WARREN COUNTY SCHOOL DISTRICT

PLANNED INSTRUCTION

COURSE DESCRIPTION

Course Title: AP Physics I
Course Number: 00356
Course Prerequisites: Algebra II and Physics CP

Course Description: AP Physics 1 is an algebra-based, introductory college-level physics course that explores topics such as Newtonian mechanics (including rotational motion); work, energy, and power; mechanical waves and sound; and introductory, simple circuits. Through inquiry-based learning, students will develop scientific critical thinking and reasoning skills.

Suggested Grade Level: Grades 10-12
Length of Course: Two Semesters
Units of Credit: 1
PDE Certification and Staffing Policies and Guidelines (CSPG) Required Teacher Certifications:
CSPG 56 Physics
To find the CSPG information, go to CSPG
Certification verified by the WCSD Human Resources Department: ☒Yes ☐No

WCSD STUDENT DATA SYSTEM INFORMATION

Course Level: AP (1) GPA +10%
Mark Types: Check all that apply.
☒F – Final Average ☒MP – Marking Period ☒EXM – Final Exam

GPA Type: ☐ GPAEL-GPA Elementary ☐ GPAML-GPA for Middle Level ☒ NHS-National Honor Society
☒ UGPA-Non-Weighted Grade Point Average ☒ GPA-Weighted Grade Point Average

State Course Code: 03165
To find the State Course Code, go to State Course Code, download the Excel file for *SCED*, click on SCED 6.0 tab, and choose the correct code that corresponds with the course.

TEXTBOOKS AND SUPPLEMENTAL MATERIALS

Board Approved Textbooks, Software, and Materials:

Title: Physics Principles with Applications
Publisher: Pearson
ISBN #: 0-978-0-13-344768-2
Copyright Date: 2014
WCSD Board Approval Date: 5/14/2018

Supplemental Materials: The College Board: AP Physics 1: Algebra-Based Course and Exam Description; PH: Conceptual Physics; PH: Physical Science Concepts in Action; Related websites

Curriculum Document

WCSD Board Approval:

Date Finalized: 1/10/2025
Date Approved: 2/10/2025
Implementation Year: 2025-2026

SPECIAL EDUCATION, 504, and GIFTED REQUIREMENTS

The teacher shall make appropriate modifications to instruction and assessment based on a student's Individual Education Plan (IEP), Chapter 15 Section 504 Plan (504), and/or Gifted Individual Education Plan (GIEP).

SCOPE AND SEQUENCE OF CONTENT AND CONCEPTS

Marking Period 1

- Unit 1: Kinematics
- Unit 2: Force and Translational Dynamics

Marking Period 2

- Unit 2: Force and Translational Dynamics continued
- Unit 3: Work, Energy, and Power
- Unit 4: Linear Momentum

Marking Period 3

- Unit 4: Linear Momentum continued
- Unit 5: Torque and Rational Dynamics
- Unit 6: Energy and Momentum of Rotating Systems

Marking Period 4

- Unit 6: Energy and Momentum of Rotating Systems continued
- Unit 7: Oscillations
- Unit 8: Fluids

Standards/Eligible Content and Skills

Performance Indicator	College Board Advanced Placement Program Standards	Marking Period Taught
Describe a scalar or vector quantity using magnitude and direction, as appropriate.	SCI.9-12.1.1.A	MP1
Scalars are quantities described by magnitude only; vectors are quantities described by both magnitude and direction.	SCI.9-12.1.1.A.1	MP1
Vectors can be visually modeled as arrows with appropriate direction and lengths proportional to their magnitude.	SCI.9-12.1.1.A.2	MP1
Distance and speed are examples of scalar quantities, while position, displacement, velocity, and acceleration are examples of vector quantities.	SCI.9-12.1.1.A.3	MP1
Vectors are notated with an arrow above the symbol for that quantity.	SCI.9-12.1.1.A.3.i	MP1
Vector notation is not required for vector components along an axis. In one dimension, the sign of the component completely describes the direction of that component.	SCI.9-12.1.1.A.3.ii	MP1
Describe a vector sum in one dimension.	SCI.9-12.1.1.B	MP1
When determining a vector sum in a given one-dimensional coordinate system, opposite directions are denoted by opposite signs.	SCI.9-12.1.1.B.1	MP1
Describe a change in an object’s position.	SCI.9-12.1.2.A	MP1
When using the object model, the size, shape, and internal configuration are ignored. The object may be treated as a single point with extensive properties such as mass and charge.	SCI.9-12.1.2.A.1	MP1
Displacement is the change in an object’s position.	SCI.9-12.1.2.A.2	MP1
Describe the average velocity and acceleration of an object.	SCI.9-12.1.2.B	MP1
Averages of velocity and acceleration are calculated considering the initial and final states of an object over an interval of time.	SCI.9-12.1.2.B.1	MP1
Average velocity is the displacement of an object divided by the interval of time in which that displacement occurs.	SCI.9-12.1.2.B.2	MP1
Average acceleration is the change in velocity divided by the interval of time in which that change in velocity occurs.	SCI.9-12.1.2.B.3	MP1
An object is accelerating if the magnitude and/or direction of the object’s velocity are changing.	SCI.9-12.1.2.B.4	MP1
Calculating average velocity or average acceleration over a very small time-interval yields a value that is very close to the instantaneous velocity or instantaneous acceleration.	SCI.9-12.1.2.B.5	MP1
Describe the position, velocity, and acceleration of an object using representations of that object’s motion.	SCI.9-12.1.3.A	MP1
Motion can be represented by motion diagrams, figures, graphs, equations, and narrative descriptions.	SCI.9-12.1.3.A.1	MP1
For constant acceleration, three kinematic equations can be used to describe instantaneous linear motion in one dimension.	SCI.9-12.1.3.A.2	MP1
Near the surface of Earth, the vertical acceleration caused by the force of gravity is downward, constant, and has a measured value approximately equal to $a_g = g \approx 10\ m/s^2$.	SCI.9-12.1.3.A.3	MP1

Performance Indicator	College Board Advanced Placement Program Standards	Marking Period Taught
Graphs of position, velocity, and acceleration as functions of time can be used to find the relationships between those quantities.	SCI.9-12.1.3.A.4	MP1
An object's instantaneous velocity is the rate of change of the object's position, which is equal to the slope of a line tangent to a point on a graph of the object's position as a function of time.	SCI.9-12.1.3.A.4.i	MP1
An object's instantaneous acceleration is the rate of change of the object's velocity, which is equal to the slope of a line tangent to a point on a graph of the object's velocity as a function of time.	SCI.9-12.1.3.A.4.ii	MP1
The displacement of an object during a time interval is equal to the area under the curve of a graph of the object's velocity as a function of time (i.e., the area bounded by the function and the horizontal axis for the appropriate interval).	SCI.9-12.1.3.A.4.iii	MP1
The change in velocity of an object during a time interval is equal to the area under the curve of a graph of the acceleration of the object as a function of time.	SCI.9-12.1.3.A.4.iv	MP1
Describe the reference frame of a given observer.	SCI.9-12.1.4.A	MP1
The choice of reference frame will determine the direction and magnitude of quantities measured by an observer in that reference frame.	SCI.9-12.1.4.A.1	MP1
Describe the motion of objects as measured by observers in different inertial reference frames.	SCI.9-12.1.4.B	MP1
Measurements from a given reference frame may be converted to measurements from another reference frame.	SCI.9-12.1.4.B.1	MP1
The observed velocity of an object results from the combination of the object's velocity and the velocity of the observer's reference frame.	SCI.9-12.1.4.B.2	MP1
Combining the motion of an object and the motion of an observer in a given reference frame involves the addition or subtraction of vectors.	SCI.9-12.1.4.B.2.i	MP1
The acceleration of any object is the same as measured from all inertial reference frames.	SCI.9-12.1.4.B.2.ii	MP1
Describe the perpendicular components of a vector.	SCI.9-12.1.5.A	MP1
Vectors can be mathematically modeled as the resultant of two perpendicular components.	SCI.9-12.1.5.A.1	MP1
Vectors can be resolved into components using a chosen coordinate system.	SCI.9-12.1.5.A.2	MP1
Vectors can be resolved into perpendicular components using trigonometric functions and relationships.	SCI.9-12.1.5.A.3	MP1
Describe the motion of an object moving in two dimensions.	SCI.9-12.1.5.B	MP1
Motion in two dimensions can be analyzed using one-dimensional kinematic relationships if the motion is separated into components.	SCI.9-12.1.5.B.1	MP1
Projectile motion is a special case of two-dimensional motion that has zero acceleration in one dimension and constant, nonzero acceleration in the second dimension.	SCI.9-12.1.5.B.2	MP1
Describe the properties and interactions of a system.	SCI.9-12.2.1.A	MP1, MP2

Performance Indicator	College Board Advanced Placement Program Standards	Marking Period Taught
System properties are determined by the interactions between objects within the system.	SCI.9-12.2.1.A.1	MP1, MP2
If the properties or interactions of the constituent objects within a system are not important in modeling the behavior of the macroscopic system, the system can itself be treated as a single object.	SCI.9-12.2.1.A.2	MP1, MP2
Systems may allow interactions between constituent parts of the system and the environment, which may result in the transfer of energy or mass.	SCI.9-12.2.1.A.3	MP1, MP2
Individual objects within a chosen system may behave differently from each other as well as from the system as a whole.	SCI.9-12.2.1.A.4	MP1, MP2
The internal structure of a system affects the analysis of that system.	SCI.9-12.2.1.A.5	MP1, MP2
As variables external to a system are changed, the system's substructure may change.	SCI.9-12.2.1.A.6	MP1, MP2
Describe the location of a system's center of mass with respect to the system's constituent parts.	SCI.9-12.2.1.B	MP1, MP2
For systems with symmetrical mass distributions, the center of mass is located on lines of symmetry.	SCI.9-12.2.1.B.1	MP1, MP2
The location of a system's center of mass along a given axis can be calculated using the equation $\vec{x}_{cm} = \sum m_i \vec{x}_i / \sum m_i$.	SCI.9-12.2.1.B.2	MP1, MP2
A system can be modeled as a singular object that is located at the system's center of mass.	SCI.9-12.2.1.B.3	MP1, MP2
Describe a force as an interaction between two objects or systems.	SCI.9-12.2.2.A	MP1, MP2
Forces are vector quantities that describe the interactions between objects or systems.	SCI.9-12.2.2.A.1	MP1, MP2
A force exerted on an object or system is always due to the interaction of that object with another object or system.	SCI.9-12.2.2.A.1.i	MP1, MP2
An object or system cannot exert a net force on itself.	SCI.9-12.2.2.A.1.ii	MP1, MP2
Contact forces describe the interaction of an object or system touching another object or system and are macroscopic effects of interatomic electric forces.	SCI.9-12.2.2.A.2	MP1, MP2
Describe the forces exerted on an object or system using a free-body diagram.	SCI.9-12.2.2.B	MP1, MP2
Free-body diagrams are useful tools for visualizing forces being exerted on a single object or system and for determining the equations that represent a physical situation.	SCI.9-12.2.2.B.1	MP1, MP2
The free-body diagram of an object or system shows each of the forces exerted on the object by the environment.	SCI.9-12.2.2.B.2	MP1, MP2
Forces exerted on an object or system are represented as vectors originating from the representation of the center of mass, such as a dot. A system is treated as though all of its mass is located at the center of mass.	SCI.9-12.2.2.B.3	MP1, MP2

Performance Indicator	**College Board Advanced Placement Program Standards**	**Marking Period Taught**
A coordinate system with one axis parallel to the direction of acceleration of the object or system simplifies the translation from free body diagram to algebraic representation.	SCI.9-12.2.2.B.4	MP1, MP2
Describe the interaction of two objects using Newton's third law and a representation of paired forces exerted on each object.	SCI.9-12.2.3.A	MP1, MP2
Newton's third law describes the interaction of two objects in terms of the paired forces that each exerts on the other.	SCI.9-12.2.3.A.1	MP1, MP2
Interactions between objects within a system (internal forces) do not influence the motion of a system's center of mass.	SCI.9-12.2.3.A.2	MP1, MP2
Tension is the macroscopic net result of forces that segments of a string, cable, chain, or similar system exert on each other in response to an external force.	SCI.9-12.2.3.A.3	MP1, MP2
An ideal string has negligible mass and does not stretch when under tension.	SCI.9-12.2.3.A.3.i	MP1, MP2
The tension in an ideal string is the same at all points within the string.	SCI.9-12.2.3.A.3.ii	MP1, MP2
In a string with nonnegligible mass, tension may not be the same at all points within the string.	SCI.9-12.2.3.A.3.iii	MP1, MP2
An ideal pulley is a pulley that has negligible mass and rotates about an axle through its center of mass with negligible friction.	SCI.9-12.2.3.A.3.iv	MP1, MP2
Describe the conditions under which a system's velocity remains constant.	SCI.9-12.2.4.A	MP1, MP2
The net force on a system is the vector sum of all forces exerted on the system.	SCI.9-12.2.4.A1	MP1, MP2
Translational equilibrium is a configuration of forces such that the net force exerted on a system is zero.	SCI.9-12.2.4.A.2	MP1, MP2
Newton's first law states that if the net force exerted on a system is zero, the velocity of that system will remain constant.	SCI.9-12.2.4.A.3	MP1, MP2
Forces may be balanced in one dimension but unbalanced in another. The system's velocity will change only in the direction of the unbalanced force.	SCI.9-12.2.4.A.4	MP1, MP2
An inertial reference frame is one from which an observer would verify Newton's first law of motion.	SCI.9-12.2.4.A.5	MP1, MP2
Describe the conditions under which a system's velocity changes.	SCI.9-12.2.5.A	MP1, MP2
Unbalanced forces are a configuration of forces such that the net force exerted on a system is not equal to zero.	SCI.9-12.2.5.A.1	MP1, MP2
Newton's second law of motion states that the acceleration of a system's center of mass has a magnitude proportional to the magnitude of the net force exerted on the system and is in the same direction as that net force.	SCI.9-12.2.5.A.2	MP1, MP2
The velocity of a system's center of mass will only change if a nonzero net external force is exerted on that system.	SCI.9-12.2.5.A.3	MP1, MP2
Describe the gravitational interaction between two objects or systems with mass.	SCI.9-12.2.6.A	MP1, MP2

Performance Indicator	**College Board Advanced Placement Program Standards**	**Marking Period Taught**
Newton's law of universal gravitation describes the gravitational force between two objects or systems as directly proportional to each of their masses and inversely proportional to the square of the distance between the systems' centers of mass.	SCI.9-12.2.6.A.1	MP1, MP2
The gravitational force is attractive.	SCI.9-12.2.6.A.1.i	MP1, MP2
The gravitational force is always exerted along the line connecting the centers of mass of the two interacting systems.	SCI.9-12.2.6.A.1.ii	MP1, MP2
The gravitational force on a system can be considered to be exerted on the system's center of mass.	SCI.9-12.2.6.A.1.iii	MP1, MP2
A field models the effects of a noncontact force exerted on an object at various positions in space.	SCI.9-12.2.6.A.2	MP1, MP2
The magnitude of the gravitational field created by a system of mass M at a point in space is equal to the ratio of the gravitational force exerted by the system on a test object of mass m to the mass of the test object.	SCI.9-12.2.6.A.2.i	MP1, MP2
If the gravitational force is the only force exerted on an object, the observed acceleration of the object is numerically equal to the magnitude of the gravitational field strength (in N/Kg) at that location.	SCI.9-12.2.6.A.2.ii	MP1, MP2
The gravitational force exerted by an astronomical body on a relatively small nearby object is called weight.	SCI.9-12.2.6.A.3	MP1, MP2
Describe situations in which the gravitational force can be considered constant.	SCI.9-12.2.6.B	MP1, MP2
If the gravitational force between two systems' centers of mass has a negligible change as the relative position of the two systems changes, the gravitational force can be considered constant at all points between the initial and final positions of the systems.	SCI.9-12.2.6.B.1	MP1, MP2
Near the surface of Earth, the strength of the gravitational field is $g \approx 10$N/kg	SCI.9-12.2.6.B.2	MP1, MP2
Describe the conditions under which the magnitude of a system's apparent weight is different from the magnitude of the gravitational force exerted on that system.	SCI.9-12.2.6.C	MP1, MP2
The magnitude of the apparent weight of a system is the magnitude of the normal force exerted on the system.	SCI.9-12.2.6.C.1	MP1, MP2
If the system is accelerating, the apparent weight of the system is not equal to the magnitude of the gravitational force exerted on the system.	SCI.9-12.2.6.C.2	MP1, MP2
A system appears weightless when there are no forces exerted on the system or when the force of gravity is the only force exerted on the system.	SCI.9-12.2.6.C.3	MP1, MP2
The equivalence principle states that an observer in a non-inertial reference frame is unable to distinguish between an object's apparent weight and the gravitational force exerted on the object by a gravitational field.	SCI.9-12.2.6.C.4	MP1, MP2
Describe inertial and gravitational mass.	SCI.9-12.2.6.D	MP1, MP2

Performance Indicator	**College Board Advanced Placement Program Standards**	**Marking Period Taught**
Objects have inertial mass, or inertia, a property that determines how much an object's motion resists changes when interacting with another object.	SCI.9-12.2.6.D.1	MP1, MP2
Gravitational mass is related to the force of attraction between two systems with mass.	SCI.9-12.2.6.D.2	MP1, MP2
Inertial mass and gravitational mass have been experimentally verified to be equivalent.	SCI.9-12.2.6.D.3	MP1, MP2
Describe kinetic friction between two surfaces.	SCI.9-12.2.7.A	MP1, MP2
Kinetic friction occurs when two surfaces in contact move relative to each other.	SCI.9-12.2.7.A.1	MP1, MP2
The kinetic friction force is exerted in a direction opposite to the motion of each surface relative to the other surface.	SCI.9-12.2.7.A.1.i	MP1, MP2
The force of friction between two surfaces does not depend on the size of the surface area of contact.	SCI.9-12.2.7.A.1.ii	MP1, MP2
The magnitude of the kinetic friction force exerted on an object is the product of the normal force the surface exerts on the object and the coefficient of kinetic friction.	SCI.9-12.2.7.A.2	MP1, MP2
The coefficient of kinetic friction depends on the material properties of the surfaces that are in contact.	SCI.9-12.2.7.A.2.i	MP1, MP2
Normal force is the perpendicular component of the force exerted on an object by the surface with which it is in contact; it is directed away from the surface.	SCI.9-12.2.7.A.2.ii	MP1, MP2
Describe static friction between two surfaces.	SCI.9-12.2.7.B	MP1, MP2
Static friction may occur between the contacting surfaces of two objects that are not moving relative to each other.	SCI.9-12.2.7.B.1	MP1, MP2
Static friction adopts the value and direction required to prevent an object from slipping or sliding on a surface.	SCI.9-12.2.7.B.2	MP1, MP2
Slipping and sliding refer to situations in which two surfaces are moving relative to each other.	SCI.9-12.2.7.B..2.i	MP1, MP2
There exists a maximum value for which static friction will prevent an object from slipping on a given surface.	SCI.9-12.2.7.B.2.ii	MP1, MP2
The coefficient of static friction is typically greater than the coefficient of kinetic friction for a given pair of surfaces.	SCI.9-12.2.7.B.3	MP1, MP2
Describe the force exerted on an object by an ideal spring.	SCI.9-12.2.8.A	MP1, MP2
An ideal spring has negligible mass and exerts a force that is proportional to the change in its length as measured from its relaxed length.	SCI.9-12.2.8.A.1	MP1, MP2
The magnitude of the force exerted by an ideal spring on an object is given by Hooke's law.	SCI.9-12.2.8.A.2	MP1, MP2
The force exerted on an object by a spring is always directed toward the equilibrium position of the object–spring system.	SCI.9-12.2.8.A.3	MP1, MP2
Describe the motion of an object traveling in a circular path.	SCI.9-12.2.9.A	MP1, MP2
Centripetal acceleration is the component of an object's acceleration directed toward the center of the object's circular path.	SCI.9-12.2.9.A.1	MP1, MP2

Performance Indicator	**College Board Advanced Placement Program Standards**	**Marking Period Taught**
The magnitude of centripetal acceleration for an object moving in a circular path is the ratio of the object's tangential speed squared to the radius of the circular path.	SCI.9-12.2.9.A.1.i	MP1, MP2
Centripetal acceleration is directed toward the center of an object's circular path.	SCI.9-12.2.9.A.1.ii	MP1, MP2
Centripetal acceleration can result from a single force, more than one force, or components of forces exerted on an object in circular motion.	SCI.9-12.2.9.A.2	MP1, MP2
At the top of a vertical, circular loop, an object requires a minimum speed to maintain circular motion. At this point, and with this minimum speed, the gravitational force is the only force that causes the centripetal acceleration.	SCI.9-12.2.9.A.2.i	MP1, MP2
Components of the static friction force and the normal force can contribute to the net force producing centripetal acceleration of an object traveling in a circle on a banked surface.	SCI.9-12.2.9.A.2.ii	MP1, MP2
A component of tension contributes to the net force producing centripetal acceleration experienced by a conical pendulum.	SCI.9-12.2.9.A.2.iii	MP1, MP2
Tangential acceleration is the rate at which an object's speed changes and is directed tangent to the object's circular path.	SCI.9-12.2.9.A.3	MP1, MP2
The net acceleration of an object moving in a circle is the vector sum of the centripetal acceleration and tangential acceleration.	SCI.9-12.2.9.A.4	MP1, MP2
The revolution of an object traveling in a circular path at a constant speed (uniform circular motion) can be described using period and frequency.	SCI.9-12.2.9.A.5	MP1, MP2
The time to complete one full circular path is defined as period, T.	SCI.9-12.2.9.A.5.i	MP1, MP2
The rate at which an object is completing revolutions is defined as frequency, f.	SCI.9-12.2.9.A.5.ii	MP1, MP2
For an object traveling at a constant speed in a circular path, the period is given by the derived equation.	SCI.9-12.2.9.A.5.iii	MP1, MP2
Describe circular orbits using Kepler's third law.	SCI.9-12.2.9.B	MP1, MP2
For a satellite in circular orbit around a central body, the satellite's centripetal acceleration is caused only by gravitational attraction. The period and radius of the circular orbit are related to the mass of the central body.	SCI.9-12.2.9.B.1	MP1, MP2
Describe the translational kinetic energy of an object in terms of the object's mass and velocity.	SCI.9-12.3.1.A	MP2
An object's translational kinetic energy is given by the equation $K=\frac{1}{2}mv^2$.	SCI.9-12.3.1.A.1	MP2
Translational kinetic energy is a scalar quantity.	SCI.9-12.3.1.A.2	MP2
Different observers may measure different values of the translational kinetic energy of an object, depending on the observer's frame of reference.	SCI.9-12.3.1.A.3	MP2
Describe the work done on an object or system by a given force or collection of forces.	SCI.9-12.3.2.A	MP2

Performance Indicator	**College Board Advanced Placement Program Standards**	**Marking Period Taught**
Work is the amount of energy transferred into or out of a system by a force exerted on that system over a distance.	SCI.9-12.3.2.A.1	MP2
The work done by a conservative force exerted on a system is path-independent and only depends on the initial and final configurations of that system.	SCI.9-12.3.2.A.1.i	MP2
The work done by a conservative force on a system—or the change in the potential energy of the system—will be zero if the system returns to its initial configuration.	SCI.9-12.3.2.A.1.ii	MP2
Potential energies are associated only with conservative forces.	SCI.9-12.3.2.A.1.iii	MP2
The work done by a nonconservative force is path-dependent.	SCI.9-12.3.2.A.1.iv	MP2
Examples of nonconservative forces are friction and air resistance.	SCI.9-12.3.2.A.1.v	MP2
Work is a scalar quantity that may be positive, negative, or zero.	SCI.9-12.3.2.A.2	MP2
The amount of work done on a system by a constant force is related to the components of that force and the displacement of the point at which that force is exerted.	SCI.9-12.3.2.A.3	MP2
Only the component of the force exerted on a system that is parallel to the displacement of the point of application of the force will change the system's total energy.	SCI.9-12.3.2.A.3.i	MP2
The component of the force exerted on a system perpendicular to the direction of the displacement of the system's center of mass can change the direction of the system's motion without changing the system's kinetic energy.	SCI.9-12.3.2.A.3.ii	MP2
The work-energy theorem states that the change in an object's kinetic energy is equal to the sum of the work (network) being done by all forces exerted on the object.	SCI.9-12.3.2.A.4	MP2
An external force may change the configuration of a system. The component of the external force parallel to the displacement times the displacement of the point of application of the force gives the change in kinetic energy of the system.	SCI.9-12.3.2.A.4.i	MP2
If the system's center of mass and the point of application of the force move the same distance when a force is exerted on a system, then the system may be modeled as an object, and only the system's kinetic energy can change.	SCI.9-12.3.2.A.4.ii	MP2
The energy dissipated by friction is typically equated to the force of friction times the length of the path over which the force is exerted.	SCI.9-12.3.2.A.4.iii	MP2
Work is equal to the area under the curve of a graph of *F* as a function of displacement.	SCI.9-12.3.2.A.5	MP2
Describe the potential energy of a system.	SCI.9-12.3.3.A	MP2
A system composed of two or more objects has potential energy if the objects within that system only interact with each other through conservative forces.	SCI.9-12.3.3.A.1	MP2
Potential energy is a scalar quantity associated with the position of objects within a system.	SCI.9-12.3.3.A.2	MP2

Performance Indicator	**College Board Advanced Placement Program Standards**	**Marking Period Taught**
The definition of zero potential energy for a given system is a decision made by the observer considering the situation to simplify or otherwise assist in analysis.	SCI.9-12.3.3.A.3	MP2
The potential energy of common physical systems can be described using the physical properties of that system.	SCI.9-12.3.3.A.4	MP2
The elastic potential energy of an ideal spring is given by the following equation, where Δx is the distance the spring has been stretched or compressed from its equilibrium length. $U_s=\frac{1}{2}k(\Delta x)^2$	SCI.9-12.3.3.A.4.i	MP2
The general form for the gravitational potential energy of a system consisting of two approximately spherical distributions of mass (e.g., moons, planets or stars) is given by the equation $\Delta U_g=-G(m_1m_2/r)$.	SCI.9-12.3.3.A.4.ii	MP2
Because the gravitational field near the surface of a planet is nearly constant, the change in gravitational potential energy in a system consisting of an object with mass m and a planet with gravitational field of magnitude g when the object is near the surface of the planet may be approximated by the equation $\Delta U_g=mg\Delta y$.	SCI.9-12.3.3.A.iii	MP2
The total potential energy of a system containing more than two objects is the sum of the potential energy of each pair of objects within the system.	SCI.9-12.3.3.A.5	MP2
Describe the energies present in a system.	SCI.9-12.3.4.A	MP2
A system composed of only a single object can only have kinetic energy.	SCI.9-12.3.4.A.1	MP2
A system that contains objects that interact via conservative forces or that can change its shape reversibly may have both kinetic and potential energies.	SCI.9-12.3.4.A.2	MP2
Describe the behavior of a system using conservation of mechanical energy principles.	SCI.9-12.3.4.B	MP2
Mechanical energy is the sum of a system’s kinetic and potential energies.	SCI.9-12.3.4.B.1	MP2
Any change to a type of energy within a system must be balanced by an equivalent change of other types of energies within the system or by a transfer of energy between the system and its surroundings.	SCI.9-12.3.4.B.2	MP2
A system may be selected so that the total energy of that system is constant.	SCI.9-12.3.4.B.3	MP2
If the total energy of a system changes, that change will be equivalent to the energy transferred into or out of the system.	SCI.9-12.3.4.B.4	MP2
Describe how the selection of a system determines whether the energy of that system changes.	SCI.9-12.3.4.C	MP2
Energy is conserved in all interactions.	SCI.9-12.3.4.C.1	MP2
If the work done on a selected system is zero and there are no nonconservative interactions within the system, the total mechanical energy of the system is constant.	SCI.9-12.3.4.C.2	MP2
If the work done on a selected system is nonzero, energy is transferred between the system and the environment.	SCI.9-12.3.4.C.3	MP2

Performance Indicator	**College Board Advanced Placement Program Standards**	**Marking Period Taught**
Describe the transfer of energy into, out of, or within a system in terms of power.	SCI.9-12.3.5.A	MP2
Power is the rate at which energy changes with respect to time, either by transfer into or out of a system or by conversion from one type to another within a system.	SCI.9-12.3.5.A.1	MP2
Average power is the amount of energy being transferred or converted, divided by the time it took for that transfer or conversion to occur.	SCI.9-12.3.5.A.2	MP2
Because work is the change in energy of an object or system due to a force, average power is the total work done, divided by the time during which that work was done.	SCI.9-12.3.5.A.3	MP2
The instantaneous power delivered to an object by the component of a constant force parallel to the object's velocity can be described with the derived equation.	SCI.9-12.3.5.A.4	MP2
Describe the linear momentum of an object or system.	SCI.9-12.4.1.A	MP2, MP3
Linear momentum is defined by the equation $\vec{p}=m\vec{v}$.	SCI.9-12.4.1.A.1	MP2, MP3
Momentum is a vector quantity and has the same direction as the velocity.	SCI.9-12.4.1.A.2	MP2, MP3
Momentum can be used to analyze collisions and explosions.	SCI.9-12.4.1.A.3	MP2, MP3
A collision is a model for an interaction where the forces exerted between the involved objects in the system are much larger than the net external force exerted on those objects during the interaction.	SCI.9-12.4.1.A.3.i	MP2, MP3
As only the initial and final states of a collision are analyzed, the object model may be used to analyze collisions.	SCI.9-12.4.1.A.3.ii	MP2, MP3
An explosion is a model for an interaction in which forces internal to the system move objects within that system apart.	SCI.9-12.4.1.A.3.iii	MP2, MP3
Describe the impulse delivered to an object or system.	SCI.9-12.4.2.A	MP2, MP3
The rate of change of momentum is equal to the net external force exerted on an object or system.	SCI.9-12.4.2.A.1	MP2, MP3
Impulse is defined as the product of the average force exerted on a system and the time interval during which that force is exerted on the system.	SCI.9-12.4.2.A.2	MP2, MP3
Impulse is a vector quantity and has the same direction as the net force exerted on the system.	SCI.9-12.4.2.A.3	MP2, MP3
The impulse delivered to a system by a net external force is equal to the area under the curve of a graph of the net external force exerted on the system as a function of time.	SCI.9-12.4.2.A.4	MP2, MP3
The net external force exerted on a system is equal to the slope of a graph of the momentum of the system as a function of time.	SCI.9-12.4.2.A.5	MP2, MP3
Describe the relationship between the impulse exerted on an object or a system and the change in momentum of the object or system.	SCI.9-12.4.2.B	MP2, MP3
Change in momentum is the difference between a system's final momentum and its initial momentum.	SCI.9-12.4.2.B.1	MP2, MP3

Performance Indicator	College Board Advanced Placement Program Standards	Marking Period Taught
The impulse–momentum theorem relates the impulse exerted on a system and the system's change in momentum.	SCI.9-12.4.2.B.2	MP2, MP3
Newton's second law of motion is a direct result of the impulse–momentum theorem applied to systems with constant mass.	SCI.9-12.4.2.B.3	MP2, MP3
Describe the behavior of a system using conservation of linear momentum.	SCI.9-12.4.3.A	MP2, MP3
A collection of objects with individual momenta can be described as one system with one center-of-mass velocity.	SCI.9-12.4.3.A.1	MP2, MP3
For a collection of objects, the velocity of a system's center of mass can be calculated using the equation $\vec{v}_{cm} = \sum\vec{p}_i/\sum m_i = \sum m_i\vec{v}_i/\sum m_i$.	SCI.9-12.4.3.A.1.i	MP2, MP3
The velocity of a system's center of mass is constant in the absence of a net external force.	SCI.9-12.4.3.A.1.ii	MP2, MP3
The total momentum of a system is the sum of the momenta of the system's constituent parts.	SCI.9-12.4.3.A.2	MP2, MP3
In the absence of net external forces, any change to the momentum of an object within a system must be balanced by an equivalent and opposite change of momentum elsewhere within the system. Any change to the momentum of a system is due to a transfer of momentum between the system and its surroundings.	SCI.9-12.4.3.A.3	MP2, MP3
The impulse exerted by one object on a second object is equal and opposite to the impulse exerted by the second object on the first. This is a direct result of Newton's third law.	SCI.9-12.4.3.A.3.i	MP2, MP3
A system may be selected so that the total momentum of that system is constant.	SCI.9-12.4.3.A.3.ii	MP2, MP3
If the total momentum of a system changes, that change will be equivalent to the impulse exerted on the system.	SCI.9-12.4.3.A.3.iii	MP2, MP3
Correct application of conservation of momentum can be used to determine the velocity of a system immediately before and immediately after collisions or explosions.	SCI.9-12.4.3.A.4	MP2, MP3
Describe how the selection of a system determines whether the momentum of that system changes.	SCI.9-12.4.3.B	MP2, MP3
Momentum is conserved in all interactions.	SCI.9-12.4.3.B.1	MP2, MP3
If the net external force on the selected system is zero, the total momentum of the system is constant.	SCI.9-12.4.3.B.2	MP2, MP3
If the net external force on the selected system is nonzero, momentum is transferred between the system and the environment.	SCI.9-12.4.3.B.3	MP2, MP3
Describe whether an interaction between objects is elastic or inelastic.	SCI.9-12.4.4.A	MP2, MP3
An elastic collision between objects is one in which the initial kinetic energy of the system is equal to the final kinetic energy of the system.	SCI.9-12.4.4.A.1	MP2, MP3
In an elastic collision, the final kinetic energies of each of the objects within the system may be different from their initial kinetic energies.	SCI.9-12.4.4.A.2	MP2, MP3
An inelastic collision between objects is one in which the total kinetic energy of the system decreases.	SCI.9-12.4.4.A.3	MP2, MP3

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In an inelastic collision, some of the initial kinetic energy is not restored to kinetic energy but is transformed by nonconservative forces into other forms of energy.	SCI.9-12.4.4.A.4	MP2, MP3
In a perfectly inelastic collision, the objects stick together and move with the same velocity after the collision.	SCI.9-12.4.4.A.5	MP2, MP3
Describe the rotation of a system with respect to time using angular displacement, angular velocity, and angular acceleration.	SCI.9-12.5.1.A	MP3
Angular displacement is the measurement of the angle, in radians, through which a point on a rigid system rotates about a specified axis.	SCI.9-12.5.1.A.1	MP3
A rigid system is one that holds its shape but in which different points on the system move in different directions during rotation. A rigid system cannot be modeled as an object.	SCI.9-12.5.1.A.1.i	MP3
One direction of angular displacement about an axis of rotation—clockwise or counterclockwise—is typically indicated as mathematically positive, with the other direction becoming mathematically negative.	SCI.9-12.5.1.A.1.ii	MP3
If the rotation of a system about an axis may be well described using the motion of the system's center of mass, the system may be treated as a single object. For example, the rotation of Earth about its axis may be considered negligible when considering the revolution of Earth about the center of mass of the Earth–Sun system.	SCI.9-12.5.1.A.iii	MP3
Average angular velocity is the average rate at which angular position changes with respect to time.	SCI.9-12.5.1.A.2	MP3
Average angular acceleration is the average rate at which the angular velocity changes with respect to time.	SCI.9-12.5.1.A.3	MP3
Angular displacement, angular velocity, and angular acceleration around one axis are analogous to linear displacement, velocity, and acceleration in one dimension and demonstrate the same mathematical relationships.	SCI.9-12.5.1.A.4	MP3
For constant angular acceleration, the mathematical relationships between angular displacement, angular velocity, and angular acceleration can be described with the relevant equations.	SCI.9-12.5.1.A.4.i	MP3
Graphs of angular displacement, angular velocity, and angular acceleration as functions of time can be used to find the relationships between those quantities.	SCI.9-12.5.1.A.4.ii	MP3
Describe the linear motion of a point on a rotating rigid system that corresponds to the rotational motion of that point, and vice versa.	SCI.9-12.5.2.A	MP3
For a point at a distance r from a fixed axis of rotation, the linear distance s traveled by the point as the system rotates through an angle $\Delta\Theta$ ¸ is given by the equation $\Delta s = r\Delta\Theta$.	SCI.9-12.5.2.A.1	MP3
Derived relationships of linear velocity and of the tangential component of acceleration to their respective angular quantities are given by the relevant equations.	SCI.9-12.5.2.A.2	MP3
For a rigid system, all points within that system have the same angular velocity and angular acceleration.	SCI.9-12.5.2.A.3	MP3

Performance Indicator	**College Board Advanced Placement Program Standards**	**Marking Period Taught**
Identify the torques exerted on a rigid system.	SCI.9-12.5.3.A	MP3
Torque results only from the force component perpendicular to the position vector from the axis of rotation to the point of application of the force.	SCI.9-12.5.3.A.1	MP3
The lever arm is the perpendicular distance from the axis of rotation to the line of action of the exerted force.	SCI.9-12.5.3.A.2	MP3
Describe the torques exerted on a rigid system.	SCI.9-12.5.3.B	MP3
Torques can be described using force diagrams.	SCI.9-12.5.3.B.1	MP3
The magnitude of the torque exerted on a rigid system by a force is described by the following equation, where θ is angle between the force vector and the position vector from the axis of rotation to the point of application of the force. $\tau = rF_{\perp} = rF\sin\theta$	SCI.9-12.5.3.B.2	MP3
Describe the rotational inertia of a rigid system relative to a given axis of rotation.	SCI.9-12.5.4.A	MP3
Rotational inertia measures a rigid system's resistance to changes in rotation and is related to the mass of the system and the distribution of that mass relative to the axis of rotation.	SCI.9-12.5.4.A.1	MP3
The rotational inertia of an object rotating a perpendicular distance *r* from an axis is described by the equation $I_{tot} = \sum I_i = \sum m_i r_i^2$.	SCI.9-12.5.4.A.2	MP3
The total rotational inertia of a collection of objects about an axis is the sum of the rotational inertias of each object about that axis.	SCI.9-12.5.4.A.3	MP3
Describe the rotational inertia of a rigid system rotating about an axis that does not pass through the system's center of mass.	SCI.9-12.5.4.B	MP3
A rigid system's rotational inertia in a given plane is at a minimum when the rotational axis passes through the system's center of mass.	SCI.9-12.5.4.B.1	MP3
The parallel axis theorem uses the following equation to relate the rotational inertia of a rigid system about any axis that is parallel to an axis through its center of mass.	SCI.9-12.5.4.B.2	MP3
Describe the conditions under which a system's angular velocity remains constant.	SCI.9-12.5.5.A	MP3
A system may exhibit rotational equilibrium (constant angular velocity) without being in translational equilibrium, and vice versa.	SCI.9-12.5.5.A.1	MP3
Free-body and force diagrams describe the nature of the forces and torques exerted on an object or rigid system.	SCI.9-12.5.5.A.1.i	MP3
Rotational equilibrium is a configuration of torques such that the net torque exerted on the system is zero.	SCI.9-12.5.5.A.1.ii	MP3
The rotational analog of Newton's first law is that a system will have a constant angular velocity only if the net torque exerted on the system is zero.	SCI.9-12.5.5.A.1.iii	MP3
A rotational corollary to Newton's second law states that if the torques exerted on a rigid system are not balanced, the system's angular velocity must be changing.	SCI.9-12.5.5.A.2	MP3

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Describe the conditions under which a system's angular velocity changes.	SCI.9-12.5.6.A	MP3
Angular velocity changes when the net torque exerted on the object or system is not equal to zero.	SCI.9-12.5.6.A.1	MP3
The rate at which the angular velocity of a rigid system changes is directly proportional to the net torque exerted on the rigid system and is in the same direction. The angular acceleration of the rigid system is inversely proportional to the rotational inertia of the rigid system.	SCI.9-12.5.6.A.2	MP3
To fully describe a rotating rigid system, linear and rotational analyses may need to be performed independently.	SCI.9-12.5.6.A.3	MP3
Describe the rotational kinetic energy of a rigid system in terms of the rotational inertia and angular velocity of that rigid system.	SCI.9-12.6.1.A	MP3, MP4
The rotational kinetic energy of an object or rigid system is related to the rotational inertia and angular velocity of the rigid system and is given by the equation $K = \frac{1}{2}I\omega^2$.	SCI.9-12.6.1.A.1	MP3, MP4
The rotational inertia of an object about a fixed axis can be used to show that the rotational kinetic energy of that object is equivalent to its translational kinetic energy, which is its total kinetic energy.	SCI.9-12.6.1.A.1.i	MP3, MP4
The total kinetic energy of a rigid system is the sum of its rotational kinetic energy due to its rotation about its center of mass and the translational kinetic energy due to the linear motion of its center of mass.	SCI.9-12.6.1.A.1.ii	MP3, MP4
A rigid system can have rotational kinetic energy while its center of mass is at rest due to the individual points within the rigid system having linear speed and, therefore, kinetic energy.	SCI.9-12.6.1.A.2	MP3, MP4
Rotational kinetic energy is a scalar quantity.	SCI.9-12.6.1.A.3	MP3, MP4
Describe the work done on a rigid system by a given torque or collection of torques.	SCI.9-12.6.2.A	MP3, MP4
A torque can transfer energy into or out of an object or rigid system if the torque is exerted over an angular displacement.	SCI.9-12.6.2.A.1	MP3, MP4
The amount of work done on a rigid system by a torque is related to the magnitude of that torque and the angular displacement through which the rigid system rotates during the interval in which that torque is exerted.	SCI.9-12.6.2.A.2	MP3, MP4
Work done on a rigid system by a given torque can be found from the area under the curve of a graph of torque as a function of angular position.	SCI.9-12.6.2.A.3	MP3, MP4
Describe the angular momentum of an object or rigid system.	SCI.9-12.6.3.A	MP3, MP4
The magnitude of the angular momentum of a rigid system about a specific axis can be described with the equation $L = I\omega$.	SCI.9-12.6.3.A.1	MP3, MP4
The magnitude of the angular momentum of an object about a given point is $L = rmv\sin\theta$.	SCI.9-12.6.3.A.2	MP3, MP4

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The selection of the axis about which an object is considered to rotate influences the determination of the angular momentum of that object.	SCI.9-12.6.3.A.2.i	MP3, MP4
The measured angular momentum of an object traveling in a straight line depends on the distance between the reference point and the object, the mass of the object, the speed of the object, and the angle between the radial distance and the velocity of the object.	SCI.9-12.6.3.A.2.ii	MP3, MP4
Describe the angular impulse delivered to an object or rigid system by a torque.	SCI.9-12.6.3.B	MP3, MP4
Angular impulse is defined as the product of the torque exerted on an object or rigid system and the time interval during which the torque is exerted.	SCI.9-12.6.3.B.1	MP3, MP4
Angular impulse has the same direction as the torque exerted on the object or system.	SCI.9-12.6.3.B.2	MP3, MP4
The angular impulse delivered to an object or rigid system by a torque can be found from the area under the curve of a graph of the torque as a function of time.	SCI.9-12.6.3.B.3	MP3, MP4
Relate the change in angular momentum of an object or rigid system to the angular impulse given to that object or rigid system.	SCI.9-12.6.3.C	MP3, MP4
The magnitude of the change in angular momentum can be described by comparing the magnitudes of the final and initial angular momenta of the object or rigid system.	SCI.9-12.6.3.C.1	MP3, MP4
A rotational form of the impulse–momentum theorem relates the angular impulse delivered to an object or rigid system and the change in angular momentum of that object or rigid system.	SCI.9-12.6.3.C.2	MP3, MP4
The angular impulse exerted on an object or rigid system is equal to the change in angular momentum of that object or rigid system.	SCI.9-12.6.3.C.2.i	MP3, MP4
The rotational form of the impulse–momentum theorem is a direct result of the rotational form of Newton’s second law of motion for cases in which rotational inertia is constant.	SCI.9-12.6.3.C.2.ii	MP3, MP4
The net torque exerted on an object is equal to the slope of the graph of the angular momentum of an object as a function of time.	SCI.9-12.6.3.C.3	MP3, MP4
The angular impulse delivered to an object is equal to the area under the curve of a graph of the net external torque exerted on an object as a function of time.	SCI.9-12.6.3.C.4	MP3, MP4
Describe the behavior of a system using conservation of angular momentum.	SCI.9-12.6.4.A	MP3, MP4
The total angular momentum of a system about a rotational axis is the sum of the angular momenta of the system’s constituent parts about that axis.	SCI.9-12.6.4.A.1	MP3, MP4
Any change to a system’s angular momentum must be due to an interaction between the system and its surroundings.	SCI.9-12.6.4.A.2	MP3, MP4
The angular impulse exerted by one object or system on a second object or system is equal and opposite to the angular impulse exerted by the	SCI.9-12.6.4.A.2.i	MP3, MP4

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second object or system on the first. This is a direct result of Newton's third law.		
A system may be selected so that the total angular momentum of that system is constant.	SCI.9-12.6.4.A.2.ii	MP3, MP4
The angular speed of a nonrigid system may change without the angular momentum of the system changing if the system changes shape by moving mass closer to or further from the rotational axis.	SCI.9-12.6.4.A.2.iii	MP3, MP4
If the total angular momentum of a system changes, that change will be equivalent to the angular impulse exerted on the system.	SCI.9-12.6.4.A.2.iv	MP3, MP4
Describe how the selection of a system determines whether the angular momentum of that system changes.	SCI.9-12.6.4.B	MP3, MP4
Angular momentum is conserved in all interactions.	SCI.9-12.6.4.B.1	MP3, MP4
If the net external torque exerted on a selected object or rigid system is zero, the total angular momentum of that system is constant.	SCI.9-12.6.4.B.2	MP3, MP4
If the net external torque exerted on a selected object or rigid system is nonzero, angular momentum is transferred between the system and the environment.	SCI.9-12.6.4.B.3	MP3, MP4
Describe the kinetic energy of a system that has translational and rotational motion.	SCI.9-12.6.5.A	MP3, MP4
The total kinetic energy of a system is the sum of the system's translational and rotational kinetic energies.	SCI.9-12.6.5.A.1	MP3, MP4
Describe the motion of a system that is rolling without slipping.	SCI.9-12.6.5.B	MP3, MP4
While rolling without slipping, the translational motion of a system's center of mass is related to the rotational motion of the system itself with the relevant equations.	SCI.9-12.6.5.B.1	MP3, MP4
For ideal cases, rolling without slipping implies that the frictional force does not dissipate any energy from the rolling system.	SCI.9-12.6.5.B.2	MP3, MP4
Describe the motion of a system that is rolling while slipping.	SCI.9-12.6.5.C	MP3, MP4
When slipping, the motion of a system's center of mass and the system's rotational motion cannot be directly related.	SCI.9-12.6.5.C.1	MP3, MP4
When a rotating system is slipping relative to another surface, the point of application of the force of kinetic friction exerted on the system moves with respect to the surface, so the force of kinetic friction will dissipate energy from the system.	SCI.9-12.6.5.C.2	MP3, MP4
Describe the motions of a system consisting of two objects interacting only via gravitational forces.	SCI.9-12.6.6.A	MP3, MP4
In a system consisting only of a massive central object and an orbiting satellite with mass that is negligible in comparison to the central object's mass, the motion of the central object itself is negligible.	SCI.9-12.6.6.A.1	MP3, MP4
The motion of satellites in orbits is constrained by conservation laws.	SCI.9-12.6.6.A.2	MP3, MP4
In circular orbits, the system's total mechanical energy, the system's gravitational potential energy, and the satellite's angular momentum and kinetic energy are constant.	SCI.9-12.6.6.A.2.i	MP3, MP4

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In elliptical orbits, the system's total mechanical energy and the satellite's angular momentum are constant, but the system's gravitational potential energy and the satellite's kinetic energy can each change.	SCI.9-12.6.6.A.2.ii	MP3, MP4
The gravitational potential energy of a system consisting of a satellite and a massive central object is defined to be zero when the satellite is an infinite distance from the central object.	SCI.9-12.6.6.A.2.iii	MP3, MP4
The escape velocity of a satellite is the satellite's velocity such that the mechanical energy of the satellite–central-object system is equal to zero.	SCI.9-12.6.6.A.3	MP3, MP4
When the only force exerted on a satellite is gravity from a central object, a satellite that reaches escape velocity will move away from the central body until its speed reaches zero at an infinite distance from the central body.	SCI.9-12.6.6.A.3.i	MP3, MP4
The escape velocity of a satellite from a central body of mass M can be derived using conservation of energy laws.	SCI.9-12.6.6.A.3.ii	MP3, MP4
Describe simple harmonic motion.	SCI.9-12.7.1.A	MP4
Simple harmonic motion is a special case of periodic motion.	SCI.9-12.7.1.A.1	MP4
SHM results when the magnitude of the restoring force exerted on an object is proportional to that object's displacement from its equilibrium position.	SCI.9-12.7.1.A.2	MP4
A restoring force is a force that is exerted in a direction opposite to the object's displacement from an equilibrium position.	SCI.9-12.7.1.A.2.i	MP4
An equilibrium position is a location at which the net force exerted on an object or system is zero.	SCI.9-12.7.1.A.2.ii	MP4
The motion of a pendulum with a small angular displacement can be modeled as simple harmonic motion because the restoring torque is proportional to the angular displacement.	SCI.9-12.7.1.A.2.iii	MP4
Describe the frequency and period of an object exhibiting SHM.	SCI.9-12.7.2.A	MP4
The period of SHM is related to the frequency f of the object's motion by the following equation: $T = 1/f$.	SCI.9-12.7.2.A.1	MP4
The period of an ideal object-ideal-spring oscillator is given by the equation $T_s = 2\pi\sqrt{(m/k)}$.	SCI.9-12.7.2.A.1.i	MP4
The period of a simple pendulum displaced by a small angle is given by the equation $T_p = 2\pi\sqrt{(l/g)}$.	SCI.9-12.7.2.A.1.ii	MP4
Describe the displacement, velocity, and acceleration of an object exhibiting SHM.	SCI.9-12.7.3.A	MP4
For an object exhibiting SHM, the displacement of that object measured from its equilibrium position can be represented by the relevant equations.	SCI.9-12.7.3.A.1	MP4
Minima, maxima, and zeros of displacement, velocity, and acceleration are features of harmonic motion.	SCI.9-12.7.3.A.1.i	MP4

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Recognizing the positions or times at which the displacement, velocity, and acceleration for SHM have extrema or zeros can help in qualitatively describing the behavior of the motion.	SCI.9-12.7.3.A.1.ii	MP4
Changing the amplitude of a system exhibiting SHM will not change the period of that system.	SCI.9-12.7.3.A.2	MP4
Properties of SHM can be determined and analyzed using graphical representations.	SCI.9-12.7.3.A.3	MP4
Describe the mechanical energy of a system exhibiting SHM.	SCI.9-12.7.4.A	MP4
The total energy of a system exhibiting SHM is the sum of the system's kinetic and potential energies.	SCI.9-12.7.4.A.1	MP4
Conservation of energy indicates that the total energy of a system exhibiting SHM is constant.	SCI.9-12.7.4.A.2	MP4
The kinetic energy of a system exhibiting SHM is at a maximum when the system's potential energy is at a minimum.	SCI.9-12.7.4.A.3	MP4
The potential energy of a system exhibiting SHM is at a maximum when the system's kinetic energy is at a minimum.	SCI.9-12.7.4.A.4	MP4
The minimum kinetic energy of a system exhibiting SHM is zero.	SCI.9-12.7.4.A.4.i	MP4
Changing the amplitude of a system exhibiting SHM will change the maximum potential energy of the system and, therefore, the total energy of the system.	SCI.9-12.7.4.A.4.ii	MP4
Describe the properties of a fluid.	SCI.9-12.8.1.A	MP4
Distinguishing properties of solids, liquids, and gases stem from the varying interactions between atoms and molecules.	SCI.9-12.8.1.A.1	MP4
A fluid is a substance that has no fixed shape.	SCI.9-12.8.1.A.2	MP4
Fluids can be characterized by their density. Density is defined as a ratio of mass to volume.	SCI.9-12.8.1.A.3	MP4
An ideal fluid is incompressible and has no viscosity.	SCI.9-12.8.1.A.4	MP4
Describe the pressure exerted on a surface by a given force.	SCI.9-12.8.2.A	MP4
Pressure is defined as the magnitude of the perpendicular force component exerted per unit area over a given surface area, as described by the equation $P = F_{\perp}/A$.	SCI.9-12.8.2.A.1	MP4
Pressure is a scalar quantity.	SCI.9-12.8.2.A.2	MP4
The volume and density of a given amount of an incompressible fluid is constant regardless of the pressure exerted on that fluid.	SCI.9-12.8.2.A.3	MP4
Describe the pressure exerted by a fluid.	SCI.9-12.8.2.B	MP4
The pressure exerted by a fluid is the result of the entirety of the interactions between the fluid's constituent particles and the surface with which those particles interact.	SCI.9-12.8.2.B.1	MP4
The absolute pressure of a fluid at a given point is equal to the sum of a reference pressure P_0, such as the atmospheric pressure P_{atm}, and the gauge pressure P_{gauge}.	SCI.9-12.8.2.B.2	MP4
The gauge pressure of a vertical column of fluid is described by the equation.	SCI.9-12.8.2.B.3	MP4

Performance Indicator	College Board Advanced Placement Program Standards	Marking Period Taught
Describe the conditions under which a fluid's velocity changes.	SCI.9-12.8.3.A	MP4
Newton's laws can be used to describe the motion of particles within a fluid.	SCI.9-12.8.3.A.1	MP4
The macroscopic behavior of a fluid is a result of the internal interactions between the fluid's constituent particles and external forces exerted on the fluid.	SCI.9-12.8.3.A.2	MP4
Describe the buoyant force exerted on an object interacting with a fluid.	SCI.9-12.8.3.B	MP4
The buoyant force is a net upward force exerted on an object by a fluid.	SCI.9-12.8.3.B.1	MP4
The buoyant force exerted on an object by a fluid is a result of the collective forces exerted on the object by the particles making up the fluid.	SCI.9-12.8.3.B.2	MP4
The magnitude of the buoyant force exerted on an object by a fluid is equivalent to the weight of the fluid displaced by the object.	SCI.9-12.8.3.B.3	MP4
Describe the flow of an incompressible fluid through a cross-sectional area by using mass conservation.	SCI.9-12.8.4.A	MP4
A difference in pressure between two locations causes a fluid to flow.	SCI.9-12.8.4.A.1	MP4
The rate at which matter enters a fluid-filled tube open at both ends must equal the rate at which matter exits the tube.	SCI.9-12.8.4.A.1.i	MP4
The rate at which matter flows into a location is proportional to the cross-sectional area of the flow and the speed at which the fluid flows.	SCI.9-12.8.4.A.1.ii	MP4
The continuity equation for fluid flow describes conservation of mass flow rate in incompressible fluids.	SCI.9-12.8.4.A.2	MP4
Describe the flow of a fluid as a result of a difference in energy between two locations within the fluid–Earth system.	SCI.9-12.8.4.B	MP4
A difference in gravitational potential energies between two locations in a fluid will result in a difference in kinetic energy and pressure between those two locations that is described by conservation laws.	SCI.9-12.8.4.B.1	MP4
Bernoulli's equation describes the conservation of mechanical energy in fluid flow.	SCI.9-12.8.4.B.2	MP4
Torricelli's theorem relates the speed of a fluid exiting an opening to the difference in height between the opening and the top surface of the fluid and can be derived from conservation of energy principles.	SCI.9-12.8.4.B.3	MP4

ASSESSMENTS

PDE Academic Standards, Assessment Anchors, and Eligible Content: The teacher must be knowledgeable of the PDE Academic Standards, Assessment Anchors, and Eligible Content and incorporate them regularly into planned instruction.

Formative Assessments: The teacher will utilize a variety of assessment methods to conduct in-process evaluations of student learning.

Effective formative assessments for this course include: Bell ringers, exit tickets, notice and wonderings, progress checks, quizzes, lab assignments, teacher questioning, class discussions, peer assessments, and model trackers.

Summative Assessments: The teacher will utilize a variety of assessment methods to evaluate student learning at the end of an instructional task, lesson, and/or unit.

Effective summative assessments for this course include: Lab reports, CER responses, chapter tests, district marking period assessments, culminating tasks, and projects.