2012. Print.
- Hendrik, Marc S., Gray Thompson, & Jon Turk. *Earth*. Stamford: Cengage, 2015. Print.
- "Doppler Shift Interactive." http://highered.mheducation.com/sites/007299181x/student_view0/chapter6/doppler_shift_interactive.html#. Accessed July 30, 2018. Web.
- "Emission Spectroscopy Laboratory." Trumbull High School.
- "Introduction to Scientific Modeling." Trumbull High School.
- "Natural Resonance, Frequency, and Wavelength Laboratory." Trumbull High School.
- "Nuclear Fusion Laboratory." Trumbull High School.
- PhET Interactive Simulations. "Wave on a String." https://phet.colorado.edu/en/simulation/wave-on-a-string. Accessed July 30, 2018. Web.

Supplemental

- "New SAT Reading Practice Test 33: Sunspots Passage." http://www.cracksat.net/sat/reading/test-33.html. Accessed July 30, 2018. Web. adapted.

- Ruth, Carolyn. “Where Do Chemical Elements Come From?” *ChemMatters* October 2009: 6-8. Print.
- “Stellar Helium.” *The Science Teacher* 70.4 (April 2003): 10. Print.

Time Allotment

- Approximately nine weeks

UNIT 2
Planetary Motion, Forces, and Energy

Unit Goals

At the completion of this unit, students will:

NGSS.HS.ESS1-4	Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.
NGSS.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.
NGSS.HS.PS2-4	Use mathematical representations of Newton's Law of Gravitation ~~and Coulomb's Law~~ to describe and predict the gravitational ~~and electrostatic~~ force between objects.
NGSS.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 motions of particles (objects) and energy associated with the relative positions of particles (objects).
NGSS.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.
NGSS.HS.PS2-3	Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.
CCS.ELA-Literacy. RST.9-10.1	Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.
CCS.ELA-Literacy. RST.9-10.7	Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.

CCS.ELA-Literacy.WHST.9-10.7	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.
CCS.ELA-Literacy.WHST.9-10.9	Draw evidence from informational texts to support analysis, reflection, and research.
CCS.ELA-Literacy.SL.9-10.5	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.
CCS.MP.2	Reason abstractly and quantitatively.
CCS.MP.4	Model with mathematics.
CCS.HSN-Q.A.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.
CCS.HSN-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling.
CCS.HSN-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
CCS.HSA-SSE.A.1	Interpret expressions that represent a quantity in terms of its context.
CCS.HSA-SSE.B.3	Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression.
CCS.HSA.CED.A.1	Create equations and inequalities in one variable and use them to solve problems.
CCS.HSA-CED.A.2	Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.

CCS.HSA-CED.A.4	Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.
CCS.HSF-IF.C.7	Graph functions expressed symbolically and show key features of the graph, by in hand in simple cases and using technology for more complicated cases.
CCS.HSS-IS.A.1	Represent data with plots on the real number line (dot plots, histograms, and box plots).
ISTE Computational Thinker (Standard 5b)	Collect data or identify relevant data sets, use digital tools to analyze them, and represent data in various ways to facilitate problem-solving and decision-making.
ISTE Computational Thinker (Standard 5c)	Break problems into component parts, extract key information, and develop descriptive models to understand complex systems or facilitate problem-solving.

Science & 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. (NGSS.HS-PS2-1) Constructing Explanations and Designing Solutions: • Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects. (NGSS.HS-PS2-3) Using Mathematics and Computational Thinking: • Use mathematical or computational representations of	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. (NGSS.HS-ESS1-4) PS2.A: Forces and Motion: • Newton's second law accurately predicts changes in the motion of macroscopic objects. (NGSS.HS-PS2-1) • Momentum is defined for a particular frame of reference; it is the mass times velocity of the	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. (NGSS.HS-PS2-4) Cause and Effect: • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (NGSS.HS-PS2-1) • Systems can be designed to cause a desired effect. (NGSS.HS-PS2-3) Scale, Proportion, and Quantity: • Algebraic thinking is used

phenomena to describe explanations. (NGSS.HS-ESS1-4) Connections to Nature of Science: Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena: • Theories and laws provide explanations in science. (NGSS.HS-PS2-1, NGSS.HS-PS2-4) • Laws are statements or descriptions of the relationships among observable phenomena. (NGSS.HS-PS2-1, NGSS.HS-PS2-4)	object. (NGSS.HS-PS2-2) • 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. (NGSS.HS-PS2-2, NGSS.HS-PS2-3) 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. (NGSS.HS-PS2-4) • 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. (NGSS.HS-PS2-4) 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,	to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth). (NGSS.HS-ESS1-4) Systems and System Models: • When investigating or describing a system, the boundaries and initial conditions of the system need to be defined. (NGSS.HS-PS2-2) 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. (NGSS.HS-PS3-2) Connections to Engineering, Technology, and Applications of Science: Energy and Matter: • 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. (NGSS.HS-ESS1-4)

	within the system, energy is continually transferred from one object to another and between its various possible forms. (NGSS.HS-PS3-2) • At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (NGSS.HS-PS3-2) • These relationships are better understood at the macroscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the configuration (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. (NGSS.HS-PS3-2) ETS1.A: Defining and Delimiting Engineering Problems: • Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk migration 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. (NGSS.HS-ETS1-1) 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. (NGSS.HS-ETS1-2)	

Unit Essential Questions

- What evidence-based models can be studied and developed to explain and predict the motion and interaction of objects in a system?
- What causes objects to move and interact the way that they do?
- How do Kepler's Laws provide a basis to understand motions of orbiting objects?
- How can Kepler's Laws of Motion be used to predict changes in the motion of macroscopic objects?
- How can Newton's Law of Universal Gravitation describe and predict the effects of gravitational force between distant objects?
- What is the role of force in the motion of an object?
- If an object interacts with another object (collision), how is the motion of the object(s) affected?
- What factors need to be considered in designing a means to reduce the force in a collision?
- What is the role of energy in a system?
- How can energy be modeled and applied to objects in a system?

Scope and Sequence

1. Kepler's Laws of Planetary Motion
2. Newton's Law of Universal Gravitation
3. Newton's Second Law of Motion
4. Forms of energy and energy conservation
5. Momentum, conservation of momentum, and impulse
6. Engineering Design Challenge: Egg Drop

Assured Assessments

Formative Assessment:

- Students will model the relationship between the time a force is applied and the distance a projectile will travel; through the laboratory investigation, students will define the scientific principle of impulse.

Summative Assessment:

- Students will design, construct, and test a device to reduce the force of impact on an object. Students will be assessed on their ability to mathematically model the velocity, momentum, and impulse of their device, and will evaluate the overall effectiveness of their design in relation to applicable scientific and engineering principles.

Resources

Core

- Feather, Jr., Ralph M., Charles William McLaughlin, Marilyn Thompson, & Dinah Zike. *Physical Science with Earth Science*. Columbus: Glencoe, 2012. Print.
- Hendrik, Marc S., Gray Thompson, & Jon Turk. *Earth*. Stamford: Cengage, 2015. Print.
- "Comparing Work and Energy Laboratory." Trumbull High School.
- "Modeling the Development of Planetary Systems Laboratory." Trumbull High School.
- "Modeling Constant Velocity Laboratory." Trumbull High School.
- "Modeling Gravitational Force Laboratory." Trumbull High School
- "Modeling Impulse Laboratory." Trumbull High School.
- "Modeling Newton's Second Law of Motion Laboratory." Trumbull High School.
- "Modeling Planetary Motion Laboratory (Kepler's Laws)." Trumbull High School.
- PhET Interactive Simulations. "The Moving Man." https://phet.colorado.edu/en/simulation/moving-man. Accessed July 30, 2018. Web.
- the Physics Classroom. "Egg Drop Interactive." http://www.physicsclassroom.com/Physics-Interactives/Momentum-and-Collisions/Egg-Drop/Egg-Drop-Interactive. Accessed July 30, 2018. Web.

Supplemental

- PhET Interactive Simulations. "Collision Lab." https://phet.colorado.edu/en/simulation/collision-lab. Accessed July 30, 2018. Web.
- PhET Interactive Simulations. "Gravity Force Lab." https://phet.colorado.edu/en/simulation/gravity-force-lab. Accessed July 30, 2018. Web.
- Sechrist, Darren. "Sudden Impact." *Current Science* Nov. 8, 2002: 10-11.
- "Solar System – Planet Movement Animation." *YouTube*, uploaded by Michal4767, Jan. 7, 2012, https://www.youtube.com/watch?v=gvSUPFZp7Yo. Accessed July 30, 2018. Web.

Time Allotment

- Approximately nine weeks

UNIT 3
Terrestrial Processes and Cycling of Matter

Unit Goals

At the completion of this unit, students will:

NGSS.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.
NGSS.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.
NGSS.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.
NGSS.HS.ESS2-3	Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.
NGSS.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).
NGSS.HS ESS2-5	Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.
NGSS.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~~ has influenced human activity.
CCS.ELA-Literacy.RST.9-10.1	Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.

CCS.ELA-Literacy.RST.9-10.8	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.
CCS.ELA-Literacy.WHST.9-10.1	Write arguments focused on discipline-specific content.
CCS.ELA-Literacy.WHST.9-10.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
CCS.ELA-Literacy.WHST.9-10.7	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.
CCS.ELA-Literacy.WHST.9-10.8	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.
CCS.ELA-Literacy.WHST.9-10.9	Draw evidence from informational texts to support analysis, reflection, and research.
CCS.ELA-Literacy.SL.9-10.5	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.
CCS.MP.2	Reason abstractly and quantitatively.
CCS.MP.4	Model with mathematics.
CCS.HSN-Q.A.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.
CCS.HSN-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling.

CCS.HSN-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
CCS.HSF-IF.B.5	Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes.
CCS.HSS-ID.B.6	Represent data on two quantitative variables on a scatter plot, and describe how those variables are related.
ISTE Computational Thinker (Standard 5c)	Break problems into component parts, extract key information, and develop descriptive models to understand complex systems or facilitate problem-solving.
ISTE Creative Communicator (Standard 6c)	Communicate complex ideas clearly and effectively by creating or using a variety of digital objects such as visualizations, models, or simulations.
ISTE Global Collaborator (Standard 7b)	Use collaborative technologies to work with others, including peers, experts, or community members, to examine issues and problems from multiple viewpoints.

Science & 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. (NGSS.HS-PS1-8, NGSS.HS-ESS2-1, NGSS.HS-ESS2-3) 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	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. (NGSS.HS-ESS1-6) ESS2.A: Earth Materials and	Energy and Matter: • In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. (NGSS.HS-PS1-8) • Energy drives the cycling of matter within and between systems. (NGSS.HS-ESS2-3) 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

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. (NGSS.HS-PS3-4, NGSS,HS-ESS2-5) 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. (NGSS.HS-ESS1-6) • 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. (NGSS.HS-ESS3-1) Connections to Nature of Science: Scientific Knowledge Is Based on Empirical Evidence: • Science knowledge is based on empirical evidence. (NGSS.HS-ESS2-3) • Science disciplines share common rules of evidence used to evaluate explanations about natural systems. (NGSS.HS-ESS2-	Systems: • Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (NGSS.HS-ESS2-1) • 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. (NGSS.HS-ESS2-3) 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 heat that drives mantle convection. Plate tectonics can be viewed as the surface expression of mantle convection. (NGSS.HS-ESS2-3)	of its various materials. (NGSS.HS-ESS2-5) Cause and Effect: • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (NGSS.HS-ESS3-1) 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. (NGSS.HS-PS3-4) 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. (NGSS.HS-ESS2-1) • Much of science deals with constructing explanations of how things change and how they remain stable. (NGSS.HS.ESS1-6) 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).

3) • Science includes the process of coordinating patterns of evidence with current theory. (NGSS.HS-ESS2-3) 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. (NGSS.HS-ESS1-6) • Models, mechanisms, and explanations collectively serve as tools in the development of a scientific theory. (NGSS.HS-ESS1-6)	• 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. (NGSS.HS-ESS2-1) 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. (NGSS.HS-ESS2-5) ESS3.A: Natural Resources: • Resource availability has guided the development of human society. (NGSS.HS-ESS3-1) ESS3.B: Natural Hazards: • Natural hazards and other geologic events have shaped the course of human history; they have	Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise. (NGSS.HS-ESS1-4, NGSS.HS-ESS2-3) Influence of Science, Engineering, and Technology on Society and the Natural World: • Modern civilization depends on major technological systems. (NGSS.HS-ESS3-1)

	significantly altered the sizes of human populations and have driven human migrations. (NGSS.HS-ESS3-1) PS1.C: Nuclear Processes: • Nuclear processes, including fusion, fission, and radioactive decay of unstable nuclei, involve release or absorption of energy. The total number of neutrons plus protons does not change in any nuclear process. (NGSS.HS-PS1-8) • 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 to NGSS.HS-ESS1-6) 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. (NGSS.HS-PS3-4) • 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). (NGSS.HS-PS3-4)	

	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. (NGSS.HS-PS3-4) PS4.A: Wave Properties: • Geologists use seismic waves and their reflection at interfaces between layers to probe structures deep in the planet. (secondary to NGSS.HS-ESS2-3)	

Unit Essential Questions

- Why are the surfaces of the Earth and the Moon different?
- What is the relationship between geographic features of the Earth's crust and its internal processes?
- What is the Plate Tectonic Theory, and what evidence supports it?
- What are the characteristics of different plate boundaries?
- How is seismic activity related to tectonism?
- What is "Deep Time"?
- What is radiometric dating, and how can it be utilized to determine absolute age of crustal materials?
- How is volcanic activity related to tectonism?
- What is convection, and how is this process related to volcanism?
- What are the difference characteristics of the three main types of rocks, and how do they form?
- What is the Hydrologic Cycle?
- How do the properties and behavior of water shape the Earth's surface?
- How is human development impacted by natural hazards (seismic and volcanic events, flooding, drought, and mass wasting)?

Scope and Sequence

1. Characteristics of Earth's surface features
2. Tectonism

3. Relative/absolute ages of terrains
4. Cycling of matter and thermal energy
5. Hydrologic processes
6. Geohazards

Assured Assessments

Formative Assessment:

- Students will use the Incorporated Institutions of Seismology (IRIS) Earthquake Browser to monitor seismic activity around the world, observing the distribution, magnitude, frequency, and depth of earthquakes in various locations, and defining the tectonic plate boundary for each location based on their seismic characteristics.

Summative Assessment:

- Students will participate in an assessment consisting of multiple-choice questions, and interpreting and analyzing data, related to tectonism. Aspects of temporal and spatial scales of Earth's processes, the formation of terrestrial features, and the cycling of matter due to tectonism will be assessed.

Resources

Core

- Feather, Jr., Ralph M., Charles William McLaughlin, Marilyn Thompson, & Dinah Zike. *Physical Science with Earth Science*. Columbus: Glencoe, 2012. Print.
- Hendrik, Marc S., Gray Thompson, & Jon Turk. *Earth*. Stamford: Cengage, 2015. Print.
- "Comparing the Specific Heat Capacities of Different Substances Laboratory." Trumbull High School.
- "Incorporated Institutes of Seismology (IRIS) Earthquake Browser." http://ds.iris.edu/ieb/index.html?format=text&nodata=404&starttime=1970-01-01&endtime=2025-01-01&minmag=0&maxmag=10&mindepth=0&maxdepth=900&orderby=time-desc&limit=1000&maxlat=85.96&minlat=-85.96&maxlon=180.00&minlon=-180.00&zm=1&mt=ter. Web.
- "Modeling Thermal Energy Laboratory." Trumbull High School.
- "Natural Hazards Impact on Human Population Activity." Trumbull High School.
- NOAA National Centers for Environmental Information. "Marine Geology and Geophysics Surface of the Earth (ETOPO2v2)." https://www.ngdc.noaa.gov/mgg/image/2minrelief.html. Web.
- "Near Side Mercator Image of the Moon." Rand McNally, 1981. Print.

Supplemental

- "Absolute Dating." Science Learning Hub, May 20, 2011. https://www.sciencelearn.org.nz/resources/1486-absolute-dating. Accessed July 30, 2018. Web.
- Bell, Michael. *The Face of Connecticut: People, Geology, and the Land*. Hartford: Connecticut Department of Environmental Protection, 1985. Print.

- "Kinetic Molecular Theory." SAT practice article adapted from "Kinetic Molecular Theory." *World of Physics*. Farmington Hills, MI: Gale, 2014. Print.
- "New SAT Reading Practice Test 7." http://www.cracksat.net/sat/reading/test-7.html. Accessed July 30, 2018. Web. adapted from *Science World*, about continental drift and plate tectonics.
- Terry, Travis. "Going DEEP with Plate Tectonics: Study Guide and Practice," 2003. https://www.teacherspayteachers.com/Product/Worksheet-Plate-Tectonics-Study-Guide-and-Practice-1204872. Accessed July 30, 2018. Web.

Time Allotment

- Approximately nine weeks

UNIT 4
Natural Resources and Energy Production

Unit Goals

At the completion of this unit, students will:

NGSS.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~~ has influenced human activity.
NGSS.HS.ESS3-2	Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.
NGSS.HS.ESS3-4	Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.
NGSS.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.
NGSS.HS.PS3-5	Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.
NGSS.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.
CCS.ELA-Literacy.RST.9-10.1	Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.
CCS.ELA-Literacy.RST.9-10.8	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.
CCS.ELA-Literacy.WHST.9-10.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

CCS.ELA-Literacy.WHST.9-10.7	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.
CCS.ELA-Literacy.WHST.9-10.8	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.
CCS.ELA-Literacy.WHST.9-10.9	Draw evidence from informational texts to support analysis, reflection, and research.
CCS.ELA-Literacy.SL.9-10.5	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.
CCS.MP.2	Reason abstractly and quantitatively.
CCS.MP.4	Model with mathematics.
CCS.HSN-Q.A.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.
CCS.HSN-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling.
CCS.HSN-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
ISTE Innovative Designer (Standard 4a)	Know and use a deliberate design process for generating ideas, testing theories, creating innovative artifacts, or solving authentic problems.

ISTE Computational Thinker (Standard 5c)	Break problems into component parts, extract key information, and develop descriptive models to understand complex systems or facilitate problem-solving.
ISTE Creative Communicator (Standard 6c)	Communicate complex ideas clearly and effectively by creating or using a variety of digital objects such as visualizations, models, or simulations.
ISTE Global Collaborator (Standard 7c)	Contribute constructively to project teams, assuming various roles and responsibilities to work effectively toward a common goal.

Science & 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). (NGSS.HS-ESS3-2) 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. (NGSS.HS-PS2-5)	ESS3.A: Natural Resources: • Resource availability has guided the development of human society. (NGSS.HS-ESS3-1) • 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. (NGSS.HS-ESS3-2) 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. (NGSS.HS-ESS3-1) ESS3.C: Human Impacts on Earth Systems: • Scientists and engineers	Cause and Effect: • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (NGSS.HS-PS2-5, NGSS.HS-ESS3-1) • 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. (NGSS.HS-PS3-5) Stability and Change: • Feedback (negative or positive) can stabilize or destabilize a system. (NGSS.HS-ESS3-4) 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

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. (NGSS.HS-PS3-3, NGSS.HS-ESS3-4) • 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. (NGSS.HS-ESS3-1) Developing and Using Models: • Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system. (NGSS.HS-PS3-5) 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	can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation. (NGSS.HS-ESS3-4) 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. (NGSS.HS-PS2-4) • 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. (NGSS.HS-PS2-5) PS3.A: Definitions of Energy: • At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (NGSS.HS-PS3-3) • "Electrical energy" may mean energy stored in a battery or energy transmitted by electric currents. (secondary to NGSS.HS-PS2-5)	system. (NGSS.HS-PS3-3) 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. (NGSS.HS-ESS3-1, NGSS.HS.ESS3-3) • Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. (NGSS.HS-PS3-3, NGSS.HS-ESS3-2, NGSS.HS-ESS3-4)

design solution. (NGSS.HS-ESS3-2)	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. (NGSS.HS-PS3-5) 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. (NGSS.HS-PS3-3) 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 to NGSS.HS-PS3-3) 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 to NGSS.HS-	

	ESS3-2, secondary to NGSS.HS-ESS3-4)	

Unit Essential Questions

- How is the distribution of mineral resources and fossil fuels related to depositional processes?
- How have human activities been influenced by the occurrence of natural resources?
- What methods are utilized to obtain natural resources, and what best practices can be employed to exploit resources while minimizing detrimental effects on the environment?
- What is electricity?
- What is the relationship between electricity and magnetism?
- How can natural resources be used to generate electrical energy?

Scope and Sequence

1. Mineral resources and fossil fuels
2. Electromagnetism
3. Electrical generation

Assured Assessments
Formative Assessment:

- Students will demonstrate an understanding of the proportional relationship between electrical current and the strength of a magnetic field by constructing and evaluating the performance of an electromagnet.

Summative Assessment:

- Students will select a source of energy, and design, construct, and test a device to generate electricity. Students will be assessed on their ability to explain and evaluate aspects of their design and to evaluate the device's performance.

Resources
Core

- Feather, Jr., Ralph M., Charles William McLaughlin, Marilyn Thompson, & Dinah Zike. *Physical Science with Earth Science*. Columbus: Glencoe, 2012. Print.
- Hendrik, Marc S., Gray Thompson, & Jon Turk. *Earth*. Stamford: Cengage, 2015. Print.
- "Constructing an Electromagnet." Trumbull High School.
- Office of Energy Efficiency & Renewable Energy. *Office of Energy Efficiency & Renewable Energy Video Gallery*. https://www.energy.gov/eere/videos. Accessed July 30, 2018. Web.
- "Ohm's Law Laboratory." Trumbull High School.

Supplemental

- "Cookie Mining Laboratory." Trumbull High School.

- "New SAT Reading Practice Test 42: Paired Passages – Solar Farming." http://www.cracksat.net/sat/reading/test-42.html. Accessed July 30, 2018. Web. adapted.
- "New SAT Reading Practice Test 43: Carbon Dioxide Passage." http://www.cracksat.net/sat/reading/test-43.html. Accessed July 30, 2018. Web. adapted.
- "New SAT Reading Practice Test 53: Hydrogen Passage." http://www.cracksat.net/sat/reading/test-53.html. Accessed July 30, 2018. Web. adapted.
- "Renewable Power Sources." https://online.kidsdiscover.com/unit/electricity/topic/renewable-power-sources?ReturnUrl=/unit/electricity/topic/renewable-power-sources. Web.
- "Water, Wind, and Other Sources of Energy." https://online.kidsdiscover.com/unit/energy/topic/water-wind-and-other-sources-of-energy?ReturnUrl=/unit/energy/topic/water-wind-and-other-sources-of-energy. Web.

Time Allotment

- Approximately nine weeks

COURSE CREDIT

One THS credit in Science

One class period daily for a full year

ASSURED STUDENT PERFORMANCE RUBRICS

- Trumbull High School School-Wide Writing Rubric (attached)
- Trumbull High School School-Wide Problem-Solving Rubric (attached)
- Trumbull High School School-Wide Independent Learning and Thinking Rubric (attached)

Trumbull High School School-Wide Writing Rubric

Category/ Weight	Exemplary 4 Student work:	Goal 3 Student work:	Working Toward Goal 2 Student work:	Needs Support 1-0 Student work:
Purpose X_______	• Establishes and maintains a clear purpose • Demonstrates an insightful understanding of audience and task	• Establishes and maintains a purpose • Demonstrates an accurate awareness of audience and task	• Establishes a purpose • Demonstrates an awareness of audience and task	• Does not establish a clear purpose • Demonstrates limited/no awareness of audience and task
Organization X_______	• Reflects sophisticated organization throughout • Demonstrates logical progression of ideas • Maintains a clear focus • Utilizes effective transitions	• Reflects organization throughout • Demonstrates logical progression of ideas • Maintains a focus • Utilizes transitions	• Reflects some organization throughout • Demonstrates logical progression of ideas at times • Maintains a vague focus • May utilize some ineffective transitions	• Reflects little/no organization • Lacks logical progression of ideas • Maintains little/no focus • Utilizes ineffective or no transitions
Content X_______	• Is accurate, explicit, and vivid • Exhibits ideas that are highly developed and enhanced by specific details and examples	• Is accurate and relevant • Exhibits ideas that are developed and supported by details and examples	• May contain some inaccuracies • Exhibits ideas that are partially supported by details and examples	• Is inaccurate and unclear • Exhibits limited/no ideas supported by specific details and examples
Use of Language X_______	• Demonstrates excellent use of language • Demonstrates a highly effective use of standard writing that enhances communication • Contains few or no errors. Errors do not detract from meaning	• Demonstrates competent use of language • Demonstrates effective use of standard writing conventions • Contains few errors Most errors do not detract from meaning	• Demonstrates use of language • Demonstrates use of standard writing conventions • Contains errors that detract from meaning	• Demonstrates limited competency in use of language • Demonstrates limited use of standard writing conventions • Contains errors that make it difficult to determine meaning

Trumbull High School School-Wide Problem-Solving Rubric

Category/ Weight	**Exemplary 4**	**Goal 3**	**Working Toward Goal 2**	**Needs Support 1-0**
Understanding X_______	• Student demonstrates clear understanding of the problem and the complexities of the task	• Student demonstrates sufficient understanding of the problem and most of the complexities of the task	• Student demonstrates some understanding of the problem but requires assistance to complete the task	• Student demonstrates limited or no understanding of the fundamental problem after assistance with the task
Research X_______	• Student gathers compelling information from multiple sources including digital, print, and interpersonal	• Student gathers sufficient information from multiple sources including digital, print, and interpersonal	• Student gathers some information from few sources including digital, print, and interpersonal	• Student gathers limited or no information
Reasoning and Strategies X_______	• Student demonstrates strong critical thinking skills to develop a comprehensive plan integrating multiple strategies	• Student demonstrates sufficient critical thinking skills to develop a cohesive plan integrating strategies	• Student demonstrates some critical thinking skills to develop a plan integrating some strategies	• Student demonstrates limited or no critical thinking skills and no plan
Final Product and/or Presentation X_______	• Solution shows deep understanding of the problem and its components • Solution shows extensive use of 21^{st}-century technology skills	• Solution shows sufficient understanding of the problem and its components • Solution shows sufficient use of 21^{st}-century technology skills	• Solution shows some understanding of the problem and its components • Solution shows some use of 21^{st}-century technology skills	• Solution shows limited or no understanding of the problem and its components • Solution shows limited or no use of 21^{st}-century technology skills

Trumbull High School School-Wide
Independent Learning and Thinking Rubric

Category/ Weight	Exemplary 4	Goal 3	Working Toward Goal 2	Needs Support 1-0
Proposal X________	• Student demonstrates a strong sense of initiative by generating compelling questions, creating uniquely original projects/work	• Student demonstrates initiative by generating appropriate questions, creating original projects/work	• Student demonstrates some initiative by generating questions, creating appropriate projects/work	• Student demonstrates limited or no initiative by generating few questions and creating projects/work
Independent Research & Development X________	• Student is analytical, insightful, and works independently to reach a solution	• Student is analytical, and works productively to reach a solution	• Student reaches a solution with direction	• Student is unable to reach a solution without consistent assistance
Presentation of Final Product X________	• Presentation shows compelling evidence of an independent learner and thinker • Solution shows deep understanding of the problem and its components • Solution shows extensive and appropriate application of 21st-century skills	• Presentation shows clear evidence of an independent learner and thinker • Solution shows adequate understanding of the problem and its components • Solution shows adequate application of 21st-century skills	• Presentation shows some evidence of an independent learner and thinker • Solution shows some understanding of the problem and its components • Solution shows some application of 21st-century skills	• Presentation shows limited or no evidence of an independent learner and thinker • Solution shows limited or no understanding of the problem and its components • Solution shows limited or no application of 21st-century skills