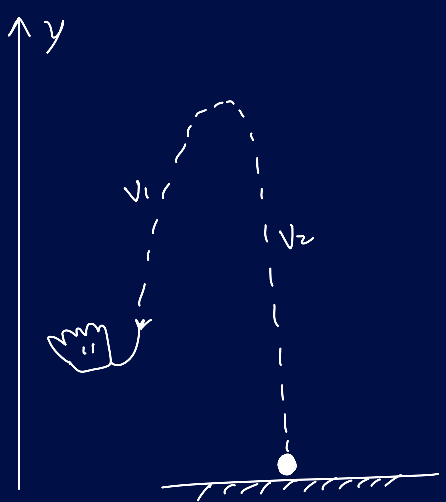
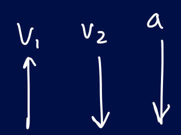
Freely-Falling Objects

1. Any object moving freely (i.e., when air resistance may be neglected) under the influence of gravity alone, regardless of its former motion.
2. The magnitude of the acceleration due to gravity alone = g = 9.80 m/s^2.
3. If we choose our *y*-axis to point away from the center of the earth, a = – g.
4. The phrase "free-fall" makes us think that the kinematic equations for motion with a = – g apply only to objects that are actually moving toward the surface of the earth. But if we throw a ball into the air, the ball is still experiencing *downward acceleration* due to gravity.

***Tip*: Think of "free fall" as a phrase describing *downward acceleration*, not necessarily downward velocity.**

Equation
$v = v_0 + at$
$\Delta x = \frac{1}{2}(v_0 + v)t$
$\Delta x = v_0 t + \frac{1}{2}at^2$
$v^2 = v_0^2 + 2a\Delta x$





Significant

Freely-Falling Object Example

A hot-air balloonist, rising vertically with a constant speed of 5.00 m/s, releases a sandbag at an instant when the balloon is 40.0 m above the ground. The effects of air resistance on the sandbag can be neglected.

a) Compute the position and velocity of the sandbag 0.250 s after its release.
b) Compute the position and velocity of the sandbag 1.00 s after its release.
c) With what i) velocity and ii) speed does the sandbag hit the ground?
d) What is the greatest height above the ground that the sandbag reaches? How long does it take for the sandbag to reach this height?
e) Sketch graphs of acceleration vs. time, velocity vs. time, and position vs. time for the motion.

a) $\Delta y = v_0 t - \frac{1}{2}gt^2 = 40.9m$ $\quad v = v_0 - gt = 2.55 m/s$

b) $\Delta y = 40.1m$ $\quad v = -4.80 m/s$

c) $y = 0, \ \Delta y = -40m$

$v = -\sqrt{v_0^2 + 2a\Delta y} = -28.4 m/s$

d) $v^2 = v_0^2 + 2a\Delta y$

$0 = v_0^2 - 2g\Delta y$

$\Delta y = v_0^2/2g = y_{max} - y_0$

$y_{max} = 41.3m$

$\Delta y = \frac{1}{2}(v_0 + v)t$

$t = 2y/(v_0+v)$

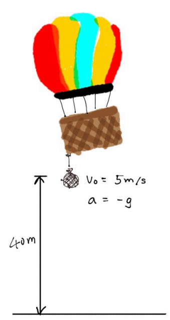
$= 2*1.3/5$

$= 0.52$

$v = v_0 + at$

$0 = 5 - gt$

$t = 5/g = 0.51$



Kinematic Equations for Objects in Free-Fall where Acceleration = -*g*

$$v = v_0 - gt$$

$$y = y_0 + v_0 t - \frac{1}{2}gt^2$$

$$v^2 = v_0^2 - 2g(y - y_0)$$