TAMALPAIS UNION HIGH SCHOOL DISTRICT

Course of Study: Physics in the Universe

Title of Course: **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, Archie Williams 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): **None**
Check all that apply: ✅ UC A-G course ✅ Graduation Requirement ❑ Elective ❑ Honors/AP ❑ ROP	

Introduction

Physics in the Universe is a course built upon performance expectations (PEs) that blend the disciplinary core ideas (DCIs) of physics and earth science with scientific and engineering practices (SEPs) and crosscutting concepts (CCCs). This 3 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: Formation of the Universe and Light

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 that 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 by investigating 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.

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 the energy released during the processes of fission, fusion, and radioactive decay.

Transfer

Students will predict, model, argue with evidence and draw conclusions about the future of the universe.

Meaning Making

UNDERSTANDINGS

Students will understand that…

CCCs

- 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.

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?

Acquisition

HS-PS2-4 Use mathematical representations of Newton's Law of Gravitation to describe and predict the gravitational 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.	*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	*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
Stage 2 - Evidence		
Learning Goals Measured: HS-ESS1-2	**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.	
	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 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.
	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, modified Math, will be provided for extra support to complete mathematical computations.

Stage 1 Desired Results
Unit 2: Earth Formation and Earth Processes Students examine evidence of the past and present that helps them develop an understanding of Earth's systems and how they were formed. They evaluate the importance of astronomical impacts to 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.

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-ESS1-5. Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks.

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.

HS-ESS2-3. Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection

Transfer

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.

Meaning Making

UNDERSTANDINGS

Students will understand that…

CCCs

- 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 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.

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 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

Students will be skilled at…

SEPs

- Scientists *analyze data* from radiometric dating to create valid and reliable claims

	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.	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 continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks.	**Success Criteria** HS-ESS1-5.	
	Sample Assessment 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.	
	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 3: Forces and Motion

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 reentry and landing of spacecraft. Students will engage in an engineering challenge to design a device/system that minimizes impact from landing.

<table>
<tr><td rowspan="4">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</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</td><td>ESSENTIAL QUESTIONS
1. How do we describe and explain the motion of planets, moons, asteroids and satellites?
2. How do we describe and explain collisions between planets and asteroids or</td></tr>
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<td rowspan="4">system.
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.
HS-ESS1-4. Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.</td>
<td>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 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.</td>
<td>planets and satellites?
3. How do human-made satellites stay in orbit? Why don't they fall to Earth?
4. How are spacecraft designed to escape from and safely return to Earth's gravity?</td>
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<tr>
<td colspan="2">Acquisition</td>
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<tr>
<td>Students will know…
<u>DCIs</u>
● 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</td>
<td>Students will be skilled at…
<u>SEPs</u>
● 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.</td>
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	landing. ● Weight is a force and is determined by the strength of the local gravitational field. As a result the same object will have different weights on Earth, Earth's moon and Mars.	
Stage 2 - Evidence		
Learning Goals Measured: HS-PS2-3. Students will demonstrate and understanding total momentum within the system, an ability to work within the design constraints within the assignment, and 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.	**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.	
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 stop watches. They will explore the driving question, what happens to a person's speed if pushed with a constant force?	
	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.	

Stage 1 Desired Results

Unit 4: Energy and Energy Applications

Students examine human energy sources and uses in a variety of contexts – 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.

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-PS3-2. Develop and use models to illustrate the energy at the macroscopic scale can be accounted for as a combination of energy associated with the motion of particles and energy associated with the relative positions of particles.

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

Transfer

Students will design, build and refine (improve efficiency) a device or system that converts one energy form into another.

Meaning Making

UNDERSTANDINGS

Students will understand that…

CCCs

- 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.

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.)?

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.	***Acquisition***	
	Students will know… 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.	*Students will be skilled at…* 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	
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.	**Success Criteria** HS-ESS3-2. HS-ETS1-1. **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.
Stage 3 – Learning Plan	
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	**Sample Assignment:** Students design and test strategies to improve the efficiency of an energy transformation system, where electric energy is converted to heat energy using electric heaters in water. **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). ● 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 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.

Stage 1 Desired Results
Unit 5: Energy and Energy Applications - Electricity and Magnetism 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.

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-PS3-1. Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.

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-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.

Transfer

Students will design and test modifications for improving the efficiency of an electrical motor or an electrical generator.

Meaning Making

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 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.

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?
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 energy of one component in a system when the	**Success Criteria** HS-PS3-1. **Sample Assessment**	

<table>
<tr><td>change in energy of the other component(s) and energy flows in and out of the system are known.</td><td>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.</td></tr>
<tr><th colspan="2">Stage 3 – Learning Plan</th></tr>
<tr><td rowspan="2">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</td><td>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.</td></tr>
<tr><td>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.</td></tr>
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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.

BOT Approved: 1/23/18
Updated: 2/6/18, 12/24
UC Approved (d) 2/5/18,
UC Revision approved (d) 05/2024