Free Fall

Formulas for Constant Acceleration

1. $v = at + v_0$
2. $s - s_0 = \bar{v}t = (\frac{v + v_0}{2})t$
3. $s = \frac{1}{2}at^2 + v_0 t + s_0$
4. $v^2 - v_0{}^2 = 2a(s - s_0)$

Notes:

1. If time is not involved in the problem, use equation 4.
2. If time is involved in the problem as a given value or as the unknown, use equation 1 or 3.
3. At the zenith, vertical velocity v_y=0.
4. For initial velocities:
    1. V_0=0 if we drop the ball
    2. V_0= (+) if we toss it upward
    3. V_0= (-) if we throw it downward

One Dimensional Motion: Recipe

1. Draw a cartoon with the coordinate axis at ground level.
2. Label the diagram with the given information.
3. Pick the proper equation and solve!

- **Free-fall: In the air, no friction, no parachutes. On earth, $a = -10\ m/s^2$.**
- **The acceleration is always (-) because gravity *always* pulls down.**

Example: Brad throws an orange straight up at 60 m/s.

a) Find the total time airborne

b) Find the time to the apex

c) Find the location at the zenith

d) Find the velocity with which it hits the ground

e) Find the time at which the speed is 20 m/s

Example: Standing atop a building at 1125 m tall, Ken tosses a ball upward at 80 m/s.

a) Find the total time airborne

b) Find time to apex

c) Elevation of apex

d) Find the velocity at elevation 1320 m

e) Find the time when the ball is at (0, 1400)

Intuitions for Free Fall

- Any object in the air whose motion is influenced only by gravity, $a = -10\ m/s^2$.
- $-10\ m/s^2$ tells us that the velocity is changing in chunks of -10 m/s each second.
- If the object has initial upward velocity, gravity will take some time to stop the object and then give it negative velocity as it returns to earth.
- The position of the object is not as straightforward as the velocity.
- If an object is dropped from rest, the distance fallen each second is proportional to the odd numbers. Therefore, the total distance fallen is proportional to the sum of the odd integers.
- Note: Equation 3 is quadratic ($y = at^2 + \ldots$)
- Warning: **Please do not** use distance = (rate)(time).
- Use equations 2 or 3.