AP Physics 1
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Kinematic Equations of Motion

General Equations >

DISPLACEMENT

Displacement is the *change in position* of an object:

$$\Delta x = x_f - x_0, \tag{2.1}$$

where Δx is displacement, x_f is the final position, and x_0 is the initial position.

Distance

Distance is the total path length travelled by an object between two points.

$d_{Total} = d_1 + d_2 + d_3 + \ldots$

Time

This quantity refers to the interval of time over which an observed event takes place. We find the time interval by taking the difference between the initial and final time readings of the clock used to measure the event.

$$\Delta t = t_f - t_0$$

Velocity

AVERAGE VELOCITY

Average velocity is *displacement (change in position) divided by the time of travel*,

$$\bar{v} = \frac{\Delta x}{\Delta t} = \frac{x_f - x_0}{t_f - t_0}, \tag{2.5}$$

where $\bar{v}$ is the *average* (indicated by the bar over the v) velocity, Δx is the change in position (or displacement), and x_f and x_0 are the final and beginning positions at times t_f and t_0, respectively. If the starting time t_0 is taken to be zero, then the average velocity is simply

$$\bar{v} = \frac{\Delta x}{t}. \tag{2.6}$$

Instantaneous velocity

Instantaneous velocity measures the speed and direction of an object at a precise infinitesimal point in time. We often use calculus derivatives to evaluate this, but can also find the instantaneous velocity using graphical techniques.

Speed

Average Speed is defined in terms of distance and time.

$$V_{avg} = d_{Total} / t_{total}$$

Acceleration

AVERAGE ACCELERATION

Average Acceleration is *the rate at which velocity changes*,

$$\overline{a} = \frac{\Delta v}{\Delta t} = \frac{v_f - v_0}{t_f - t_0}, \quad (2.10)$$

where $\overline{a}$ is average acceleration, v is velocity, and t is time. (The bar over the a means *average* acceleration.)

Instantaneous acceleration

Instantaneous acceleration measures how the velocity of an object is changing at a precise infinitesimal point in time. We often use calculus derivatives to evaluate this, but can also find the instantaneous acceleration using graphical techniques.

Uniform Acceleration Equations >

Use these forms of the kinematic equations for objects that are not in free-fall

$$V_f = V_i + at$$

$$\Delta x = V_i t + \frac{1}{2}at^2$$

$$V_f^2 = V_i^2 + 2a\Delta x$$

$$\Delta x = \frac{1}{2}(V_i + V_f)\, t$$

Use these modified forms of the kinematic equations for objects in free-fall

*Note: The negative sign in the equations take into account that the direction of the acceleration due to gravity, **g** is downward. This means that you should always enter **g** as a positive value and when using these forms of the equations and assume that upward is the positive reference direction of motion.*

$$V_f = V_i - gt$$

$$\Delta y = V_i t - \frac{1}{2}gt^2$$

$$V_f^2 = V_i^2 - 2g\Delta y$$

$$\Delta y = \frac{1}{2}(V_i + V_f)\, t$$