San Mateo Union High School District
Course of Study

Physics in the Universe

Approved by:
BOARD OF TRUSTEES
3/9/17

I. **Course Description**

A. UC/CSU "a-g" Level D Subject Area: Science

B. Rationale for Course

The content for Physics 1-2 in grades 9 through 12 will generally be drawn from the Science Content Standards for California Public Schools, the Next Generation Science Standards and the Common Core State Standards for Literacy in History/Social Studies, Science and Technical Subjects.

Grade Level: 9-12

C. Credits: 10

D. Pre-Requisites: Minimum of co-enrollment in Algebra 1-2

E. Brief Course Description

In Physics 1, students will study the underlying causes and effects of forces on Earth and in the Universe, including: Gravitational, Contact, Magnetic, Nuclear and Electrostatic forces. Students will investigate the nature of energy, and matter and their conservation. They will have the opportunity to study the formation of the geophysics features of Earth and Cosmic Evolution. They will examine the collection of evidence supporting physical models. Students will also examine the principles of waves, and how we use waves in information technology, including information storage and transfer. Students will work on projects which demonstrate students' mastery of course, regularly conduct experimental investigations, and participate in engineering practices.

II. **Course Purpose: Goals and Student Outcomes**

Students will explore the physics of natural and built systems by investigating cross-cutting concepts such as: cause and effect, motion and stability, and energy and matter. Students will engage in science and engineering practices such as: engaging in argument, using computational thinking, and developing, using, and evaluating models.

III. **Course Outline**

Instructional Segment (Order is not prescribed)	**Forces and Motion**	**Forces at a Distance**	**Energy Conversion and Renewable Energy**	**Nuclear Processes and Earth History**	**Waves and Electromagnetic Radiation**	**Stars and the Origin of the Universe**

Essential 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?*	*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?*	*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?*	*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?*	*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?*	*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?*
Unit Description	Module 1: What does a mountain peak have in common with a pickup truck? If the vehicle is involved in a crash, its hood will crumple and bend under the force of the collision. Mountain ranges, like the Himalayas, are shortened and pushed upwards just like the hood of a crashed car. Even though the	Module 2: 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 IS1 primarily	Module 3: We use *energy [CCC-5 Cross Cutting Concept-5]* every moment of every day, but where does it come from? Our body utilizes energy stored in chemical bonds between the atoms of our food, which were rearranged within plants using energy from the Sun. The light energy shining out from a computer was converted from	Module 4: ***Energy [CCC-5]*** related to changes in the nuclei of atoms drives about 20% of California's electricity generation (California Energy Commission Energy Almanac 2015) (from fission in nuclear power plants), half the heat flowing upwards from Earth's interior (from the	Module 5: At the end of the last module, students found **evidence [SEP-7 Science and Engineering Practice-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	Module 6: *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*

	two processes occur at very different ***scales [CCC-3]***, they are both governed by Newton's Laws.	involved interactions between objects that appeared to be physically touching. IS2 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.	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. Each of these examples represents the *flow of energy* within different components of the Earth *system [CCC-4]*. 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 [CCC-5]*	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 Instructional Segment, students will develop **models [SEP-2]** for these processes.	understand that evidence, they must first understand the basic properties of waves. IS5 introduces mathematical representations of waves and develops models of wave properties and behaviors.	*the cores of stars. Others 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.*

Possible Common Activities	Speed Lab, Graphing Speed, Graphing Acceleration, Atwood Lab	Free fall lab, Orbit lab, engineering for safety	Induction Lab, Pendulum lab (also for waves), Rube Goldberg engineering	Missing mass lab, Rock lab	Stations lab, Sound speed lab, Modeling Earthquake lab, EM lab, Color Lab	Hertzprung/Russel Diagram, Expansion Lab, Black Body Spec trum Lab
NGSS Performance Expectations	HS-PS2-1 HS-PS2-2 HS-PS2-3 HS-ETS1-1 HS-ETS1-2 HS-ETS1-3 HS-ETS1-4	HS-PS2-4 HS-PS2-6 HS-ESS1-4	HS-PS2-5 HS-PS3-1 HS-PS3-2 HS-PS3-3 HS-PS4-5 HS-ESS3-2 HS-ESS3-3 HS-ETS1-1 HS-ETS1-2 HS-ETS1-3 HS-ETS1-4	HS-PS1-8 HS-ESS1-5 HS-ESS1-6 HS-ESS2-1	HS-PS4-1 HS-PS4-3 HS-PS4-4 HS-PS4-5 HS-PS4-2 HS-ESS2-1	HS-ESS1-1 HS-ESS1-2 HS-ESS1-3
Disciplinary Core Ideas	• PS2.A : Forces and Motion • ETS1.A: Defining and Delimiting Engineering Problems • ETS1.B: Developing Possible Solutions	• PS2.A: Forces and Motion • ETS1.A: Defining and Delimiting Engineering Problems • ETS1.B: Developing Possible Solutions	• PS3.D: Energy in Chemical Processes and Everyday Life • PS3.A: Definitions of Energy • PS3.B: Conservation of Energy and Energy Transfer • PS3.C: Relationship Between Energy and Forces	• PS1.C: Nuclear Processes • PS1.A Structure and Properties of Matter • ESS1.C: The History of Planet Earth • ESS2.B: Plate Tectonics and Large-Scale System Interactions	• PS4.A: Wave Properties • PS4.B: Electromagnetic Radiation • PS4.C: Information Technologies and	• ESS1.A: The Universe and Its Stars • PS1.C: Nuclear Processes

Science and Engineering Practices	• Analyzing and Interpreting Data • Mathematics and Computational Thinking • Developing and Using Models • Planning and Carrying Out Investigations • Defining Problems • Designing Solutions	• Analyzing and Interpreting Data • Mathematics and Computational Thinking • Developing and Using Models	• Developing and Using Models	• Developing and Using Models	• Asking Questions • Using Mathematics and Computational Thinking • Engaging in Argument from Evidence	• Developing and Using Models • Constructing Explanations
Crosscutting Concepts	• Cause and Effect: Mechanism and Explanation • Systems and System Models • Structure and Function	• Cause and Effect • Structure and Function • Scale, Proportion, and Quantity	• Energy and Matter: Flows, Cycles, and Conservation	• Energy and Matter: Flows, Cycles, and Conservation	• Energy and Matter • Systems and System Models Stability and Change	• Energy and Matter Cause and Effect • Patterns • Scale, Proportion, and Quantity

IV. **Key Assignments**

This course will afford students opportunities to participate in all phases of the scientific process, including formulation of well-posed scientific questions and hypotheses, design of experiments and/or data collection strategies, analysis of data, and drawing of conclusions.

V. **Instructional Methods and/or Strategies including Instructional Technology**

Guided Inquiry, Direct Instruction, Collaborative Group Work, Independent Research,

VI. **Assessment Methods and/or Tools**

Examples of assessment methods include Standard-Based Grading, the creation of visuals and written works, engineering projects, laboratory activities, videos, and basic pencil-paper tests.

VII. **Textbook(s) and Supplemental Instructional Materials**

- Conceptual Physics - The High School Physics Program
  Edition 10, Published 2009, Paul Hewitt
  The text is intended to be used in and out of the classroom, for reference and practice.

- Supplemental Instructional Materials include: PhET from University of Colorado, which engage students through an intuitive, game-like environment where students learn through exploration and discovery, as well as Veritasium on Youtube, and The Physics Classroom.

Performance Expectations For Physics in the Universe: Links provide details on disciplinary core ideas, science and engineering practices and crosscutting concepts encapsulated by the designated performance expectation. Some performance expectations, particularly the Earth and Space Science (ESS) standards, are covered partially in this course of study, and the remaining components are covered either in the Biology: The Living Earth or Chemistry in Earth Systems.

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-PS2-1. Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

HS-PS2-2. Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.

HS-PS2-3. Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.*

HS-PS2-4 Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.

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

HS-PS2-6 Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.*

HS-PS3-1. Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the 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 position of particles (objects).

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-PS3-5 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.

HS-PS4-1. Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.

HS-PS4-2. Evaluate questions about the advantages of using a digital transmission and storage of information.

HS-PS4-3. Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or
a particle model, and that for some situations one model is more useful than the other.

HS-PS4-4. Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation
have when absorbed by matter.

HS-PS4-5. Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.*

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-ESS1-4. Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.

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-ESS3-2. Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.*

HS-ESS3-3. Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity.

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

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.