Projectile Motion

Projectile Motion is the term we give to objects that are moving in two directions.

Projectiles will have motion in both the horizontal and vertical directions.

We can use our motion equations from previous chapters but we must remember to deal with x and y velocities separate.

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Motion in the x (horizontal) direction

Since there is no acceleration that changes the velocities in the x direction, the horizontal component of velocity will remain constant.

Use the equation for velocity in the x directions:

$$V_x = \frac{\Delta x}{t}$$

$$\Delta x = v_x t$$

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Motion in the y (vertical) direction

Since gravity is accelerating the object, the velocities in the y direction will be changing. As an object falls, it gains velocity in the downward direction. As an object rises, it loses velocity.

Use these equations:

$$\Delta y = \frac{1}{2}at^2 + v_{oy}t \qquad v_{fy} = v_{oy} + at$$

$$v_{fy}^2 = v_{oy}^2 + 2a\Delta y$$

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Time

Time is the ONLY piece of information that will be the same in both the x and y directions. The time it takes something to fall with be the same amount of time it travels in the x direction.

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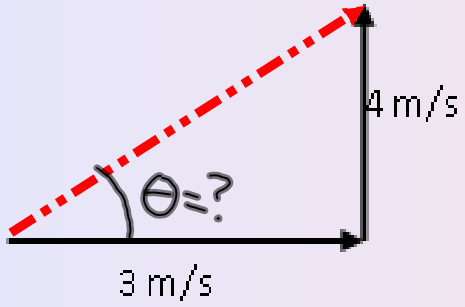
Total Velocity and Vector Components

By taking the velocity in the x and the velocity in the y and adding them together as vectors, you will find the total velocity.



$a^2+b^2=c^2$

$3^2+4^2=c^2$

$c=5\,m/s$

$\text{Tan}\,\theta=\frac{o}{a}=\frac{4}{3}$

$\theta=25.32°$

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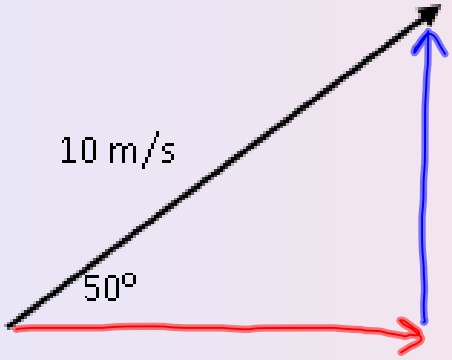
Because we know velocities are vectors, we can also break total velocities up into their x and y components



$\text{Sin}\,50°=\frac{y}{10}$

$V_{oy}=7.66\,m/s$

$\text{Cos}\,50°=\frac{x}{10}$

$V_x=6.43\,m/s$

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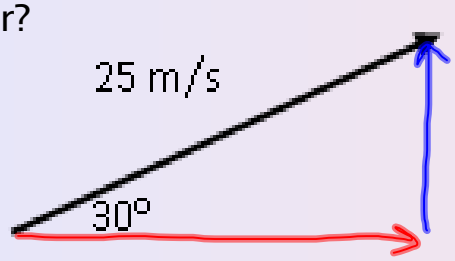
Find the initial x and y velocities of a water balloon that is launched with a total initial velocity of 25m/s at 30 degrees above the horizontal.

$\cos 30° = \frac{x}{25}$ $V_x = 21.65 m/s$ $\sin 30° = \frac{y}{25}$ $V_{by} = 12.5 m/s$

Now that you know the y velocity, how long will it be in the air?



$V_{y_0} = 12.5 m/s$
$a = -10 m/s^2$
$V_{fy} = 0 m/s$
$t = ?$
$V_{fy} = V_{oy} + at$
$0 = 12.5 - 10t$
$t = 1.25s \times 2 = \boxed{2.50s}$

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Now that you know how long it will be in the air, how far will it go in the x direction?

$t = 2.5s$
$V_x = 21.65 m/s$

$\Delta x = vt$
$\Delta x = 21.65(2.5)$
$\boxed{\Delta x = 54.13 m}$

What will be the water balloons maximum height in the y direction?

$\Delta y = ?$
$V_{oy} = 12.5 m/s$
$a = -10 m/s^2$
$V_{fy} = 0$

$V_f^2 = V_o^2 + 2a\Delta y$
$0 = 12.5^2 + 2(-10)(\Delta y)$
$\boxed{\Delta y = 7.81 m}$

$\Delta y = \frac{1}{2}at^2 + V_o t$
$\Delta y = \frac{1}{2}(-10)1.25^2 + 12.5(1.25)$
$\boxed{\Delta y = 7.81 m}$

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Memorize these Rules that Projectiles will Follow

1. Projectiles will always maintain a constant velocity horizontally (ignoring air resistance)
2. Projectiles always experience a constant vertical acceleration of 9.8 m/s^2 downward. In class we will use -10 m/s^2 for all problems.
3. Horizontal (x) and vertical (y) motion are completely independent of each other. Therefore, the velocity of a projectile can be separated into horizontal and vertical components.
4. For a projectile beginning and ending at the same height, the time it takes to rise to its highest point equals the time it takes to fall back to the original position.
5. For a projectile beginning and ending at the same height, the initial speed is equal to the final speed but the velocities have equal magnitudes, but opposite signs (+/-).
6. Objects dropped from a moving vehicle will have the same velocity as the moving vehicle

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