

AP PHYSICS 1 Curriculum Map

KINEMATICS

- Reference Frames and Displacement
- Average Velocity and Instantaneous Velocity
- Motion at Constant Acceleration
- Falling Objects
- Adding Vectors by Components
- Projectile Motion: projectiles fired horizontally and at an angle
- Graphical Analysis of Motion

BIG IDEA 3: The interactions of an object with other objects can be described by forces.

The student is able to express the motion of an object using narrative, mathematical, and graphical representations.

The student is able to design an experimental investigation of the motion of an object.

The student is able to analyze experimental data describing the motion of an object and is able to express the results of the analysis using narrative, mathematical, and graphical representations.

Chapters in the Book: 1,2,3

Standards:

HS-ETS1-1

HS-ETS1-2

HS-ETS1-3

HS-ETS1-4

HS-PS2-1.

HS-PS2-2.

HS-PS2-3.

HS-PS2-4.

HS-PS2-5.

HS-PS2-6.

Assessments: FCI, math proficiency quiz, constant motion lab quiz, constant motion quiz acceleration lab quiz, projectile quiz, lab practical, Kinematics Test

DYNAMICS

- Forces
- Free-Body-Diagrams
- Newton's Laws of Motion
- Mass and Weight
- Applications Involving Friction, Inclines

BIG IDEA 1: Objects and systems have properties such as mass and charge. Systems may have internal structure.

The student is able to design an experiment for collecting data to determine the relationship between the net force exerted on an object its inertial mass and its acceleration.

The student is able to design a plan for collecting data to measure gravitational mass and to measure inertial mass and to distinguish between the two experiments.

BIG IDEA 2: Fields existing in space can be used to explain interactions.

The student is able to apply $\vec{F} = m\vec{g}$ to calculate the gravitational force on an object with mass m in a gravitational field of strength g in the context of the effects of a net force on objects and systems.

BIG IDEA 3: The interactions of an object with other objects can be described by forces.

The student is able to represent forces in diagrams or mathematically using appropriately labeled vectors with magnitude, direction, and units during the analysis of a situation.

The student is able to analyze a scenario and make claims (develop arguments, justify assertions) about the forces exerted on an object by other objects for different types of forces or components of forces.

The student is able to challenge a claim that an object can exert a force on itself.
The student is able to describe a force as an interaction between two objects and identify both objects for any force.
The student is able to construct explanations of physical situations involving the interaction of bodies using Newton's third law and the representation of action-reaction pairs of forces.
The student is able to use Newton's third law to make claims and predictions about the action-reaction pairs of forces when two objects interact.
The student is able to analyze situations involving interactions among several objects by using free-body diagrams that include the application of Newton's third law to identify forces.
The student is able to predict the motion of an object subject to forces exerted by several objects using an application of Newton's second law in a variety of physical situations with acceleration in one dimension.
The student is able to design a plan to collect and analyze data for motion (static, constant, or accelerating) from force measurements and carry out an analysis to determine the relationship between the net force and the vector sum of the individual forces.
The student is able to reexpress a free-body diagram representation into a mathematical representation and solve the mathematical representation for the acceleration of the object.
The student is able to create and use free-body diagrams to analyze physical situations to solve problems with motion qualitatively and quantitatively.
The student is able to make claims about various contact forces between objects based on the microscopic cause of those forces.
The student is able to explain contact forces (tension, friction, normal, buoyant, spring) as arising from interatomic electric forces and that they therefore have certain directions.

BIG IDEA 4: Interactions between systems can result in changes in those systems.

The student is able to use representations of the center of mass of an isolated two-object system to analyze the motion of the system qualitatively and semiquantitatively.
The student is able to make predictions about the motion of a system based on the fact that acceleration is equal to the change in velocity per unit time, and velocity is equal to the change in position per unit time.
The student is able to evaluate using given data whether all the forces on a system or whether all the parts of a system have been identified.
The student is able to create mathematical models and analyze graphical relationships for acceleration, velocity, and position of the center of mass of a system and use them to calculate properties of the motion of the center of mass of a system.
The student is able to apply Newton's second law to systems to calculate the change in the center-of-mass velocity when an external force is exerted on the system.
The student is able to use visual or mathematical representations of the forces between objects in a system to predict whether or not there will be a change in the center-of-mass velocity of that system.

Chapters in the Book: 4

Standards:

HS-ETS1-1	HS-ETS1-2	HS-ETS1-3	HS-ETS1-4
HS-PS2-1.	HS-PS2-2.	HS-PS2-3.	HS-PS2-4.
HS-PS2-5.	HS-PS2-6.		

Assessments: Type 3 Pretest, Force Diagram Quiz, Newton's 1st law quiz, Newton's 2nd law Quiz, Newton's 3rd law Quiz, lab practical, Type 3 Posttest

ENERGY

- Work
- Kinetic Energy and the Work-Energy Theorem
- Potential Energy: Gravitational and Elastic
- Mechanical Energy and its Conservation
- Power

BIG IDEA 3: The interactions of an object with other objects can be described by forces.

The student is able to make predictions about the changes in kinetic energy of an object based on considerations of the direction of the net force on the object as the object moves.

The student is able to use net force and velocity vectors to determine qualitatively whether kinetic energy of an object would increase, decrease, or remain unchanged.

The student is able to use force and velocity vectors to determine qualitatively or quantitatively the net force exerted on an object and qualitatively whether kinetic energy of that object would increase, decrease, or remain unchanged.

The student is able to apply mathematical routines to determine the change in kinetic energy of an object given the forces on the object and the displacement of the object.

BIG IDEA 4: Interactions between systems can result in changes in those systems.

The student is able to calculate the total energy of a system and justify the mathematical routines used in the calculation of component types of energy within the system whose sum is the total energy.

The student is able to predict changes in the total energy of a system due to changes in position and speed of objects or frictional interactions within the system.

The student is able to make predictions about the changes in the mechanical energy of a system when a component of an external force acts parallel or antiparallel to the direction of the displacement of the center of mass.

The student is able to apply the concepts of Conservation of Energy and the Work-Energy theorem to determine qualitatively and/or quantitatively that work done on a two-object system in linear motion will change the kinetic energy of the center of mass of the system, the potential energy of the systems, and/or the internal energy of the system.

BIG IDEA 5: Changes that occur as a result of interactions are constrained by conservation laws.

The student is able to define open and closed systems for everyday situations and apply conservation concepts for energy, charge, and linear momentum to those situations.

The student is able to set up a representation or model showing that a single object can only have kinetic energy and use information about that object to calculate its kinetic energy.

The student is able to translate between a representation of a single object, which can only have kinetic energy, and a system that includes the object, which may have both kinetic and potential energies.

The student is able to calculate the expected behavior of a system using the object model (i.e., by ignoring changes in internal structure) to analyze a situation. Then, when the model fails, the student can justify the use of conservation of energy principles to calculate the change in internal energy due to changes in internal structure because the object is actually a system.

The student is able to describe and make qualitative and/or quantitative predictions about everyday examples of systems with internal potential energy.

The student is able to make quantitative calculations of the internal potential energy of a system from a description or diagram of that system.

The student is able to apply mathematical reasoning to create a description of the internal potential energy of a system from a description or diagram of the objects and interactions in that system.

The student is able to describe and make predictions about the internal energy of systems.

The student is able to calculate changes in kinetic energy and potential energy of a system, using information from representations of that system. [
The student is able to design an experiment and analyze data to examine how a force exerted on an object or system does work on the object or system as it moves through a distance.
The student is able to design an experiment and analyze graphical data in which interpretations of the area under a force-distance curve are needed to determine the work done on or by the object or system.
The student is able to predict and calculate from graphical data the energy transfer to or work done on an object or system from information about a force exerted on the object or system through a distance.
The student is able to make claims about the interaction between a system and its environment in which the environment exerts a force on the system, thus doing work on the system and changing the energy of the system (kinetic energy plus potential energy).
The student is able to predict and calculate the energy transfer to (i.e., the work done on) an object or system from information about a force exerted on the object or system through a distance.
The student is able to make qualitative predictions about natural phenomena based on conservation of linear momentum and restoration of kinetic energy in elastic collisions.
The student is able to apply the principles of conservation of momentum and restoration of kinetic energy to reconcile a situation that appears to be isolated and elastic, but in which data indicate that linear momentum and kinetic energy are not the same after the interaction, by refining a scientific question to identify interactions that have not been considered. Students will be expected to solve qualitatively and/or quantitatively for one-dimensional situations and only qualitatively in two-dimensional situations.
The student is able to apply mathematical routines appropriately to problems involving elastic collisions in one dimension and justify the selection of those mathematical routines based on conservation of momentum and restoration of kinetic energy.
The student is able to design an experimental test of an application of the principle of the conservation of linear momentum, predict an outcome of the experiment using the principle, analyze data generated by that experiment whose uncertainties are expressed numerically, and evaluate the match between the prediction and the outcome.
The student is able to classify a given collision situation as elastic or inelastic, justify the selection of conservation of linear momentum and restoration of kinetic energy as the appropriate principles for analyzing an elastic collision, solve for missing variables, and calculate their values.
The student is able to qualitatively predict, in terms of linear momentum and kinetic energy, how the outcome of a collision between two objects changes depending on whether the collision is elastic or inelastic.
The student is able to apply the conservation of linear momentum to a closed system of objects involved in an inelastic collision to predict the change in kinetic energy.

Chapters in the Book: 5

Assessments: Lab Quiz, Work Quiz, Energy Bar diagram Quiz, Equations Quiz, Lab practical, Unit Test

MOMENTUM

- **Impulse and Change in Momentum**
- **Conservation of Momentum**
- **Conservation of Energy and Momentum in Collisions (1 dimension)**
- **Conservation of Momentum in Collisions (2 dimensions: qualitative and semi-quantitative only)**

BIG IDEA 3: The interactions of an object with other objects can be described by forces.

The student is able to justify the selection of data needed to determine the relationship between the direction of the force acting on an object and the change in momentum caused by that force.

The student is able to justify the selection of routines for the calculation of the relationships between changes in momentum of an object, average force, impulse, and time of interaction.

The student is able to predict the change in momentum of an object from the average force exerted on the object and the interval of time during which the force is exerted.

The student is able to analyze data to characterize the change in momentum of an object from the average force exerted on the object and the interval of time during which the force is exerted.

The student is able to design a plan for collecting data to investigate the relationship between changes in momentum and the average force exerted on an object over time.

BIG IDEA 4: Interactions between systems can result in changes in those systems.

The student is able to calculate the change in linear momentum of a two-object system with constant mass in linear motion from a representation of the system (data, graphs, etc.).

The student is able to analyze data to find the change in linear momentum for a constant-mass system using the product of the mass and the change in velocity of the center of mass.

The student is able to apply mathematical routines to calculate the change in momentum of a system by analyzing the average force exerted over a certain time on the system.

The student is able to perform analysis on data presented as a force-time graph and predict the change in momentum of a system.

BIG IDEA 5: Changes that occur as a result of interactions are constrained by conservation laws.

The student is able to define open and closed systems for everyday situations and apply conservation concepts for energy, charge, and linear momentum to those situations.

The student is able to make qualitative predictions about natural phenomena based on conservation of linear momentum and restoration of kinetic energy in elastic collisions.

The student is able to apply the principles of conservation of momentum and restoration of kinetic energy to reconcile a situation that appears to be isolated and elastic, but in which data indicate that linear momentum and kinetic energy are not the same after the interaction, by refining a scientific question to identify interactions that have not been considered. Students will be expected to solve qualitatively and/or quantitatively for one-dimensional situations and only qualitatively in two-dimensional situations.

The student is able to apply mathematical routines appropriately to problems involving elastic collisions in one dimension and justify the selection of those mathematical routines based on conservation of momentum and restoration of kinetic energy.

The student is able to design an experimental test of an application of the principle of the conservation of linear momentum, predict an outcome of the experiment using the principle, analyze data generated by that experiment whose uncertainties are expressed numerically, and evaluate the match between the prediction and the outcome.

The student is able to classify a given collision situation as elastic or inelastic, justify the selection of conservation of linear momentum and restoration of kinetic energy as the appropriate principles for analyzing an elastic collision, solve for missing variables, and calculate their values.

The student is able to qualitatively predict, in terms of linear momentum and kinetic energy, how the outcome of a collision between two objects changes depending on whether the collision is elastic or inelastic.

The student is able to plan data collection strategies to test the law of conservation of momentum in a two-object collision that is elastic or inelastic and analyze the resulting data graphically.

The student is able to apply the conservation of linear momentum to a closed system of objects involved in an inelastic collision to predict the change in kinetic energy.

The student is able to analyze data that verify conservation of momentum in collisions with and without an external friction force.

The student is able to classify a given collision situation as elastic or inelastic, justify the selection of conservation of linear momentum as the appropriate solution method for an inelastic collision, recognize that

there is a common final velocity for the colliding objects in the totally inelastic case, solve for missing variables, and calculate their values.

The student is able to predict the velocity of the center of mass of a system when there is no interaction outside of the system but there is an interaction within the system (i.e., the student simply recognizes that interactions within a system do not affect the center of mass motion of the system and is able to determine that there is no external force).

Chapters in the Book: 6

Standards:

HS-ETS1-1

HS-ETS1-2

HS-ETS1-3

HS-ETS1-4

HS-PS3-1.

HS-PS3-2.

HS-PS3-3.

HS-PS3-4.

HS-PS3-5.

Assessments: Lab Quiz, momentum quiz, collision quiz, lab practical, Unit Test

CIRCULAR MOTION AND GRAVITATION

- Kinematics of Uniform Circular Motion
- Dynamics of Uniform Circular Motion
- Newton's Law of Universal Gravitation
- Gravity Near the Earth's Surface
- Satellites and "Weightlessness"
- Kepler's Laws

BIG IDEA 1: Objects and systems have properties such as mass and charge. Systems may have internal structure.

The student is able to design a plan for collecting data to measure gravitational mass and to measure inertial mass and to distinguish between the two experiments.

BIG IDEA 2: Fields existing in space can be used to explain interactions.

The student is able to apply $\vec{F} = m\vec{g}$ to calculate the gravitational force on an object with mass m in a gravitational field of strength g in the context of the effects of a net force on objects and systems.

The student is able to apply $g = G\frac{M}{r^2}$ to calculate the gravitational field due to an object with mass M , where the field is a vector directed toward the center of the object of mass M .

The student is able to approximate a numerical value of the gravitational field (g) near the surface of an object from its radius and mass relative to those of the Earth or other reference objects.

BIG IDEA 3: The interactions of an object with other objects can be described by forces.

The student is able to represent forces in diagrams or mathematically using appropriately labeled vectors with magnitude, direction, and units during the analysis of a situation.

The student is able to analyze a scenario and make claims (develop arguments, justify assertions) about the forces exerted on an object by other objects for different types of forces or components of forces.

The student is able to describe a force as an interaction between two objects and identify both objects for any force.

The student is able to construct explanations of physical situations involving the interaction of bodies using Newton's third law and the representation of action-reaction pairs of forces.

The student is able to use Newton's third law to make claims and predictions about the action-reaction pairs of forces when two objects interact.

The student is able to analyze situations involving interactions among several objects by using free-body diagrams that include the application of Newton's third law to identify forces.

The student is able to design a plan to collect and analyze data for motion (static, constant, or accelerating) from force measurements and carry out an analysis to determine the relationship between the net force and the vector sum of the individual forces.
The student is able to reexpress a free-body diagram representation into a mathematical representation and solve the mathematical representation for the acceleration of the object.
The student is able to create and use free-body diagrams to analyze physical situations to solve problems with motion qualitatively and quantitatively.
The student is able to use Newton's law of gravitation to calculate the gravitational force the two objects exert on each other and use that force in contexts other than orbital motion.
The student is able to use Newton's law of gravitation to calculate the gravitational force between two objects and use that force in contexts involving orbital motion
The student is able to connect the concepts of gravitational force and electric force to compare similarities and differences between the forces.
The student is able to articulate situations when the gravitational force is the dominant force and when the electromagnetic, weak, and strong forces can be ignored.

BIG IDEA 4: Interactions between systems can result in changes in those systems.

The student is able to evaluate using given data whether all the forces on a system or whether all the parts of a system have been identified.

Chapters in the Book: 7,8

Standards:

HS-ETS1-1 HS-ETS1-2 HS-ETS1-3 HS-ETS1-4
 HS-PS2-1. HS-PS2-2.

Assessments: UCM Quiz, UGM Quiz, Unit Test

TORQUE AND ROTATIONAL MOTION

- **Torque**
- **Center of Mass (qualitative)**
- **Rotational Kinematics**
- **Rotational Dynamics and Rotational Inertia**
- **Rolling Motion (without slipping)**
- **Rotational Kinetic Energy**
- **Angular Momentum and its Conservation**

BIG IDEA 3: The interactions of an object with other objects can be described by forces.

The student is able to use representations of the relationship between force and torque.
The student is able to compare the torques on an object caused by various forces.
The student is able to estimate the torque on an object caused by various forces in comparison to other situations.
The student is able to design an experiment and analyze data testing a question about torques in a balanced rigid system.
The student is able to calculate torques on a two-dimensional system in static equilibrium, by examining a representation or model (such as a diagram or physical construction).
The student is able to make predictions about the change in the angular velocity about an axis for an object when forces exerted on the object cause a torque about that axis.
The student is able to plan data collection and analysis strategies designed to test the relationship between a torque exerted on an object and the change in angular velocity of that object about an axis.

The student is able to predict the behavior of rotational collision situations by the same processes that are used to analyze linear collision situations using an analogy between impulse and change of linear momentum and angular impulse and change of angular momentum.

In an unfamiliar context or using representations beyond equations, the student is able to justify the selection of a mathematical routine to solve for the change in angular momentum of an object caused by torques exerted on the object.

The student is able to plan data collection and analysis strategies designed to test the relationship between torques exerted on an object and the change in angular momentum of that object.

BIG IDEA 4: Interactions between systems can result in changes in those systems.

The student is able to use representations of the center of mass of an isolated two-object system to analyze the motion of the system qualitatively and semiquantitatively.

The student is able to describe a representation and use it to analyze a situation in which several forces exerted on a rotating system of rigidly connected objects change the angular velocity and angular momentum of the system.

The student is able to plan data collection strategies designed to establish that torque, angular velocity, angular acceleration, and angular momentum can be predicted accurately when the variables are treated as being clockwise or counterclockwise with respect to a well-defined axis of rotation, and refine the research question based on the examination of data.

The student is able to describe a model of a rotational system and use that model to analyze a situation in which angular momentum changes due to interaction with other objects or systems.

The student is able to plan a data collection and analysis strategy to determine the change in angular momentum of a system and relate it to interactions with other objects and systems.

The student is able to use appropriate mathematical routines to calculate values for initial or final angular momentum, or change in angular momentum of a system, or average torque or time during which the torque is exerted in analyzing a situation involving torque and angular momentum.

The student is able to plan a data collection strategy designed to test the relationship between the change in angular momentum of a system and the product of the average torque applied to the system and the time interval during which the torque is exerted.

BIG IDEA 5: Changes that occur as a result of interactions are constrained by conservation laws.

The student is able to make qualitative predictions about the angular momentum of a system for a situation in which there is no net external torque.

The student is able to make calculations of quantities related to the angular momentum of a system when the net external torque on the system is zero.

The student is able to describe or calculate the angular momentum and rotational inertia of a system in terms of the locations and velocities of objects that make up the system. Students are expected to do qualitative reasoning with compound objects. Students are expected to do calculations with a fixed set of extended objects and point masses.

Chapters in the Book: 8

Standards:

HS-ETS1-1

HS-ETS1-2

HS-ETS1-3

HS-ETS1-4

HS-PS2-1.

HS-PS2-2.

Assessments: Torque Quiz, Angular momentum quiz, lab practical, Unit Test

SIMPLE HARMONIC MOTION

- Simple Harmonic Motion
- SHM Graphs: position, velocity, acceleration, energy
- Energy in SHM
- Mass-Spring Systems
- Simple Pendulum

BIG IDEA 3: The interactions of an object with other objects can be described by forces.

The student is able to predict which properties determine the motion of a simple harmonic oscillator and what the dependence of the motion is on those properties.

The student is able to design a plan and collect data in order to ascertain the characteristics of the motion of a system undergoing oscillatory motion caused by a restoring force.

The student can analyze data to identify qualitative or quantitative relationships between given values and variables (i.e., force, displacement, acceleration, velocity, period of motion, frequency, spring constant, string length, mass) associated with objects in oscillatory motion to use that data to determine the value of an unknown.

The student is able to construct a qualitative and/or a quantitative explanation of oscillatory behavior given evidence of a restoring force.

BIG IDEA 5: Changes that occur as a result of interactions are constrained by conservation laws.

The student is able to calculate the expected behavior of a system using the object model (i.e., by ignoring changes in internal structure) to analyze a situation. Then, when the model fails, the student can justify the use of conservation of energy principles to calculate the change in internal energy due to changes in internal structure because the object is actually a system.

The student is able to describe and make qualitative and/or quantitative predictions about everyday examples of systems with internal potential energy.

The student is able to make quantitative calculations of the internal potential energy of a system from a description or diagram of that system.

The student is able to apply mathematical reasoning to create a description of the internal potential energy of a system from a description or diagram of the objects and interactions in that system.

The student is able to describe and make predictions about the internal energy of systems.

The student is able to calculate changes in kinetic energy and potential energy of a system, using information from representations of that system.

Chapters in the Book: 13

Standards:

HS-ETS1-1

HS-ETS1-2

HS-ETS1-3

HS-ETS1-4

HS-PS4-1.

HS-PS4-2.

HS-PS4-3.

HS-PS4-4.

Assessments: Pendulum Quiz, Unit Test

ELECTRIC CHARGE AND ELECTRIC FORCE

- Static Electricity; Electric Charge and its Conservation
- Electric Charge in the Atom
- Charging Processes
- Coulomb's Law

BIG IDEA 1: Objects and systems have properties such as mass and charge. Systems may have internal structure.

The student is able to make claims about natural phenomena based on conservation of electric charge.

The student is able to make predictions, using the conservation of electric charge, about the sign and relative quantity of net charge of objects or systems after various charging processes, including conservation of charge in simple circuits.

The student is able to construct an explanation of the two-charge model of electric charge based on evidence produced through scientific practices.

The student is able to challenge the claim that an electric charge smaller than the elementary charge has been isolated.

BIG IDEA 3: The interactions of an object with other objects can be described by forces.

The student is able to use Coulomb's law qualitatively and quantitatively to make predictions about the interaction between two electric point charges.

The student is able to connect the concepts of gravitational force and electric force to compare similarities and differences between the forces.

BIG IDEA 5: Changes that occur as a result of interactions are constrained by conservation laws.

The student is able to define open and closed systems for everyday situations and apply conservation concepts for energy, charge and linear momentum to those situations.

Chapters in the Book: 15,16

Standards:

HS-ETS1-1	HS-ETS1-2	HS-ETS1-3	HS-ETS1-4	HS-PS4-1.
HS-PS4-2.	HS-PS4-3.	HS-PS4-4.		

Assessments: Coulomb's Law Quiz, Unit Test