Chapter Title: Motion along a straight line

Sections: Instantaneous Velocity & Speed, Acceleration, Constant Acceleration, Free-Fall Acceleration

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Instantaneous Velocity & Speed

From the last lecture, average velocity, $v_{avg} = \frac{\Delta x}{\Delta t} = \frac{x_f - x_i}{t_f - t_i}$

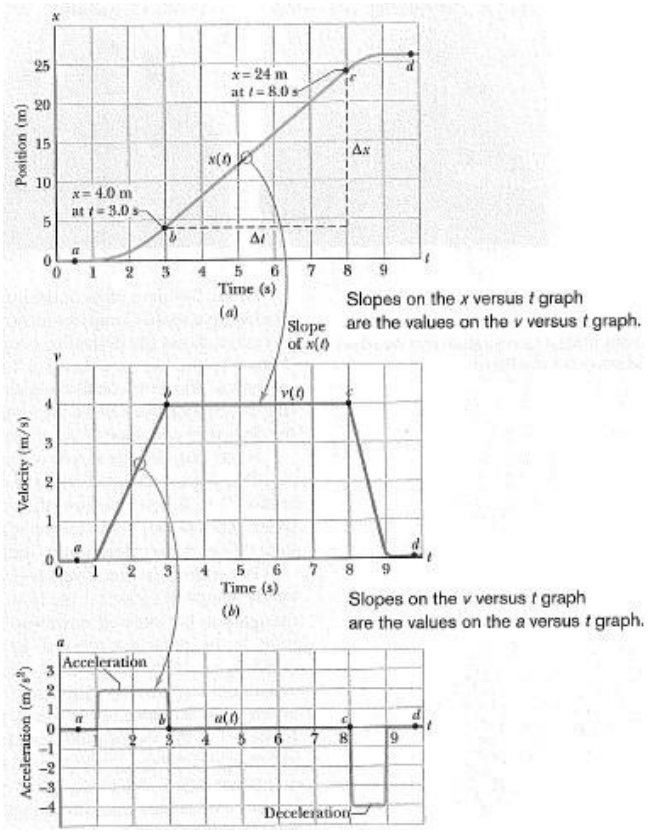
Where x_i and x_f are initial and final positions, respectively. The time t_i and t_f are at the time at positions x_i and x_f, respectively.

However, we have seen that the velocity has not remained the same or nearly the same over time.

Instantaneous velocity, or simply velocity, $v = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} = \frac{dx}{dt}$

That means, it (velocity, v) is the rate at which an object changes its position with time at that given instant.

Here, speed is simply the magnitude of velocity.



Acceleration

Fundamentally, acceleration means,

Acceleration $= \frac{Change\ in\ velocity}{Change\ in\ time}$

Average Acceleration, $a_{avg} = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{t_f - t_i}$

Instantaneous Acceleration or Simply Acceleration, $a = \frac{dv}{dt} = \frac{d^2x}{dt^2}$

Negative acceleration is called Deceleration which means speed decreases over time.

Constant Acceleration

$$v = v_0 + at$$

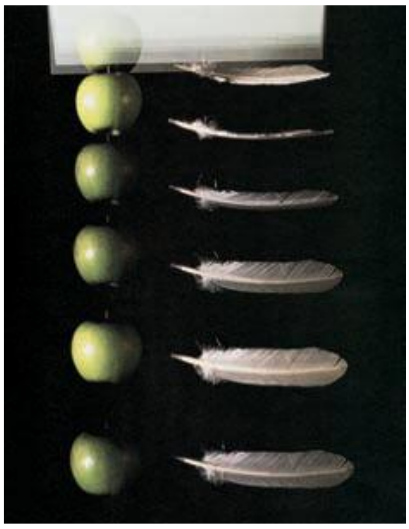
$$x - x_0 = v_0 t + \frac{1}{2}at^2$$

$$v^2 = v_0^2 + 2a(x - x_0)$$

$$x - x_0 = \frac{1}{2}(v + v_0)t$$

$$x - x_0 = vt - \frac{1}{2}at^2$$

Free-Fall Acceleration



If an object is released from a height in a vacuum and allowed to fall under the influence of gravity, the object moves downward with constant acceleration. This acceleration is called free-fall acceleration.

Example,

An apple and a feather, simultaneously released from rest in a large vacuum chamber, fall with identical motions.

The apple and the feather fall with the same acceleration.

The magnitude of this acceleration is denoted by g and has a value.

$g = 9.8\, m/s^2$