Learning goals for AP Physics 2016-17 school year

Kinematics

Kin.1 Understand general relationships among position, velocity, and acceleration for the motion of a particle in a straight line, so that:
Given a graph of one of the kinematic quantities, position, velocity, or acceleration, as a function of time, they can recognize in what intervals the two other are positive, negative, or zero, and can identify and sketch a graph of each as a function of time. (Weight = 3)

Kin.2 Understand general relationships among position, velocity, and acceleration for the motion of a particle in a straight line, so that:
Given an expression for one of the kinematic quantities, position, velocity, or acceleration, as a function of time, they can determine the other two as a function of time, and find when these quantities are zero, or achieve their maximum and minimum values. (Calculus..) (Weight = 2)

Kin.3 Understand the special case of motion with constant acceleration, so they can:
Write down expressions for velocity and position as functions of time, and identify or sketch sketch graphs of these quantities.
Use the kinematic equations to solve problems involving one-dimensional motion with constant acceleration. (Weight = 2)

Kin.4 Know how to deal with situations in which acceleration is a specified function of velocity and time so they can write appropriate differential equation and solve it for v(t) by separation of variables, incorporating correctly a given value of v. (calculus) (Weight = 2)

Kin.5 Motion in 2 dimensions: You should be able to add, subtract and resolve displacement and velocity vectors so you can:
✦Determine components of a vector along two specified, mutually perpendicular axes.
✦Determine the net displacement of a particle or the location of a particle to another particle.
✦Determine the change in velocity of a particle or the velocity of one particle relative to another particle.
✦Understand the general motion of a particle in a uniform gravitational field so that you can:
✦Write expressions for the horizontal and vertical components of velocity and position as functions of time, and sketch and identify graphs of these components.
✦Use expressions in analyzing the motion of a projectile that is projectile that is projected with an arbitrary initial velocity.
(Weight = 6)

Kin.6 Understand the general motion of a particle in two dimensions so that, given functions x(t) and y(t) which describe this motion, they can determine the components, magnitude, and direction of the particle's velocity and acceleration as functions of time. (Calculus..) (Weight = 3)

Learning goals for AP Physics 2016-17 school year

Newton's Laws of Motion

NL.1 Static equilibrium (first law)

✦ analyze situations in which a particle remains at rest, or moves with constant velocity, under the influence of several forces. (Weight = 3)

NL.2 Dynamics of a single particle (second law)

✦understand the relation between the force that acts on an object and the resulting change in the object's velocity, so you can:

✦Calculate, for an object moving in one dimension, the velocity change that results when a constant force *F* acts over a specified time interval. (conceptual)

✦Calculate, for an object moving in one dimension, the velocity change that results when a force *F(t)* acts over a specified time interval. (calculus)

✦Determine, for an object moving in a plane whose velocity vector undergoes a specified change over a specified time interval, the average force that acted on the object. (Weight = 2)

NL.3 Understand how Newton's Second Law, F=F *net* =*m*a, applies to an object subject to force s such as gravity, the pull of strings, or contact forces so you can:

✦Draw a well-labeled, free-body diagram showing all real forces that act on the object

✦Write down the vector equation that results from applying Newton's Second Law to the object, and take components of this equation along appropriate axes.

✦Analyze situations in which an object moves with specified acceleration under the influence of one or more forces so they can determine the magnitude and direction of the net force, or of one of the forces that makes up the net force, such as motion up or down with constant acceleration. (Weight = 5)

NL.4 Understand the significance of the coefficient of friction, so you can:

✦ Write down the relationship between the normal and frictional forces on a surface

✦Analyze situations in which an object moves along a rough inclined plane or horizontal surface

✦Analyze under what circumstances an object will start to slip, or to calculate the magnitude of the force of static friction (Weight = 3)

NL.5 Understand the effect of drag forces on the motion of an object, so you can:

✦ Find the terminal velocity of an object moving vertically under the influence of a retarding force dependent on velocity.

✦Describe qualitatively, with the aid of graphs, the acceleration, velocity, and displacement of such a particle when it is released from rest or is projected vertically with specified initial velocity.

✦Use Newton's Second Law to write a differential equation for the velocity of the object as a function of time

✦Use the method of separation of variables to derive the equation for the velocity as a function of time from the differential equation that follows from Newton's Second Law.

✦Derive an expression for the acceleration as a function of time for an object falling under the influence of drag forces (Weight = 3)

NL.6 Systems of two or more objects(third law)

✦ Understand Newton's Third Law so that, for a given system, they can identify the force pairs and the objects on which they act, and state the magnitude and direction of each force.

✦apply Newton's Third Law in analyzing the force of contact between two objects that accelerate together along a horizontal or vertical line, or between two surfaces that slide across one another.

✦Know that tension is a constant in a light string that passes over a massless pulley and should be able to use this fact in analyzing the motion of a system of two objects joined by a string.

✦Solve problems in which application of Newton's laws leads to two or three simultaneous linear equations involving unknown forces or accelerations (Weight = 4)

Work, Energy, Power

WEP.1 Work and the work-energy theorem

Understand the definition of work, including when it is positive, negative, or zero, so they can:
✦Calculate the work done by a specified constant force on an object that undergoes a specified displacement.
✦Relate the work done by a force to the area under a graph of force as a function of position, and calculate this work in the case where the force is a linear function of position.
✦Use integration to calculate the work performed by a force *F(x)* on an object that undergoes a specified displacement in one dimension.
✦Use the scalar product operation to calculate the work performed by a specified constant force *F* on an object that undergoes a displacement in a plane.
(Weight = 2)

WEP.2 Understand and be able to apply the work-energy theorem, so you can:
✦Calculate the change in kinetic energy or speed that results from performing a specified amount of work on an object.
✦Calculate the work performed by the net force, or by each of the forces that make up the net force, on an object that undergoes a specified change in speed or kinetic energy.
✦Apply the theorem to determine the change in an object's kinetic energy and speed that results from the application of specified forces, or to determine the force that is required in order to ring an object to rest in a specified distance. (Weight = 2)

WEP.3 Forces and potential energy

Understand the concept of a conservative force, so you can:
✦State alternative definitions of "conservative forces" and explain why these definitions are equivalent
✦Describe examples of conservative forces and non-conservative forces. (Weight = 1)

WEP.4 Understand the concept of a conservative force so you can:
✦ State the general relation between force and potential energy, and explain why potential energy can be associated only with conservative forces.
✦Calculate a potential energy function associated with a specified one-dimensional force *F(x).*
✦Calculate the magnitude and direction of a one-dimensional force when given the potential energy function U(x) for the force.
✦Write an expression for the force exerted by an ideal spring and for the potential energy of a stretched or compressed spring.
✦Calculate the potential energy of one or more objects in a uniform gravitational field.
(Weight = 2)

WEP.5 Conservation of energy

Understand the concepts of mechanical energy and of total energy, so you can:
✦State and apply the relation between the work performed on an object by non-conservative forces and the change in an object's mechanical energy.
✦Describe and identify situations in which mechanical energy is converted to other forms of energy.
✦Analyze situations in which an object's mechanical energy is changed by friction or by a specified externally applied force.
(Weight = 2)

Learning goals for AP Physics 2016-17 school year

WEP.6 Understand the conservation of energy, so you can:

✦Identify situations in which mechanical energy is or is not conserved

✦Apply conservation of energy in analyzing the motion of systems of connected objects, such as an Atwood's machine.

✦Apply conservation of energy i analyzing the motion of objects that move under the influence of springs.

✦Apply conservation of energy in analyzing the motion of objects that move under the influence of other non-constant one-dimensional forces.

✦*Recognize and solve problems that call for application both of conservation of energy and Newton's Laws*.

(Weight = 3)

WEP.7 Understand the definition of power, so you can:

✦Calculate the power required to maintain the motion of an object with constant acceleration (e.g., to move an object along a level surface, to raise an object at a constant rate, or to overcome friction for an object that is moving at a constant speed).

✦Calculate the work performed by a force that supplies constant power, or the average power supplied by a force that performs a specified amount of work.

(Weight = 2)

Systems of particles,linear momentum

P&J.1 Center of mass

Understand the technique for finding center of mass, so you can:

✦Identify by inspection the center of mass of a symmetrical object.

✦Locate the center of mass of a system consisting of two such objects.

✦*Use integration to find the center of mass of a thin rod of non-uniform density.*

(Weight = 1.5)

P&J.2 Using Center of Mass to solve problems:

- ✦ Understand and apply the relation between center-of-mass velocity and linear momentum, and between center-of-mass acceleration and net external force for a system of particles.
- ✦ Define center of gravity and to use this concept to express the gravitational potential energy of a rigid object in terms of the position of its center of mass.

(Weight = 2)

P&J.3 Impulse and momentum

Understand impulse and linear momentum so you can:

✦ Relate mass,velocity, and linear momentum for a moving object, and calculate the total linear momentum of a system of objects.

✦Relate impulse to the change in linear momentum and the average force acting on an object.

Conservation of linear momentum, collisions

Understand linear momentum conservation, so you can:

✦Explain how linear momentum conservation follows as a consequence of Newton's Third Law for an isolated system.

✦Identify situations in which linear momentum, or a component of the linear momentum vector, is conserved.

(Weight = 3)

Learning goals for AP Physics 2016-17 school year

P&J.4 State and apply the relations between linear momentum and center-of-mass motion for a system of particles. (This learning goal is concerned with graphing and calculus accepts of solving problems)

✦Calculate the area under a force versus time graph and relate it to the change in momentum of an object.

✦Calculate the change in momentum of an object given a function *F(t)* for the net force action on the object.

(Weight = 1.5)

P&J.5 Momentum and Energy together:

- ✦ Apply linear momentum conservation to one-dimensional elastic and inelastic collisions and two-dimensional completely inelastic collisions.
    - ✦Apply linear momentum conservation to two-dimensional elastic and inelastic collisions.
    - ✦Analyze situations in which two or more objects are pushed apart by a spring or other agency, and how much energy is released in such a process.

(Weight = 2.5)

P&J.6 Understand **frames of reference**, so you can:

✦Analyze the uniform motion of an object relative to a moving medium such as a flowing stream.

✦Analyze the motion of particles relative to a frame of reference that is accelerating horizontally or vertically at a uniform rate

(Weight = 1.5)

Uniform circular motion

Cir.1 Understand the uniform circular motion of a particle, so you can:

✦Relate the radius of the circle and the speed or rate of revolution of the particle to the magnitude of the centripetal acceleration.

✦Describe the direction of the particle's velocity and acceleration at any instant, and sketch or identify graphs of these quantities.

✦Determine the components of the velocity and acceleration vectors at any instant during the motion. (Weight = 1.5)

Cir.2 Analyze situations in which an object moves with specified acceleration under the influence of one or more forces so they can determine the magnitude and direction of the net force, or of one of the forces that makes up the net force, in situations such as the following:

✦Motion in a horizontal circle (e.g., mass on a rotating merry-go-round, or car rounding a banked curve).

✦Motion in a vertical circle(e.g., mass swinging on the end of a string, cart rolling down a curved track, rider on a ferris wheel). (Weight = 1.5)

Cir.3 Torque and rotational statics

Understand the concept of torque, so you can:

✦Calculate the magnitude and direction of the torque associated with a given force

✦Calculate the torque on a rigid object due to gravity

✦Analyze problems in statics, so you can:

- ✦State the conditions for translational and rotational equilibrium of a rigid object.
- ✦Apply these conditions in analyzing the equilibrium of a rigid object under the combined influence of a number of coplanar forces applied at different locations.

(Weight = 2)

Learning goals for AP Physics 2016-17 school year

Cir.4 Develop both a qualitative and quantitative understanding of rotational inertia, so you can:

- ✦Qualitative:
  - ✦ Determine by inspection which of a set of symmetrical objects of equal mass has the greatest rotational inertia.
  - ✦Determine by what factor an object's rotational inertia changes if all its dimensions are increased by the same factor.
- ✦Quantitative:
  - ✦Develop skill in computing rotational inertia so they can find the rotational inertia of:
  - ✦A collection of point masses lying in a plane about an axis perpendicular to the plane.

(Weight = 1)

Cir.5 You can use integration to solve for the rotational inertial of:

- ✦A thin rod of uniform density, about an arbitrary axis perpendicular to the rod.
- ✦A thin cylindrical shell about its axis, or an object that may be viewed as being made up of coaxial shells.
- ✦also, you can state and apply the parallel-axis theorem.

(Weight = 1.5)

Cir.6 Rotational kinematics and dynamics

- ✦ Understand the analogy between translational and rotational kinematics so they can write and apply relations among the angular acceleration, angular velocity, and angular displacement of an object that rotates about a fixed axis with constant angular acceleration.
- ✦ Use the right-hand rule to associate an angular velocity vector with a rotating object.

(Weight = 1.5)

Cir.7 Understand the dynamics of <u>fixed-axis rotation</u>, so you can:

✦Describe in detail the analogy between fixed-axis rotation and straight-line translation.
✦Determine the angular acceleration with which a rigid object is accelerated about a fixed axis when subjected to a specified external torque or force.
✦Determine the *radial and tangential acceleration* of a point on a rigid object.
✦Apply *conservation of energy* to problems of fixed-axis rotation.
✦Analyze problems involving *strings and massive pulleys*.
(Weight = 3)

Cir.8 Understand the <u>motion</u> of a rigid object along a surface, so you can:

✦Write down, justify, and apply the relation between linear and angular velocity, or between linear and angular acceleration, for an object of circular cross-section that rolls without slipping along a fixed plane, and determine the velocity and acceleration of an arbitrary point on such an object.
✦Apply the equation of translational and rotational motion simultaneously in analyzing rolling with slipping.
✦Calculate the total kinetic energy of an object that is undergoing both translational and rotational motion, and applying energy conservation in analyzing such motion.
(Weight = 3)

Cir.9 Angular momentum and its conservation

Use the vector product and the right-hand rule, so you can
✦Calculate the torque of a specified force about an arbitrary origin.
✦Calculate the angular momentum of vector for a moving particle.
✦Calculate the angular momentum vector for a rotating rigid abject in simple cases where this vector lies parallel to the angular velocity vector.

- ✦**Understand angular momentum conservation, so you can:**
  - ✦Recognize the conditions under which the law of conservation is applicable and relate this law to one-and two-particle systems such as satellite orbits.

✦State the relation between net external torque and angular momentum, and identify situations in which angular momentum is conserved.
✦Analyze problems in which the amount of inertia of an object is changed as it rotates freely about a fixed axis.
✦Analyze a collision between a moving particle and a rigid object that can rotate about a fixed axis or about its center of mass.
(Weight = 3)

Simple harmonic motion (dynamics and energy relationship)

SHM.1 Understand simple harmonic motion, so you can:
✦Sketch or identify a graph of displacement as a function of time, and determine from such a graph the amplitude,period, and frequency of the motion.
✦Write down an appropriate expression for displacement of the form $A \sin t$ or $A \cos t$ to describe the motion.
✦*Find an expression for a system in SHM. (calculus component)*
✦State the relations between acceleration,velocity, and displacement, and identify points in the motion where these quantities are zero or achieve their greatest positive and negative values.
✦Recognize that a system that obeys a differential equation of the form (equation) must execute simple harmonic motion, and determine the frequency and period of such motion.
(Weight = 1.5)

SHM.2 State and apply the relation between frequency and period (Weight = 0.5)

SHM.3 Energy and SHM:
✦ State how the total energy of an oscillating system depends on the amplitude of the motion, sketch or identify a graph of kinetic or potential energy as a function of time, and identify points in the motion where this energy is all potential or all kinetic.
✦Calculate the kinetic and potential energies of an oscillating system as functions of time, sketch or identify graphs of these functions, and prove that the sum of kinetic and potential energy is constant.
✦Calculate the maximum displacement or velocity of a particle that moves in simple harmonic motion with specified initial position and velocity. (Weight = 2)

SHM.4 Develop a qualitative understanding of resonance so they can identify situations in which a system will resonate in response to a sinusoidal external force. (Weight = 1)

SHM.5 Special case: Mass on a spring
Apply their knowledge of simple harmonic motion to the case of a mass on a spring, so you can:
✦Derive the expression for the period of oscillation of a mass on a spring.
✦Apply the expression for the period of oscillation of a mass on a spring.
✦Analyze problems i which a mass hangs from a spring and oscillates vertically
✦Analyze problems in which a mass attached to a spring oscillates horizontally.
✦Determine the period of oscillation for systems involving series or parallel combinations of identical springs, or springs of differing lengths.
(Weight = 2)

SHM.6 Special Case: Pendulum and other oscillations
Apply your knowledge of simple harmonic motion to the case of a pendulum, so you can:
✦Derive the expression for the period of a simple pendulum.

✦State what approximation must be made in deriving the period.
✦Apply the expression for the period of a simple pendulum.
✦Analyze the motion of a torsional pendulum or physical pendulum in order to determine the period of small oscillations.
(Weight = 2)

Newton's law of gravity

Grav.1 Know Newton's Law of Universal Gravitation, so you can:
✦Determine the force that one spherically symmetrical mass exerts on another.
✦Determine the strength of the gravitational field at a specified point outside a spherically symmetrical mass.
✦Describe the gravitational force *inside and outside* a uniform sphere, and calculate how the field at the surface depends on the radius and density of the sphere.
(Weight = 2)

Grav.2 Orbits of planets and satellites
Understand the motion of an object in orbit under the influence of gravitational forces, so you can:
For a circular orbit:
✦Recognize that the motion does not depend on the object's mass; describe qualitatively how the velocity, period of revolution, and centripetal acceleration depend upon the radius of the orbit; and derive expressions for the velocity and period of revolution in such and orbit.
(Weight = 1.5)

Grav.3 Derivations and applications of circular orbits:
- ✦ Derive Kepler's Third Law for the case of circular orbits.
- ✦ Derive and apply the relations among kinetic energy,potential energy, and total energy for such an orbit
- ✦ for a general orbit:
  - ✦State **Kepler's three laws** of planetary motion and use them to describe in qualitative terms the motion of an object in an elliptical orbit.

(Weight = 1.5)

Grav.4 Apply the conservation of angular momentum to determine the velocity and radial distance at any point in the orbit.
✦Apply angular momentum conservation and energy conservation to relate the speeds of an object at the two extremes of an elliptical orbit.
(Weight = 1.5)

Grav.5 Apply energy conservation in analyzing the motion of an object that is projected straight up from a planet's surface or that is projected directly toward the planet from far above the surface.
(Weight = 1.5)

Learning goals for AP Physics 2016-17 school year

Laboratory and Experimental Situations

Lab 1a Design Experiments

Students can describe the purpose of the experiment or a problem to be investigated. (Weight = 1)

This skill is about showing that you understand the point, purpose and problem to be investigated in the lab through written expression. Is your paragraph clear? Do you clearly state the purpose of the lab or the problem to be investigated?

Lab 1b Design Experiments

Students can identify equipment needed and describe how it is to be used also describe the procedures to be used, including controls and measurements to be taken. (Weight = 2)

This skill is about showing that you have a plan and that you know what materials and steps are necessary for that plan to take place. This is connected to the "Lab 1a" skill in that you must know the goal of the lab in order to have a plan. Your goal here is to articulate and express your plan through written expression and clearly communicate the how behind the lab. With the goal in mind, answer these questions: What do you have to do in order to accomplish the goal or to solve the problem? What detailed steps are required in order to do this? What materials will you need? What variables are you working with and what are you measuring? How and what will you control in the experiment to avoid error or skewed data?

Lab 1c Design Experiments

Students can draw a diagram or provide a description of an experimental setup. (Weight = 1)

This skill is about showing your experimental plan and design through a drawing. This helps the reader to visualize your plan. In order to be complete, you need to make sure your drawing is thorough and labeled, as well as having a detailed description above or below your drawing to assist the reader in interpreting the drawing and the plan. (Think of a newspaper, journal, or magazine image...there is always a description below to help the reader out.)

Lab 2 Observe and Measure real Phenomena

Students should be able to make relevant observations, and be able to take measurements with a variety of instruments. (Cannot be assessed via paper and pencil examinations.) (Weight = 4)

This skill is all about being in the moment with your lab partners and helping to accomplish the goal of the experiment by taking quality measurements. This skill is graded through teacher observations and as long as you are being an active member in the group (active in the sense that you are helping to take measurements and acquire quality data, and are actively recording the data), you will succeed at this skill.

Lab 3a Analyze Data

Students can display data in graphical or tabular form, and draw a best fit line and curves to data points. (Weight = 4)

This skill is all about representing your data/findings via tables and graphing. This is an organizational and important skill to master. Answer these questions as you create your graph. Do your tables and graphs have a detailed and quality titles (the title should clearly and briefly express what the graph is representing)? Do you have labels on your x and y axis? Do you have an appropriate scale on your x and y axis (the graphical shape should take up the entire graph, not be squeezed into a corner)? Did you plot all your points? (You need to be honest with yourselves and your audience and plot all your data, not just what you think are the best data points.") Do you have a best fit line or curves (if appropriate) and do they represent the average of your trials? Do you have labels or a legend for multiple lines/curves? (The reader should be able to look at your tables and graphs and clearly and easily understand what the data is representing without having to re-read the purpose section or search around for understanding)

Learning goals for AP Physics 2016-17 school year

Lab 3b Analyze Data

Students can perform calculations with the data. (Weight = 2)

Graphs are not only for math class...in fact, in physics, graphs can reveal some really cool details and quantities! This skill is about using the data you have collected in order to perform a calculation. (For example, using the slope of the line to discover an important quantity, or finding the area under a line to find a quantity)

Make sure that you know what you are looking for, and how a graph can be useful in finding unknown quantities.

Lab 3c Analyze Data

Students can make extrapolations and interpolations from the data (Weight = 2)

This skill is all about interpreting and expressing information about the data. The point of collecting data is so that you can interpret it and find out something new or to confirm ideas, predictions, and theories. Asking yourself these questions can help you to thoroughly analyze and express your findings: Going back to the goal, what was I trying to accomplish/discover? What does the data suggest about my goal or the question I was asking (what can I say confidently now that I have this data)? What patterns or trends did I find in the data, with respect to my initial goal?

Lab 4a Analyze errors

Students can identify sources of error and how they propagate. (Weight = 1)

This skill is all about taking an honest look at and reflecting on your experimental procedure and your findings (post-experiment) to see if there were any areas where the data could be skewed or show bias. This skill is also about suggesting ways to minimize error in future experiments. This skill will be discussed in class.

Lab 4b Analyze errors

Students can estimate magnitude and direction of errors. (Weight = 1)

Lab 4c Analyze errors

Students can determine significant digits. (Weight = 0.5)

Lab 4d Analyze errors

Students can identify ways to reduce error. (Weight = 1)

How does friction play a roll? How can you minimize human error?

Lab 5a Communicate Results

Students can draw inferences and conclusions from experimental data. (Weight = 2)

This skill is about summarizing your results in a, “big picture” way, and then suggesting ways to improve the lab for future trials. Consider these questions: What general or specific conclusions can I make about the topic at hand after a thorough examination of my data and findings?

Lab 5a Communicate Results

Students can suggest ways to improve experiment and propose questions to improve experiment. (Weight = 2)

If you were to do the experiment again, or if you were to guide someone else through the experiment again, what improvements could you make to the process?

Rubric:

8 - You have totally mastered the skill, meaning you have demonstrated a full understanding of the concepts involved, have clearly showed all steps of your reasoning, have used all notation correctly, wrote exemplary and clear prose and have made no algebraic errors.

7 – You have totally mastered the skill, but you might have made a small notational error, or a very small (non-fatal) algebraic error.

Learning goals for AP Physics 2016-17 school year

6 – You have a firm grasp of the skill, meaning you have demonstrated a full or almost understanding of the concepts involved, but you possibly didn't show steps in your reasoning, didn't use notation totally consistently, you could have written clearer prose, and/or made more than one (non-fatal) algebraic errors.
5 – You have demonstrated some conceptual understanding of the skill. You possibly have some confused reasoning, did not completely answer the question, did not use consistent notation, wrote muddled prose, and/or made more than one (non-fatal) algebraic errors.
4 **–** You have demonstrated a weak or no conceptual understanding. You possibly have confused reasoning, poor prose, and/or made one or more serious (fatal) algebraic errors.
0 – You left the problem blank. This is more of a placeholder till you are able to reassess.