*AP Physics 1 (#4560)

Description ***AP Physics 1: Algebra-Based is the equivalent to a first-semester college course in algebra-based physics. The course covers Newtonian mechanics (including rotational dynamics and angular momentum); work, energy, and power; mechanical waves and sound. It will also introduce electric circuits.***

Credits 1

Textbooks/Resources Knight, Randy, Jones, Brian and Field, Stuart. College Physics: A strategic approach, 3rd ed. Pearson Education Inc. 2015
ISBN: 9778-0-13-353967-7

Required Assessments Standards-based district-wide assessment

Board Approved May 2006

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AASD Science Goals for K-12 Students

- Students will demonstrate understanding of key science concepts and apply them to their world.
- Students will demonstrate knowledge and understanding that scientific knowledge is continually undergoing revision and refinement based on new experiments and data.
- Students will demonstrate knowledge and understanding that the process of science is based on questioning and providing empirical evidence to support claims.
- Students will apply scientific concepts and processes to evaluate consequences and make informed, responsible choices (regarding self, others, environment).
- Students will demonstrate understanding that science and technology are critical in order to provide and evaluate alternative solutions to problems in our world.
- Students will engage in STEM experiences as both scientists and engineers in order to prepare for postsecondary and career readiness.

AASD Science Standards for Students in AP Physics (4560)

Science & Engineering Practices

1. Asking Questions and Defining Problems
2. Developing and Using Models
3. Planning and Carrying Out Investigations
4. Analyzing and Interpreting Data
5. Using Mathematics, Information and Computer Technology, and Computational Thinking
6. Constructing Explanations and Designing Solutions
7. Engaging in Argument from Evidence
8. Obtaining, Evaluating, and Communicating Information

AP Physics Content Power Standards:

1. Objects and systems have properties such as mass and charge. Systems may have internal structure.
2: Fields existing in space can be used to explain interactions.
3: The interactions of an object with other objects can be described by forces.
4: Interactions between systems can result in changes in those systems.
5: Changes that occur as a result of interactions are constrained by conservation laws.
6: Waves can transfer energy and momentum from one location to another without the permanent transfer of mass and serve as a mathematical model for the description of other phenomena.

AASD Next Generation Science Standards

High School Physical Sciences (HS-PS)

Matter and Its Interactions

By the end of **grade twelve**, students will:

HS-PS1-1	Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms
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-PS1-3	Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles
HS-PS1-4	Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes

in total bond energy

HS-PS1-5 Apply scientific principles and evidence to provide an explanation about the effects of changing temperature or concentration of the reacting particles on the rate at which a reaction occurs.

HS-PS1-6 Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium

HS-PS1-7 Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction

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

Motion and Stability: Forces and Interactions

By the end of **grade twelve**, students will:

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

Energy

By the end of **grade twelve**, students will:

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 motion 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 in 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-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

Waves and Their Applications in Technologies for Information Transfer

By the end of **grade twelve**, students will:

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 describe 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

High School Life Sciences (HS-LS)

From Molecules to Organisms: Structures and Processes

By the end of **grade twelve**, students will:

HS-LS1-1 Construct and explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells

HS-LS1-2 Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms

HS-LS1-3 Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis

HS-LS1-4 Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms

HS-LS1-5 Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy

HS-LS1-6 Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules

HS-LS1-7 Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy

Ecosystems: Interactions, Energy, and Dynamics

By the end of **grade twelve**, students will:

HS-LS2-1 Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales

HS-LS2-2 Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales

HS-LS2-3 Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic an anaerobic conditions

HS-LS2-4 Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem

HS-LS2-5 Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere

HS-LS2-6 Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem

HS-L2-7 Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity

HS-LS2-8 Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce

Heredity: Inheritance and Variation of Traits

By the end of **grade twelve**, students will:

HS-LS3-1 Ask questions to clarify relationship about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring

HS-LS3-2 Make and defend a claim based on evidence that inheritable genetic variations may results from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors

HS-LS3-3 Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population

Biological Evolution: Unity and Diversity

By the end of **grade twelve**, students will:

HS-LS4-1 Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical Evidence

HS-LS4-2 Construct and explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment

HS-LS4-3 Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait

HS-LS4-4 Construct an explanation based on evidence for how natural selection leads to adaptation of populations

HS-LS4-5 Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species

HS-LS4-6 Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity

High School Earth Sciences (HS-ES)

Earth's Place in the Universe

By the end of **grade twelve**, students will:

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 and 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 computation 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

Earth's Systems

By the end of **grade twelve**, students will:

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-ESS2-2 Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems

HS-ESS2-3 Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection

HS-ESS2-4 Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate

HS-ESS2-5 Plan and conduct an investigation of the properties of water and its effect on Earth materials and surface processes

HS-ESS2-6 Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere

HS-ESS2-7 Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth

Earth and Human Activity

By the end of **grade twelve**, students will:

HS-ESS3-1 Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, ad changes in climate have influenced human activity

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
HS-ESS3-5 Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems
HS-ESS3-6 Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity

High School Engineering Design (HS-ET)

Engineering Design

By the end of **grade twelve**, students will:

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

AP Physics Power Standard 1: Objects and systems have properties such as mass and charge. Systems may have internal structure.

Essential Learning Objectives	Performance Indicators	Classroom Assessments
1. Student develops a deep understanding of science by engage in age-appropriate science and engineering habits.	**Performance will be satisfactory when the student:** a. asks questions and defines problems. b. develops and uses models. c. plans and carries out investigations. d. analyzes and interprets data. e. uses mathematics, information and computer technology, and computational thinking. f. constructs explanations and designs solutions. g. engages in argument from evidence. h. obtains, evaluates, and communicates information.	• Quizzes and tests • Projects • Research • Performance assessment
Above objective aligned with AASD Next Generation Science Standards AASD Science & Engineering Practices		
2. Student demonstrates understanding of how objects and systems have properties such as mass and charge. systems may have internal structure.	**Performance will be satisfactory when the student understands:** **Essential Knowledge 1.A.1:** A system is an object or a collection objects. Objects are treated as having no internal structure. a. A collection of particles in which internal interactions change little or not at all, or in which changes in these interactions are irrelevant to the question addressed, can be treated as an object. b. Some elementary particles are fundamental particles (e.g., electrons). Protons and neutrons are composed of fundamental particles (i.e., quarks) and might be treated as either systems or objects, depending on the question being addressed. c. The electric charges on neutrons and protons result from their quark compositions. **Essential Knowledge 1.A.5**: Systems have properties determined by the properties and interactions of their constituent atomic and molecular substructures. In AP Physics, when the properties of the constituent parts are not important	• Quizzes and tests • Projects • Laboratory experiences & reports • Research and class presentations • Performance assessment (inquiry focused)

	in modeling the behavior of the macroscopic system, the system itself may be referred to as an object. **Essential Knowledge 1.B.1**: Electric charge is conserved. The net charge of a system is equal to the sum of the charges of all the objects in the system. a. An electrical current is a movement of charge through a conductor. b. A circuit is a closed loop of electrical current. **Essential Knowledge 1.B.1**: Electric charge is conserved. The net charge of a system is equal to the sum of the charges of all the objects in the system. a. An electrical current is a movement of charge through a conductor. b. A circuit is a closed loop of electrical current. **Essential Knowledge 1.B.3**: The smallest observed unit of charge that can be isolated is the electron charge, also known as the elementary charge. a. The magnitude of the elementary charge is equal to 1.6×10^{-19} coulombs. b. Electrons have a negative elementary charge; protons have a positive elementary charge of equal magnitude, although the mass of a proton is much larger than the mass of an electron. **Essential Knowledge 1.C.1**: Inertial mass is the property of an object or a system that determines how its motion changes when it interacts with other objects or systems. **Essential Knowledge 1.C.2**: Gravitational mass is the property of an object or a system that determines the strength of the gravitational interaction with other objects, systems, or gravitational fields. a. The gravitational mass of an object determines the amount of force exerted on the object by a gravitational field. b. Near the Earth's surface, all objects fall (in a vacuum) with the same acceleration, regardless of their inertial mass.	

	Essential Knowledge 1.C.3: Objects and systems have properties of inertial mass and gravitational mass that are experimentally verified to be the same and that satisfy conservation principles. **Essential Knowledge 1.E.2**: Matter has a property called resistivity. a. The resistivity of a material depends on its molecular and atomic structure. b. The resistivity depends on the temperature of the material.	
Above objective aligned with AASD Next Generation Science Standards: HS-PS1-A, HS-PS1-B, HS-PS1-C, HS-ESS1, HS-PS2-A , HS-PS2-B, HS-PS2-C, HS-PS3-A, HS-PS3-B, HS-PS3-D		

AP Physics Power Standard 2: Fields existing in space can be used to explain interactions.

Essential Learning Objectives	Performance Indicators	Classroom Assessments
3. Student demonstrates understanding of how fields existing in space can be used to explain interactions.	**Performance will be satisfactory when the student understands:** **Essential Knowledge 2.A.1**: A vector field gives, as a function of position (and perhaps time), the value of a physical quantity that is described by a vector. a. Vector fields are represented by field vectors indicating direction and magnitude. b. When more than one source object with mass or electric charge is present, the field value can be determined by vector addition. c. Conversely, a known vector field can be used to make inferences about the number, relative size, and location of sources.	• Quizzes and tests • Projects • Laboratory experiences & reports • Research and class presentations • Performance assessment (inquiry focused)

	Essential Knowledge 2.B.1: A gravitational field g at the location of an object with mass m causes a gravitational force of magnitude mg to be exerted on the object in the direction of the field. a. On the Earth, this gravitational force is called weight. b. The gravitational field at a point in space is measured by dividing the gravitational force exerted by the field on a test object at that point by the mass of the test object and has the same direction as the force. c. If the gravitational force is the only force exerted on the object, the observed free-fall acceleration of the object (in meters per second squared) is numerically equal to the magnitude of the gravitational field (in newtons/kilogram) at that location. **Essential Knowledge 2.B.2**: The gravitational field caused by a spherically symmetric object with mass is radial and, outside the object, varies as the inverse square of the radial distance from the center of that object. a. The gravitational field caused by a spherically symmetric object is a vector whose magnitude outside the object is equal to $G\frac{M}{r^2}$ b. Only spherically symmetric objects will be considered as sources of the gravitational field.	
Above objective aligned with AASD Next Generation Science standards: HS-PS2-B, PS3-A		

AP Physics Power Standard 3: The interactions of an object with other objects can be described by forces.

Essential Learning Objectives	Performance Indicators	Classroom Assessments
4. Student demonstrates understanding that interactions of an object with other objects can be described by forces.	**Performance will be satisfactory when the student understands:** **Essential Knowledge 3.A.1**: An observer in a particular reference frame can describe the motion of an object using such quantities as position, displacement, distance, velocity, speed, and acceleration. a. Displacement, velocity, and acceleration are all vector quantities. b. Displacement is change in position. Velocity is the rate of change of position with time. Acceleration is the rate of change of velocity with time. Changes in each property are expressed by subtracting initial values from final values. c. A choice of reference frame determines the direction and the magnitude of each of these quantities **Essential Knowledge 3.A.2**: Forces are described by vectors. a. Forces are detected by their influence on the motion of an object. b. Forces have magnitude and direction. **Essential Knowledge 3.A.3**: A force exerted on an object is always due to the interaction of that object with another object. a. An object cannot exert a force on itself. b. Even though an object is at rest, there may be forces exerted on that object by other objects. c. The acceleration of an object, but not necessarily its velocity, is always in the direction of the net force exerted on the object by other objects. **Essential Knowledge 3.A.4**: If one object exerts a force on a second object, the second object always exerts a force of equal magnitude on the first object in the opposite direction. **Essential Knowledge 3.B.1**: If an object of interest interacts with several other objects, the net force is the vector sum of the individual forces.	• Quizzes and tests • Projects • Laboratory experiences & reports • Research and class presentations • Performance assessment (inquiry focused)

	Essential Knowledge 3.B.2: Free-body diagrams are useful tools for visualizing forces being exerted on a single object and writing the equations that represent a physical situation. a. An object can be drawn as if it was extracted from its environment and the interactions with the environment identified. b. A force exerted on an object can be represented as an arrow whose length represents the magnitude of the force and whose direction shows the direction of the force. c. A coordinate system with one axis parallel to the direction of the acceleration simplifies the translation from the free-body diagram to the algebraic representation. **Essential Knowledge 3.C.1**: Gravitational force describes the interaction of one object that has mass with another object that has mass. a. The gravitational force is always attractive. b. The magnitude of force between two spherically symmetric objects of mass m1 and m2 is $G\frac{m_1 m_2}{r^2}$ where r is the center-to-center distance between the objects. c. In a narrow range of heights above the Earth's surface, the local gravitational field, g, is approximately constant. **Essential Knowledge 3.C.2**: Electric force results from the interaction of one object that has an electric charge with another object that has an electric charge. a. Electric forces dominate the properties of the objects in our everyday experiences. However, the large number of particle interactions that occur make it more convenient to treat everyday forces in terms of nonfundamental forces called contact forces, such as normal force, friction, and tension. b. Electric forces may be attractive or repulsive, depending upon the charges on the objects involved. **Essential Knowledge 3.C.4**: Contact forces result from the interaction of one object touching another object and they arise from interatomic electric forces. These forces include tension, friction, normal, spring (Physics 1).	

	Essential Knowledge 3.D.1: The change in momentum of an object is a vector in the direction of the net force exerted on the object. **Essential Knowledge 3.D.2**: The change in momentum of an object occurs over a time interval. a. The force that one object exerts on a second object changes the momentum of the second object (in the absence of other forces on the second object). b. The change in momentum of that object depends on the impulse, which is the product of the average force and the time interval during which the interaction occurred. **Essential Knowledge 3.E.1**: The change in the kinetic energy of an object depends on the force exerted on the object and on the displacement of the object during the interval that the force is exerted. a. Only the component of the net force exerted on an object parallel or antiparallel to the displacement of the object will increase (parallel) or decrease (antiparallel) the kinetic energy of the object. b. The magnitude of the change in the kinetic energy is the product of the magnitude of the displacement and of the magnitude of the component of force parallel or antiparallel to the displacement. c. The component of the net force exerted on an object perpendicular to the direction of the displacement of the object can change the direction of the motion of the object without changing the kinetic energy of the object. This should include uniform circular motion and projectile motion. **Essential Knowledge 3.E.1**: The change in the kinetic energy of an object depends on the force exerted on the object and on the displacement of the object during the interval that the force is exerted. a. Only the component of the net force exerted on an object parallel or antiparallel to the displacement of the object will increase (parallel) or decrease (antiparallel) the kinetic energy of the object. b. The magnitude of the change in the kinetic energy is the product of the magnitude of the displacement and of the magnitude of the component of force parallel or	

	antiparallel to the displacement. c. The component of the net force exerted on an object perpendicular to the direction of the displacement of the object can change the direction of the motion of the object without changing the kinetic energy of the object. This should include uniform circular motion and projectile motion. **Essential Knowledge 3.F.3**: A torque exerted on an object can change the angular momentum of an object. a. Angular momentum is a vector quantity, with its direction determined by a right-hand rule. b. The magnitude of angular momentum of a point object about an axis can be calculated by multiplying the perpendicular distance from the axis of rotation to the line of motion by the magnitude of linear momentum. c. The magnitude of angular momentum of an extended object can also be found by multiplying the rotational inertia by the angular velocity. d. The change in angular momentum of an object is given by the product of the average torque and the time the torque is exerted. **Essential Knowledge 3.G.1**: Gravitational forces are exerted at all scales and dominate at the largest distance and mass scales.	
Above objective aligned with AASD Next Generation Science standards: HS-PS2-A, HS-PS2-B, HS-PS3-B, HS-PS3-C, HS-PS4-B, HS-ESS1-B, HS-PS1-C, HS-PS1-D, HS-ESS1-A		

AP Physics Power Standard 4: Interactions between systems can result in changes in those systems.

Essential Learning Objectives	Performance Indicators	Classroom Assessments
5. Student demonstrates understanding of how interactions between systems can result in changes in those systems.	**Performance will be satisfactory when the student understands:** **Essential Knowledge 4.A.1:** The linear motion of a system can be described by the displacement, velocity, and acceleration of its center of mass. **Essential Knowledge 4.A.2:** The acceleration is equal to the rate of change of velocity with time, and velocity is equal to the rate of change of position with time. a. The acceleration of the center of mass of a system is directly proportional to the net force exerted on it by all objects interacting with the system and inversely proportional to the mass of the system. b. Force and acceleration are both vectors, with acceleration in the same direction as the net force. **Essential Knowledge 4.A.3:** Forces that systems exert on each other are due to interactions between objects in the systems. If the interacting objects are parts of the same system, there will be no change in the center-of-mass velocity of that system. **Essential Knowledge 4.B.1:** The change in linear momentum for a constant-mass system is the product of the mass of the system and the change in velocity of the center of mass**.** **Essential Knowledge 4.B.2:** The change in linear momentum of the system is given by the product of the average force on that system and the time interval during which the force is exerted.	• Quizzes and tests • Projects • Laboratory experiences & reports • Research and class presentations • Performance assessment (inquiry focused)

	a. The units for momentum are the same as the units of the area under the curve of a force versus time graph. b. The changes in linear momentum and force are both vectors in the same direction. **Essential Knowledge 4.C.1:** The energy of a system includes its kinetic energy, potential energy, and microscopic internal energy. Examples should include gravitational potential energy, elastic potential energy, and kinetic energy. **Essential Knowledge 4.C.2:** Mechanical energy (the sum of kinetic and potential energy) is transferred into or out of a system when an external force is exerted on a system such that a component of the force is parallel to its displacement. The process through which the energy is transferred is called work. a. If the force is constant during a given displacement, then the work done is the product of the displacement and the component of the force parallel or antiparallel to the displacement. b. Work (change in energy) can be found from the area under a graph of the magnitude of the force component parallel to the displacement versus displacement. **Essential Knowledge 4.D.1:** Torque, angular velocity, angular acceleration, and angular momentum are vectors and can be characterized as positive or negative depending upon whether they give rise to or correspond to counterclockwise or clockwise rotation with respect to an axis. **Essential Knowledge 4.D.2:** The angular momentum of a system may change due to interactions with other objects or systems. a. The angular momentum of a system with respect to an axis of rotation is the sum of the angular momenta, with respect to that axis, of the objects that make up the system. b. The angular momentum of an object about a fixed axis	

	can be found by multiplying the momentum of the particle by the perpendicular distance from the axis to the line of motion of the object. c. Alternatively, the angular momentum of a system can be found from the product of the system's rotational inertia and its angular velocity. **Essential Knowledge 4.D.3:** The change in angular momentum is given by the product of the average torque and the time interval during which the torque is exerted.	
Above objective aligned with AASD Next Generation Science standards: HS-PS2-A, HS-PS3-A, HS-PS3-C, HS-PS3-D, HS-PS3-B, HS-PS1-C, HS-ESS1-A		

AP Physics Power Standard 5: Changes that occur as a result of interactions are constrained by conservation laws.

Essential Learning Objectives	Performance Indicators	Classroom Assessments
6. Student demonstrates understanding of how changes that occur as a result of interactions are constrained by conservation laws.	**Performance will be satisfactory when the student understands:** **Essential Knowledge 5.A.1:** A system is an object or a collection of objects. The objects are treated as having no internal structure. **Essential Knowledge 5.A.2:** For all systems under all circumstances, energy, charge, linear momentum, and angular momentum are conserved. For an isolated or a closed system, conserved quantities are constant. An open system is one that exchanges any conserved quantity with its surroundings. **Essential Knowledge 5.A.3:** An interaction can be either a force exerted by objects outside the system or the transfer of some quantity with objects outside the system. **Essential Knowledge 5.A.4:** The boundary between a system and its environment is a decision made by the person considering the situation in order to simplify or otherwise assist in analysis. **Essential Knowledge 5.B.1:** Classically, an object can only have kinetic energy since potential energy requires an interaction between two or more objects. **Essential Knowledge 5.B.2:** A system with internal structure can have internal energy, and changes in a system's internal structure can result in changes in internal energy.	• Quizzes and tests • Projects • Laboratory experiences & reports • Research and class presentations • Performance assessment (inquiry focused)

	Essential Knowledge 5.B.3: A system with internal structure can have potential energy. Potential energy exists within a system if the objects within that system interact with conservative forces. a. The work done by a conservative force is independent of the path taken. The work description is used for forces external to the system. Potential energy is used when the forces are internal interactions between parts of the system. b. Changes in the internal structure can result in changes in potential energy. Examples should include mass-spring oscillators, objects falling in a gravitational field. c. The change in electric potential in a circuit is the change in potential energy per unit charge **Essential Knowledge 5.B.4:** The internal energy of a system includes the kinetic energy of the objects that make up the system and the potential energy of the configuration of the objects that make up the system. a. Since energy is constant in a closed system, changes in a system's potential energy can result in changes to the system's kinetic energy. b. The changes in potential and kinetic energies in a system may be further constrained by the construction of the system. **Essential Knowledge 5.B.5:** Energy can be transferred by an external force exerted on an object or system that moves the object or system through a distance; this energy transfer is called work. Energy transfer in mechanical or electrical systems may occur at different rates. Power is defined as the rate of energy transfer into, out of, or within a system **Essential Knowledge 5.B.9:** Kirchhoff's loop rule describes conservation of energy in electrical circuits. The application of Kirchhoff's laws to circuits is introduced in Physics 1 and further developed in Physics 2 in the context of more complex circuits, including those with capacitors. a. Energy changes in simple electrical circuits are conveniently represented in terms of energy change	

	per charge moving through a battery and a resistor. b. Since electric potential difference times charge is energy, and energy is conserved, the sum of the potential differences about any closed loop must add to zero. c. The electric potential difference across a resistor is given by the product of the current and the resistance. d. The rate at which energy is transferred from a resistor is equal to the product of the electric potential difference across the resistor and the current through the resistor. **Essential Knowledge 5.C.3:** Kirchhoff's junction rule describes the conservation of electric charge in electrical circuits. Since charge is conserved, current must be conserved at each junction in the circuit. Examples should include circuits that combine resistors in series and parallel. **Essential Knowledge 5.D.1:** In a collision between objects, linear momentum is conserved. In an elastic collision, kinetic energy is the same before and after. a. In a closed system, the linear momentum is constant throughout the collision. b. In a closed system, the kinetic energy after an elastic collision is the same as the kinetic energy before the collision. **Essential Knowledge 5.D.2:** In a collision between objects, linear momentum is conserved. In an inelastic collision, kinetic energy is not the same before and after the collision. a. In a closed system, the linear momentum is constant throughout the collision. b. In a closed system, the kinetic energy after an inelastic collision is different from the kinetic energy before the collision. **Essential Knowledge 5.D.3:** The velocity of the center of mass of the system cannot be changed by an interaction within the system a. The center of mass of a system depends upon the masses and positions of the objects in the system. In an	

	isolated system (a system with no external forces), the velocity of the center of mass does not change. b. When objects in a system collide, the velocity of the center of mass of the system will not change unless an external force is exerted on the system. **Essential Knowledge 5.E.1:** If the net external torque exerted on the system is zero, the angular momentum of the system does not change. **Essential Knowledge 5.E.2:** The angular momentum of a system is determined by the locations and velocities of the objects that make up the system. The rotational inertia of an object or system depends upon the distribution of mass within the object or system. Changes in the radius of a system or in the distribution of mass within the system result in changes in the system's rotational inertia, and hence in its angular velocity and linear speed for a given angular momentum. Examples should include elliptical orbits in an Earth-satellite system. Mathematical expressions for the moments of inertia will be provided where needed. Students will not be expected to know the parallel axis theorem.	
Above objective aligned with AASD Next Generation Science standards: HS-PS2-A, HS-PS3-A, HS-PS3-B, HS-PS3-C, HS-PS3-D		

AP Physics Power Standard 6: Waves can transfer energy and momentum from one location to another without the permanent transfer of mass and serve as a mathematical model for the description of other phenomena.

Essential Learning Objectives	Performance Indicators	Classroom Assessments
7. Student demonstrates and understanding of how waves can transfer energy and momentum from one location to another without the permanent transfer of mass and serve as a mathematical model for the description of other phenomena.	**Performance will be satisfactory when the student understands:** **Essential Knowledge 6.A.1**: Waves can propagate via different oscillation modes such as transverse and longitudinal. a. Mechanical waves can be either transverse or longitudinal. Examples should include waves on a stretched string and sound waves. **Essential Knowledge 6.A.2:** For propagation, mechanical waves require a medium, while electromagnetic waves do not require a physical medium. Examples should include light traveling through a vacuum and sound not traveling through a vacuum. **Essential Knowledge 6.A.3**: The amplitude is the maximum displacement of a wave from its equilibrium value. **Essential Knowledge 6.A.4**: Classically, the energy carried by a wave depends upon and increases with amplitude. Examples should include sound waves. **Essential Knowledge 6.B.1**: For a periodic wave, the period is the repeat time of the wave. The frequency is the number of repetitions of the wave per unit time. **Essential Knowledge 6.B.2**: For a periodic wave, the wavelength is the repeat distance of the wave.	• Quizzes and tests • Projects • Laboratory experiences & reports • Research and class presentations • Performance assessment (inquiry focused)

	Essential Knowledge 6.B.4: For a periodic wave, wavelength is the ratio of speed over frequency. **Essential Knowledge 6.B.5**: The observed frequency of a wave depends on the relative motion of source and observer. This is a qualitative treatment only. **Essential Knowledge 6.D.2**: Two or more traveling waves can interact in such a way as to produce amplitude variations in the resultant wave. **Essential Knowledge 6.D.3**: Standing waves are the result of the addition of incident and reflected waves that are confined to a region and have nodes and antinodes. Examples should include waves on a fixed length of string, and sound waves in both closed and open tubes. . **Essential Knowledge 6.D.4**: The possible wavelengths of a standing wave are determined by the size of the region to which it is confined. a. A standing wave with zero amplitude at both ends can only have certain wavelengths. Examples should include fundamental frequencies and harmonics. b. Other boundary conditions or other region sizes will result in different sets of possible wavelengths. **Essential Knowledge 6.D.5**: Beats arise from the addition of waves of slightly different frequency. a. Because of the different frequencies, the two waves are sometimes in phase and sometimes out of phase. The resulting regularly spaced amplitude changes are called beats. Examples should include the tuning of an instrument. b. The beat frequency is the difference in frequency between the two waves.	

Above objective aligned with AASD Next Generation Science standards:
HS-PS1-C, HS-PS4-A, HS-PS4-B

Resources and Appendices:

SCIENCE PRACTICES

Each learning objective combines physics content with one or more of seven foundational science practices. The complete list is at:
http://advancesinap.collegeboard.org/math-and-science/practice

Science Practice 1: The student can use representations and models to communicate scientific phenomena and solve scientific problems.

Science Practice 2: The student can use mathematics appropriately.

Science Practice 3: The student can engage in scientific questioning to extend thinking or to guide investigations within the context of the AP course.

Science Practice 4: The student can plan and implement data collection strategies in relation to a particular scientific question.

Science Practice 5: The student can perform data analysis and evaluation of evidence.

Science Practice 6: The student can work with scientific explanations and theories.

Science Practice 7: The student is able to connect and relate knowledge across various scales, concepts, and representations in and across domains.

College Board AP Physics 1 Course and Exam Description including Curriculum Framework

http://media.collegeboard.com/digitalServices/pdf/ap/ap-physics-1-2-course-and-exam-description.pdf

CCSS-ELA: Literacy in Science
Grade 12

	Essential Learning Objectives	Performance Indicators
Reading	**1. Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account** (RST.11-12.1)	**Performance will be satisfactory when the student:** a. Can analyze science and technical texts. b. Can employ techniques for selecting textual evidence to support analysis c. Can employ techniques such as graphic organizers, two column notes, etc…to identify the important distinctions made by the author.
	2. Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. (RST.11-12.2)	**Performance will be satisfactory when the student:** a. Can employ techniques to determine the central ideas or conclusions from a science/technical text b. Can produce a summary of a science/technical source
	3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text. (RST.11-12-3)	**Performance will be satisfactory when the student:** a. Can analyze features of text that describe a complex multistep procedure b. Can employ graphic organizers to understand texts that describe a complex multistep procedure c. Can employ techniques for locating textual information related to the outcome of a procedure or process d. Can analyze specific results based on explanations in the text

	Essential Learning Objectives	Performance Indicators
Reading	**4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11–12 texts and topics.** (RST.11-12.4)	**Performance will be satisfactory when the student:** a. Can employ several strategies for determining the meaning of unknown words (science content-specific vocabulary). Methods may include using sentence clues, or a dictionary.
	5. Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas. (RST.11-12.5)	**Performance will be satisfactory when the student:** a. Can analyze how a text structures information or ideas into categories or hierarchies b. Can determine how a text organizations information or ideas into categories or hierarchies
	6. Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved (RST.11-12.6)	**Performance will be satisfactory when the student:** a. Can evaluate one claim by employing two sources b. Can determine an author's purpose c. Can provide textual details to support thinking about author's purpose d. Demonstrates an understanding that authors' differing points of view are dependent upon their claims, reasoning, and evidence presented
	7. Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (RST.11-12.7)	**Performance will be satisfactory when the student:** a. Can utilize techniques to evaluate material presented in multiple formats and what is being taught b. Can manipulate data and extract relevant information pertaining to the subject at hand c. Can relate visual material to pertinent case studies d. Can raise probing questions and utilize problem solving techniques.

	Essential Learning Objectives	Performance Indicators
Reading	**8. Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.** (RST.11-12.8)	**Performance will be satisfactory when the student:** a. Can analyze an author's hypotheses, data, analysis, and conclusions in a science or technical text in light of other information presented. b. Can utilize techniques for verifying data, corroborating, and challenging conclusions with other sources of information
	9. Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (RST.11-12.9)	**Performance will be satisfactory when the student:** a. Can employ a variety of techniques for gathering information from a range of sources. b. Can synthesize information from a range of sources into a coherent understanding of a process, phenomenon, or concept. c. Can evaluate textual sources to resolve conflicting information.
	10. By the end of grade 12, read and comprehend science/technical texts in the grades 11–12 text complexity band independently and proficiently. (RST.11-12.10)	**Performance will be satisfactory when the student:** a. Can employ techniques to discern meaning from appropriately difficult text sources. b. Can employ techniques to engage with and appreciate appropriately difficult text. c. Can select engaging, interesting, and motivating texts that are appropriate to who they are as readers.

	Essential Learning Objectives	Performance Indicators
Writing	**11. Write arguments focused on *discipline-specific content*.** (W.11-12.1)	**Performance will be satisfactory when the student:** a. identifies qualities of arguments, b. writes an argument to support a claim, c. acknowledges and distinguishes claims from alternate or opposing claims, d. uses logical reasoning and relevant evidence (credible sources) to support a claim, e. uses words, phrases, clauses, and syntax to clarify relationships and create cohesion, f. writes with a formal style, g. writes with a predictable structure (introduction with statement of claim, clearly organized evidence, and conclusion that supports argument), and h. anticipates and recognizes audiences' values and bias.
	12. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (W.11-12.2)	**Performance will be satisfactory when the student:** a. introduces a topic; organizes complex ideas, concepts, and information so that each new element builds on that which precedes it to create a unified whole; includes formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aid in comprehension, b. develops the topic thoroughly by selecting the most significant and relevant facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic, c. uses appropriate and varied transitions and syntax to link the major sections of the text, create cohesion, and clarify the relationships among complex ideas and concepts, d. uses precise language, domain-specific vocabulary, and techniques such as metaphor, simile, and analogy to manage the complexity of the topic, e. establishes and maintains a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing, and f. provides a concluding statement or section that follows from and supports the information or explanation presented (e.g., articulating implications or the significance of the topic).
	13. Not applicable as a separate requirement (W.11-12.3)	

	Essential Learning Objectives	Performance Indicators
Writing	**14. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.** (W.11-12.4)	**Performance will be satisfactory when the student:** a. identifies audience, purpose, and task (expectations), b. demonstrates techniques for organizing writing, c. uses style appropriate to purpose and task (audience opinion, informative, explanatory, and narrative), d. designs consistent, appropriate style for writing, and e. produces clear and coherent writing.
	15. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (W.11-12.5)	**Performance will be satisfactory when the student:** a. uses planning, revision, editing, rewriting, or a new approach to strengthen writing, b. explains techniques used to make writing appropriate for purpose and audience, and c. produces writing that is well-developed and strong.
	16. Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information. (W.11-12.6)	**Performance will be satisfactory when the student:** a. uses technology (including Internet) to produce, publish, and update individual or shared writing, b. uses technology to link to and display information, c. uses technology to interact and collaborate with others, and d. updates information in response to feedback.

	Essential Learning Objectives	Performance Indicators
Writing	**17. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.** (W.11-12.7)	**Performance will be satisfactory when the student:** a. uses research to answer a self-generated question or solve a problem, b. narrows or broadens research when appropriate, c. synthesizes multiple sources, and d. demonstrates understanding of the subject through research.
	18. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (W.11-12.8)	**Performance will be satisfactory when the student:** a. gathers relevant information from multiple authoritative print and digital sources, using advanced searches effectively, b. assesses the strengths and limitations of each source in terms of the task, purpose, and audience, c. integrates information into the text selectively to maintain the flow of ideas, d. avoids plagiarism and overreliance on any one source, and e. follows a standard format for citation.

	Essential Learning Objectives	Performance Indicators
Writing	**19. Draw evidence from informational texts to support analysis, reflection, and research.** (W.11-12.9)	**Performance will be satisfactory when the student:** a. critically reads informational texts, b. identifies argument/claim/message in text and then analyzes credibility of source: author, timeliness, publisher, purpose, etc., c. assesses whether reasoning is valid and the evidence is relevant, d. identifies false statements and fallacious reasoning, and e. cites evidence from informational text to strengthen their research.
	20. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences. (W.11-12.10)	**Performance will be satisfactory when the student:** a. completes various pieces of writing over extended and shorter time frames, b. organizes clear and coherent pieces of writing for a variety of reasons and in a variety of settings, and c. understands that writing pieces are organized and developed based on task, audience and purpose.