Moon Area School District Curriculum Map

Course: AP Physics 1
Grade Level: 10^{th}, 11^{th}, 12^{th}
Content Area: Science
Frequency: Full-Year Course
Textbook: Serway, RA & Vuille, C. College Physics. Cengage Learning, Stamford, 2015.

Big Ideas

1. SYSTEMS (SYS)- Objects and systems have properties such as mass and charge. Systems may have internal structures.

2. FIELDS (FLD)- Fields exist in space can be used to explain interactions.

3. FORCE INTERACTIONS (INT)- The interactions of an object with other objects can be described by forces.

4. CHANGE (CHA)- Interactions between systems can result in changes in those systems.

5. CONSERVATION (CON)- Changes that occur as a result of interactions are constrained by conservation laws.

Essential Questions

6. How can the motion of objects be predicted and/or explained?
7. Can equations be used to answer questions regardless of the questions specificity?
8. How can the idea of frames of reference allow two people to tell the truth yet have conflicting reports?
9. How can we use models to help us understand motion?
10. Why is the general rule for stopping your car "when you double your speed you must give yourself four times as much distance to stop?"
11. How can properties of internal and gravitational mass be experimentally verified to be the same?
12. How do you decide what to believe scientific claims?
13. How does something we cannot see determine how an object behaves?
14. How do objects with mass respond when placed in a gravitational field?
15. Why is the acceleration due to gravity constant at the Earth's surface?
16. Are different kinds of forces really different?
17. How can Newton's laws of motion be used to predict the behavior of objects?
18. Why does the same push change motion of a shopping cart more than the motion of a car?
19. How does pushing something give it energy?
20. How is energy exchanged and transformed within or between systems?
21. How does the choice of system influence how energy is stored or how work is done?

22. Hoe does energy conservation allow the riders in the back car of a rollercoaster to have a thrilling ride?
23. How can the idea of potential energy be used to describe the work done to move celestial bodies?
24. How is the energy transferred between objects and systems?
25. How does the law of conservation govern the interactions between objects and systems?
26. How does pushing an object change its momentum?
27. How do interactions with other objects or systems change the linear momentum of a system?
28. How is the physics definition of momentum different from how momentum is used to describe things in everyday life?
29. How does the law of conservation of momentum govern interactions between objects or systems?
30. How can momentum be used to determine fault in car crashes?
31. How does changing the mass of an object affect the gravitational force?
32. Why is a refrigerator hard to push in space?
33. Why do we feel pulled toward the Earth but not toward a pencil?
34. How can acceleration due to gravity be modified?
35. How can Newton's laws of motion be used to predict the behavior of objects?
36. How can we use forces to predict the behavior of objects and keep us safe?
37. How is the acceleration of the center of mass of a system related to the net force exerted on a system?
38. Why is it more difficult to stop a fully loaded dump truck than a small passenger car?
39. How does a restoring force differ from a "regular" force?
40. How does the presence of restoring forces predict and lead to harmonic motion?
41. How does a spring cause an object to oscillate?
42. How can oscillators be used to make our lives easier?
43. How does the law of conservation of momentum govern interactions between objects and systems?
44. How can energy stored in a spring be used to create motion?
45. How does a system at rotational equilibrium compare to a system in translational equilibrium?
46. How does the choice of system and rotation point affect the forces that can cause a torque on an object or a system?
47. How can balanced forces cause rotation?
48. Why does it matter where the door handle is placed?
49. Why are long wrenches more effective?
50. How can an external net torque change the angular momentum of the system?
51. Why is a rotating bicycle wheel more stable than a stationary one?
52. How does the conservation of angular momentum govern the interactions between objects and systems?
53. Why do planets move faster when they travel closer to the sun?

Primary Resource(s) & Technology:
College Physics Serway Vuille 10th edition, AP Physics 1 Workbook
Microsoft Teams, Promethean Boards, Student Laptops/iPads

Pennsylvania and/or focus standards referenced at:
www.pdesas.org
www.education.pa.gov

Big Ideas/ EQs	Focus Standard(s)	Assessed Competencies (Key content and skills)	Timeline
3 (6, 7, 8) 4 (9, 10)	Kinematics 3.2.P.B1 3.2.P.B6	• Express the motion of an object using narrative, mathematical, and graphical representations. • Design an experimental investigation of the motion of an object. • Analyze experimental data describing the motion of an object and be able to express the results of the analysis using narrative, mathematical, and graphical representations. • Use representations of the center of mass of an isolated two-object system to analyze the motion of the system qualitatively and semi-quantitatively. • 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. • 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.	19-22 class periods
1 (11, 12, 13) 2 (14, 15) 3 (16, 17)	Dynamics 3.2.10.B1 3.2.10.B6 3.2.P.B1 3.2.P.B2 3.2.P.B6 3.2.P.B7 3.2.12.B2 3.2.12.B6	• Model verbally or visually the properties of a system based on its substructure and relate this to changes in the system properties over time as external variables are changed. • Apply F mg = υρ 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.	21-24 class periods

4(18)		• Make claims about various contact forces between objects based on the microscopic cause of these forces. • Explain contact forces (tension, friction, normal, buoyant, spring) as arising from interatomic electric forces and that they therefore have certain directions. • Design an experiment for collecting data to determine the relationship between the net force exerted on an object, its inertial mass, and its acceleration. • Design a plan for collecting data to measure gravitational mass and inertial mass and to distinguish between the two experiments. • Represent forces in diagrams or mathematically using appropriately labeled vectors with magnitude, direction, and units during the analysis of a situation. • 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. • Challenge a claim that an object can exert a force on itself. • Describe a force as an interaction between two objects, and identify both objects for any force. • Construct explanations of physical situations involving the interaction of bodies using Newton's third law and the representation of action/reaction pairs of forces. • Use Newton's third law to make claims and predictions about the action-reaction pairs of forces when two objects interact. • Analyze situations involving interactions among several objects by using free-body diagrams that include the application of Newton's third law to identify forces. • 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. • Design a plan to collect and analyze data for motion (static, constant, or accelerating) from force measurement, and carry out an analysis to determine the relationship	

		between the net force and the vector sum of the individual forces. • Re-express a free-body diagram into a mathematical representation, and solve the mathematical representation for the acceleration of the object. • Create and use free-body diagrams to analyze physical situations to solve problems with motion qualitatively and quantitatively. • Use representations of the center of mass of an isolated two-object system to analyze the motion of the system qualitatively and semi-quantitatively. • Evaluate, using given data, whether all the forces on a system or all the parts of a system have been identified. • 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. • 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.	
3 (19) 4 (20, 21, 22) 5 (23, 24, 25)	Energy 3.2.10.B1 3.2.10.B2 3.2.10.B6 3.2.P.B1 3.2.P.B6 3.2.12.B2 3.2.12.B6	• Define open and closed systems for everyday situations and apply conservation concepts for energy, charge, and linear momentum to those situations. • 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. • Use net force and velocity vectors to determine qualitatively whether the kinetic energy of an object would increase, decrease, or remain unchanged. • Use force and velocity vectors to determine qualitatively or quantitatively the net force exerted on an object and qualitatively whether the kinetic energy of that object would increase, decrease, or remain unchanged. • Apply mathematical routines to determine the change in kinetic energy of an object	19-22 class periods

		given the forces on the object and the displacement of the object. • 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. • Predict changes in the total energy of a system due to changes in position and speed of objects or frictional interactions within the system. • 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. • 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. • Create 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. • 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. • 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. • Describe and make qualitative and/or quantitative predictions about everyday		

		examples of systems with internal potential energy. • Make quantitative calculations of the internal potential energy of a system from a description or diagram of that system. • 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. • Describe and make predictions about the internal energy of systems. • Calculate changes in kinetic energy and potential energy of a system using information from representations of that system. • Design an experiment and analyze data to determine how a force exerted on an object or system does work on the object or system as it moves through a distance. • 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. • 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. • 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). • 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.	
3 (26) 4(27, 28)	Momentum 3.2.10.B1 3.2.10.B6 3.2.P.B1	• Justify the selection of data needed to determine the relationship between the direction of the force acting on an object	12-15 class periods

5 (29, 30)	3.2.P.B2 3.2.P.B6 3.2.12.B2 3.2.12.B6	and the change in momentum caused by that force. • 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. • 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. • 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. • Design a plan for collecting data to investigate the relationship between changes in momentum and the average force exerted on an object over time. • 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.). • 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. • 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. • Perform an analysis on data presented as a force-time graph and predict the change in momentum of a system. • Define open and closed systems for everyday situations and apply conservation concepts for energy, charge, and linear momentum to those situations. • Make qualitative predictions about natural phenomena based on conservation of linear momentum and restoration of kinetic energy in elastic collisions. • 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 qualitatively in two-dimensional situations. • 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. • 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. • 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. • 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. • 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. • Apply the conservation of linear momentum to a closed system of objects involved in an inelastic collision to predict the change in kinetic energy. • Analyze data that verify conservation of momentum in collisions with and without an external frictional force.	

		• 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. • 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).	
1 (31, 32) 2 (33, 34) 3 (35, 36) 4 (37, 38)	Circular Motion and Gravitation 3.2.10.B1 3.2.10.B6 3.2.P.B1 3.2.P.B2 3.2.12.B1 3.2.12.B6	• Articulate situations when the gravitational force is the dominant force and when the electromagnetic, weak, and strong forces can be ignored. • Use Newton's law of gravitation to calculate the gravitational force that two objects exert on each other and use that force in contexts other than orbital motion. • Use Newton's law of gravitation to calculate the gravitational force between two objects and use that force in contexts involving orbital motion. • 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. • Apply g=Gm/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. • Approximate a numerical value of the gravitational field (g) near the surface of an object from its radius and mass relative to those of Earth or other reference objects. • Design a plan for collecting data to measure gravitational mass and to measure inertial mass and to distinguish between the two experiments.	7-9 class periods

		• Evaluate, using given data, whether all the forces on a system or whether all the parts of a system have been identified.	
3 (39, 40, 41, 42) 5 (43, 44)	Simple Harmonic Motion 3.2.10.B1 3.2.10.B6 3.2.P.B1 3.2.P.B2 3.2.12.B1 3.2.12.B6	• Predict which properties determine the motion of a simple harmonic oscillator and what the dependence of the motion is on those properties. • 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. • Analyze data to identify qualitative and 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 and use those data to determine the value of an unknown. • Construct a qualitative and/ or quantitative explanation of oscillatory behavior given evidence of a restoring force. • Calculate changes in kinetic energy and potential energy of a system using information from representations of that system.	2-5 class periods
3 (45, 46, 47, 48, 49) 4 (50, 51) 5 (52, 53)	Torque and Rotational Motion 3.2.10.B1 3.2.10.B6 3.2.P.B1 3.2.P.B2 3.2.12.B1 3.2.12.B6	• Use representations of the relationship between force and torque. • Compare the torques on an object caused by various forces. • Estimate the torque on an object caused by various forces in comparison with other situations. • Design an experiment and analyze data testing a question about torques in a balanced rigid system. • Calculate torques on a two-dimensional system in static equilibrium by examining a representation or model (such as a diagram or physical construction). • 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.	12-17 class periods

		• 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. • 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, 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. • 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. • 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. • 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. • 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. • 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.	

		• 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. • 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. • Make qualitative predictions about the angular momentum of a system for a situation in which there is no net external torque. • Make calculations of quantities related to the angular momentum of a system when the net external torque on the system is zero. • 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. Use qualitative reasoning with compound objects and perform calculations with a fixed set of extended objects and point masses.	