AP-C Objectives (from College Board Learning Objectives for AP Physics)

- 1. Motion in one dimension
  - a. Students should understand the general relationships among position, velocity, and acceleration for the motion of a particle along a straight line, so that
    - i. Given a graph of one of the kinematic quantities, position, velocity, or acceleration, as a function of time, they can recognize in what time intervals the other two are positive, negative, or zero and can identify or sketch a graph of each as a function of time.
    - ii. 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.
  - b. Students should understand the special case of motion with constant acceleration, so they can:
    - i. Write down expressions for velocity and position as functions of time, and identify or sketch graphs of these quantities.
    - ii. Use the equations below to solve problems involving one-dimensional motion with constant acceleration
      - 1. $v = v_0 + at$
      - 2. $x = x_0 + v_0 t + \frac{1}{2} a t^2$
      - 3. $v^2 = v_0^2 + 2a(x - x_0)$
    - iii. Students should know how to deal with situations in which acceleration is a specified function of velocity and time so they can write an appropriate differential equation and solve it for v(t) by separation of variables, incorporating correctly a given initial value of v.

Position, Velocity, Acceleration

Objectives

1. Given a graph of one of the kinematic quantities, position, velocity, or acceleration, as a function of time, they can recognize in what time intervals the other two are positive, negative, or zero and can identify or sketch a graph of each as a function of time.
2. 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.

▼ Position / Displacement

An object's position is its location at a given point in time. The vector from the origin of the coordinate system to the object's position is known as the position vector, **r**.

As an object moves, its position changes, This change in position is called displacement, **Δr.**

Position and displacement are both vectors, they have magnitude and direction.

In one dimension, position is given by the x-coordinate, and displacement by **Δx**

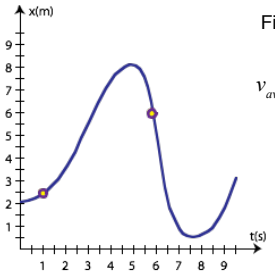
$$\Delta r = r_f - r_i$$

$$\Delta r = r - r_0$$

▼ Average Velocity

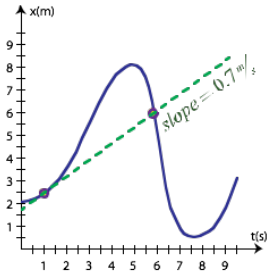
Velocity is the rate at which position changes.
Average velocity is the displacement during a time interval divided by the time interval.

$$v_{avg} = \frac{\Delta x}{\Delta t} = \frac{x_f - x_i}{t_f - t_i}$$



Find average velocity between 1 and 6 seconds.

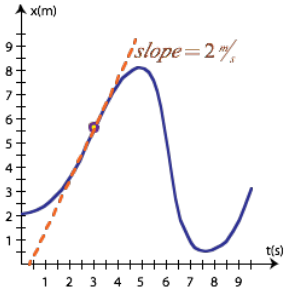
$$v_{av} = \frac{\Delta x}{\Delta t} = \frac{x_f - x_i}{t_f - t_i} = \frac{6m - 2.5m}{6s - 1s} = \frac{3.5m}{5s} = 0.7\,{}^{m}\!/_{s}$$

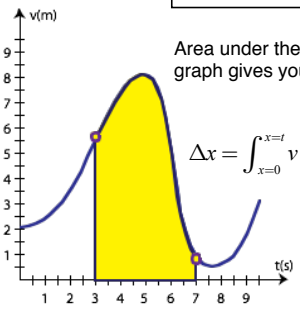


▼ Instantaneous Velocity

If you look at average velocity over a very small time interval, you obtain instantaneous velocity (instantaneous velocity is the derivative of position with respect to time.)

$$v = \lim_{\Delta t \to 0} v_{avg} = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} = \frac{dx}{dt}$$





Area under the velocity-time graph gives you displacement

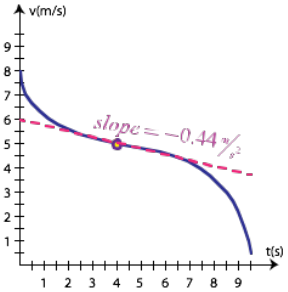
$$\Delta x = \int_{x=0}^{x=t} v\,dt$$

▼ Acceleration

acceleration is the rate at which velocity changes.

$$a = \lim_{\Delta t \to 0} \frac{\Delta v}{\Delta t} = \frac{dv}{dt} = \frac{d^2x}{dt^2}$$

$$a_{av} = \frac{\Delta v}{\Delta t}$$



Polynomial Derivatives

$$x = At^n \qquad \frac{dx}{dt} = nAt^{n-1}$$

Examples

$$x(t) = 2 - 4t + 2t^2 - 3t^3$$

$$v = \frac{dx}{dt} = -9t^2 + 4t - 4$$

$$a = \frac{d^2x}{dt^2} = -18t + 4$$

Constant Acceleration

Objectives

- 1. Write down expressions for velocity and position as functions of time, and identify or sketch graphs of these quantities.
- ▼ 2. Use the equations below to solve problems involving one-dimensional motion with constant acceleration.
  - a. $v = v_0 + at$
  - b. $x = x_0 + v_0 t + \frac{1}{2} at^2$
  - c. $v^2 = v_0^2 + 2a(x - x_0)$

▼ Using Kinematic Equations

When you know any three kinematic quantities with constant acceleration, you can solve for the other two.

▼ Relative Velocity

An F-16 refueling in mid-air is moving at ~ 300 knots with respect to the Earth.

The tanker aircraft also moves at 300 knots with respect to the Earth.

With respect to the tanker, the F-16 has a velocity of zero.

$$v_{AC} = v_{AB} + v_{BC}$$

- v_{BC}: velocity of B with respect to C
- v_{AB}: velocity of A with respect to B
- v_{AC}: velocity of A with respect to C