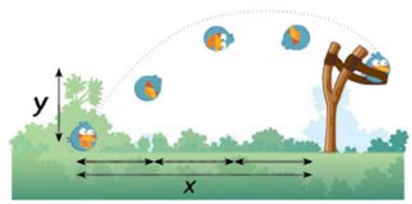
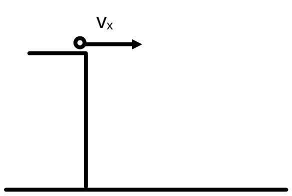
1.11 Projectile Motion (I)

Projectile Motion involves throwing, launching, or dropping an object through the air.



Objects Launched Horizontally Through the Air:



Key Ideas:

- this object has the same velocity throughout the entire motion
- there is acceleration in the y direction (due to gravity), constant velocity in the x direction
- the time it takes the object to hit the ground in this motion would be the same as the time it would take to just fall vertically

The horizontal displacement is sometimes called the "range".

x	y
$\vec{v}$	$\vec{v}_i = 0$
$\vec{d}$	$\vec{v}_f$
	$\vec{g} = -9.81\ m/s^2$
t	t

Questions we can answer from this scenario:

1. How long the object is in the air.
2. How far the object lands from the cliff.
3. The velocity of the object when it lands.

1. How long the object is in the air:

Given *d*, you can solve for *t*.

$$\vec{d} = \vec{v}_i t + 1/2\vec{a}t^2 \qquad \vec{d}_y = 1/2\vec{g}t^2$$

$$\vec{d}_y = \overset{0}{\cancel{v_{iy}t}} + 1/2\vec{g}t^2 \qquad \boxed{t = \sqrt{\frac{2\vec{d}_y}{\vec{g}}}}$$

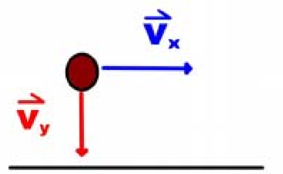
The Half-Time Eqn.

2. How far the object lands from the cliff:

$$\vec{v} = \vec{d} / t$$

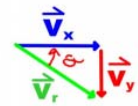
$$\vec{d}_x = \vec{v}_x t$$

3. The velocity of the object when it lands:



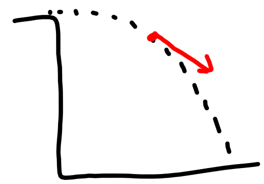
$$\vec{v}_f^2 = \cancel{\vec{v}_i^2}^{\,0} + 2\vec{a}\vec{d}$$

$$v_{fy} = \sqrt{2\vec{g}\vec{d}_y}$$

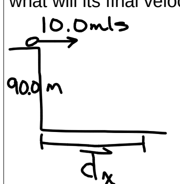


Use trig to determine the angle and resultant.

We must find the resultant of the two velocities at play.



Ex.) An object thrown horizontally with a velocity of 10.0 m/s from the top of a 90.0 m building. How far from the base of the building will the object land and what will its final velocity be?



$t \cdot \vec{V}_x = \frac{\vec{d}_x}{\cancel{t}} \cdot \cancel{t}$ $\quad \vec{d}_x = \vec{V}_x \cdot t$

$\Delta\vec{d}_y = \cancel{\vec{V}_{1y} t} + \frac{1}{2}\vec{a}_y t^2$

$\Delta\vec{d}_y = \frac{1}{2}\vec{a}_y t^2$

$-90.0 = (\frac{1}{2})(-9.81)t^2$

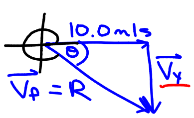
$\frac{-90.0}{-4.905} = \frac{-4.905t^2}{-4.905}$

$\vec{d}_x = \vec{V}_x t$

$\vec{d}_x = (10.0)(4.28)$

$\boxed{\vec{d}_x = 42.8\text{m}}$

$\sqrt{18.34...} = t$ $\quad t = 4.28\text{ s}$



$\vec{V}_{fy}^2 = \cancel{\vec{V}_{iy}^2} + 2\vec{a}\vec{d}_y$

$V_{fy} = \sqrt{2(-9.81)(-90.0)} = 42.02...$

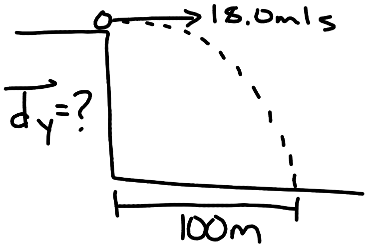
$\sqrt{10.0^2 + 42.02...^2} = \vec{V}_f$

$\tan\theta = \frac{42.02}{10.0}$

$\theta = 77°$

$\vec{V}_f = 43.2\text{ m/s}$ [down] [283°]

Ex.) A watermelon is thrown from the top of a cliff with a horizontal velocity of 18.0 m/s. If the melon hits the ground 100 m from the cliff, how high is the cliff?



$\vec{v}_x = \frac{\vec{d}_x}{t}$

$18.0 = \frac{100}{t}$ $\quad t = 5.55\,s$

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

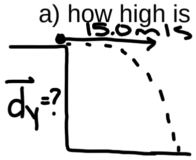
$= \cancel{0t} + (\frac{1}{2})(-9.81)(5.55)^2$

$= -151$

$= \boxed{151\,m\ [down]}$

Ex.) A ball is thrown horizontally with a velocity of 15.0 m/s from the top of a cliff. If it takes 5.50 s for the ball to hit the ground;

a) how high is the cliff?



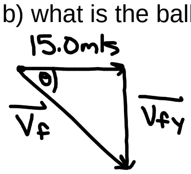
$t = 5.50\,s$

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

$= \cancel{0t} + (\frac{1}{2})(-9.81)(5.50)^2$

$= \boxed{148\,m\ [down]}$

b) what is the ball's final velocity?



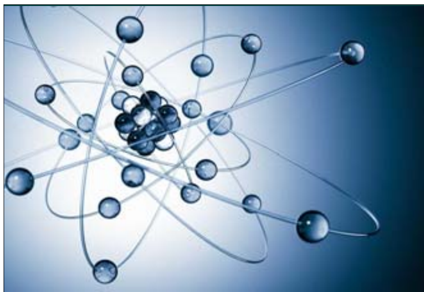
$\vec{v}_{fy} = \sqrt{2\vec{a}_y \vec{d}_y}$

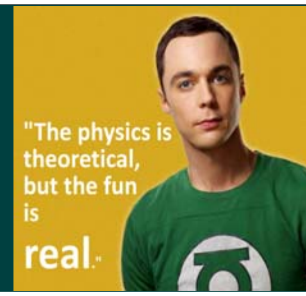
$= \sqrt{2(-9.81)(148)}$

$\vec{v}_{fy} = 53.955$

$\vec{v}_f = \sqrt{15.0^2 + 53.955^2}$

$\boxed{\vec{v}_f = 56.0\,m/s\ [74°]}$





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