CollegeBoard AP

AP PHYSICS 1: ALGEBRA-BASED

AP Pacing Guide for Flipped Classrooms: Jan.–April 2021

Overview

Due to the challenges associated with hybrid and remote learning in 2020-21, a significant amount of the content and skills colleges are requiring for credit will likely need to be assigned to students as homework or independent learning. This guide allows students who are currently behind to complete all course topics from the course and exam description by May. This guide assumes students will complete approximately 30 minutes of AP Daily videos (~10 minutes each) and topic questions each day in lieu of, or addition to, assignments the teacher would ordinarily give.

How to Implement

This guide assumes students covered only ~27% of the course content and skills in the fall of 2020. For classes that have been forced off schedule, there may not be time for teacher-led instruction of all remaining topics.

- Teachers should **assign the AP Daily videos and topic questions** listed below as student assignments each week.
- Using the reports generated by the topic questions, teachers should focus their limited, direct class time on the Learning Objectives where students need more help.
- If students are ahead of the pace indicated below, teachers will be able to incorporate additional days or weeks to spend more time on challenging topics, practicing course skills, or reviewing for the exam.

Week 1: Jan. 4–8

Topic		Recommended Asynchronous Student Assignments	Options for Synchronous Instructional Focus*	Check for Understanding
3.1	Vector Fields	AP Daily Video 1		
3.2	Fundamental Forces	AP Daily Video 1	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.	Topic Questions

*Prioritize the most challenging Learning Objectives for your students for direct, synchronous instruction.

Topic		Recommended Asynchronous Student Assignments	Options for Synchronous Instructional Focus*	Check for Understanding
3.3	Gravitational and Electric Forces	AP Daily Video 1	3.C.1.1: 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. 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 (for circular orbital motion only in Physics 1). 3.C.2.2: Connect the concepts of gravitational force and electric force to compare similarities and differences between the forces.	Topic Questions
3.4	Gravitational Field / Acceleration Due to Gravity on Different Planets	AP Daily Video 1	2.B.1.1: 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. 2.B.2.1: Apply $g = G\,m/r^2$ 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. 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.	Topic Questions

Week 2: Jan. 11–15

Topic		Recommended Asynchronous Student Assignments	Options for Synchronous Instructional Focus*	Check for Understanding
3.5	Inertial vs. Gravitational Mass	AP Daily Video 1	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.	Topic Questions
3.6	Centripetal Acceleration and Centripetal Force	AP Daily Video 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.	Topic Questions

Topic		Recommended Asynchronous Student Assignments	Options for Synchronous Instructional Focus*	Check for Understanding
3.7	Free-Body Diagrams for Objects in Uniform Circular Motion	AP Daily Video 1	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. 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. 3.B.2.1: Create and use free-body diagrams to analyze physical situations to solve problems with motion qualitatively and quantitatively.	Topic Questions
3.8	Applications of Circular Motion and Gravitation	AP Daily Video 1 AP Daily Video 2 AP Daily Video 3	3.A.1.1: Express the motion of an object using narrative, mathematical, and graphical representations. 3.A.1.2: Design an experimental investigation of the motion of an object. 3.A.1.3: Analyze experimental data describing the motion of an object and express the results of the analysis using narrative, mathematical, and graphical representations. 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. 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. 3.A.3.3: Describe a force as an interaction between two objects and identify both objects for any force. 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. *(continued on next page)`*	Topic Questions Personal Progress Check

Topic		Recommended Asynchronous Student Assignments	Options for Synchronous Instructional Focus*	Check for Understanding
3.8	Applications of Circular Motion and Gravitation	AP Daily Video 1 AP Daily Video 2 AP Daily Video 3	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. 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.	Topic Questions Personal Progress Check

Week 3: Jan. 18–22

Topic		Recommended Asynchronous Student Assignments	Options for Synchronous Instructional Focus*	Check for Understanding
4.1	Open and Closed Systems - Energy	AP Daily Video 1 AP Daily Video 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.	Topic Questions

Week 4: Jan. 25–29

Topic		Recommended Asynchronous Student Assignments	Options for Synchronous Instructional Focus*	Check for Understanding
4.2	Work and Mechanical Energy	AP Daily Video 1 AP Daily Video 2 AP Daily Video 3 AP Daily Video 4 AP Daily Video 5 AP Daily Video 6	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. 3.E.1.2: Use net force and velocity vectors to determine qualitatively whether the kinetic energy of an object would increase, decrease, or remain unchanged. 3.E.1.3: 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. *(continued on next page)*`	Topic Questions

Topic		Recommended Asynchronous Student Assignments	Options for Synchronous Instructional Focus*	Check for Understanding
4.2	Work and Mechanical Energy	AP Daily Video 1 AP Daily Video 2 AP Daily Video 3 AP Daily Video 4 AP Daily Video 5 AP Daily Video 6	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. 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. 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. 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. 4.C.2.2: 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.	Topic Questions

Weeks 5 and 6: Feb. 1–12

Topic		Recommended Asynchronous Student Assignments	Options for Synchronous Instructional Focus*	Check for Understanding
4.3	Conservation of Energy, the Work-Energy Principle, and Power	AP Daily Video 1 AP Daily Video 2 AP Daily Video 3 AP Daily Video 4 AP Daily Video 5 AP Daily Video 6 AP Daily Video 7 AP Daily Video 8	5.B.1.1: 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. 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. *(continued on next page)*	Topic Questions Personal Progress Check

Topic		Recommended Asynchronous Student Assignments	Options for Synchronous Instructional Focus*	Check for Understanding
4.3	Conservation of Energy, the Work-Energy Principle, and Power	AP Daily Video 1 AP Daily Video 2 AP Daily Video 3 AP Daily Video 4 AP Daily Video 5 AP Daily Video 6 AP Daily Video 7 AP Daily Video 8	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. 5.B.3.1: Describe and make qualitative and/or quantitative predictions about everyday examples of systems with internal potential energy. 5.B.3.2: Make quantitative calculations of the internal potential energy of a system from a description or diagram of that system. 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. 5.B.4.1: Describe and make predictions about the internal energy of systems. 5.B.4.2: Calculate changes in kinetic energy and potential energy of a system using information from representations of that system. 5.B.5.1: 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. 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. 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. *(continued on next page)*	Topic Questions Personal Progress Check

Topic		Recommended Asynchronous Student Assignments	Options for Synchronous Instructional Focus*	Check for Understanding
4.3	Conservation of Energy, the Work-Energy Principle, and Power	AP Daily Video 1 AP Daily Video 2 AP Daily Video 3 AP Daily Video 4 AP Daily Video 5 AP Daily Video 6 AP Daily Video 7 AP Daily Video 8	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). 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.	Topic Questions Personal Progress Check

Week 7: Feb. 15–19

Topic		Recommended Asynchronous Student Assignments	Options for Synchronous Instructional Focus*	Check for Understanding
5.1	Momentum and Impulse	AP Daily Video 1 AP Daily Video 2 AP Daily Video 3	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. 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. 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. 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. 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.	Topic Questions

Week 8: Feb. 22–26

Topic		Recommended Asynchronous Student Assignments	Options for Synchronous Instructional Focus*	Check for Understanding
5.2	Representations of Changes in Momentum	AP Daily Video 1 AP Daily Video 2 AP Daily Video 3	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.). 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. 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. 4.B.2.2: Perform an analysis on data presented as a force-time graph and predict the change in momentum of a system.	Topic Questions
5.3	Open and Closed Systems: Momentum	AP Daily Video 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.	Topic Questions

Week 9: Mar. 1–5

Topic		Recommended Asynchronous Student Assignments	Options for Synchronous Instructional Focus*	Check for Understanding
5.4	Conservation of Linear Momentum	AP Daily Video 1 AP Daily Video 2 AP Daily Video 3 AP Daily Video 4 AP Daily Video 5 AP Daily Video 6 AP Daily Video 7	5.D.1.1: Make qualitative predictions about natural phenomena based on conservation of linear momentum and restoration of kinetic energy in elastic collisions. 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 qualitatively in two-dimensional situations. 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. 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. 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. *(continued on next page)*`	Topic Questions Personal Progress Check

Topic		Recommended Asynchronous Student Assignments	Options for Synchronous Instructional Focus*	Check for Understanding
5.4	Conservation of Linear Momentum	AP Daily Video 1 AP Daily Video 2 AP Daily Video 3 AP Daily Video 4 AP Daily Video 5 AP Daily Video 6 AP Daily Video 7	5.D.2.1: 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. 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. 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. 5.D.2.4: Analyze data that verify conservation of momentum in collisions with and without an external frictional force. 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. 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).	Topic Questions Personal Progress Check

Week 10: Mar. 8–12

Topic		Recommended Asynchronous Student Assignments	Options for Synchronous Instructional Focus*	Check for Understanding
6.1	Period of Simple Harmonic Oscillators	AP Daily Video 1 AP Daily Video 2 AP Daily Video 3 AP Daily Video 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. 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. 3.B.3.3: 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. 3.B.3.4: Construct a qualitative and/or quantitative explanation of oscillatory behavior given evidence of a restoring force.	Topic Questions

Week 11: Mar. 15–19

Topic		Recommended Asynchronous Student Assignments	Options for Synchronous Instructional Focus*	Check for Understanding
6.2	Energy of a Simple Harmonic Oscillator	AP Daily Video 1 AP Daily Video 2 AP Daily Video 3 AP Daily Video 4	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. 5.B.3.1: Describe and make qualitative and/or quantitative predictions about everyday examples of systems with internal potential energy. 5.B.3.2: Make quantitative calculations of the internal potential energy of a system from a description or diagram of that system. 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. 5.B.4.1: Describe and make predictions about the internal energy of systems. 5.B.4.2: Calculate changes in kinetic energy and potential energy of a system using information from representations of that system.	Topic Questions Personal Progress Check

Week 12: Mar. 22–26

Topic		Recommended Asynchronous Student Assignments	Options for Synchronous Instructional Focus*	Check for Understanding
7.1	Rotational Kinematics	AP Daily Video 1 AP Daily Video 2 AP Daily Video 3	3.A.1.1: Express the motion of an object using narrative, mathematical, and graphical representations.	Topic Questions

Week 13: Mar. 29–Apr. 2

Topic		Recommended Asynchronous Student Assignments	Options for Synchronous Instructional Focus*	Check for Understanding
7.2	Torque and Angular Acceleration	AP Daily Video 1 AP Daily Video 2 AP Daily Video 3 AP Daily Video 4 AP Daily Video 5 AP Daily Video 6	3.F.1.1: Use representations of the relationship between force and torque. 3.F.1.2: Compare the torques on an object caused by various forces. 3.F.1.3: Estimate the torque on an object caused by various forces in comparison with other situations. 3.F.1.4: Design an experiment and analyze data testing a question about torques in a balanced rigid system. 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). 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. 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. 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. 3.F.3.2: 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. 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.	Topic Questions

Week 14: Apr. 5–9

Topic		Recommended Asynchronous Student Assignments	Options for Synchronous Instructional Focus*	Check for Understanding
7.3	Angular Momentum and Torque	AP Daily Video 1 AP Daily Video 2 AP Daily Video 3	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. 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. 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. 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. 4.D.3.1: 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. 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.	Topic Questions

Week 15: Apr. 12–16

Topic		Recommended Asynchronous Student Assignments	Options for Synchronous Instructional Focus*	Check for Understanding
7.4	Conservation of Angular Momentum	AP Daily Video 1 AP Daily Video 2 AP Daily Video 3 AP Daily Video 4	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. 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. 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. Use qualitative reasoning with compound objects and perform calculations with a fixed set of extended objects and point masses.	Topic Questions Personal Progress Check