TAMALPAIS UNION HIGH SCHOOL DISTRICT
Larkspur, California

Course of Study
Physics in the Universe

Course Author(s): **PhUn Team-Todd Samet, Michael Wing, Simon McBride, Paula Berry**	Schools where the course will be taught: **Redwood High School, Sir Francis Drake High School, Tamalpais High School, Tamiscal High School** and **San Andreas High School**
Length of Course: **1 year**	Subject Area and Discipline: **Physics and Earth Science**
Grade Levels: **9th grade**	Is this course an integrated course? **Yes**
Is this course being submitted for possible UC honors designation? **No**	Are you seeking UC approval? If so, in what area (A-G)? **Yes, Lab Science D**
Prerequisites (required or recommended): **None**	Co-requisites (required or recommended): **Algebra 1-2 (recommended)**
Check all that apply: ❑ **x** UC A-G course ❑ **x** Graduation Requirement ❑ Elective ❑ Honors/AP ❑ ROP BOT Approved: 1/23/18 Updated: 2/6/18 UC Approved (d): 2/5/18	

Introduction

Physics in the Universe is a freshman level course that implements the Next Generation Science Standards. The course is built upon Performance Expectations (PEs) that blend the Disciplinary Core Ideas (DCIs) of physics and earth science with Science and Engineering practices (SEPs) and Crosscutting Concepts (CCCs). This three dimensional approach supports students in developing scientific knowledge and the skills of scientists and engineers. By using in depth phenomena central to these fields of science, students develop an understanding of the core ideas related to the formation of the Universe, the Processes that Change Earth, Energy Formation and Its Use, and Technology. The performance expectations focus on several scientific practices including: developing and using models, planning and conducting investigations, analyzing and interpreting data, using mathematical and computational thinking, and constructing explanations which students use to demonstrate understanding of the core ideas. Students are expected to demonstrate understanding of several engineering practices, including design and evaluation as well as to develop an understanding of the cross cutting concepts central to the nature of science.

Stage 1 Desired Results

Unit 1: Big Bang to Sun

Students investigate the Big Bang as a theory for the origin of the universe, with a focus on supporting evidence. They investigate the composition of stars, from their spectra, to understand the presence of common elements in the Universe. In analyzing spectra, students learn the basic characteristics of waves and electromagnetic spectrum. Through the unit they deepen their understanding of waves when they investigate the doppler effect and waves of objects in motion and apply this knowledge to understand the redshift as evidence of the Big Bang theory. They study telescopes, as energy collection devices that allow us to gather evidence about the universe and its formation. Students consider how stars form and focus on the relationship between gravity and matter in creating the conditions necessary for nuclear fusion and star formation. Students model the process of nuclear fusion that stars undergo to produce the elements found on Earth and in our Universe. The composition of the Earth, especially the relative abundance of elements, and life on Earth are dependent on the processes of stars. As a result of nuclear fusion, the sun produces energy that is transmitted to earth. Students explore how the sun's electromagnetic energy affects the Earth.

<table>
<tr><td rowspan="4">ESTABLISHED LEARNING GOALS
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 in the form of radiation.
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.
HS-ESS1-3 Communicate scientific ideas about the way stars, over their life cycle, produce elements.
HS-PS1-8 Develop models to illustrate the changes in the composition of the nucleus of the atom and</td><td colspan="2">Transfer</td></tr>
<tr><td colspan="2">Students will predict, model, argue with evidence and draw conclusions about the future of the universe.</td></tr>
<tr><td colspan="2">Meaning Making</td></tr>
<tr><td>UNDERSTANDINGS
Students will understand that...
<u>CCCs</u>
● The scale of space and time in the universe is vast and difficult to conceptualize from a human perspective.
● Energy cannot be created or destroyed—it only moves between one place and another place, between objects and/or fields, or between systems.</td><td>ESSENTIAL QUESTIONS
What is the diversity you see in the astronomical objects in telescope images?
1. Why is there a diversity in the astronomical objects observed in telescope images?
2. How were these stars born, how do they live and how do they die?
3. How is life on earth dependent on stars? What would happen if there were no stars?
4. If you were looking at the night sky in a billion years, what would it look like?</td></tr>
</table>

<table>
<tr><td rowspan="2">the energy released during the processes of fission, fusion, and radioactive decay.
HS-PS2-4 Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.
HS-PS4-1 Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.
HS-PS4-4 Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.</td><td colspan="2">Acquisition</td></tr>
<tr><td>Students will know...
(DCIs)
● Multiple lines of evidence support the Big Bang theory and the evolution of stars
● All matter in the universe formed with the Big Bang and in stars
● All matter in the universe is subject to and organized by gravity.
● Matter is converted to energy in stars and radiated across the universe</td><td>Students will be skilled at...
(SEPs)
● The origin of the universe happened so long ago and at such a large scale that scientists use models to build and communicate their understanding of this phenomenon.These models incorporate indirect evidence in support of their explanations. Models are always simple versions of a more complex reality.
● Scientists ask carefully constructed/purposeful/testable questions to clarify or refine existing models</td></tr>
<tr><td colspan="3">Stage 2 - Evidence</td></tr>
<tr><td rowspan="2">Learning Goals Measured:
HS-ESS1-2</td><td colspan="2">Success Criteria:
Part 1: Students will include the following lines of evidence: absorption and emission lines from the area where the neutron stars collided will match up with those produced by gold on earth.
Part 2: Students will draw a model based on spectral line data table that incorporates relative distance, spectral absorption and/or emission lines, compression of wavelength, and relative velocity of objects
Part 3: Students will identify the following limitations:
scales of distance and wavelength/frequency, simplification of spectra, not visible light, time is not represented, particle-wave duality, wave drawing only one photon.</td></tr>
<tr><td colspan="2">Sample Assessment: Students will engage in an Instructionally Embedded Performance task based on a recent astronomical phenomena-A Neutron Star Collision that they will read about in a recent news article. They will answer the following questions: How</td></tr>
</table>

	did they know what elements were made during the collision? How far away is it? They will do this by: **Part 1:** Construct an explanation that supports a claim for the presence of specific elements in astronomical objects, based on valid and reliable evidence. **Part 2:** Construct a model that explains the difference between local and distant spectra and estimates the distance from the observer. **Part 3:** Evaluate limitations and merits of their own model to describe spectral shifts
Stage 3 – Learning Plan	
Learning Goals Addressed: DCI -Wave properties, EM Spectrum, SEP-Engaging in Argument from Evidence CCC -Cause and Effect: Mechanisms and Prediction	**Sample Assignment:** Students will conduct an investigation of the **Properties of Light** to make claims about the observed phenomena. They will use the evidence they gather to make their claims about the behavior of light. This will address the SEP-Engaging in Argument from Evidence, while learning about the DCIs of wave properties and Electromagnetic Radiation. These provide evidence for the origins of the universe.
	Sample Lab: Students will conduct a lab investigation, The Earth's Energy Budget, where they determine the amount of solar energy available to a small portion of Earth to better understand the Earth's overall energy balance. They will experiment by recording the heat gained by water in a specific location and then they will calculate the solar input. This lab will consider the limitations of data analysis when analyzing and interpreting data (SEP), while learning about light being converted to thermal energy when absorbed by matter (DCI) and how energy and matter flows into, out of and within a system (CCC).
	Differentiated Approaches: ● Students will be provided outcomes for each lesson/activity so they understand what is expected of them. These will be in the form of the DCIs, CCCs, and SEPs. ● Students will work with heterogeneously grouped partners during investigations and activities such as the Properties of Light activity. They will be making claims from evidence gathered and have multiple opportunities to discuss their findings using reasoning with their peers. ● New vocabulary will be supported by providing Vocabulary Building Scaffolds which include visuals, definitions and applications of the terms. These can be translated into a variety of languages for ELL students.

	- Students will use white boards to focus on the SEP of modeling in this unit. They will be given opportunities to depict their findings through modeling, get peer input on their initial models, revise their models, get further input and finally draw conclusions. - Support documents for students who are in Algebra Foundations or modified Math classes, will be provided for extra support to complete mathematical computations.

<table>
<tr><th colspan="3">Stage 1 Desired Results</th></tr>
<tr><td colspan="3">Unit 2: Formation of Solar System and Earth
Students investigate the Law of Universal Gravitation and Kepler's Law in order to understand the formation of the solar system. They develop models of systems driven by the Law of Universal Gravitation such as the planetary system, the Earth-moon system, the Earth-International Space Station system and the Earth-satellite system. By analyzing data and recognizing patterns within the data, students calculate the orbits of other bodies such as Ceres and a variety of comets. Engineering connections will be made using computational models of orbits. Newton's Second Law will be explored using mathematical and computational thinking to draw conclusions about the effects of gravity on the earth, the moon and different planets. This thinking will be applied to the phenomena of rocket launches in order to understand the phenomena of energy needed to escape Earth's gravitational field. Impulse and momentum will be investigated for re-entry and landing of spacecraft. Students will engage in an engineering challenge to design a device/system that minimizes impact from landing.</td></tr>
<tr><td rowspan="5">ESTABLISHED LEARNING GOALS 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.
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.
HS-PS2-3. Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a</td><td colspan="2">Transfer</td></tr>
<tr><td colspan="2">Students will engage in an engineering challenge to minimize the impact of re-entry on spacecraft.</td></tr>
<tr><td colspan="2">Meaning Making</td></tr>
<tr><td>UNDERSTANDINGS
Students will understand that...
<u>CCCs</u>
Algebraic thinking (scale, proportion and quantity) is used to examine scientific data and predict the effect of a change in one variable on another. We use algebraic tools to study and predict both planetary motion and motion of objects on Earth.
The study of planetary motion and the motion of objects on Earth both</td><td>ESSENTIAL QUESTIONS
How do we describe and explain the motion of planets, moons, asteroids and satellites?
How do we describe and explain collisions between planets and asteroids or planets and satellites?
How do human-made satellites stay in orbit? Why don't they fall to Earth?
How are spacecraft designed to escape from and safely return to Earth's gravity?</td></tr>
</table>

macroscopic object during a collision. [HS-PS2-4](). Use mathematical representations of Newton’s Law of Gravitation and Coulomb’s Law to describe and predict the gravitational and electrostatic forces between objects. [HS-ESS1-4.]() Use mathematical or computational representations to predict the motion of orbiting objects in the solar system. [HS-ETS1-2](). Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.	require empirical evidence and mathematical representations to identify *patterns*. These patterns can be used for further study of cause and effect relationships. ● Universal laws - including Kepler’s and Newton’s - allow for explanations about the *stability* of planetary orbits and the motion objects on Earth.	
	Acquisition	
	Students will know… DCIs ● Objects in orbit are governed by the law of universal gravitation. Those objects, whether planets, moons or satellites, always display a predictable relationship between orbital distance and orbital period. ● Force is a function of mass and acceleration. Earth’s gravitational field is exceptionally strong and, as a result, rockets must generate a correspondingly large force to escape from it. ● Momentum is a function of mass and velocity and is conserved in any collision. Earth’s gravitational field is exceptionally strong and, as a result, spacecraft re-entering Earth’s gravity must take significant precautions to minimize their momentum on landing. ● Weight is a force and is determined by the strength of the local gravitational field. As a	*Students will be skilled at…* SEPs ● With careful *experimental design and measurement* the effects of gravity on Earth can be directly observed. ● Data collected from these *experiments* can be used to explain relationships among force, mass, and acceleration as they apply to the motion of planets and objects on those planets. ● Data collected from these *experiments* can be used to explain relationships among momentum, force and velocity as they apply to collisions in the solar system and on the Earth. ● Scientists use engineering practices to *design solutions* for the complex problems of escape from and re-entry to Earth’s gravitational field.

	result the same object will have different weights on Earth, Earth's moon and Mars.	

Stage 2 - Evidence	
Learning Goals Measured: 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.	**Success Criteria** HS-PS2-3.
	Sample Assessment Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision. The context will be of a probe landing on another planet. Students will demonstrate an understanding of total momentum within the system and an ability to work within the design constraints within the assignment. Students will engage in a process of optimizing design based on an assessment of criteria and an analysis of trade offs to meet required criteria.

Stage 3 – Learning Plan	
Learning Goals Addressed: *DCI*- Forces and Motion *SEP*- Analyze and Interpret Data *CCC* - Cause and Effect	**Sample Assignment:** Students will develop an understanding of Newton's Laws by experimenting with force, mass and acceleration using skateboards, bathroom scales, meter sticks, and stopwatches. They will explore the driving question, what happens to a person's speed if pushed with a constant force?
	Sample Lab: Students will conduct a **Forces in Orbit Lab** activity where they will develop an understanding of how opposing forces interact to allow stable orbits. They will determine how orbital periods change as the distance between the planet and the sun varies. Students will learn about (DCI) Newton's law of gravitation and use (SEP) mathematical and computational thinking. Students will use algebraic thinking to examine the data they produce in the lab to see how the orbital period is affected by changes in the radius of the orbit and gravity of the sun.
	Differentiated Approaches: ● Note-taking guides will be provided for students with visuals and text already on the notetaking guides when learning about the specifics of forces and motion. Video explanations will be used to support students in developing a mastery of the concepts.

	● Sentence Stems/Starters will be provided for group and class discussions. ● Mathematics support tools and reference guides will be provided for mathematics development of Newton's Laws. ● Students will be given choice about how they design their device in the engineering challenge. They have the opportunity to continuously revise their design until suitable.

<table>
<tr><th colspan="3">Stage 1 Desired Results</th></tr>
<tr><td colspan="3">Unit 3: Earth Processes
Students examine evidence of the past and present tho help them develop an understanding of Earth's systems and how they were formed. They evaluate the importance of astronomical impacts on early Earth's history. This includes the role of asteroids in providing both energy and material to early Earth, comets in providing water, and the large collision that is believed to have created the moon. Students consider cause and effect relationships associated with these various events. In addition, students will examine evidence for the dating of events in Earth's history by exploring nuclear structure and processes, radioactive decay and radiometric dating. Students examine evidence from earthquake waves and their properties in developing a model for the structure of Earth's interior. They also observe patterns on Earth's surface, including rock ages and structural features, using this evidence to examine cause and effect relationships between surface and interior processes, including the underlying mechanisms of plate tectonics and the formation of ore-bearing rock deposits.</td></tr>
<tr><td rowspan="4">ESTABLISHED LEARNING GOALS
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.
HS-PS4-1. Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.
HS-ESS1-5. Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of</td><td colspan="2">Transfer</td></tr>
<tr><td colspan="2">Students will develop a model of the Earth's interior based on the geological features studied on the surface and their understanding of earthquake waves and their properties.</td></tr>
<tr><td colspan="2">Meaning Making</td></tr>
<tr><td>UNDERSTANDINGS
Students will understand that...
<u>CCCs</u>
● Mathematical representations are needed to identify patterns of radiometric decay that are necessary in dating geological events.
● Empirical evidence from earthquakes permit the identification of patterns leading to an understanding</td><td>ESSENTIAL QUESTIONS
What evidence can we use to understand the structure and conditions of Earth's interior?
1. What evidence can we use to understand the structure and conditions of Earth's formation and the young Earth?
2. What evidence can we use to understand Earth's past, present and future?
3. What evidence can we use to</td></tr>
</table>

plate tectonics to explain the ages of crustal rocks. 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. 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.	of Earth's interior structure. ● The cause and effect relationships in the formation of Earth and its oceans can be predicted by examining what is known about smaller scale mechanisms within the system.	study cause and effect relationships among Earth's composition, structure and processes? 4. What evidence can we use to study cause and effect relationships between Earth's interior and Earth's surface features?
	Acquisition	
	Students will know… DCIs ● Ancient craters on the Moon and Mars indicate that the early Earth was also bombarded by asteroids and comets and these impacts were critical in forming the Earth's core, oceans and the Earth-Moon system. ● Radioactive decay provides a means for dating geological materials and also provides much of the heat in the Earth's interior that drives plate tectonics.. ● The Earth has an iron core, both solid and liquid, and a solid rocky mantle and crust. There is a relationship between this internal structure and Earth's surface features. ● The age of Earth's rocks, older continental rock and younger oceanic rock, provides evidence for understanding the processes of plate tectonics.	*Students will be skilled at…* SEPs ● Scientists *analyze data* from radiometric dating to create valid and reliable claims about the history of Earth and its formation. These claims are incorporated into *arguments* that are evaluated on their merits and may be revised based on counter-claims and counter-arguments. ● Scientists *analyze data* from earthquakes to create valid and reliable claims about the structure and composition of Earth's interior. These claims are incorporated into *arguments* that are evaluated on their merits and may be revised based on counter-claims and counter-arguments.
Stage 2 - Evidence		
Learning Goals Measured: HS-ESS1-5. Evaluate evidence of the past and current movements of	**Success Criteria** HS-ESS1-5.	
	Sample Assessment	

continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks.	Students evaluate a variety of map evidence related to structure of ocean basins and continental margins - including geological features, rock types, heat flow and magnetism. They will create an argument, using claim-evidence-reasoning format, to explain the differential ages of the mapped rocks.
Stage 3 – Learning Plan	
Learning Goals Addressed: *DCI* - Nuclear Processes *SEP* - Plan and Carry Out Investigations; Analyze and Interpret Data; Construct Explanations *CCC* - Patterns; Matter and Energy	**Sample Assignment:** Students plan and conduct an experiment to determine penetrating ability of alpha, beta and gamma radiation. Students have access to a variety of shielding materials and thicknesses along with Geiger-Muller tubes and counters. They will analyze experimental data and use it to construct an evidence-based explanation on the nature of radioactive decay.
	Sample Lab: Students will conduct an investigation, **Experimenting with Impacts**, to determine how the Earth was shaped in its early history by extraterrestrial impact events. Students will design their own investigation to study how a variety of factors might affect the results of an extraterrestrial impact on the Earth. Students will (DCI) study objects from space such as meteorites and comets to develop an understanding of Earth's early history and formation. This investigation will focus on (SEP) experimental design and data analysis, producing data to design models on a smaller scale to better understand a system at a larger scale.
	Differentiated Approaches: ● When students are asked to use claim-evidence-reasoning, sentence starters/frames will be provided to help students formulate their thoughts and express their ideas. ● When phenomena are presented they will include realia and visuals to help students develop understanding of content. ● Reading guides will support students to gain access to the information in texts and articles when exploring geological features, rock types, heat flow and magnetism. ● Students will be provided with alternate testing supports, such as visuals, word banks, and kinetic movement opportunities to demonstrate their understanding of how each geological feature/etc. might explain the age of the rock.

Stage 1 Desired Results
Unit 4: Energy Sourcing Students will analyze and evaluate human energy sources and uses in a variety of contexts

<table>
<tr><td colspan="3">– including past versus present, personal, local, regional, and national comparisons. In the process, they are introduced to energy forms and their measurement. Students consider both qualitative and quantitative analysis of energy and energy forms and consider how to best communicate those comparisons. They conduct experimental work on both the 1st and 2nd laws of thermodynamics – energy conversions and energy efficiency. Students consider a systems-level view of electrical generation with the focus on energy conversions, efficiencies and ultimate sources for generation. The students engage in engineering practices where they design, build and refine a device that converts one form of energy to another. They examine relationships between energy sources and system design by comparing the costs and benefits of different energy sources. They evaluate societal energy use and make recommendations for energy options in the future.</td></tr>
<tr><td rowspan="7">ESTABLISHED LEARNING GOALS
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.
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.
HS-ESS3-2. Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.
HS-ESS3-3. Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity.
HS-ETS1-1. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.</td><td colspan="2">Transfer</td></tr>
<tr><td colspan="2">Students will design, build and refine (improve efficiency) a device or system that converts one energy form into another.</td></tr>
<tr><td colspan="2">Meaning Making</td></tr>
<tr><td>UNDERSTANDINGS
Students will understand that…
<u>CCCs</u>
● Systems can be designed to do specific tasks, such as generating electric current. Scientists create models to simulate, explain and predict the behavior of these systems.
● The total amount of energy in closed systems is conserved; never created or destroyed. In considering systems that generate electricity, scientists understand that while energy is conserved, some energy is 'lost' as it is converted to non-useful forms.
● In analyzing electrical generations, energy changes in the system can be described in terms of energy flows into, out of, and within that system.</td><td>ESSENTIAL QUESTIONS
1. How much energy does one human need in a day?
2. How much energy does one human use in a day?
3. What is the best energy source to meet human needs and wants?
4. Why do humans in the United States no longer use wood for heating and animals for plowing farm fields? Why do humans in other parts of the world still use these methods?
5. Why do humans in the United States currently use fossil fuels as the primary source for electricity and transportation? How might this change as we move into the future?
6. How will our current energy choices impact the future (climate change, environment, resource availability, etc.)?</td></tr>
<tr><td colspan="2">Acquisition</td></tr>
<tr><td>Students will know…</td><td>Students will be skilled at…</td></tr>
</table>

	DCIs ● Energy is the ability to do work or to exert a force over a distance and it comes in a variety of forms. Humans use energy found in many of these forms to meet our needs and wants. ● Energy cannot be created or destroyed, but can be transported and converted. Human energy use most commonly involves a series of energy conversions. ● All energy conversions result in some energy converted to less useful forms. Minimizing this energy 'loss' or inefficiency is a focus of much engineering design in this field. ● Electric current can be generated from rotary motion using magnetic fields and conducting material. Humans have many methods/designs for producing electric currents/electricity. ● There are various sources of useful energy available to humans, and each has costs and benefits associated with it. Societal and public policy choices depend on accurately assessing these costs and benefits. ● When evaluating cost, benefits and solutions, scientists take into account a range of constraints, including cost, safety, reliability, and aesthetics. They also consider social, cultural and environmental impacts in formulating proposed solutions.	SEPs ● Scientists ask questions that challenge arguments regarding the value of specific energy sources. ● Scientists pose questions to analyze complex real-world problems, such as evaluating options for future energy use, by specifying criteria and constraints for successful solutions. ● Scientists use reliable and valid information to evaluate the costs and benefits of energy use. ● Scientists use reliable and valid information to make claims about the most appropriate energy sources to meet human needs in specific locations.
Stage 2 - Evidence		

<table>
<tr>
<td rowspan="2">Learning Goals Measured:
HS-ESS3-2. Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.
HS-ETS1-1. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.</td>
<td>Success Criteria
HS-ESS3-2.
HS-ETS1-1.</td>
</tr>
<tr>
<td>Sample Assessment
Students analyze current energy use/energy source data for California. They evaluate costs/benefits for the various energy sources and develop a plan for changing energy sourcing to meet predicted needs 25 and 50 years from present.</td>
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<tr>
<th colspan="2">Stage 3 – Learning Plan</th>
</tr>
<tr>
<td rowspan="3">Learning Goals Addressed:
DCI- Conservation of Energy and Energy Transfer
SEP- Design Solutions; Use Mathematical and Computational Thinking
CCC- Matter and Energy; Systems and System Models</td>
<td>Sample Assignment:
Students will conduct research and evaluate data to determine the positive and negative aspects of different energy sources for producing electricity in California. Using the claim-evidence-reasoning-rebuttal format, they will construct an evidence-based argument for the sourcing of California's electricity fifty years from now.</td>
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<tr>
<td>Sample Lab:
Students will conduct an Energy Transformation lab by developing a research question and conducting an investigation to explore Energy Transformations and System Efficiency. The lab investigation will focus on converting electrical energy to heat energy by using an electric heater designed specifically for heating liquids. Students will develop an understanding of the system from a qualitative and quantitative perspective and make design modifications to improve its efficiency. The lab will emphasize that energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems while conducting this investigation (DCI). In addition, students will develop an understanding that energy and matter flows into, out of, and within a system (CCC).</td>
</tr>
<tr>
<td>Differentiated Approaches:
Pre-assessments will be used to determine students' prior knowledge of energy and energy transformations and to communicate what is expected of them. In addition, students</td>
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</table>

	will identify energy sources they are familiar with given their different cultural backgrounds. ● Online resources such as Newsela will be provided to vary lexical level of readings used through the unit. ● When given engineering challenges such as building a device to convert one form of energy into another, students will use KWL charts and concept maps to broaden their understandings of material and allow students to know where they are in their learning and their design process.

<table>
<tr><th colspan="3">Stage 1 Desired Results</th></tr>
<tr><td colspan="3">Unit 5: Using Energy
Students examine the physics of generating electricity. They explore and compare electromagnetic induction and the photoelectric effect as alternatives for generating electricity. Students will plan and conduct investigations to examine details of electromagnetic induction and observe evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current. Additionally, they will plan and conduct an investigation that manipulates the variables in the design of an electromagnet and measures the strength of an induced magnetic field as a result of their design changes. Included in their investigations they will evaluate the roles of conductors, semiconductors and insulators. They will compare the electricity produced by electromagnetic induction with electricity produced by the photoelectric effect using photovoltaic panels. Students will engage in an engineering challenge around electric motor design as a culminating project.</td></tr>
<tr><td rowspan="5">ESTABLISHED LEARNING GOALS
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.
HS-PS2-6.Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.
HS-PS3-1.Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the</td><td colspan="2">Transfer</td></tr>
<tr><td colspan="2">Students will design and test modifications for improving the efficiency of an electrical motor or an electrical generator.</td></tr>
<tr><td colspan="2">Meaning Making</td></tr>
<tr><td>UNDERSTANDINGS
Students will understand that…
CCCs
● The total amount of energy and matter in closed systems is conserved. This includes systems generating electricity from heat and those generating electricity from sunlight.
● Changes of energy and matter in a system can be described in terms of energy and matter flows</td><td>ESSENTIAL QUESTIONS

1. How do scientists and engineers determine the appropriate materials for building the most efficient electric generating system?
2. What are some design challenges in producing electricity by electromagnetic induction? What are some design challenges in producing electricity by photoelectric effect?</td></tr>
</table>

other component(s) and energy flows in and out of the system are known. 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). 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. 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.	into, out of, and within that system. This includes systems generating electricity from heat and those generating electricity from sunlight. ● When investigating or describing systems generating electricity, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. ● Models of circuit diagrams can be used to predict the behavior of an electrical generating system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.	3. What are the costs and benefits associated with the production of an electrical current using kinetic energy and using light energy? 4. How can energy changes be predicted when altering variables in an energy transfer system, for example in photovoltaic cells or an electric motor?

	Acquisition	
	Students will know… DCIs ● Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. These fields provide a mechanism for generating electricity to meet societal needs. ● The availability of energy limits what can occur in any system. This applies to electricity generated by either electromagnetic induction, limited by the fuel source, or the photoelectric effect, limited by availability of sunlight. ● “Electrical energy” may mean energy stored in a battery or energy transmitted by electric currents. Humans use large amounts of electrical energy for a variety of sources. ● Solar cells are human-made devices that likewise capture the Sun’s energy and produce electrical energy. Solar energy systems have great potential for producing electricity but also currently have critical limitations. ● Photovoltaic materials, such as those found in solar cells, emit electrons when they absorb light of a high-enough frequency.	Students will be skilled at… SEPs ● The design of a system - such as an electric power plant or a solar energy farm – is dependent upon how the components of the system interact. Altering the design of those components can improve the efficiency of the system overall. ● Science and engineering come together to match concept with design through investigation. ● Science and engineering use mathematical and computational thinking to guide their design of systems and determine the sources of energy utilized. This thinking is necessary to improve or maximize the system’s efficiency.

Stage 2 - Evidence	
Learning Goals Measured: HS-PS3-1.Create a computational model to calculate the change in the	**Success Criteria** HS-PS3-1.

energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.	**Sample Assessment** Students design and test changes to a photovoltaic system with the goal of improving energy output. They predict results for their design changes and design an experiment to test their predictions.
Stage 3 – Learning Plan	
Learning Goals Addressed: *DCI*– Forces at a distance; Relationship between energy and forces SEP – Plan and carry out investigations CCC – Cause and Effect; Energy and Matter	**Sample Assignment:** Students investigate the effects of changing variables in the design of an electromagnet. They will indirectly measure the strength of an induced magnetic field as a result of their design changes.
	Sample Lab: Students will design an investigation to test how the sun's changing position affects the output of solar **photovoltaic cells**. They will model and test the effects of both seasonal and daily changes in the sun's position by changing the orientation of their experimental light source. Students will take into consideration that their design changes have to model real world conditions. Students will then use their results to determine the possibility of meeting their own family's electrical needs with photovoltaics and compare the relative advantages of fossil fuels and solar energy for generating electricity. Students engage in the analysis of data to identify design features of their system to optimize its output (SEP) and design the system to cause a desired effect (CCC).
	Differentiated Approaches: Include descriptions of how to meet the needs of diverse learners in the context of the sample assignment above (2-3 examples recommended). ● Wall anchor charts and table tents will be used by teachers to help students develop academic vocabulary and language about photovoltaic systems. ● When carrying out their investigations, students will be given the opportunity to access a variety of support materials when designing an experiment and for those who need it, shortened/scaffolded labs will be available.

Stage 1 Desired Results
Unit 6: Communication Technology Students examine human applications of the electromagnetic spectrum in the context of modern

<table>
<tr><td colspan="3">technology. Students live in a world of WiFi, cell phones, satellite radio, TV, radar, microwave ovens and medical X-rays. Each of these technologies uses a small portion of the EM spectrum for specific purposes in communications, medicine, military and personal life. Students will explore the risks and benefits of the EM spectrum from radio waves to gamma ray radiation. They will consider the differences between analog and digital versions of technologies and participate in an engineering challenge to improve an electromagnetically based device. This will give students the opportunity to choose a device of interest and determine how to make it better. Building on the study of EM radiation from Unit 1, this brings electromagnetic waves full circle from the first unit to the last.</td></tr>
<tr><td rowspan="7">ESTABLISHED LEARNING GOALS

HS-PS4-1. Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.
HS-PS4-2. Evaluate questions about the advantages of using a digital transmission and storage of information.
HS-PS4-4. Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.
HS-PS4-5. Communicate technical information about about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.
HS-ETS1-2 Design a solution to a complex real-world problem by breaking it down into</td><td colspan="2">Transfer</td></tr>
<tr><td colspan="2">Students will build a simple crystal radio and engage in an engineering challenge to optimize the signal strength.</td></tr>
<tr><td colspan="2">Meaning Making</td></tr>
<tr><td>UNDERSTANDINGS
Students will understand that…
CCCs
● Cause and effect relationships can be suggested and predicted for human designed technologies by examining what is known about smaller scale mechanisms within those systems.
● Investigating or designing technological systems requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal the function of the technology and/or solve any related problems.</td><td>ESSENTIAL QUESTIONS
1. Why do we use radio waves and microwaves, but not ultraviolet or gamma rays, to communicate by television and cell phones?

2. Why have modern systems of digital communication replaced older analog systems?

3. Is using energy from the electromagnetic spectrum dangerous?

4. If electromagnetic waves are dangerous, why are they used in the medical field?

5. How might our use of the electromagnetic spectrum change in the future?</td></tr>
<tr><td colspan="2">Acquisition</td></tr>
<tr><td>Students will know…
DCIs
● Multiple technologies</td><td>Students will be skilled at…
SEPs
● Define a design problem in</td></tr>
</table>

smaller, more manageable problems that can be solved through engineering.	based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g., medical imaging, cell phone communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them. ● When light or longer wavelength electromagnetic radiation – such as radiation used in cell phones and wifi – is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells. ● The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing. ● Communication technology uses longer wavelength and lower frequency energy from the EM spectrum. Most medical applications use shorter wavelength, higher frequency energy. ● Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long	communication technology that involves the development of a process or system with interacting components and criteria and constraints that may include social, technical and/or environmental considerations ● Evaluate questions that challenge the premise (s) of an argument, the interpretation of a data set, or the suitability of a design related to communication technology. ● Apply scientific ideas, principles, and/or evidence to provide an explanation of technological phenomena and solve design problems, taking into account possible unanticipated effects.

<table>
<tr><td></td><td>distances as a series of wave pulses.
● When creating design solutions, 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.</td><td></td></tr>
<tr><th colspan="3">Stage 2 - Evidence</th></tr>
<tr><td rowspan="2">Learning Goals Measured:

HS-PS4-4. Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.</td><td colspan="2">Success Criteria
HS-PS4-4</td></tr>
<tr><td colspan="2">Sample Assessment:
Students will choose a specific technology used by humans, find 2-3 published materials about the chosen technology and determine the validity and reliability of the information presented based on their understanding of radiation emitted by the technology and its effects.</td></tr>
<tr><th colspan="3">Stage 3 – Learning Plan</th></tr>
<tr><td rowspan="2">Learning Goals Addressed:
HS-PS4-2.

DCI: Wave Properties
CCC:Stability and Change
SEP: Asking Questions and Designing Solutions</td><td colspan="2">Sample Assignment:
Students will choose a device that originally was analog and now has a digital version. They will compare and contrast how the information is communicated using both forms of the device. They will evaluate whether or not the digital version has advantages over the analog version based on its uses.</td></tr>
<tr><td colspan="2">Sample Lab: Students will conduct an investigation to explore how scientists communicate with far off robotic spacecraft that have been sent on planetary missions using NASA’s Deep Space Network. They will conduct the lab Catching a Wave from Space and they will model the mathematics used to communicate with spacecraft. They will use sound waves as an analog for light waves and parabolic transmitters and receivers to represent antennas on spacecraft and on Earth. Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experience in the modern world and in scientific research. Students will investigate a an essential tool for producing,</td></tr>
</table>

	transmitting and capturing signals from space crafts so that the information contained in them can be interpreted. (DCI) Online source. https://www.jpl.nasa.gov/edu/teach/activity/catching-a-whisper-from-space/
	Differentiated Approaches: • When reading published materials, students will be given the opportunity to develop a clear understanding of the content by engaging in a Stronger, Clearer Protocol with their peers. This will give them an opportunity to engage in discourse about the concepts, build on their understanding, clarify their findings and draw conclusions about the validity and reliability of the information. • Students will be offered the option of deconstructing, modifying, or building a device and reporting on its structure, creating a schematic, or writing an instruction manual. • Students will be assigned to heterogeneous groups to evaluate a device of their choice. • Students will be given a graphic organizer to help delineate the different strengths of EM spectrum, and relate this to ionizing and non-ionizing radiation in order to understand the dangers some radiation poses to humans.

Instructional Materials:

Suggested textbook(s), materials, equipment and resources • NGSS and NSTA websites and online resources • The Big History Project online resources • Discovery Education Online Textbook • Access to laptops and chromebooks for online simulations such as Phet activities and PBS interactive websites. • Significant amounts of physics and earth science lab material	

and equipment is needed. In addition to ongoing consumable expenses, the course will require initial capital expenses to fund permanent equipment.	

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