Physics of the Universe Honors 361531H/32H

Title: Honors Physics of the Universe
Length of course: Full Year
Subject area: Laboratory Science (D) / Physics
UC honors designation? Yes
Prerequisites: Biology of Living Earth (Required)
Algebra 1 (Required)
Co-requisites: Geometry (Recommended)
Integrated (Academics / CTE)? No
Grade levels:
10th, 11th, 12th

Course Description

Course overview:

Physics of the Universe Honors is a rigorous laboratory-based college preparatory course that establishes a deep understanding of the fundamental laws that govern the universe. The course is divided into coherent instructional segments centered on concepts of force and motion, Newton's laws, gravitation, electrostatic and other forces, energy conversion and renewable energy, nuclear processes and earth history, waves and electromagnetism, and stars and the origin of the universe. As students achieve the Performance Expectations (PEs) within each unit, they uncover Disciplinary Core Ideas (DCIs) from Physical Science, Earth and Space Science, and Engineering by applying their understanding of real life situations to explain a phenomenon, solve a problem, or design an engineering solution. Students engage in multiple Science and Engineering Practices (SEPs) in each unit and focus on one or two Crosscutting Concepts (CCCs) as tools to make sense of their observations and investigations. Throughout each instructional segment, students are challenged to use calculations that describe results quantitatively, as well as be able to explain qualitatively how those calculations represent relationships between the included variables. Honors level students are expected to both apply equations appropriately and fully explain what they mean. Each semester of the course ends with a comprehensive culmination project through which students demonstrate understanding of physics concepts and practice planning and carrying out their own authentic investigations. Physics of the Universe AB Honors meets the District Graduation requirement for physical science.

Course content:

Unit 0: Reviewing Science and Engineering Practices (SEP)

In this introductory unit, students will get reacquainted with the ***science and engineering practices*** from prior science and/or engineering classes, most likely Chemistry in the Earth System or Biology of Living Earth. In this unit, students will design a small experiment, and in doing so will build on their previous scientific skills including: safety procedures and policies, research background information and prior findings, design an experiment, identify independent and dependent variables, conduct experiment, read measuring instruments (temperature, length, weight/mass), log data into notebook, organize data into tables, convert data tables into graphs, analyze and evaluate results, account for experimental error, and communicate results using CLAIM, EVIDENCE, and REASON and through a scientific report. While, we will cover some SEPs in this introductory unit, all SEPs will be addressed in further depth and detail throughout the yearlong course as they become applicable to the unit in question.

Content (to be covered as students conduct their experiment):

The nature of science and the scientific processes allow scientists to be able to study natural phenomena by following a collective series of steps, in which observations lead to questions,

questions to possible hypotheses, then testing of the hypothesis by only changing one variable, analyzing the results, and drawing conclusions to determine the validity of both the data (experiment) and the hypothesis. In the scientific community, if a hypothesis has obtained substantial evidence, then it can become a theory. On the other hand, a law is a statement (can be mathematical) that describes (not explains) natural phenomena.

One significant differentiation in this honors course is attention to and analysis of experimental error. When conducting an experiment, it is important to note the quality of the data. There will always be human error, and this should always be noted in the discussion part of a lab report. It is important to be both accurate AND precise. (Accuracy is how close the experimental value is to the true value, and precise is how exact the experimental value is.) Measurement uncertainties and significant figures will be used to reflect the exactness of such measurements. Significant figures are important because they indicate the “certain” versus the “uncertain” values that are obtained from a measuring tool. In addition, percent experimental error is used to calculate the accuracy of the data, how close the experimental value is to the actual value. The formula for percent error is the following:

% Error = (Theoretical Value - Experimental Value)/Theoretical Value) x 100

It is important to understand how to read instruments in science, especially in Physics where things are read at a smaller scale. The ability to read and collect data both accurately and precisely will determine the quality of the data. Physics is a field of study focusing on how the universe behaves, with numerous forms of applicable measurement. A focus on fundamental laboratory techniques, lab safety, use of metric units and conversions, graphical analysis and interpretation, use of electronic tools for data collection and manipulation and scientific communication and technical writing.

Physics uses the SI units: meter for length, kilogram for mass, second for time, kelvin for temperature, and mole for amount of substance. It also uses prefixes to easily convert between a large unit and a small unit. Some of the prefixes are as follow: *Kilo- (k)* is for 1000, *centi- (c)* is for 1/100, and *Milli- (m)* is for 1/1000. Some units are derived, meaning they come from a combination of units. Volume is one of these units: 1L = 1000 ml = 1000 cm3.

Unit Assignment(s):

Students will be taking a look at the amount of carbon dioxide that is released from different sources. Now that students are aware that carbon dioxide is a greenhouse gas that is a major cause for today’s climate change, they will be able to determine where most of the carbon dioxide is coming from. Using a balloon, students (or teacher) will collect carbon dioxide from breathing (cellular respiration), fossil fuels (car exhaust), and outside air. They will determine the amount of carbon dioxide in each solution using Bromothymol Blue solution, in which CO_2 reacts with water to form carbonic acid, and the carbonic acid will change the color of the solution from blue to green and then to yellow. Students will use this information to identify the pH of the solution, and therefore the amount of carbon dioxide in each of the tested variables. Students will be placing their data in a designated bound notebook. Students will need to submit a finalized lab report on their findings. In addition, students will research the current carbon dioxide levels are for Los Angeles, have heavily populated cities and compare it to rural cities. Students will also look at whether the amount of carbon dioxide has increased throughout the years.

Unit Lab Activities:

The laboratory activities are inquiry-based and discovery-based, and serve to prepare students for university-level study. Through these labs, students will engage in hands on activities utilizing their scientific thinking. Each lab will allow students to observe natural phenomena, identify methods of collecting and organizing data, evaluating the data, and interpreting/analyzing the data. Students will be required to make observations and predictions of their observations. With this information, students will be aided in forming a testable hypothesis, and in turn they will design an experiment to test their hypothesis, collect the data, and draw a conclusion of their hypothesis by linking their data and analysis of data to evaluate their overall experimental design. The overall goal is for students to learn that science is more than just theories, but a process of learning about the natural world through experimentation and research.

Unit 1: Forces and Motion
NGSS Standards:

HS-PS2-1. Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration. [Clarification Statement: Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object rolling down a ramp, or a moving object being pulled by a constant force.] [Assessment Boundary: Assessment is limited to one-dimensional motion and to macroscopic objects moving at non-relativistic speeds.]

HS-PS2-2. Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system. [Clarification Statement: Emphasis is on the quantitative conservation of momentum in interactions and the qualitative meaning of this principle.] [Assessment Boundary: Assessment is limited to systems of two macroscopic bodies moving in one dimension.]

HS-PS2-3. Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.* [Clarification Statement: Examples of evaluation and refinement could include determining the success of the device at protecting an object from damage and modifying the design to improve it. Examples of a device could include a football helmet or a parachute.] [Assessment Boundary: Assessment is limited to qualitative evaluations and/or algebraic manipulations.]

HS-ETS1-1. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

HS-ETS1-4. Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

Guiding Questions:

- How can Newton's Laws be used to explain how and why things move?
- How can mathematical models of Newton's Laws be used to test and improve engineering designs?

Unit Summary:

Students will learn that Newton's Laws provide a basis for understanding forces and motion and, therefore, serve as a foundation for a study of physics. In order to gain a deeper understanding of how motion is affected by forces and be able to describe those effects both qualitatively and quantitatively, students will apply Newton's Laws mathematically or with computational models to predict the motion of objects (SEP-5). In a end-of-unit culminating project, students will use these calculations to draw connections to real-world applications of Newton's Laws. Applying Newton's Laws becomes quite complicated when considering the forces within deforming bodies, but through investigation, students will uncover the idea that these simple laws lie at the heart of even the most sophisticated computer simulations. Students will be challenged to both quantitatively and qualitatively describe how changes in motion relate to forces. Their unit activities include investigation of collisions in Earth's crust as well as completion of an engineering challenge.

Unit Assignment(s):

Sample Assignment: Real-World Application of Newton's Laws of Motion

Major Focus Question: How do Newton's Laws of Motion help us predict or explain why and how objects move?

Assignment Overview: Students create a "mini-lesson" on Newton's Laws of Motion to present to the class [SEP-8]. Each team will pick a real-life situation where Newton's laws are applicable and use at least two different sources to research how these laws are utilized in engineering to construct a useful tool or instrument. Student presentations should include a general description/definition of the law demonstrating the application of the principle. Presentations should also include sample calculations with a full explanation of what that information can be used for when predicting motion. Students will create visual presentations that make strategic use of digital media to enhance findings, reasoning, evidence, and add interest. These presentations give students an opportunity to show how much they have learned about how force impacts motion both quantitatively and qualitatively [SEP-6].

Unit Lab Activities:

Lab 1: Modeling Geologic Forces

Major Focus Question: How do forces cause specific geologic features?

Lab Overview: Students conduct an investigation during which they apply different forces to layers of different sand distinguished by color in a sandbox. Students see layers deformed, simulating geological folding and mountain building, tying their investigation of forces to physics applications in earth science. Students work in pairs to explain the forces acting on a small section of sand near the middle of the model, and then explain how Newton's Second Law ($F = ma$) applies to this situation. Students also explore and explain how friction plays a role in this simulation. Students will submit a written report that includes collected data, calculations, and interpretation of their collected data in the context of Newton's Laws.

Unit 2: Forces at a Distance

NGSS Standards:

HS-PS2-4. Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects. [Clarification Statement: Emphasis is on both quantitative and conceptual descriptions of gravitational and electric fields.] [Assessment Boundary: Assessment is limited to systems with two objects.]

HS-PS2-6. Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.* [Clarification Statement: Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.] [Assessment Boundary: Assessment is limited to provided molecular structures of specific designed materials.]

HS-ESS1-4. Use mathematical or computational representations to predict the motion of orbiting objects in the solar system. [Clarification Statement: Emphasis is on Newtonian gravitational laws governing orbital motions, which apply to human-made satellites as well as planets and moons.] [Assessment Boundary: Mathematical representations for the gravitational attraction of bodies and Kepler's Laws of orbital motions should not deal with more than two bodies, nor involve calculus.]

Guiding Questions:

- How can different objects interact when they are not even touching?
- How do interactions between matter at the microscopic scale affect the macroscopic properties of matter that we observe?
- How do satellites stay in orbit?

Unit Summary:

The prior unit introduces the concept of force as an influence that tends to change the motion of a body or produce motion or stress within a stationary body. While forces govern a wide range of interactions, the design challenge and many of the simplest applications from the first instructional unit primarily involved interactions between objects that appeared to be physically touching. During this unit, students will build upon this foundational understanding of forces by examining gravity and electromagnetism, both of which are forces that can be modeled as fields that span space [SEP-2]. Despite the fact that students cannot see them, students interact with these fields on a daily basis and are already familiar with those forces' pushes and pulls. Students will investigate gravitational and electromagnetic forces, describe the relationships between field forces and motion of objects, and use mathematics to quantitatively predict effects [SEP-3]. Investigations include predicting the motion of orbiting objects in the solar system and linking the macroscopic properties of materials to microscopic electromagnetic attractions.

Unit Assignment(s):

Sample Assignment: Modeling Satellite Orbits

Major Focus Question: How do variables such as mass, distance, and launch speed determine satellite motion?

Assignment Overview: Students interpret an existing computer program of a two-body gravitational system. They are challenged to identify an error in the implementation of the gravity equations in sample code provided. Next, students modify that computer code to correctly reflect the mass of the Earth and a small artificial communications satellite orbiting around it. Students can vary different parameters in the code such as the distance from Earth or initial speed and see how those parameters affect the path of the satellite [CCC-2]. Students further investigate gravitational interactions between Earth and satellites when mass of the satellite is changed. For extension, students will use another simulation to model [SEP-2] how orbital motion is impacted when variables of mass and distance apart are changed in order to derive relationships described in Newton's Law of Gravitation. Students will answer questions such as, "At what initial launch speeds will the satellite stay in orbit?" and "What is the tradeoff between the cost of fuel and the payload mass?"

Unit Lab Activities:

Lab 1: Investigating Polarization

Major Focus Question: How do different charges interact with each other?

Lab Overview: Students create charge differentials in objects such as glass rods and balloons by rubbing and by induction and then determine which objects are positively charged and which are negatively charged [CCC-6]. Next, students are expected to demonstrate and explain the process of polarization based on their observations. Concepts such as Coulomb's Law are explored so that students are explaining lab results both quantitatively and qualitatively [SEP-4]. Students will submit a lab report analyzing their results and giving their conclusions.

Unit 3: Conservation of Energy

NGSS Standards:

HS-PS2-5. Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric

current. [Assessment Boundary: Assessment is limited to designing and conducting investigations with provided materials and tools.]

HS-PS3-1. Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known. [Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.] [Assessment Boundary: Assessment is limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.]

HS-PS3-2. Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects). [Clarification Statement: Examples of phenomena at the macroscopic scale could include the conversion of kinetic energy to thermal energy, the energy stored due to position of an object above the earth, and the energy stored between two electrically-charged plates. Examples of models could include diagrams, drawings, descriptions, and computer simulations.]

HS-PS3-3. Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.* [Clarification Statement: Emphasis is on both qualitative and quantitative evaluations of devices. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators. Examples of constraints could include use of renewable energy forms and efficiency.] [Assessment Boundary: Assessment for quantitative evaluations is limited to total output for a given input. Assessment is limited to devices constructed with materials provided to students.]

HS-PS3-5. 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. [Clarification Statement: Examples of models could include drawings, diagrams, and texts, such as drawings of what happens when two charges of opposite polarity are near each other.] [Assessment Boundary: Assessment is limited to systems containing two objects.]

HS-PS4-5. Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.* [Clarification Statement: Examples could include solar cells capturing light and converting it to electricity; medical imaging; and communications technology.] [Assessment Boundary: Assessments are limited to qualitative information. Assessments do not include band theory.]

HS-ESS3-2. Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.* [Clarification Statement: Emphasis is on the conservation, recycling, and reuse of resources (such as minerals and metals) where possible, and on minimizing impacts where it is not. Examples include developing best practices for agricultural soil use, mining (for coal, tar sands, and oil shales), and pumping (for petroleum and natural gas). Science knowledge indicates what can happen in natural systems—not what should happen.]

HS-ESS3-3. Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity. [Clarification Statement: Examples of factors that affect the management of natural resources include costs of resource extraction and waste management, per-capita consumption, and the development of new technologies. Examples of factors that affect human sustainability include agricultural efficiency, levels of conservation, and urban planning.] [Assessment Boundary: Assessment for computational simulations is limited to using provided multi-parameter programs or constructing simplified spreadsheet calculations.]

HS-ETS1-1. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

HS-ETS1-4. Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

Guiding Questions:

- How do power plants generate electricity?
- What engineering designs can help increase the efficiency of our electricity production and reduce the negative impacts of using fossil fuels?

Unit Summary:

Students explore their interactions with energy usage and with energy generation in order to understand how energy can be transformed from one form to another. One such real-world interaction with energy that students explore is how the light energy shining out from a computer is converted from the electric potential energy of electrons from the wall socket that flowed through wires, which may trace back to a wind turbine, which did work harnessing the movement of air masses, which absorbed thermal energy from the solid Earth, which originally absorbed the energy from the Sun [CCC-2]. With each interaction, students are expected to explain how that energy can change from one form to another. Students are expected to connect these ideas with perhaps the most unifying crosscutting concept in physics and all other science, the conservation of energy [CCC-5]. In this unit, students track energy transfer and conversion through different stages of power plants and evaluate different power plant technologies. Furthermore, students investigate electromagnetism to create models of how generators work and obtain and communicate information about how solar photovoltaic systems operate. As a culminating activity, students design and test their own energy conversion devices.

Unit Assignment(s):

Sample Assignment: Exploring Electricity and Magnetism using a Compass

Major Focus Question: How does electricity affect magnetic fields?

Assignment Overview: Students will recreate Ørsted's simple investigation [SEP-3] in which he noticed that a compass needle would be deflected from magnetic north when an electric current passed through a wire that was held above the magnet. Students are challenged to get a compass needle to deflect a fixed amount (e.g., so that it points northeast at 45° instead of north). They will need to explore what happens when they change the direction of the wire, the voltage through the wire, or the number of winds of the wire around the compass or move the compass to different locations around the wire. Students will then be able to create an informative poster communicating [SEP-8] how each of these variables affects [CCC-2] the compass needle, including explanations of the relationship between each variable and the quantitative effect of changing each.

Unit Lab Activities:

Students generate electricity by moving a cylindrical magnet in and out of a coil connected to a small light bulb. Students select variables to manipulate in order to examine the effect on the produced magnetic or electric field respectively. Variables may include coil thickness, number of cylinders in a coil, the size of the cylinder, or the speed in which the magnet goes in and out of the coil. Students use their data to derive a proportionality that shows how each variable is related quantitatively to the others, which is included in their lab report.

Unit 4: Nuclear Processes

NGSS Standards:

HS-ESS1-5. Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks [Clarification Statement: Emphasis is on the ability of plate tectonics to explain the ages of crustal rocks Examples include evidence of the ages oceanic crust increasing with distance from mid-ocean ridges (a result of plate spreading) and the ages of North American continental crust increasing with distance away from a central ancient core (a result of past plate interactions)] (Also addressed in the High School Chemistry in the Earth System course)

HS-ESS1-6. Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history [Clarification Statement: Emphasis is on using available evidence within the solar system to reconstruct the early history of Earth, which formed along with the rest of the solar system 46 billion years ago Examples of evidence include the absolute ages of ancient materials (obtained by radiometric dating of meteorites, moon rocks, and Earth's oldest minerals), the sizes and compositions of solar system objects, and the impact cratering record of planetary surfaces] (Also addressed in the High School Living Earth course)

HS-ESS2-1. Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features [Clarification Statement: Emphasis is on how the appearance of land features (such as mountains, valleys, and plateaus) and sea-floor features (such as trenches, ridges, and seamounts) are a result of both constructive forces (such as volcanism, tectonic uplift, and orogeny) and destructive mechanisms (such as weathering, mass wasting, and coastal erosion)] [Assessment Boundary: Assessment does not include memorization of the details of the formation of specific geographic features of Earth's surface.] (Also addressed in the High School Living Earth course)

HS-PS1-8. Develop models to illustrate the changes in the composition of the nucleus of

the atom and the energy released during the processes of fission, fusion, and radioactive decay [Clarification Statement: Emphasis is on simple qualitative models, such as pictures or diagrams, and on the scale of energy released in nuclear processes relative to other kinds of transformations] [Assessment Boundary: Assessment does not include quantitative calculation of energy released. Assessment is limited to alpha, beta, and gamma radioactive decays.]

Guiding Questions:

- What does E=mc2 mean?
- How do nuclear reactions illustrate conservation of energy and mass?
- How do we determine the age of rocks and other geologic features?

Unit Overview:

Energy [CCC-5] related to changes in the nuclei of atoms drives about 20 percent of California's electricity generation (California Energy Commission Energy Almanac 2016) (from fission in nuclear power plants), half the heat flowing upwards from Earth's interior (from the radioactive decay of unstable elements) (Gando et al. 2011), and all of the energy we receive from the Sun (from nuclear fusion in its core). In this unit, students develop models [SEP-2] for these processes.

Unit Assignment(s):

Sample Assignment: Modeling Atomic Structure and Nuclear Processes

Major Focus Question: What occurs at the level of the internal structure of the atom during nuclear processes such as fission, fusion and radioactive decay?

Assignment Overview: Students develop a model [SEP-2] of the internal structure of atoms and then extend it to include the processes of fission, fusion, and radioactive decay. They apply this model to understanding nuclear power and radiometric dating. They use evidence from rock ages to reconstruct the history of the Earth and processes that shape its surface.

Unit Lab Activities:

Lab 1: Modeling Radioactive Decay

Major Focus Question: How is half life related to the change in mass of an isotope over time?

Lab Overview: Students will model [SEP-2] radioactive decay using pennies. Students will simulate the transformation of a radioactive isotope over time, graph and analyze the data. Students will relate their analysis to radioactive decay and half-lives. After completing this exercise students will have a better understanding of half-life and be able to complete multiple calculation types including: number of half lives, mass of isotope remaining, amount of isotope decomposed and use the first order rate law to determine decay time.

Unit 5: Waves and Electromagnetic Radiation

NGSS Standards:

HS-ESS2-1. Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features [Clarification Statement: Emphasis is on how the appearance of land features (such as mountains, valleys, and plateaus) and seafloor features (such as trenches, ridges, and seamounts) are a result of both constructive forces (such as volcanism, tectonic uplift, and orogeny) and destructive mechanisms (such as weathering, mass wasting, and coastal erosion)] [Assessment Boundary: Assessment does not include memorization of the details of the formation of specific geographic features of Earth's surface.] (Introduced in IS4)

HS-PS4-1. Use mathematical representations to support a claim regarding relationships

among the frequency, wavelength, and speed of waves traveling in various media [Clarification Statement: Examples of data could include electromagnetic radiation traveling in a vacuum and glass, sound waves traveling through air and water, and seismic waves traveling through the Earth] [Assessment Boundary: Assessment is limited to algebraic relationships and describing those relationships qualitatively.]

HS-PS4-2. Evaluate questions about the advantages of using a digital transmission and storage of information [Clarification Statement: Examples of advantages could include that digital information is stable because it can be stored reliably in computer memory, transferred easily, and copied and shared rapidly Disadvantages could include issues of easy deletion, security, and theft]

HS-PS4-3. Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other [Clarification Statement: Emphasis is on how the experimental evidence supports the claim and how a theory is generally modified in light of photoelectric effect] [Assessment Boundary: Assessment does not include using quantum theory.]

HS-PS4-4. Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter [Clarification Statement: Emphasis is on the idea that photons associated with different frequencies of light have different energies, and the damage to living tissue from electromagnetic radiation depends on the energy of the radiation Examples of published materials could include trade books, magazines, web resources, videos, and other passages that may reflect bias] [Assessment Boundary: Assessment is limited to qualitative descriptions.]

HS-PS4-5. Communicate technical information about how some technological devices use

the principles of wave behavior and wave interactions with matter to transmit and capture information and energy [Clarification Statement: Examples could include solar cells capturing light and converting it to electricity; medical imaging; and communications technology] [Assessment Boundary: Assessments are limited to qualitative information. Assessments do not include band theory.]

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a practice or disciplinary core idea

Guiding Questions:

- How do we know what is inside the Earth?
- Why do people get sunburned by UV light?
- How do can we transmit information over wires and wirelessly?

Unit Overview:

At the end of unit 4, students found evidence [SEP-7] that supported the idea that massive blocks of crust are moving, sometimes diving deep into Earth's interior. One of the main ways that we investigate Earth's interior is through seismic waves. Before students can understand that evidence, they must first understand the basic properties of waves. Unit 5 introduces mathematical representations of waves and develops models of wave properties and behaviors.

Unit Assignment(s):

Sample Assignment: Mathematical Representation of Mechanical and Electromagnetic Waves

Major Focus Question: What are the relationships between wavelength, frequency and speed of waves? What variables affect the interaction between waves and matter?

Assignment Overview: Students make mathematical models [SEP-5] of waves and apply them to seismic waves traveling through the Earth. They obtain and communicate information about other interactions between waves and matter with a particular focus on electromagnetic waves. They obtain, evaluate, and communicate information about health hazards associated with electromagnetic waves. They use models of wave behavior to explain information transfer using waves and the wave-particle duality.

Unit Lab Activities:

Lab 1: Speed of Sound Determination

Major Focus Question: How fast does sound travel and how can we measure it?

Lab Overview: Students will measure the speed of sound waves at room temperature by timing an echo using a faster timing system such as a data-collection interface connected to a microphone placed next to a hollow tube. The microphone will be placed next to the opening of a hollow tube. When students make a sound by snapping their fingers next to the opening, the computer will begin collecting data. After the sound reflects off the opposite end of the tube, a graph will be displayed showing the initial sound and the echo. Students will then be able to determine the round trip time and calculate the speed of sound [SEP-5].

Unit 6: Stars and the Origin of the Universe

NGSS Standards:

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. [Clarification Statement: Emphasis is on the energy transfer mechanisms that allow energy from nuclear fusion in the sun's core to reach Earth. Examples of evidence for the model include observations of the masses and lifetimes of other stars, as well as the ways that the sun's radiation varies due to sudden solar flares (“space weather”), the 11-year sunspot cycle, and non-cyclic variations over centuries.] [Assessment Boundary: Assessment does not include details of the atomic and subatomic processes involved with the sun’s nuclear fusion.]

HS-ESS1-2. Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe. [Clarification Statement: Emphasis is on the astronomical evidence of the red-shift of light from galaxies as an indication that the universe is currently expanding, the cosmic microwave background as the remnant radiation from the Big Bang, and the observed composition of ordinary matter of the universe, primarily found in stars and interstellar gases (from the spectra of electromagnetic radiation from stars), which matches that predicted by the Big Bang theory (3/4 hydrogen and 1/4 helium).]

HS-ESS1-3. Communicate scientific ideas about the way stars, over their life cycle, produce elements. [Clarification Statement: Emphasis is on the way nucleosynthesis, and therefore the different elements created, varies as a function of the mass of a star and the stage of its lifetime.] [Assessment Boundary: Details of the many different nucleosynthesis pathways for stars of differing masses are not assessed.]

Guiding Questions:

- How do we know what stars are made of?
- What fuels our Sun? Will it ever run out of that fuel?
- Do other stars work the same way as our Sun?
- How do patterns in motion of the stars tell us about the origin of our universe?

Unit Overview:

According to the NGSS storyline, “High school students can examine the processes governing the formation, evolution, and workings of the solar system and universe. Some concepts studied are fundamental to science, such as understanding how the matter of our world formed during the Big Bang and within the cores of stars. Other concepts are practical, such as understanding how short-term changes in the behavior of our sun directly affect humans. Engineering and technology play a large role here in obtaining and analyzing the data that support the theories of the formation of the solar system and universe.” In this unit, students apply their model of nuclear fusion to trace the flow of energy from the Sun’s core to Earth. They use evidence from the spectra of stars and galaxies to determine the composition of stars and construct an explanation of the origin of the Universe.

Unit Assignment(s):

Sample Assignment: Graphing and Analyzing Patterns in the Physical Characteristics of Stars

Major Focus Question: What patterns can be discovered when analyzing brightness, temperature and distance of stars? How can we use graphs to discover relationships between variables?

Assignment Overview: Students review a table of a number of properties of the 100 nearest stars and the 100 brightest stars using a spreadsheet. They construct graphs of different properties looking for **patterns** [CCC-1] in this data. They find that many of the factors, are uncorrelated (“It looks like bright stars can be located both near and far from us.”), but they should see a definite pattern between brightness and temperature—hotter stars are brighter and colder stars are dimmer. They may begin with a linear scale [CCC-3], but with such a large range in the brightness of stars (less than 1% as bright up to 100 times brighter than the Sun), they discover will need to adjust to a logarithmic scale [CCC-3].

Unit Lab Activities:

Unit Lab Activities:

Lab 1: Modeling the Expansion of the Universe

Major Focus Question: How is the rate of expansion in the universe related to distance from a fixed point?

Lab Overview: Students in groups use a large balloon and blow it up to 8 cm in diameter to model the expanding universe. Students then make nine random dots on the balloon and label them A-I. Point A represents the Milky Way Galaxy while the other eight points represent eight distant galaxies. Students measure the distance from Point A to all the other points. They then blow the balloon up to several larger sizes and measure the distance from point A to all the other points. The purpose of this lab is threefold: (1) students understand the that the universe is expanding, (2) Students measure and calculate that galaxies farther away from Point A (the Milky Way) are moving at a greater distance and speed than those closer to Point A, and (3) that it is space itself (in this model the balloon) that is expanding and moving the galaxies.

Honors Final Exam Details:

The fall final exam will cover the first three units and will assess students' understanding through the use of multiple choice questions, short answer responses, and calculation-based constructed response. Additionally, there will be a lab practical, where students will be assessed on their ability to make accurate measurements with typical physics lab instruments correctly apply fundamental physics principles, design simple experiments, interpret empirical data, evaluate results, apalyze measurement errors and communicate their findings clearly.

The spring final exam will be a cumulative exam, consisting of all four units and all concepts covered. Students will be assessed through multiple choice, short answer responses, and calculation-based constructed response. Both mathematical and conceptual concepts will be assessed, with the calculation-based constructed response focusing primarily on the application of mathematics and the integration of various physics concepts. As with the fall semester, students will be assessed again on their hands on performance with a laboratory final. The laboratory final will be drawn from one of the last five units and will likely cover Newton’s laws, nuclear processes, and wave properties. Students will be assessed not only on their performance in the lab, but also on post-lab questions that delve into the core mathematical and conceptual concepts at hand. Students will submit a written final report that will serve as a portion of their final examination grade.

Course Materials

Websites

Title	Author(s)/Editor(s)/Compiler(s)	Affiliated Institution or Organization	U
CK12.org	[empty]	CK-12 Foundation	htt
Phet Simulations	[empty]	University of Colorado	htt