BEXLEY CITY SCHOOLS

AP PHYSICS 1 |Curriculum Map and Pacing Guide

COURSE DESCRIPTION: This course is designed to be the equivalent of the first semester of an introductory algebra-based college course. Students master foundational physics principles while engaging in science practice to foster deeper understanding. This course requires 25 percent of time spent in laboratory work. This course explores topics, such as Newtonian mechanics, rotational motion, work, energy and power, mechanical waves and sound, optics and introductory simple circuits.	**Course SCI351** **1 year, 1.25 credit** **Grades 11-12** **Prerequisite:** Honors Chemistry, Algebra II

QUARTER 1

Topic: Kinematics

Key Terms: reference frame, time interval, position, displacement, distance, path length, average velocity, instantaneous velocity, uniform acceleration, scalars, vectors, free fall, motion, slope, position vs time graphs, velocity vs time graphs, acceleration vs time graphs

Measurable Skills: making predictions, problem solving, designing experiments, investigating, reading graphs, making graphs, collecting data, analyzing data

AP College Board Essential Knowledge	Student Learning Targets (AP Learning Objectives and Science Practices)	Learning Activities/Investigations
2.A.1 3.A.1 5.A.1	**3.A.1.1:** Express the motion of an object using narrative, mathematical, and graphical representations. **[SP 1.5, 2.1, 2.2]**	Meeting Point Lab Tortoise and Hare Lab
	3.A.1.2: Design an experimental investigation of the motion of an object. **[SP 4.2]**	Graph Matching Lab Mastering Physics
	3.A.1.3: 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. **[SP 5.1]**	

QUARTER 1		
Topic: Dynamics		
Key Terms: system, force, free body diagrams, air resistance, inertia, weight, gravitational mass, inertial mass, center of mass		
Measurable Skills: making predictions, problem solving, investigating, collecting interpreting and recording data, constructing free body diagrams, making graphs, collecting data, analyzing data		
AP College Board Essential Knowledge	**Student Learning Targets (AP Learning Objectives and Science Practices)**	**Learning Activities/Investigations**
1.C.1 1.C.3 2.B.1 3.A.2 3.C.4 4.A.1 4.A.2 4.A.3	**1.C.1.1:** Design an experiment for collecting data to determine the relationship between the net force exerted on an object its inertial mass and its acceleration. **[SP 4.2]**	Force plate demos Friction Lab
	1.C.3.1: Design a plan for collecting data to measure gravitational mass and to measure inertial mass and to distinguish between the two experiments. **[SP 4.2]**	Newton's 2nd Law Inquiry
	2.B.1.1: Apply F=mg 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. **[SP 2.2, 7.2]**	Projectile Motion Inquiry Mastering Physics
	3.A.2.1: Represent forces in diagrams or mathematically using appropriately labeled vectors with magnitude, direction, and units during the analysis of a situation. **[SP 1.1]**	
	3.A.3.1: 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. **[SP 6.4, 7.2]**	
	3.A.3.2: Challenge a claim that an object can exert a force on itself. **[SP 6.1]**	
	3.A.3.3: Describe a force as an interaction between two objects and identify both objects for any force. **[SP 1.4]**	
	3.A.4.1: Construct explanations of physical situations involving the interaction of bodies using Newton's third law and the representation of action-reaction pairs of forces. **[SP 1.4, 6.2]**	
	3.A.4.2: Use Newton's third law to make claims and predictions about the action-reaction pairs of forces when two objects interact. **[SP 6.4, 7.2]**	
	3.A.4.3: Analyze situations involving interactions among several objects by using free-body diagrams that include the application of Newton's third law to identify forces. **[SP 1.4]**	

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Measurable Skills: making predictions, problem solving, investigating, collecting interpreting and recording data, constructing free body diagrams, making graphs, collecting data, analyzing data		
AP College Board Essential Knowledge	**Student Learning Targets (AP Learning Objectives and Science Practices)**	**Learning Activities/Investigations**
	3.B.1.1: 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. **[SP 6.4, 7.2]**	
	3.B.1.2: 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. **[SP 4.2, 5.1]**	
	3.B.1.3: Re-express a free-body diagram representation into a mathematical representation and solve the mathematical representation for the acceleration of the object. **[SP 1.5, 2.2]**	
	3.B.2.1: Create and use free-body diagrams to analyze physical situations to solve problems with motion qualitatively and quantitatively. **[SP 1.1, 1.4, 2.2]**	
	3.C.4.1: Make claims about various contact forces between objects based on the microscopic cause of those forces. **[SP 6.1]**	
	3.C.4.2: Explain contact forces (tension, friction, normal, buoyant, spring) as arising from interatomic electric forces and that they therefore have certain directions. **[SP 6.2]**	
	4.A.1.1 Use representations of the center of mass of an isolated two-object system to analyze the motion of the system qualitatively and semi quantitatively. **[SP 1.2, 1.4, 2.3, 6.4]**	
	4.A.2.1: 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. **[SP 6.4]**	
	4.A.2.2: Evaluate using given data whether all the forces on a system or whether all the parts of a system have been identified. **[SP 5.3]**	

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AP College Board Essential Knowledge	**Student Learning Targets (AP Learning Objectives and Science Practices)**	**Learning Activities/Investigations**
	4.A.2.3: 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. **[SP 1.4, 2.2]**	
	4.A.3.1: 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. **[SP 2.2]**	
	4.A.3.2: 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. **[SP 1.3]**	

QUARTER 2		
Topic: Circular Motion and Gravitation		
Key Terms: tangential speed, rotational speed, centripetal acceleration, centripetal force, universal law of acceleration, period, frequency, apparent weightlessness		
Measurable Skills: making predictions, problem solving, designing experiments, investigating, reading graphs, making graphs, collecting data, analyzing data		
AP College Board Essential Knowledge	**Student Learning Targets (AP Learning Objectives and Science Practices)**	**Learning Activities/Investigations**
1.C.3 2.B.1 3.A.2	**1.C.3.1:** Design a plan for collecting data to measure gravitational mass and to measure inertial mass and to distinguish between the two experiments. **[SP 4.2]**	Flying Pigs Lab Mastering Physics
3.A.3 3.A.4 3.B.1	**2.B.1.1:** Apply F=mg 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. **[SP 2.2, 7.2]**	

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AP College Board Essential Knowledge	**Student Learning Targets (AP Learning Objectives and Science Practices)**	**Learning Activities/Investigations**
3.B.2 3.C.1 3.C.2 3.G.1 4.A.2	**2.B.2.1:** Apply g=GMr2 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*. **[SP 2.2]**	
	2.B.2.2: 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. **[SP 2.2]**	
	3.A.2.1: Represent forces in diagrams or mathematically using appropriately labeled vectors with magnitude, direction, and units during the analysis of a situation. **[SP 1.1]**	
	3.A.3.1: 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. **[SP 6.4, 7.2]**	
	3.A.3.3: Describe a force as an interaction between two objects and identify both objects for any force. **[SP 1.4]**	
	3.A.4.1: Construct explanations of physical situations involving the interaction of bodies using Newton's third law and the representation of action-reaction pairs of forces. **[SP 1.4, 6.2]**	
	3.A.4.2: Use Newton's third law to make claims and predictions about the action-reaction pairs of forces when two objects interact. **[SP 6.4, 7.2]**	
	3.A.4.3: Analyze situations involving interactions among several objects by using free-body diagrams that include the application of Newton's third law to identify forces. **[SP 1.4]**	
	3.B.1.2: 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. **[SP 4.2, 5.1]**	

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AP College Board Essential Knowledge	**Student Learning Targets (AP Learning Objectives and Science Practices)**	**Learning Activities/Investigations**
	3.B.1.3: Re-express a free-body diagram representation into a mathematical representation and solve the mathematical representation for the acceleration of the object. **[SP 1.5, 2.2]**	
	3.B.2.1: Create and use free-body diagrams to analyze physical situations to solve problems with motion qualitatively and quantitatively. **[SP 1.1, 1.4, 2.2]**	
	3.C.1.1: 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. **[SP 2.2]**	
	3.C.1.2: Use Newton's law of gravitation to calculate the gravitational force between two objects and use that force in contexts involving orbital motion. **[SP 2.2]**	
	3.C.2.2: Connect the concepts of gravitational force and electric force to compare similarities and differences between the forces. **[SP 7.2]**	
	3.G.1.1: Articulate situations when the gravitational force is the dominant force and when the electromagnetic, weak, and strong forces can be ignored. **[SP 7.1]**	
	4.A.2.2: Evaluate using given data whether all the forces on a system or whether all the parts of a system have been identified. **[SP 5.3]**	

QUARTER 2		
Topic: Energy		
Key Terms: work, joule, kinetic energy, gravitational potential energy, elastic potential energy, spring stiffness constant, conservative forces, non-conservative forces, law of conservation of energy, mechanical energy, power, watt		
Measurable Skills: making predictions, problem solving, designing experiments, investigating, reading graphs, making graphs, collecting data, analyzing data		
AP College Board Essential Knowledge	**Student Learning Targets (AP Learning Objectives and Science Practices)**	**Learning Activities/Investigations**
3.E.1 4.C.1 4.C.2 5.A.2 5.B.2 5.B.3 5.B.4 5.B.5 5.D.1 5.D.2	**3.E.1.1:** 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. **[SP 6.4, 7.2]**	ENERGY OF A CART ILD Conservation of Energy Inquiry Lab
	3.E.1.2: Use net force and velocity vectors to determine qualitatively whether kinetic energy of an object would increase, decrease, or remain unchanged. **[SP 1.4]**	Mastering Physics
	3.E.1.3: 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. **[SP 1.4, 2.2]**	
	3.E.1.4: 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. **[SP 2.2]**	
	4.C.1.1: 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. **[SP 1.4, 2.1, 2.2]**	
	4.C.1.2: Predict changes in the total energy of a system due to changes in position and speed of objects or frictional interactions within the system. **[SP 6.4]**	
	4.C.2.1: 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. **[SP 6.4]**	
	4.C.2.2: Apply the concepts of Conservation of Energy and the Work-Energy theorem to determine qualitatively and/or quantitatively that	

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	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. **[SP 1.4, 2.2, 7.2]**	
	5.A.2.1: Define open and closed systems for everyday situations and apply conservation concepts for energy, charge, and linear momentum to those situations. **[SP 6.4, 7.2]**	
	5.B.1.1: 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. **[SP 1.4, 2.2]**	
	5.B.1.2: 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**. [SP 1.5]**	
	5.B.2.1: 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. **[SP 1.4, 2.1]**	
	5.B.3.1: Describe and make qualitative and/or quantitative predictions about everyday examples of systems with internal potential energy. **[SP 2.2, 6.4, 7.2]**	
	5.B.3.2: Make quantitative calculations of the internal potential energy of a system from a description or diagram of that system. **[SP 1.4, 2.2]**	

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AP College Board Essential Knowledge	**Student Learning Targets (AP Learning Objectives and Science Practices)**	**Learning Activities/Investigations**
	5.B.3.3: 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. **[SP 1.4, 2.2]**	
	5.B.4.1: Describe and make predictions about the internal energy of systems. **[SP 6.4, 7.2]**	
	5.B.4.2: Calculate changes in kinetic energy and potential energy of a system, using information from representations of that system. **[SP 1.4, 2.1, 2.2]**	
	5.B.5.1: 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. **[SP 4.2, 5.1]**	
	5.B.5.2: 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. **[SP 4.2, 5.1]**	
	5.B.5.3: 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. . **[SP 1.4, 2.2, 6.4]**	
	5.B.5.4: 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). **[SP 6.4, 7.2]**	
	5.B.5.5: 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. **[SP 2.2, 6.4]**	

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AP College Board Essential Knowledge	**Student Learning Targets (AP Learning Objectives and Science Practices)**	**Learning Activities/Investigations**
	5.D.1.1: Make qualitative predictions about natural phenomena based on conservation of linear momentum and restoration of kinetic energy in elastic collisions. **[SP 6.4, 7.2]**	
	5.D.1.2: 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. **[SP 2.2, 3.2, 5.1, 5.3]**	
	5.D.1.3: 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. **[SP 2.1, 2.2]**	
	5.D.1.4: 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. **[SP 4.2, 5.1, 5.3, 6.4]**	
	5.D.1.5: 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. **[SP 2.1, 2.2]**	

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	5.D.2.1: Predict qualitatively, 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. **[SP 6.4, 7.2]**	
	5.D.2.3: Apply the conservation of linear momentum to a closed system of objects involved in an inelastic collision to predict the change in kinetic energy. **[SP 6.4, 7.2]**	

QUARTER 2		
Topic: Momentum		
Key Terms: law of conservation of momentum, elastic collision, inelastic collision, impulse, momentum		
Measurable Skills: making predictions, problem solving, designing experiments, investigating, reading graphs, making graphs, collecting data, analyzing data		
AP College Board Essential Knowledge	**Student Learning Targets (AP Learning Objectives and Science Practices)**	**Learning Activities/Investigations**
3.D.1 3.D.2 4.B.1	**3.D.1.1:** 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. **[SP 4.1]**	Collision lab Unbreakable Egg Lab MOMENTUM ILD
4.B.2 5.B.2 5.D.1 5.D.2 5.D.3	**3.D.2.1:** 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. **[SP 2.1]**	Mastering Physics
	3.D.2.2: 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. **[SP 6.4]**	

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Measurable Skills: making predictions, problem solving, designing experiments, investigating, reading graphs, making graphs, collecting data, analyzing data		
AP College Board Essential Knowledge	**Student Learning Targets (AP Learning Objectives and Science Practices)**	**Learning Activities/Investigations**
	3.D.2.3: 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. **[SP 5.1]**	
	3.D.2.4: Design a plan for collecting data to investigate the relationship between changes in momentum and the average force exerted on an object over time. **[SP 4.2]**	
	4.B.1.1: 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*.). **[SP 1.4, 2.2]**	
	4.B.1.2: 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. **[SP 5.1]**	
	4.B.2.1: 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. **[SP 2.2]**	
	4.B.2.2: Perform analysis on data presented as a force-time graph and predict the change in momentum of a system. **[SP 5.1]**	
	5.A.2.1: Define open and closed systems for everyday situations and apply conservation concepts for energy, charge, and linear momentum to those situations. **[SP 6.4, 7.2]**	
	5.D.1.1: Make qualitative predictions about natural phenomena based on conservation of linear momentum and restoration of kinetic energy in elastic collisions. **[SP 6.4, 7.2]**	
	5.D.1.2: 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	

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	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. **[SP 2.2, 3.2, 5.1, 5.3]**	
	5.D.1.3: 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. **[SP 2.1, 2.2]**	
	5.D.1.4: 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. **[SP 4.2, 5.1, 5.3, 6.4]**	
	5.D.1.5: 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. **[SP 2.1, 2.2]**	
	5.D.2.1: Predict qualitatively, 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. **[SP 6.4, 7.2]**	
	5.D.2.2: 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. **[SP 4.1, 4.2, 5.1]**	

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AP College Board Essential Knowledge	**Student Learning Targets (AP Learning Objectives and Science Practices)**	**Learning Activities/Investigations**
	5.D.2.3: Apply the conservation of linear momentum to a closed system of objects involved in an inelastic collision to predict the change in kinetic energy **[SP 6.4, 7.2]**	
	5.D.2.4: Analyze data that verify conservation of momentum in collisions with and without an external friction force. **[SP 4.1, 4.2, 4.4, 5.1, 5.3]**	
	5.D.2.5: 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**. [SP 2.1, 2.2]**	
	5.D.3.1: 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). **[SP 6.4]**	

QUARTERS 2-3		
Topic: Torque and Rotational Dynamics		
Key Terms: equilibrium, statics, stable equilibrium, unstable equilibrium, neutral equilibrium, torque, fulcrum, center of mass, angular velocity, angular acceleration, moment of inertia, angular momentum, law of conservation of angular momentum, right hand rule		
Measurable Skills: making predictions, problem solving, designing experiments, investigating, reading graphs, making graphs, collecting data, analyzing data		
AP College Board Essential Knowledge	**Student Learning Targets (AP Learning Objectives and Science Practices)**	**Learning Activities/Investigations**
3.F.1 3.F.2 3.F.3 4.A.1 4.D.1 4.D.2	**3.F.1.1:** Use representations of the relationship between force and torque. **[SP 1.4]**	STATICS ILD Torque Lab
	3.F.1.2: Compare the torques on an object caused by various forces. **[SP 1.4]**	Rotational Dynamics Inquiry Lab
	3.F.1.3: Estimate the torque on an object caused by various forces in comparison to other situations. **[SP 2.3]**	ROTATIONAL MOTION ILD
4.D.3 5.E.1 5.E.2	**3.F.1.4:** Design an experiment and analyze data testing a question about torques in a balanced rigid system. **[SP 4.1, 4.2, 5.1]**	Dizzy Physics Lab Torque Lab
	3.F.1.5: Calculate torques on a two-dimensional system in static equilibrium, by examining a representation or model (such as a diagram or physical construction). **[SP 1.4, 2.2]**	Mastering Physics
	3.F.2.1: 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. **[SP 6.4]**	
	3.F.2.2: 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. **[SP 4.1, 4.2, 5.1]**	
	3.F.3.1: 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. **[SP 6.4, 7.2]**	
	3.F.3.2: Justify in an unfamiliar context or using representations beyond equations the selection of a mathematical routine to solve for the change in angular momentum of an object caused by torques exerted on the object. **[SP 2.1]**	

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AP College Board Essential Knowledge	**Student Learning Targets (AP Learning Objectives and Science Practices)**	**Learning Activities/Investigations**
	3.F.3.3: 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. **[SP 4.1, 4.2, 5.1, 5.3]**	
	4.A.1.1: Use representations of the center of mass of an isolated two-object system to analyze the motion of the system qualitatively and semi-quantitatively. **[SP 1.2, 1.4, 2.3, 6.4]**	
	4.D.1.1: 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. **[SP 1.2, 1.4]**	
	4.D.1.2: 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. [**SP 3.2, 4.1, 4.2, 5.1, 5.3]**	
	4.D.2.1: 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. **[SP 1.2, 1.4]**	
	4.D.2.2: 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. **[SP 4.2]**	
	4.D.3.1: Use appropriate mathematical routines to calculate values for initial or final angular momentum, or change in angular momentum of	

QUARTERS 2-3		
Topic: Torque and Rotational Dynamics		
Key Terms: equilibrium, statics, stable equilibrium, unstable equilibrium, neutral equilibrium, torque, fulcrum, center of mass, angular velocity, angular acceleration, moment of inertia, angular momentum, law of conservation of angular momentum, right hand rule		
Measurable Skills: making predictions, problem solving, designing experiments, investigating, reading graphs, making graphs, collecting data, analyzing data		
AP College Board Essential Knowledge	**Student Learning Targets (AP Learning Objectives and Science Practices)**	**Learning Activities/Investigations**
	a system, or average torque or time during which the torque is exerted in analyzing a situation involving torque and angular momentum. **[SP 4.3]**	
	4.D.3.2: 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. **[SP 4.1, 4.2]**	
	5.E.1.1: Make qualitative predictions about the angular momentum of a system for a situation in which there is no net external torque. **[SP 6.4, 7.2]**	
	5.E.1.2: Make calculations of quantities related to the angular momentum of a system when the net external torque on the system is zero. **[SP 2.1, 2.2]**	
	5.E.2.1: 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. **[SP 2.2]**	

QUARTER 3		
Topic: Simple Harmonic Motion		
Key Terms: simple harmonic motion, amplitude, frequency, period, wavelength, sinusoidal, pendulum, damping, resonance		
Measurable Skills: making predictions, problem solving, designing experiments, investigating, reading graphs, making graphs, collecting data, analyzing data		
AP College Board Essential Knowledge	**Student Learning Targets (AP Learning Objectives and Science Practices)**	**Learning Activities/Investigations**
3.B.3 5.B.2 5.B.3 5.B.4	**3.B.3.1:** Predict which properties determine the motion of a simple harmonic oscillator and what the dependence of the motion is on those properties. **[SP 6.4, 7.2]**	Pendulum Inquiry Lab
	3.B.3.2: 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. **[SP 4.2]**	Mastering Physics
	3.B.3.3: 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. **[SP 2.2, 5.1]**	
	3.B.3.4: Construct a qualitative and/or a quantitative explanation of oscillatory behavior given evidence of a restoring force. **[SP 2.2, 6.2]**	
	5.B.2.1: 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. **[SP 1.4, 2.1]**	
	5.B.3.1: Describe and make qualitative and/or quantitative predictions about everyday examples of systems with internal potential energy. **[SP 2.2, 6.4, 7.2]**	
	5.B.3.2: Make quantitative calculations of the internal potential energy of a system from a description or diagram of that system. **[SP 1.4, 2.2]**	

QUARTER 3		
Topic: Simple Harmonic Motion		
Key Terms: simple harmonic motion, amplitude, frequency, period, wavelength, sinusoidal, pendulum, damping, resonance		
Measurable Skills: making predictions, problem solving, designing experiments, investigating, reading graphs, making graphs, collecting data, analyzing data		
AP College Board Essential Knowledge	**Student Learning Targets (AP Learning Objectives and Science Practices)**	**Learning Activities/Investigations**
	5.B.3.3: 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. **[SP 1.4, 2.2]**	
	5.B.4.1: Describe and make predictions about the internal energy of systems. **[SP 6.4, 7.2]**	
	5.B.4.2: Dalculate changes in kinetic energy and potential energy of a system, using information from representations of that system. **[SP 1.4, 2.1, 2.2]**	

QUARTER 3		
Topic: Mechanical Waves and Sound		
Key Terms: transverse wave, longitudinal wave, wave speed, wavelength, constructive interference, destructive interference, wave front, standing waves, node, antinode		
Measurable Skills: making predictions, problem solving, designing experiments, investigating, reading graphs, making graphs, collecting data, analyzing data		
AP College Board Essential Knowledge	**Student Learning Targets (AP Learning Objectives and Science Practices)**	**Learning Activities/Investigations**
6.A.1 6.A.2 6.A.3 6.A.4 6.B.1 6.B.2 6.B.4 6.B.5	**6.A.1.1:** Use a visual representation to construct an explanation of the distinction between transverse and longitudinal waves by focusing on the vibration that generates the wave. **[SP 6.2]**	Waves Inquiry Lab Waves on a string problem
	6.A.1.2: Describe representations of transverse and longitudinal waves. **[SP 1.2]**	Speed of Sound Lab
	6.A.2.1: Describe sound in terms of transfer of energy and momentum in a medium and relate the concepts to everyday examples. **[SP 6.4, 7.2]**	Mastering Physics

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Measurable Skills: making predictions, problem solving, designing experiments, investigating, reading graphs, making graphs, collecting data, analyzing data		
AP College Board Essential Knowledge	**Student Learning Targets (AP Learning Objectives and Science Practices)**	**Learning Activities/Investigations**
6.D.1 6.D.2 6.D.3	**6.A.3.1:** Use graphical representation of a periodic mechanical wave to determine the amplitude of the wave. **[SP 1.4]**	
6.D.4 6.D.5	**6.A.4.1:** Explain and/or predict qualitatively how the energy carried by a sound wave relates to the amplitude of the wave, and/or apply this concept to a real-world example. **[SP 6.4]**	
	6.B.1.1: Use a graphical representation of a periodic mechanical wave (position versus time) to determine the period and frequency of the wave and describe how a change in the frequency would modify features of the representation. **[SP 1.4, 2.2]**	
	6.B.2.1: Use a visual representation of a periodic mechanical wave to determine wavelength of the wave. **[SP 1.4]**	
	6.B.4.1: Design an experiment to determine the relationship between periodic wave speed, wavelength, and frequency and relate these concepts to everyday examples. **[SP 4.2, 5.1, 7.2]**	
	6.B.5.1: Create or use a wave front diagram to demonstrate or interpret qualitatively the observed frequency of a wave, dependent upon relative motions of source and observer. **[SP 1.4]**	
	6.D.1.1: Use representations of individual pulses and construct representations to model the interaction of two wave pulses to analyze the superposition of two pulses. **[SP 1.1, 1.4]**	
	6.D.1.2: Design a suitable experiment and analyze data illustrating the superposition of mechanical waves (only for wave pulses or standing waves). **[SP 4.2, 5.1]**	

QUARTER 3		
Topic: Mechanical Waves and Sound		
Key Terms: transverse wave, longitudinal wave, wave speed, wavelength, constructive interference, destructive interference, wave front, standing waves, node, antinode		
Measurable Skills: making predictions, problem solving, designing experiments, investigating, reading graphs, making graphs, collecting data, analyzing data		
AP College Board Essential Knowledge	**Student Learning Targets (AP Learning Objectives and Science Practices)**	**Learning Activities/Investigations**
	6.D.1.3: Design a plan for collecting data to quantify the amplitude variations when two or more traveling waves or wave pulses interact in a given medium. **[SP 4.2]**	
	6.D.2.1: Analyze data or observations or evaluate evidence of the interaction of two or more traveling waves in one or two dimensions (i.e., circular wave fronts) to evaluate the variations in resultant amplitudes. **[SP 5.1]**	
	6.D.3.1: Refine a scientific question related to standing waves and design a detailed plan for the experiment that can be conducted to examine the phenomenon qualitatively or quantitatively. **[SP 2.1, 3.2, 4.2]**	
	6.D.3.2: Predict properties of standing waves that result from the addition of incident and reflected waves that are confined to a region and have nodes and antinodes. **[SP 6.4]**	
	6.D.3.3: Plan data collection strategies, predict the outcome based on the relationship under test, perform data analysis, evaluate evidence compared to the prediction, explain any discrepancy and, if necessary, revise the relationship among variables responsible for establishing standing waves on a string or in a column of air. **[SP 3.2, 4.1, 5.1, 5.2, 5.3]**	
	6.D.3.4: Describe representations and models of situations in which standing waves result from the addition of incident and reflected waves confined to a region. **[SP 1.2]**	
	6.D.4.1: Challenge with evidence the claim that the wavelengths of standing waves are determined by the frequency of the source regardless of the size of the region. **[SP 1.5, 6.1]**	

QUARTER 3		
Topic: Mechanical Waves and Sound		
Key Terms: transverse wave, longitudinal wave, wave speed, wavelength, constructive interference, destructive interference, wave front, standing waves, node, antinode		
Measurable Skills: making predictions, problem solving, designing experiments, investigating, reading graphs, making graphs, collecting data, analyzing data		
AP College Board Essential Knowledge	**Student Learning Targets (AP Learning Objectives and Science Practices)**	**Learning Activities/Investigations**
	6.D.4.2: Calculate wavelengths and frequencies (if given wave speed) of standing waves based on boundary conditions and length of region within which the wave is confined, and calculate numerical values of wavelengths and frequencies. Examples should include musical instruments. **[SP 2.2]**	
	6.D.5.1: Use a visual representation to explain how waves of slightly different frequency give rise to the phenomenon of beats. **[SP 1.2]**	

QUARTER 4		
Topic: Electric Charge and Electric Force		
Key Terms: electric charge, conductor, insulator, conservation of charge, conduction, induction, Coulomb's Law		
Measurable Skills: making predictions, problem solving, designing experiments, investigating, reading graphs, making graphs, collecting data, analyzing data		
AP College Board Essential Knowledge	**Student Learning Targets (AP Learning Objectives and Science Practices)**	**Learning Activities/Investigations**
1.B.1 1.B.2 1.B.3 3.C.2 5.A.2	**1.B.1.1:** Make claims about natural phenomena based on conservation of electric charge. **[SP 6.4]**	Tape Lab Electrostatics Inquiry
	1.B.1.2: 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. **[SP 6.4, 7.2]**	Mastering Physics
	1.B.2.1: Construct an explanation of the two-charge model of electric charge based on evidence produced through scientific practices. **[SP 6.2]**	

QUARTER 4		
Topic: Electric Charge and Electric Force		
Key Terms: electric charge, conductor, insulator, conservation of charge, conduction, induction, Coulomb's Law		
Measurable Skills: making predictions, problem solving, designing experiments, investigating, reading graphs, making graphs, collecting data, analyzing data		
AP College Board Essential Knowledge	**Student Learning Targets (AP Learning Objectives and Science Practices)**	**Learning Activities/Investigations**
	1.B.3.1: Challenge the claim that an electric charge smaller than the elementary charge has been isolated. **[SP 1.5, 6.1, 7.2]**	
	3.C.2.1: Use Coulomb's law qualitatively and quantitatively to make predictions about the interaction between two electric point charges. **[SP 2.2, 6.4]**	
	3.C.2.2: Connect the concepts of gravitational force and electric force to compare similarities and differences between the forces. **[SP 7.2]**	
	5.A.2.1: Define open and closed systems for everyday situations and apply conservation concepts for energy, charge, and linear momentum to those situations. **[SP 6.4**, **7.2]**	

QUARTER 4		
Topic: DC Circuit		
Key Terms: electric potential, potential difference, voltage, voltmeter, electric current, ampere, ammeter, conventional current, resistance, ohms, Ohm's law, direct current, battery, emf, internal resistance, series, parallel, Kirchhoff's rules, loop rule, junction rule		
Measurable Skills: making predictions, problem solving, designing experiments, investigating, reading graphs, making graphs, collecting data, analyzing data		
AP College Board Essential Knowledge	**Student Learning Targets (AP Learning Objectives and Science Practices)**	**Learning Activities/Investigations**
1.B.1 1.E.1	**1.B.1.1:** Make claims about natural phenomena based on conservation of electric charge. **[SP 6.4]**	Light Bulbs Demo (series and parallel)
1.E.2 5.B.9 5.C.3	**1.B.1.2:** 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. **[SP 6.4, 7.2]**	DC circuit PhET LED Playdoh circuits Mastering Physics

QUARTER 4		
Topic: DC Circuit		
Key Terms: electric potential, potential difference, voltage, voltmeter, electric current, ampere, ammeter, conventional current, resistance, ohms, Ohm's law, direct current, battery, emf, internal resistance, series, parallel, Kirchhoff's rules, loop rule, junction rule		
Measurable Skills: making predictions, problem solving, designing experiments, investigating, reading graphs, making graphs, collecting data, analyzing data		
AP College Board Essential Knowledge	**Student Learning Targets (AP Learning Objectives and Science Practices)**	**Learning Activities/Investigations**
	1.E.2.1: Choose and justify the selection of data needed to determine resistivity for a given material. **[SP 4.1]**	
	5.B.9.1: Construct or interpret a graph of the energy changes within an electrical circuit with only a single battery and resistors in series and/or in, at most, one parallel branch as an application of the conservation of energy (Kirchhoff's loop rule). **[SP 1.1, 1.4]**	
	5.B.9.2: Apply conservation of energy concepts to the design of an experiment that will demonstrate the validity of Kirchhoff's loop rule ($\sum\Delta V=0$) in a circuit with only a battery and resistors either in series or in, at most, one pair of parallel branches. **[SP 4.2, 6.4, 7.2]**	
	5.B.9.3: Apply conservation of energy (Kirchhoff's loop rule) in calculations involving the total electric potential difference for complete circuit loops with only a single battery and resistors in series and/or in, at most, one parallel branch. **[SP 2.2, 6.4, 7.2]**	
	5.C.3.1: Apply conservation of electric charge (Kirchhoff's junction rule) to the comparison of electric current in various segments of an electrical circuit with a single battery and resistors in series and in, at most, one parallel branch and predict how those values would change if configurations of the circuit are changed. **[SP 6.4, 7.2]**	
	5.C.3.2: Design an investigation of an electrical circuit with one or more resistors in which evidence of conservation of electric charge can be collected and analyzed. **[SP 4.1, 4.2, 5.1]**	
	5.C.3.3: Use a description or schematic diagram of an electrical circuit to calculate unknown values of current in various segments or branches of the circuit. **[SP 1.4, 2.2]**	

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

1.1 The student can *create representations and models* of natural or man–made phenomena and systems in the domain.
1.2 The student can *describe representations and models* of natural or man–made phenomena and systems in the domain.
1.3 The student can *refine representations and models of natural or man–made phenomena and systems* in the domain.
1.4 The student can *use representations and models* to analyze situations or solve problems qualitatively and quantitatively.
1.5 The student can *re-express key elements of natural phenomena across multiple representations* in the domain.

Science Practice 2. The student can use mathematics appropriately.

2.1 The student can *justify the selection of a mathematical routine* to solve problems.
2.2 The student can *apply mathematical routines* to quantities that describe natural phenomena.
2.3 The student can *estimate numerically quantities that describe* natural phenomena.

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

3.1 The student can *pose scientific questions.*
3.2 The student can *refine scientific questions.*
3.3 The student can *evaluate scientific questions.*

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

4.1 The student can *justify the selection of the kind of data* needed to answer a particular scientific question.
4.2 The student can design a plan for collecting data to answer a particular scientific question.
4.3 The student can collect data to answer a particular scientific question.
4.4 The student can evaluate sources of data to answer a particular scientific question.

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

5.1 The student can analyze data to identify patterns or relationships.
5.2 The student can refine observations and measurements based on data analysis.
5.3 The student can evaluate the evidence provided by data sets in relation to a particular scientific question.

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

6.1 The student can justify claims with evidence.
6.2 The student can construct explanations of phenomena based on evidence produced through scientific practices.

6.3 The student can articulate the reasons that scientific explanations and theories are refined or replaced.
6.4 The student can make claims and predictions about natural phenomena based on scientific theories and models.
6.5 The student can evaluate alternative scientific explanations.

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

7.1 The student can *connect phenomena and models* across spatial and temporal scales.
7.2 The student can *connect concepts* in and across domain(s) to generalize or extrapolate in and/or across enduring understandings and/or big ideas.

District Instructional Resource:

Giancoli Physics: Principles with Applications AP Edition (2014) / Pearson (6-year online subscription: 2019-2020 to 2024-2025)

Standards Alignment:

AP Physics 1: Algebra-Based Course and Exam Description (2017) – retrieved Jan. 2, 2019 https://apcentral.collegeboard.org/pdf/ap-physics-1-course-and-exam-description.pdf?course=ap-physics-1