



Physics of the Universe, Honors Course Outline

Basic Course Information

Course Name: Physics of the Universe, Honors

Credits: 10

Course Length: 2 semesters

Domain: Science

Honors: Yes

UC A-G: yes

UC A-G Requirement Fulfilled: Laboratory Science (d) Physics/Earth and Space Sciences

CTE Industry Sector: None

Other Information: None

Grade Levels: 9,10,11,12

Prerequisites: Integrated Mathematics 1

Corequisites: Integrated Mathematics 2

Course Creation/Revision Date: 09/30/2019

Course Description and Content

Course Description: 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 Units: Reviewing Science and Engineering Practices (SEP)

Unit Summary:

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.

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 CO₂ 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.

Forces and Motion

Unit Summary

- 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?

Students make predictions using Newton's laws. Students mathematically describe how changes in motion relate to forces. They investigate collisions in Earth's crust and in an engineering challenge. Students will also use Kepler's laws when considering the motion of celestial objects such as planetary motion in our solar system.

Unit Assignment(s)

Students will use computer simulations to collect and analyze data about gravitational forces to make sense of Newton's Laws to predict the gravitational forces between objects. Emphasis is on both quantitative and conceptual descriptions of gravitational fields. The students will demonstrate their understanding by presenting and comparing their predictions with the rationale behind their methods. Other students will critique, respond and adapt their mathematical models based on the feedback.

Unit Lab Activities:

Force, Mass, and Acceleration: What Is the Mathematical Relationship Among the Net Force Exerted on

an Object, the Object's Inertial Mass, and Its Acceleration? The purpose of this lab is to *introduce* students to the core idea of forces and motion, part of the disciplinary core idea (DCI) of Motion and Stability: Forces and Interactions from the *NGSS*, by having them determine the mathematical relationship among the net force acting on an object, its mass, and its acceleration. Students will observe and graph the acceleration of objects in order to uncover patterns and causal relationships that are supported by their data. They will create claims with their evidence and reasoning that they present to their peers to demonstrate their understanding.

Forces at a Distance

Unit Summary

Forces at a Distance

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?

Students investigate gravitational and electromagnetic forces and describe them mathematically. They predict the motion of orbiting objects in the solar system. They link the macroscopic properties of materials to microscopic electromagnetic attractions.

Unit Assignment(s)

Students use the analysis of the motion of the objects before the interaction to identify a system with essentially no net force on it. Based on the analysis of the total momentum of the system, students support the claim that the momentum of the system is the same before and after the interaction between the objects in the system, so that momentum of the system is constant. Students identify that the analysis of the momentum of each object in the system indicates that any change in momentum of one object is balanced by a change in the momentum of the other.

Unit Lab Activities:

Engineering Design (Rube Goldberg Project)- Students design a device that converts one form of energy into another form of energy. Students develop a plan for the device in which they:

- Identify what scientific principles provide the basis for the energy conversion design;
- Identify the forms of energy that will be converted from one form to another in the designed system;
- Identify losses of energy by the design system to the surrounding environment;
- Describe the scientific rationale for choices of materials and structure of the device, including how student-generated evidence influenced the design; and
- Describe that this device is an example of how the application of scientific knowledge and engineering design can increase benefits for modern civilization while decreasing costs and risk.

Energy Conversion and Renewable Energy

Unit Summary

- 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?

Students track energy transfer and conversion through different stages of power plants. They evaluate different power plant technologies. They investigate electromagnetism to create models of how generators work and obtain and communicate information about how solar photovoltaic systems operate. They design and test their own energy conversion devices in the lab and apply their knowledge of the conservation of energy, systems and models to test the effect changes as they vary the design of their energy conversion device which may be a wind turbine or solar array.

Unit Assignment(s)

Students use the given computer simulation about solar panel type and placement to model the proposed solutions by: Selecting logical and realistic inputs; and Using the model to simulate the effects of different solutions, trade-offs, or other decisions.

Students will conduct and write their analysis in four categories:

- compare the simulated results to the expected results.
- interpret the results of the simulation and predict the effects of the proposed solutions within and between systems relevant to the problem based on the interpretation.
- identify the possible negative consequences of solutions that outweigh their benefits.
- identify the simulation's limitations.

Unit Lab Activities:

Guiding Question: Conservation of Energy and Wind Turbines: How Can We Maximize the Amount of Electrical Energy That Will Be Generated by a Wind Turbine Based on the Design of Its Blades? The purpose of this lab is to *introduce* students to the disciplinary core idea (DCI) of Energy from the *NGSS* by giving them an opportunity to determine how to maximize the amount of electrical energy produced by a wind turbine. Students will plan and carry out an investigation to determine which design functions best in different wind conditions. They will present their ideas and write a recommendation article of blade design based on their results.

Nuclear Processes and Earth History

Unit Summary

- What does $E=mc^2$ mean?
- How do nuclear reactions illustrate conservation of energy and mass?
- How do we determine the age of rocks and other geologic features?

Students develop a model 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 Assignment(s)

Modeling Earth's Dynamics- Students use evidence to develop a model in which they identify and describe the following components:

- Descriptions and locations of specific continental features and specific ocean-floor features;
- A geographic scale, showing the relative sizes/ extents of continental and/or ocean floor features;
- Internal processes (such as volcanism and tectonic uplift) and surface processes (such as weathering and erosion); and
- A temporal scale showing the relative times over which processes act to produce continental and/or ocean-floor features.

Unit Lab Activities:

Students identify that crustal materials of different ages are arranged on Earth's surface in a pattern that can be attributed to plate tectonic activity and formation of new rocks from magma rising where plates are moving apart. Students identify the given evidence to be evaluated. They will be provided with some data, simulations and rock specimen examples. Students will present and write their claims based on their evidence from their lab data sources.

Waves and Electromagnetic Radiation

Unit Summary

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

Students make mathematical models 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 Assignment(s)

Wave and Particle Models of Light: Students identify a given explanation that is to be supported by the claims, evidence, and reasoning to be evaluated, and that includes the following idea: Electromagnetic radiation can be described either by a wave model or a particle model, and for some situations one model

is more useful than the other. After looking at the various computer models, the students will explain verbally which representation functions best for various goals. After hearing various explanations students will determine which reasoning makes the most sense to them for each application and write a report.

Unit Lab Activities:

The lab for this unit will help students understand ultraviolet (UV) light, the different types of UV light and relationship between UV light and sun protection factor (SPF). Students will design an experience with UV beads and various materials and sunscreens to measure the amount of UV transmission. They will show their learning through their analysis of the materials and sunscreens based on their data and their knowledge of UV light.

Stars and the Origins of the Universe

Unit Summary

- How do we know what are stars made out 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?

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)

For this activity students will be able to explain how the composition of the Sun differs from that of Earth and describe the various layers of the Sun and their functions. They will look at a variety of data and images collected about the sun and then construct a conceptual model of the composition of the sun. Students will also create descriptive labels for each element of sun and how we learned about that aspect of the sun.

Unit Lab Activities:

The lab for this unit will have students collecting data from their spectroscope from a variety of light sources to create a system to identify colors associated with the composition of the light. They will apply the use of spectroscopy to determine physical data of celestial objects such as temperature, chemical composition and relative motion. The collection of their results will be written to summarize their understanding of the types of data that are useful in identifying celestial objects.

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, analyze 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.

Framework: <https://www.cde.ca.gov/ci/sc/cf/>

Course Materials

Text Book Title: Physics

Author: Raymond A Serway and Jerry S.

Edition: 2007

Publisher: Holt

Publication Date: 2007

Text Url: NA

Other Materials:

Argument Driven Inquiry: Physics

Victor Sampson, Todd L. Hutner, Daniel FitzPatrick, Adam LaMee, and Jonathon Grooms

NSTA Press Book

2017

<https://argumentdriveninquiry.com/science>

Approval Dates: C&I 10/1/19