**AP Objectives: Kinematics (Linear)**

*Big Idea 1: Objects and systems have properties such as mass and charge. Systems may have internal structure.*

Enduring Understanding 1.A: The internal structure of a system determines many properties of the system.

**Essential Knowledge 1.A.1:** A system is an object or a collection of objects. Objects are treated as having no internal structure.

a. A collection of particles in which internal interactions change little or not at all, or in which changes in these interactions are irrelevant to the question addressed, can be treated as an object.

*Big Idea 3: The interactions of an object with other objects can be described by forces.*

Enduring Understanding 3.A: All forces share certain common characteristics when considered by observers in inertial reference frames.

**Essential Knowledge 3.A.1:** An observer in a particular reference frame can describe the motion of an object using such quantities as position, displacement, distance, velocity, speed, and acceleration.

a. Displacement, velocity, and acceleration are all vector quantities.

b. Displacement is change in position. Velocity is the rate of change of position with time. Acceleration is the rate of change of velocity with time. Changes in each property are expressed by subtracting initial values from final values.

c. A choice of reference frame determines the direction and the magnitude of each of these quantities.

**Learning Objective (3.A.1.1):**

The student is able to express the motion of an object using narrative, mathematical, and graphical representations. [See Science Practices 1.5, 2.1, and 2.2]

**Learning Objective (3.A.1.2):**

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

[See Science Practice 4.2]

**Learning Objective (3.A.1.3):**

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

[See Science Practice 5.1]

Enduring Understanding 3.F: A force exerted on an object can cause a torque on that object.

Boundary Statement: Quantities such as angular acceleration, velocity, and momentum are defined as vector quantities, but in this course the determination of “direction” is limited to clockwise and counterclockwise with respect to a given axis of rotation.

**Essential Knowledge 3.F.2:** The presence of a net torque along any axis will cause a rigid system to change its rotational motion or an object to change its rotational motion about that axis.

a. Rotational motion can be described in terms of angular displacement, angular velocity, and angular acceleration about a fixed axis.

b. Rotational motion of a point can be related to linear motion of the point using the distance of the point from the axis of rotation.

*Big Idea 4: Interactions between systems can result in changes in those systems.*

Enduring Understanding 4.A: The acceleration of the center of mass of a system is related to the net force exerted on the system, where$ \rightharpoonaccent{a}=\frac{Σ\rightharpoonaccent{F}}{m}$.

Boundary Statement: Physics 1 includes no calculations of center of mass; the equation is not provided until Physics 2. However, without doing calculations, Physics 1 students are expected to be able to locate the center of mass of highly symmetric mass distributions, such as a uniform rod or cube of uniform density, or two spheres of equal mass.

**Essential Knowledge 4.A.1:** The linear motion of a system can be described by the displacement, velocity, and acceleration of its center of mass.

**Learning Objective (4.A.1.1):**

The student is able to use representations of the center of mass of an isolated two-object system to analyze the motion of the system qualitatively and semi-quantitatively. [See Science Practices 1.2, 1.4, 2.3, and 6.4]

**Essential Knowledge 4.A.2:** The acceleration is equal to the rate of change of velocity with time, and velocity is equal to the rate of change of position with time.

**Learning Objective (4.A.2.1):**

The student is able to make predictions about the motion of a system based on the fact that acceleration is equal to the change in velocity per unit time, and velocity is equal to the change in position per unit time. [See Science Practice 6.4]

**Learning Objective (4.A.2.3):**

The student is able to create mathematical models and analyze graphical relationships for acceleration, velocity, and position of the center of mass of a system and use them to calculate properties of the motion of the center of mass of a system. [See Science Practices 1.4 and 2.2]