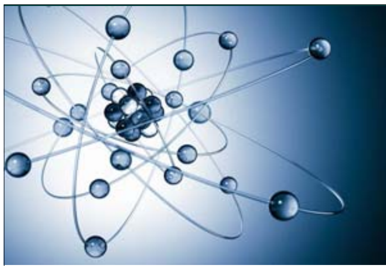
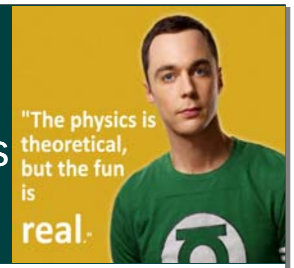


Unit 1: Kinematics



1.7 Applications of the Acceleration Due to Gravity

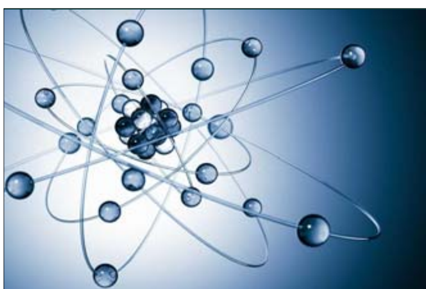
History Lesson:

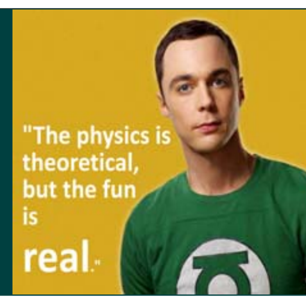
Artistotle theorized that items that stayed on the ground, like rocks, stayed there because that was their "natural place." Items that stayed in the air, like birds, stayed in the sky because that was their "natural place." This was the first thinking regarding gravity.

Galileo came to be an he performed actual experiements to study gravity. From his experiements, Galileo concluded that all objects, regardless of their mass, fall at the same acceleration. Years later, this theory was confirmed.

Ta Da!:

Acceleration Due to Gravity
Near Earth........................ $|\vec{a}_g| = 9.81\ \text{m/s}^2$





Key Points:

1. $\vec{g}$ is a vector.
2. $\vec{g}$ can be used in place of $\vec{a}$ in any kinematics equation.
3. It is actually only -9.81 m/s^2 at sea level.
4. -9.81 m/s^2 is an exact value and is not subject to sig digs (it is on your formula sheet).

An apple is dropped from a height of 1.25 m.

a) How long did it take the apple to hit the ground?

$\vec{v}_i = 0\,m/s$

$\vec{d} = -1.25\,m$

$\vec{a} = -9.81\,m/s^2$

$t = ?$

$\Delta\vec{d} = \vec{v}_i t + \frac{1}{2}\vec{a}t^2$

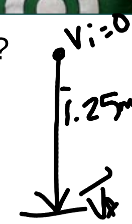
$-1.25 = 0t + (\frac{1}{2})(-9.81)t^2$

$\frac{-1.25}{-4.905} = \frac{-4.905t^2}{-4.905}$

$\sqrt{0.2548...} = \sqrt{t^2}$

$t = 0.505\,s$

b) With what velocity was the apple moving just before it hit the ground?



$\vec{v}_f = ?$

* $\vec{v}_f^{\,2} = \vec{v}_i^{\,2} + 2\vec{a}\vec{d}$

$\sqrt{\vec{v}_f^{\,2}} = \sqrt{0^2 + 2(-9.81)(-1.25)}$

$\vec{v}_f = 4.95\,m/s$ [down]

* when using this formula, use logic to decide direction

Ex.) A pizza is thrown up in the air with a velocity of 5.2 m/s. How high will it go?

$\vec{v}_f = 0$ m/s

$\vec{d} = ?$

$\vec{v}_i = +5.2$ m/s

$\vec{a} = -9.81$ m/s^2

$$\vec{v}_f^{\,2} = \vec{v}_i^{\,2} + 2\vec{a}\vec{d}$$

$$0^2 = 5.2^2 + 2(-9.81)\vec{d}$$

$$\frac{-27.04}{-19.62} = \frac{-19.62\vec{d}}{-19.62}$$

$$\boxed{\vec{d} = 1.4\text{ m [up]}}$$

Ex.) Dave jumps up to hit a volleyball. He hangs in the air for 12.0 s before hitting the ground.

a) How high did he go?

$\vec{v}_f = 0$ m/s

$t = 6.00$ s

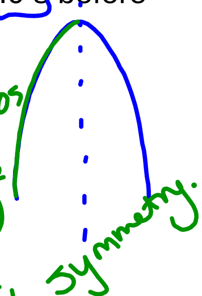
$\vec{a} = -9.81$ m/s^2

$\vec{d} = ?$

$$\Delta\vec{d} = \vec{v}_f t - \tfrac{1}{2}\vec{a}t^2 \quad t: 6.0\text{ s}$$

$$= 0t - (\tfrac{1}{2})(-9.81)(6)^2$$

$$\boxed{\Delta\vec{d} = 177\text{ m [up]}}$$



b) What was the initial velocity of Dave?

$\vec{v}_f = 0\,m/s$

$\vec{a} = -9.81\,m/s^2$

$t = 6.0\,s$

$\vec{d} = 177\,m$

$\vec{v}_i = ?$

$\Delta \vec{d} = \left(\frac{\vec{v}_f + \vec{v}_i}{2}\right)t$ OR $\vec{v}_f = \vec{v}_i + \vec{a}t$

OR $\vec{v}_f^{\,2} = \vec{v}_i^{\,2} + 2\vec{a}\vec{d}$

$\boxed{\vec{v}_i = 58.9\,m/s\,[up]}$

Ex.) A baseball player throws a ball vertically into the air with an initial velocity of 18.9 m/s. It is caught the same distance above the ground as it was thrown.

a) How high does it go?

$\vec{v}_i = 18.9\,m/s$

$\vec{a} = -9.81\,m/s^2$

$\vec{v}_f = 0\,m/s$

$\vec{d} = ?$

$\vec{v}_f^{\,2} = \vec{v}_i^{\,2} + 2\vec{a}\vec{d}$

$0^2 = 18.9^2 + 2(-9.81)\vec{d}$

$-357.21 = -19.62\vec{d}$

$\boxed{\vec{d} = 18.2\,m\,[up]}$

b) How long was it in the air?

$\vec{V}_i = 18.9 m/s$

$\vec{V}_f = 0 m/s$

$\vec{a} = -9.81 m/s^2$

$\vec{d} = 18.2 m$

$t_{up} = ?$

$$\Delta\vec{d} = \left(\frac{\vec{V}_i + \vec{V}_f}{2}\right)t$$

$$18.2 = \left(\frac{18.9 + 0}{2}\right)t$$

$$t_{up} = 1.93 s$$

$$t_{total} = 2(1.93) = \boxed{3.85 s}$$

Symmetry

Ex.) An egg is thrown downward out of a window. If the window is 11.2 m above the ground, and it took the egg 0.550 s to hit the ground, what was the initial velocity of the egg?

$\vec{V}_i = ?$

$\vec{a} = -9.81 m/s^2$

$\vec{d} = -11.2 m$

$t = 0.550 s$

$$\Delta\vec{d} = \vec{V}_i t + \tfrac{1}{2}\vec{a}t^2$$

$$-11.2 = \vec{V}_i(0.550) + (\tfrac{1}{2})(-9.81)(.550)^2$$

$$\frac{-9.716}{0.550} = \frac{\vec{V}_i(0.550)}{0.550}$$

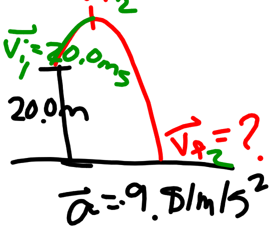
$$\boxed{\vec{V}_i = -17.7 m/s}$$

Ex.) A care package is thrown vertically upwards from a helicopter hovering 20.0 m over the ground. The initial velocity of the object is 20.0 m/s.

a) Calculate the final velocity of the object just before it hits the ground.

$\vec{v}_{f_1} = 0\ m/s$

$\vec{v}_{i_2} = 0\ m/s$



① $\vec{v}_f^{\,2} = \vec{v}_i^{\,2} + 2\vec{a}\vec{d}$

$0^2 = 20.0^2 + 2(-9.81)\vec{d}$

$-400 = -19.62\vec{d}$

$\vec{d} = 20.4\ m$

$+\ 20.0\ m$

$\vec{d} = 40.4\ m$

$\vec{v}_f^{\,2} = \vec{v}_i^{\,2} + 2\vec{a}\vec{d}$

$\sqrt{\vec{v}_f^{\,2}} = \sqrt{0^2 + 2(-9.81)(40.4)}$

$\boxed{\vec{v}_f = 28.1\ m/s\ [down]}$

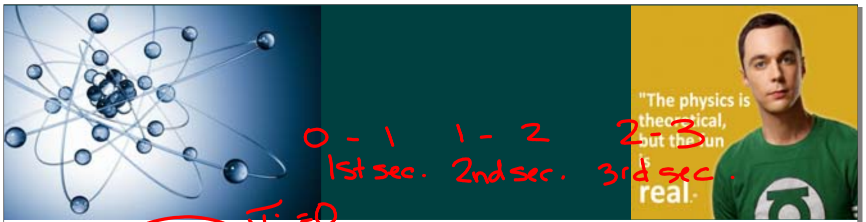
b) Calculate the time it takes the package to hit the ground.

$\Delta\vec{d}_{up} = \left(\frac{\vec{v}_f + \vec{v}_i}{2}\right) t_{up} \quad + \quad \vec{d}_{down} = \left(\frac{\vec{v}_f + \vec{v}_i}{2}\right) t_{down}$

$20.4 = \left(\frac{20 + 0}{2}\right) t_{up} \qquad 40.4 = \left(\frac{0 + 28.1}{2}\right) t_{down}$

$t_{up} = 2.04\ s \qquad t_{down} = 2.87\ s$

$\boxed{t_{total} = 4.92\ s}$



0 - 1 1st sec. 1 - 2 2nd sec. 2 - 3 3rd sec.

$\vec{v}_i = 0$

Ex.) A ball is dropped from a height of 50.0 m. How far does it fall during the third second of the fall?

$\vec{v}_i = 0\ m/s$

$\vec{d} = -50.0\ m$

$\vec{a} = -9.81\ m/s$

$\Delta\vec{d} = \vec{v}_i t + \frac{1}{2}at^2$

$-50.0 = (\frac{1}{2})(-9.81)t^2$

$t = 3.19\ s$

$\vec{d}_3 - \vec{d}_2$

$-44.145 + {+19.92}$

$\Delta\vec{d}_3 = 0t + (\frac{1}{2})(-9.81)(3)^2$

$\Delta\vec{d}_3 = -44.145\ m$

$\vec{d}_2 = 0t + (\frac{1}{2})(-9.81)(2)^2$

$\Delta\vec{d}_2 = -19.62\ m$

$\vec{d} = 24.5\ m$ [down]

Page 63 # 3 - 15.