Glendale Unified School District

High School

January 19, 2021

Department:	Science
Course Title:	Physics of the Universe
Course Code:	7163/7164
Grade Level(s):	9-12
School(s) Course Offered:	Crescenta Valley High School, Clark Magnet High School, Glendale High School, Hoover High School
UC/CSU Approved (Y/N, Subject):	Yes, (D) Science
Course Credits:	10
Recommended Prerequisite:	Concurrent with Mathematics - Integrated I or higher
Recommended Textbook:	McGraw-Hill: Inspire Physics w/ESS (2020)
Course Overview:	Physics of the Universe is a lab science course based upon the California Next Generation Science Standards (CA NGSS), authentically integrating Earth and space science content with physical science when applicable. The Disciplinary Core Ideas addressed are Matter and Its Interactions, Motion and Stability, Energy, Waves and Their Applications in Technologies for Information, Earth's Place in the Universe, Earth's Systems, and Earth and Human Activity. Additionally, the course includes Engineering Design and Links Among Engineering, Technology, Science, and Society.

First Semester-Course Content

Unit 1: **Mechanics in One Dimension** *(5 weeks)*

A. In this unit, students will seek to answer the questions "How can we model motion and forces?" Students will learn that motion can be modeled by motion diagrams, particle models, vectors, graphs, and mathematical equations. They will expand their knowledge of modeling motion to include accelerated motion. Then, students will learn that forces can be modeled using free-body diagram and that forces cause changes in motion, as described by Newton's laws of motions.
   - The learning experiences in this unit prepare students for mastery of the following performance expectations:
     - 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.
   - The learning experiences in this unit prepare students for mastery of the following Environmental Principles and Concepts:
     - Principle

B. Lessons
   - Module 2: Representing Motion – In this module, students will seek to answer the questions "How does a GPS unit know where you are?" Students will explore how motion diagrams and particle models can be used to represent motion. This will lead them to understand the basic ways to model motion. Then, they will explore how coordinate systems, vectors, and scalars are used to describe motion, leading them to understand that GPS can provide locations because we all agreed to use the same coordinate system – latitude and longitude. Students will then explore how position-time graphs can be created and interpreted, leading them to understand that position-time graphs are another way to model motion. Finally, students will explore the differences between speed and velocity and how motion can be modeled using equations. This will lead them to understand how to describe how fast something is moving.
   - Module 3: Accelerated Motion – In this module, students will seek to answer the question "Why do sudden changes in the direction or speed of jet planes affect pilots?" Students will explore nonuniform motion diagrams, velocity-time graphs, average and instantaneous acceleration, and how to calculate acceleration. This will lead them to understand that changes in direction and speed are two ways jets can accelerate. Then, students will explore how equations can be used to describe the position and velocity of an object with a constant acceleration. This will lead them to understand the most basic cases of accelerated motion, which can be expanded to understand the more complex acceleration of jets. Finally, students will explore how objects accelerate in freefall, leading them to understand that when the acceleration of a pilot is given in multiples of g, g refers to the fee-fall acceleration.

- Module 4: Forces in One Dimension – In this module, students will seek to answer the question "How do wing suits help BASE jumpers control their velocity?" Students will explore how forces cause changes in motion (including Newton's 1st and 2nd laws of motion) and practice representing forces with free-body diagrams. This will lead them to understand that wing suits allow BASE jumpers to control the forces on themselves, and thus control changes in their velocity. Then, students will explore weight, apparent weight, and drag forces. This will lead them to understand that BASE jumpers use their wing suits to adjust the size of the drag force in order to control their motion. Finally, students will explore Newton's 3rd law and apply it, along with Newton's 2nd law, to situations involving tension and normal forces, leading them to understand that the force of the air on the wingsuit/BASE jumper system is equal in magnitude to the force of the wingsuit/BASE jumper system on the air.

Unit 2: **Mechanics in Two Dimensions** (*6 weeks)*

A. In this unit, students will seek to answer the question "How can forces cause so many different types of motion?" They will learn about the basics analyzing forces in two dimensions, friction, and motion on inclined planes. Then, they will learn that gravity and drag forces determines the path of a projectile, while centripetal forces result in circular motion. Students will then learn that the gravitational force is responsible for objects falling to the ground, as well as orbits. Finally, students will learn that forces can produce changes in rotation.
   - The learning experiences in this unit prepare students for mastery of the following performance expectations:
     - HS-PS1-2 Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.
     - 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-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.
   - The learning experiences in this unit prepare students for mastery of the following Environmental Principles and Concepts:
     - Principle

B. Lessons
   - Module 5: Displacement and Force in Two Dimensions – In this module, students will seek to answer the questions "Why is this specialized train washing the train tracks?" Students will explore how to graphically and algebraically add vectors in two dimensions and how to resolve vectors into their components. This will provide them with the necessary tools to analyze the friction forces on a train.

Then, students will explore kinetic friction, static friction, and coefficients of friction between the tracks and the train's wheels in a range that allows for a safe stopping distance. Finally, students will explore motion on inclined planes and equilibrium in two dimensions. This will lead them to be able to analyze how the friction forces on a train would change if the train were going up or down a hill.

- Module 6: Motion in Two Dimensions – In this module, students will seek to answer the questions "Why do thrown basketballs travel in arcs?" Students will explore how the path of a project is determined by its launch conditions, gravity, and air resistance. This will lead them to understand why basketballs travel in arcs. Then, students will explore centripetal force, centripetal acceleration, and circular motion, and will use Newton's 2nd law for circular motion, leading them to understand the difference between projectile and circular motion, while recognizing that Newton's 2nd law applies in both cases. Finally, students will explore classical relative motion in one and two dimensions, leading them to understand that motion will appear in difference reference frames.
- Earth and Space Science Module: Earth Tectonic Processes – Students will seek to understand Plate Tectonics, Volcanoes, and Mountain Building as it relates to displacement and force in two directions.
- Module 7: Gravitation – In this module students will see to answer the question "How can gravity keep moons orbiting planets but also cause things to fall?" Students will explore Kepler's laws and Newton's law of universal gravitation, leading them to understand that Kepler's 2nd law and Newton's law of universal gravitation can be combined to describe the orbits of planets. Then, students will explore the orbits of planets and satellites and the concept of a gravitational field. They will also have a brief introduction to Einstein's theory of gravity. This will lead them to understand that the gravitational field explains why gravity causes both orbiting satellites and falling objects.
- Module 8: Rotational Motion – In this module, students will seek to answer the question "Why do all tropical cyclones in the northern hemisphere rotate the same direction?" Students will explore how rotational motion can be described in terms of angular displacement, angular velocity, angular acceleration, and angular frequency, providing them with the necessary tools to describe the rotation of a tropical cyclone. Then, students will explore Newton's 2nd law for rotational motion, leading them to understand how forces can change the rotation of a tropical cyclone. Finally, students will explore stability, static equilibrium, and rotating reference frames. This will lead them to understand that Earth's rotation determines which direction tropical cyclones rotate.

Unit 3: **<u>Momentum and Energy</u>** (9 *weeks)*

A. In this unit, students will seek to answer the questions "Why is energy important to humans and society?" Students will learn about impulse, momentum, and the conservation of momentum, which will help them analyze collisions. Then, students will learn that energy comes in many forms, can be transferred or transformed, and is conserved, and that these properties allow humans to manipulate and use energy.

Students will then learn about thermal energy, heat, heat capacity, changes of state, and the laws of thermodynamics, and the role that these concepts play in everyday life. Finally, students will learn that molecular-level structure and interactions of substances determine the properties and behaviors of substances determine how people use them.

- The learning experiences in this unit prepare students for mastery of the following performance expectations:
  - 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-PS2-6 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 positions 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-PS3-4 Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).
  - 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-ESS3-4 Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.*

B. Lessons

- Module 9: Momentum and Its Conservation – In this module, students will answer the question "How do rockets accelerate once they reach space?" They will explore impulse, momentum, and how they are related by the impulse-momentum theorem, leading them to understand applying a force to an object over time

changes its momentum. Additionally, students will explore the conservation of momentum in a variety of situations, including collisions, recoil, and gyroscopes, leading them to understand that rockets can move in space using recoil.

- Module 10: Energy and Its Conservation – In this module, students will answer the question "How can energy from power plants be stored in the power grid for later use?" They will explore work, energy, and power, and the relationships among them. This will lead them to understand that work, energy, and power have specific, precise meaning in physics that often differ from how they are used colloquially. Then, students will explore different forms of energy, with an emphasis on macroscopic kinetic energy and gravitational potential energy. This will lead students to understand that energy can be converted from one from to another during the power generation and distribution process. Students will then explore the law of conservation of energy and use it to analyze collisions, leading them to understand that while some forms of energy may not be as useful as others, energy is never lost. Finally, students will explore the benefits of simple and compound machines, leading them to understand that machines can change the size or direction of force but cannot create or destroy energy.
- Earth and Space Science Module: Earth's Resources – Students will answer questions related to Earth's resources (land, water, air, and energy) and their role in society.

Second Semester-Course Content

- Module 11: Thermal Energy – In this module, students will answer the question "Why do different parts of the pan appear to be different colors in this thermal image?" Students will explore thermal energy and how it is transferred. This will lead them to understand why different materials heat up at different rates. Then, students will explore changes of state and the first and second laws of thermodynamics, leading them to understand why thermal energy is spontaneously transferred in one direction.
- Module 12: States of Matter – In this module, students will answer the question "How will the fluid flow through this device?" They will explore fluids, pressure, the gas laws, thermal expansion, and plasma. This will lead them to understand basic properties of fluids. Then, students will explore cohesive and adhesive forces, evaporation, and condensation. This will lead them to understand that for thin tubes, like those in a microfluidic device, cohesive and adhesive forces play a major role in how fluids flow. Students will then explore Pascal's principle, buoyancy, Archimedes' principle, and Bernoulli's. This will lead them to understand how liquids flow in larger tubes, such as hoses and household pipes. Finally, students will explore the molecular structure and thermal expansion of solids, leading them to understand solids behave differently than fluids.
- Earth and Space Science Module: Earth Surface Processes – Students will answer questions related to shoreline development, seafloor features, weathering, and erosion as they pertain to momentum and energy.

Unit 4: **Waves and Light** (*7 weeks)*

A. In this unit, students will answer the question "How do waves affect our everyday lives?" They will learn about periodic motion and develop and understanding of the basic properties and behaviors of waves. Then, students will learn about the generation, manipulations, detection, and applications of sound waves. They will learn that light allows us to see and that its wave properties are responsible for effects like color and polarization. Additionally, students will learn mirrors and lenses can be used to reflect and refract light in ways that are helpful to humans. Finally, students will learn that the interference and diffraction of light are responsible for optical effects such as thin-film interference, iridescence, and diffraction patterns.
   - The learning experiences in this unit prepare students for mastery of the following performance expectations:
     - 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-PS4-3 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-ESS2-3 Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.

B. Lessons
   - Module 13: Vibrations and Waves – In this module, students will answer the question "How can this pendulum save a building from earthquake damage?" Students will explore periodic motion, including the specific cases of masses on springs, pendulums, and resonance. This will lead them to understand that a pendulum can serve as a damper for a building's earthquake-induced periodic motion. Then, students will explore the properties of mechanical waves, including amplitude, wavelength, frequency, wave speed, and period. This will lead them to understand how waves can be described and compared. Finally, students will explore the reflection, refraction, and interference of waves, leading them to understand how waves interact with each other and with various media.
   - Earth and Space Science Module: Seismic Waves – Students will utilize their understanding of vibrations and waves to answer questions about seismic waves, Earthquakes, and Earth's interior.
   - Module 14: Sound – In this module, students will answer the questions "Why does a fire truck siren pitch change as it passes you?" Students will explore the properties of sound waves, how humans perceive them, and the Doppler effect. This will lead them to understand that the Doppler effect is responsible for the changing pitch of a passing fire truck. Then, students will explore how sound is created and how musical instruments work. This will lead them to understand how a variety of pitches and sounds can be produced.

- Module 15: Fundamentals of Light – In this module, students will seek to answer the question "What does the light from a distant star or supernova tell us about it?" Students will explore the ray model of how light travels, illumination, and the speed of light. This will lead them to understand how light travels from distant starts to Earth and how long that journey takes. Then, students will explore how the wave nature of light explains diffraction, color, polarization, and the Doppler shift of light. This will lead them to understand that the Doppler shift can be used to tell us how distant astronomical objects are moving.
- Module 16: Reflection and Refraction – In this module, students will answer the question "How does light transmit information through a communication network?" Students will explore the law of reflection and images forced by plane mirrors, leading them to understand that plane mirrors can be used to direct light. Then, students will explore how curved mirrors form a variety of images. This will lead them to understand that curved mirrors can be used to create both real and virtual images in everyday situations. Students will then explore Snell's las of refraction, total internal reflection, and the dispersion of light. This will lead them to understand the fiber optic cables in communications networks use total internal reflection. Finally, students will explore how lenses, including those in the human eye and in optical equipment, are used to form images. This will lead them to understand lenses can be used in a variety of optical devices.
- Module 17: Interference – In this module, students will answer the questions "What makes this hummingbird's feathers appear shiny and shimmery?" Students will explore double-slit interference and thin-film interference. This will lead them to understand that some iridescence is produced by thin-film interference. Then, students will explore single-slit diffraction and diffraction gratings, leading them to understand that diffraction can also cause iridescence.

Unit 5: **Electricity and Magnetism** (*6 weeks)*

A. In this unit, students will seek to answer the questions "What role do electricity and magnetism play in the technology we use every day?" Students will learn that electrically charged objects exert forces on each other and that this force can be used in various applications, including capacitors. Then, students will learn that electric currents allow for the transfer of energy, which can be transformed into other useful forms of energy. Students will then learn that both permanent magnets and electromagnets produce magnetic fields, which can be used in a variety of applications, including motors. Finally, students will learn that electricity and magnetism are part of the same force and that the interaction between electric and magnetic fields allows for a variety of technological applications, including generators and the use of electromagnetic waves.
    - The learning experiences in this unit prepare students for mastery of the following performance expectations:
        - 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-PS2-4 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 positions 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-PS4-2 Evaluate questions about the advantages of using digital transmission and storage of information.
- 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.*

B. Lessons

- Module 18: Electrostatics – In this module, students will answer the question "Why does the rod cause the water to bend?" Students will explore the evidence we have for electric charge and how some materials are electric conductors while others are electric insulators. This will lead them to understand charged objects can attract or repel each other. Then, students will explore how objects can be charged, as well as Coulomb's Law. This will lead them to understand that a charged rod will exert an electrostatic force on polar water molecules. Students will then explore electric fields and how they can be modeled. This will lead them to understand that electric fields explain why a charged rod doesn't need to touch water to exert a force on it. Finally, students will explore electrical potential energy, capacitors, and how the charge of an electron was determined. This will lead them to understand that energy can be stored in electric fields.

- Module 19: Electric Current and Circuits – In this module, students will answer the question "How does energy get from the power plant to the lights in your home?" Students will explore current, electrical energy, circuit diagrams and Ohm's law. This will lead them to understand that the electric current allows for the transfer of energy from the power plant to consumers. Then, students will explore the relationships between electrical energy, power, potential difference, and resistance. This will lead them to understand that consumers often transform electrical energy into other, more useful forms of energy, such as thermal energy, light, or kinetic energy. Students will then explore series and parallel circuits and analyze them using Kirchhoff's rules, leading them to understand how basic household circuits. Finally, students will explore electrical safety devices and combined circuits, including ammeters and voltmeters, leading them to understand how more complex circuits and electrical safety devices work.
- Module 20: Magnetism – In this module, students will seek to answer the questions "What makes this electromagnet stronger than a typical refrigerator magnet?" Students will explore properties of magnets, magnetic domains, magnetic fields, and electromagnets. This will lead them to understand refrigerator magnets are made of magnetized iron that contains magnetic domains, while electromagnets use electromagnets use electric currents to produce magnetic fields. Then, they will explore the effects of magnetic forces on current-carrying wires and moving charged particles, as well as related applications, such as galvanometers and motors. This will lead them to understand that magnetic fields affect not just magnets and magnetic materials but moving charged particles as well.
- Module 21: Electromagnetism – In this module, students will answer the question "What causes the Northern Lights?" They will explore how changing magnetic fields induce currents and how generators work. This will lead them to understand significant changes in Earth's magnetic field can induce currents in wires, pipes, and even train tracks. Then, students will explore Lenz's law, eddy currents, self-inductance, and transformers. This will lead them to understand that induced currents generate magnetic fields that oppose the original change in magnetic field that induced the current. Students will then explore Thomson's experiments with cathode ray tubes and mass spectrometers, both of which demonstrate how charged particles behave in electric and magnetic fields. This will lead them to understand that the charged particles from the solar wind are affected by Earth's magnetic field, leading to the aurora. Finally, students will explore the properties and technological applications of electromagnetic waves. This will lead them to understand that visible light is one type of electromagnetic radiation.

Unit 6: **<u>Subatomic Radiation</u>** (6 *weeks)*

A. In this unit, students will seek to answer the question "What is the universe made of?" They will learn about the development of the quantum mechanics and its influence on the current atomic model. Then, they will learn that the atomic structure of materials relates to their electrical conductivity and how that conductivity can be controlled.

Finally, students will learn that atoms are made up of even smaller particles and will be introduced to the Standard Model, which describes the fundamental building blocks of the universe.

- The learning experiences in this unit prepare students for mastery of the following performance expectations:
  - 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-PS2-6 Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.*
  - HS-PS4-2 Evaluate questions about the advantages of using 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-PS4-5 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 that eventually reaches Earth 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-ESS1-6 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.

B. Lessons

- Module 22: Quantum Theory and the Atom – In this module, students will answer the questions "How could the manipulations of individual atoms be useful in future computing?" Students will explore the basics of quantized energy, the photoelectric effect, and the Compton effect. This will lead them to understand light can be modeled as a particle known as a photon. Then, they will explore de Broglie waves and Heisenberg uncertainty principle. This will lead them to understand that particles can display wave properties. Students will then explore the experiments and evidence that led to the development atomic model from the plum pudding model to the nuclear model to Bohr's model. This will lead them to understand energy levels for electrons in atoms are quantized. Finally, students will explore how quantum mechanics include the current model of the atom and

how lasers work. This will lead them to understand that the current atomic model has a nucleus of protons and neutrons surround by an electron cloud.

- Module 23: Solid-State Electronics – In this module, students will answer the question "What innovations allowed computers to shrink from taking up a whole room to fitting in your pocket?" Students will explore how the band theory of solids explains the difference between conductors, semiconductors, and insulators, and that doping can change conductivity of a semiconductor. This will lead them to understand that doping allows for the production of materials with specific conductivity. Students with them explore the basic functions of diodes and transformers, and the development of the integrated circuit. This will lead them to understand that such devices have led to smaller computers.
- Module 24: Nuclear and Particle Physics – In this module, students will answer the questions "How does the Sun produce energy and how can we replicate it?" Students will explore the structure of the nucleus, the forces acting on the particles within it, and the energy binding its particles together. This will lead them to understand energy must be absorbed or released when an atomic nucleus gains or loses nucleons. Then, students will explore radioactive decay, fission, and fusion. This will lead them to understand that the Sun produces energy through nuclear fusion. Finally, students will explore how scientists use particle accelerators and detectors to determine the fundamental make up of the universe, which is described by the Standard Model. This will lead them to understand research into the make-up of the universe is an ongoing endeavor.
- Earth and Space Science Module: Stars – Students will utilize their understanding of nuclear and particle physics to answer questions about the sun, properties of stars, and stellar evolution.
- Earth and Space Science Module: Cosmology – Students will answer questions about the formation of the universe and the formation of the solar system.