Introduction: Kinematics (Motion) in One Dimension

Unit: Kinematics (Motion) in One Dimension

Topics covered in this chapter:

In this chapter, you will study how things move and how the relevant quantities are related.

- *Linear Motion, Speed & Velocity* and *Acceleration* deal with understanding and calculating the velocity (change in position) and acceleration (change in velocity) of an object, and with representing and interpreting graphs involving these quantities.
- *Dot Diagrams* deals with a representation of motion using a series of dots that show the location of an object at equal time intervals.
- *Newton's Equations of Motion* deals with solving motion problems algebraically, using equations.
- *Motion Graphs* deals with creating and interpreting graphs of position *vs.* time and velocity *vs.* time.

Some of the challenging tasks include identifying quantities from their units, choosing the equation that relates the quantities of interest, and keeping track of positive and negative directions when working with vector quantities.

AP® This unit is part of *Unit 1: Kinematics* from the 2024 AP® Physics 1 Course and Exam Description.

Use this space for summary and/or additional notes:

Note to Teachers

In most physics textbooks, Motion Graphs are presented before Newton's Equations of Motion because the graphs are visual, and the intuitive understanding derived from graphs can then be applied to the equations. However, in recent years, many students have a weak understanding of graphs. I have found that reversing the usual order enables students to use their understanding of algebra to better understand the graphs. This is especially true in this text because students have already learned most of the relevant concepts in the Word Problems topic in the Mathematics chapter.

Standards addressed in this chapter:

NGSS Standards/MA Curriculum Frameworks (2016):

HS-PS2-10(MA). Use ~~free-body force diagrams~~, algebraic expressions, and Newton's laws of motion to predict changes to velocity and acceleration for an object moving in one dimension in various situations.

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AP® Physics 1 Learning Objectives/Essential Knowledge (2024):

1.2.A: Describe a change in an object's position.

1.2.A.1: When using the object model, the size, shape, and internal configuration are ignored. The object may be treated as a single point with extensive properties such as mass and charge.

1.2.A.2: Displacement is the change in an object's position.

1.2.B: Describe the average velocity and acceleration of an object.

1.2.B.1: Averages of velocity and acceleration are calculated considering the initial and final states of an object over an interval of time.

1.2.B.2: Average velocity is the displacement of an object divided by the interval of time in which that displacement occurs.

1.2.B.3: Average acceleration is the change in velocity divided by the interval of time in which that change in velocity occurs.

1.2.B.4: An object is accelerating if the magnitude and/or direction of the object's velocity are changing.

1.2.B.5: Calculating average velocity or average acceleration over a very small time interval yields a value that is very close to the instantaneous velocity or instantaneous acceleration.

1.3.A: Describe the position, velocity, and acceleration of an object using representations of that object's motion.

1.3.A.1: Motion can be represented by motion diagrams, figures, graphs, equations, and narrative descriptions.

1.3.A.2: For constant acceleration, three kinematic equations can be used to describe instantaneous linear motion in one dimension.

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1.3.A.3: Near the surface of Earth, the vertical acceleration caused by the force of gravity is downward, constant, and has a measured value $\vec{a}_g = \vec{g} \approx 10\,\frac{m}{s^2}$.

1.3.A.4: Graphs of position, velocity, and acceleration as functions of time can be used to find the relationships between those quantities.

1.3.A.4.i: An object's instantaneous velocity is the rate of change of the object's position, which is equal to the slope of a line tangent to a point on a graph of the object's position as a function of time.

1.3.A.4.ii: An object's instantaneous acceleration is the rate of change of the object's velocity, which is equal to the slope of a line tangent to a point on a graph of the object's velocity as a function of time.

1.3.A.4.iii: The displacement of an object during a time interval is equal to the area under the curve of a graph of the object's velocity as a function of time (i.e., the area bounded by the function and the horizontal axis for the appropriate interval).

1.3.A.4.iv: The change in velocity of an object during a time interval is equal to the area under the curve of a graph of the acceleration of the object as a function of time.

1.4.A: Describe the reference frame of a given observer.

1.4.A.1: The choice of reference frame will determine the direction and magnitude of quantities measured by an observer in that reference frame.

1.4.B: Describe the motion of objects as measured by observers in different inertial reference frames.

1.4.B.1: Measurements from a given reference frame may be converted to measurements from another reference frame.

1.4.B.2: The observed velocity of an object results from the combination of the object's velocity and the velocity of the observer's reference frame.

1.4.B.2.i: Combining the motion of an object and the motion of an observer in a given reference frame involves the addition or subtraction of vectors.

1.4.B.2.ii: The acceleration of any object is the same as measured from all inertial reference frames.

Skills learned & applied in this chapter:

- Choosing from a set of equations based on the quantities present.
- Working with vector quantities.
- Relating the slope of a graph and the area under a graph to equations.
- Using graphs to represent and calculate quantities.

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