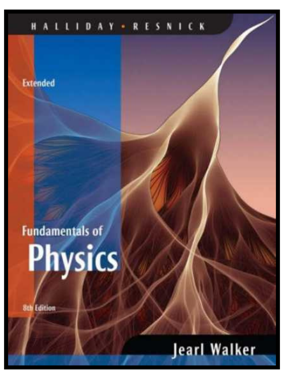
Workshop Physics

1017 - 311

University Physics I



Week 2 : Day 1

RIT

Motion with Constant Acceleration I

Motion with *a* = const. is a special case but it is rather common, so we will develop the equations that describe it.

$a = \frac{dv}{dt} \rightarrow dv = adt.$ If we integrate both sides of the equation we get:

$\int dv = \int adt = a\int dt \rightarrow v = at + C.$ Here C is the integration constant.

C can be determined if we know the velocity $v_0 = v(0)$ at $t = 0$:

$v(0) = v_0 = (a)(0) + C \rightarrow C = v_0 \rightarrow \boxed{v = v_0 + at}$ (eq. 1)

Motion with Constant Acceleration II

- **To find the position from the velocity we now integrate one more time:**

$v = \frac{dx}{dt} \rightarrow dx = vdt = (v_0 + at)\,dt = v_0 dt + atdt.$ If we integrate both sides we get:

$\int dx = \int v_0 dt + a \int tdt \rightarrow x = v_0 t + \frac{at^2}{2} + C'.$ Here C' is the integration constant.

C' can be determined if we know the position $x_o = x(0)$ at $t = 0$:

$$x(0) = x_o = (v_0)(0) + \frac{a}{2}(0) + C' \rightarrow C' = x_o$$

$$\boxed{x(t) = x_o + v_0 t + \frac{at^2}{2}} \quad \text{(eq. 2)}$$

Graphical Analysis

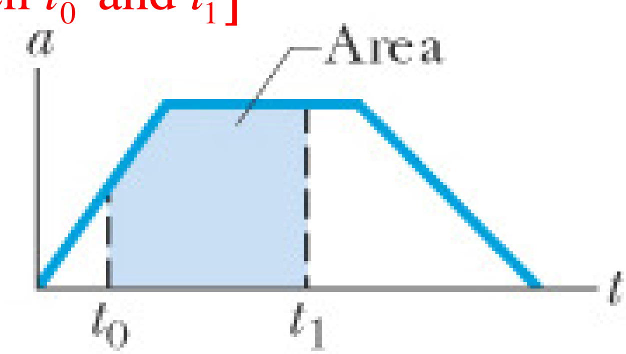
Graphical Integration in Motion Analysis (nonconstant acceleration)

When the acceleration of a moving object is not constant we must use integration to determine the velocity $v(t)$ and the position $x(t)$ of the object. The integration can be done either using the analytic or the graphical approach:

$$a = \frac{dv}{dt} \rightarrow dv = adt \rightarrow \int_{t_0}^{t_1} dv = \int_{t_0}^{t_1} adt \rightarrow v_1 - v_0 = \int_{t_0}^{t_1} adt \rightarrow v_1 = v_0 + \int_{t_0}^{t_1} adt$$

$$\int_{t_0}^{t_1} adt = [\text{Area under the } a \text{ versus } t \text{ curve between } t_0 \text{ and } t_1]$$

- **Determine change in velocity**
  - Integrate acceleration
  - Evaluate at end points
  - Area under curve is change in velocity



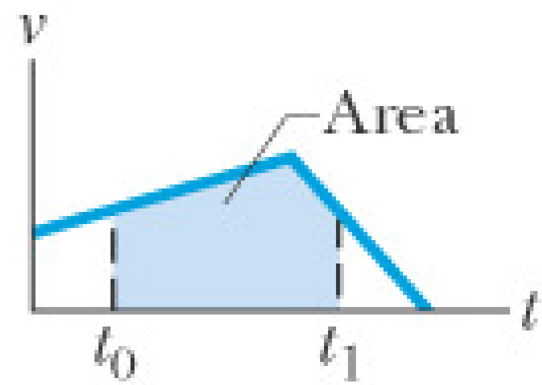
RIT

Displacement from Velocity

- **Determining displacement from a velocity graph**
  - Integrate the velocity function
  - Evaluate at end points
  - Area under curve is the displacement

$$v = \frac{dx}{dt} \rightarrow dx = v dt \rightarrow \int_{t_0}^{t_1} dx = \int_{t_0}^{t_1} v dt \rightarrow$$

$$x_1 - x_0 = \int_{t_0}^{t_1} v dt \rightarrow x_1 = x_0 + \int_{t_0}^{t_1} v dt$$

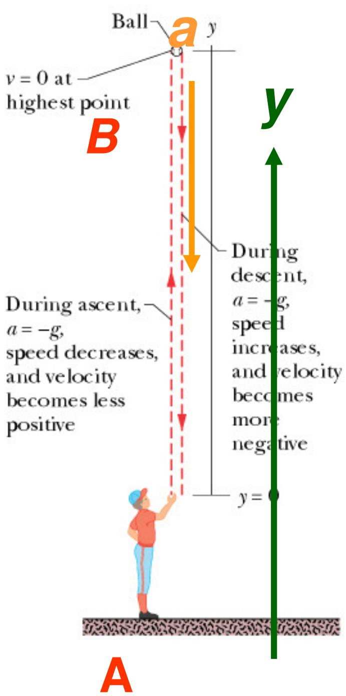


$$\int_{t_o}^{t_1} v dt = \left[\text{Area under the } v \text{ versus } t \text{ curve between } t_0 \text{ and } t_1\right]$$

Activity - Sketching a Function

- **Consider the functions x(t)**
  1. $x(t) = 12.0 - 3.2\, t - \frac{1}{2} g t^2$
  2. $x(t) = 2.0 + 5.4\, t - \frac{1}{2} g t^2$
- **Describe the motion of the object**
  - What is initial position?
  - What is initial velocity?
- **Sketch the motion**
  - Sketch graph of position
  - Sketch graph of velocity
  - Sketch graph of acceleration

Free Fall Motion



If we take the *y*-axis to point upward then the acceleration of an object in free fall *a* = -*g* and the equations for free fall take the form:

$$v = v_0 - gt \qquad \text{(eq. 1)}$$

$$x = x_o + v_0 t - \frac{gt^2}{2} \qquad \text{(eq. 2)}$$

$$v^2 - v_0^2 = -2g\left(x - x_o\right) \qquad \text{(eq. 3)}$$

Note: Even though with this choice of axes $a < 0$, the velocity can be positive (upward motion from point *A* to point *B*). It is momentarily zero at point *B*. The velocity becomes negative on the downward motion from point *B* to point *A*.

Activity – Free Fall Problems I

- **A ball is thrown upwards at 9.0 m/s toward a platform located 4.1 m above the point where you release the ball. Air resistance is negligible.**
  - a) Find the time taken to reach the platform.
  - b) Find the velocity when the ball reaches the platform.
  - *c) This time the ball misses the platform, and comes back down to hit you right on your foot. What is its velocity when it strikes you (estimate the height difference from point of release to your foot).*

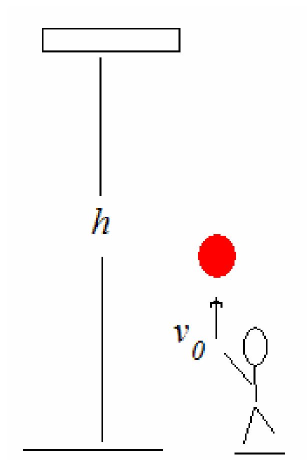
Free Fall Problems

Italicized parts are harder, and optional!

Objects falling near earth with <u>no forces acting except gravity</u> have a downwards acceleration of 9.8 m/s^2.

A ball is thrown upwards at 9.0 m/s toward platform located 4.1 m above the point where you release the ball. Air resistance is negligible.

a) Find the time taken to reach the platform.
b) Find the velocity when the ball reaches the platform.
c) This time the ball misses the platform, and comes back down to hit you right on your foot. What is its velocity when it strikes you (estimate the height difference from point of release to your foot).



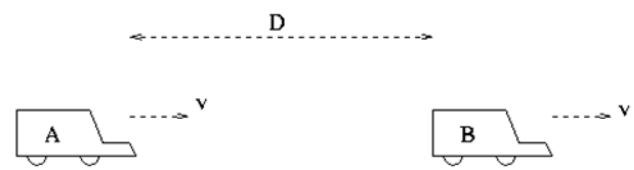
Activity – Free Fall Problems II

- Harry stands at the edge of the Grand Canyon and drops a large rock over the edge. Exactly 7.0 seconds later he sees the rock hit the bottom.
  - a) How deep is the canyon where Harry dropped the rock?
- Harry's brother Barry has walked a bit further along the canyon trail. He can't see bottom, but he knows that sound travels at 323 m/s. He drops a rock over the edge, and 8.0 seconds hears a faint sound as it hits bottom.
  - b) How deep is the canyon where Barry dropped the rock?

Activity – Kinematics Problems

- **Set up these problems and submit answers as a group**

More Kinematics Problems:



Two automobiles drive in the same direction along the highway. Each moves initially at speed 55 mph, and the distance between them is **D** meters. A deer jumps into the road in front of car B, and the driver slams on his brakes, so that the car decelerates at **5 m/s^2**. The driver of the following car, A, hesitates for **t = 0.5 seconds**, then slams on his own brakes; car A then decelerates at **3 m/s^2**.

a. How large must the distance **D** be for the two cars to avoid a collision?
b. *How does the minimum safe distance depend on the period of hesitation? Linearly? Quadratically? In some other way?*