Physics of the Universe AB 361531/32

Title: Physics of the Universe AB
Length of course: Full Year
Subject area: Laboratory Science (D) / Physics
UC honors designation? No
Prerequisites: Algebra (Required)
Co-requisites: Algebra (Required)
Integrated (Academics / CTE)? No
Grade levels: 9th, 10th, 11th, 12th

Course Description

Course overview:
Physics of the Universe AB is a laboratory-based college preparatory course. The *Physics of the Universe AB* course is defined in the 2016 California Science Framework, integrating Physics and Earth and Space Science standards from the California Next Generation Science Standards (NGSS). The course is divided into six units (instructional segments) centered on questions about observations of a specific phenomenon. Different phenomena require different amounts of classroom investigative time to explore and understand, so each IS should take a different fraction of the school year. As students achieve the Performance Expectations (PEs) within the unit, they uncover Disciplinary Core Ideas (DCIs) from Physical Science, Earth and Space Science, and Engineering. Students engage in multiple Science and Engineering Practices (SEPs) in each unit, not only those explicitly indicated in the PEs. Students also focus on one or two Crosscutting Concepts (CCCs) as tools to make sense of their observations and investigations; the CCCs are recurring themes in all disciplines of science and engineering and help tie these seemingly disparate fields together.

Physics of the Universe AB meets the District Graduation requirement for physical science.

Course content:

Forces and Motion

Newton's Laws provide a basis for understanding forces and motion and, therefore, serve as a foundation for a study of physics. Engineers and scientists apply Newton's Laws mathematically or with computational models [SEP-2] to predict the motion of objects. These calculations enable applications as diverse as building safer automobiles and providing more reliable forecasts of earthquake hazard. Applying Newton's laws becomes quite complicated when considering the forces within deforming bodies, but these simple laws lie at the heart of even the most sophisticated computer simulations. In this unit, 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.

Unit Assignment(s):

Students create "mini-lessons" on Newton's Laws of Motion to present to the class. Each team or group of students use at least two different sources to research a law of motion for a visual presentation to the class. The presentation include a general description/definition of the law plus an example demonstrating the application of the principle. Visual presentations make strategic use of digital media to enhance findings, reasoning, evidence, and add interest.

Unit Lab Activities:

Students conduct a lab applying different forces on layers of different sand distinguished by color in a sandbox. Students see layers deformed simulating geological folding and mountain building.

Students work in pairs to explain the forces action on a small section of sand near the middle of the model. Students then explain how Newton's second law (F = ma) applies to this situation and how friction plays a role in this simulation.

Forces at a Distance

The first 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. This unit builds upon this foundation by examining gravity and electromagnetism, forces that can be modeled as fields that span space. Despite the fact that we cannot see them, we interact with these fields on a daily basis and students are already familiar with their pushes and pulls. 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 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 given to them. Next, students modify a computer code to correctly reflect the mass of the Earth and a small artificial communications satellite orbiting around it. They 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 (*HS-ESS1-4*). At what initial launch speeds will the satellite stay in orbit? What is the tradeoff between the cost of fuel and the payload mass?

Unit Lab Activities:

Students create charges in objects such as glass rods and balloons by rubbing and by induction. They determine what objects are positively charged and which negatively charged. They also demonstrate and explain the process of polarization. Students will submit a lab report analyzing their results and giving their conclusions.

Conservation of Energy

We use energy every moment of every day, but where does it all come from? The light energy shining out from our computer was converted from the electric potential energy of electrons from the wall socket that flowed through wires that 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. With each interaction, energy can change from one form to another. These ideas comprise perhaps the most unifying crosscutting concept in physics and all other science, conservation of energy. In this unit 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.

Unit Assignment(s):

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. They will be given the challenge of getting the 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.

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 to examine its effect on the produced magnetic or electric field respectively. Variables such as 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.

Nuclear Processes

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):

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 Lab Activities:

Students will model radioactive decay using pennies. Students will simulate the transformation of a radioactive isotope over time, graph the data and relate it to radioactive decay and half-lives. After completing this exercise students will have a better understanding of half-life, and given the half-life of a substance be able to calculate what percent of a sample will be left after a given time.

Waves and Electromagnetic Radiation

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):

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 Lab Activities:

Students will measure the speed of sound wave 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.

Stars and the Origin of the Universe

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):

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:

Students in groups use a large balloon and blow it up to 8cm 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 distant 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.

Course Materials

Websites

Title	Author(s)/Editor(s)/Compiler(s)	Affiliated Institution or Organization
WWW.CK12.org	[empty]	CK12 Foundation
Online Simulation	[empty]	University of Colorado Boulder