# Newtons Laws

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recap

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## Newton's Laws

1. A body at rest remains at rest, or if in motion, remains, in motion at a constant velocity unless acted on by a net external force.

2. The acceleration of a system is directly proportional to and in the same direction as the net external force acting on the system, and inversely proportional to its mass.

$$F_{net}=ma$$

3. Whenever one body exerts a force on a second body, the first body experiences a force that is equal in magnitude and opposite in direction to the force that it

## Free body diagram examples

## Projectile Motion

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## Practice

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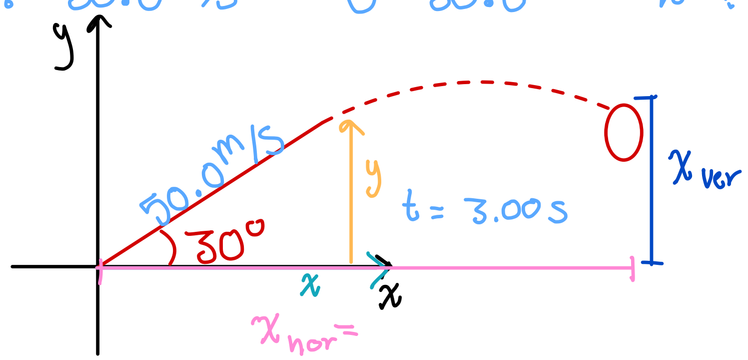
A projectile is launched at ground level with an initial speed of 50.0 m/s at an angle of 30.0° above the horizontal. It strikes a target above the ground 3.00 seconds later. What are the x and y distances from where the projectile was launched to where it

$v_0 = 50.0\ m/s$  $\theta = 30.0°$  $x = ?$




$\cos\theta = \frac{a}{h}$

$\cos 30° = \frac{x}{50.0\ m/s}$

$V_x = 50 \cdot \cos 30°$

$\sin\theta = \frac{o}{h}$

$\sin 30 = \frac{y}{50}$

$V_y = 50 \sin 30$

**What we know**

$v_x = 50 \cdot \cos 30°$
$a_x = 0\ m/s^2$
$t = 3\ s$
$x_{hor} = ?$

$v_{0y} = 50 \cdot \sin 30$
$a = -9.8\ m/s^2$
$t = 3.00\ s$
$v_{fy} = ?$

$v = \frac{x}{t}$

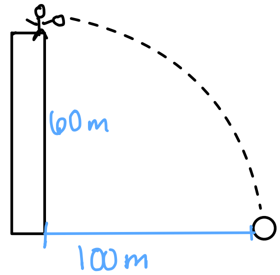
$x = vt$

$(50 \cdot \cos 30°)(3s) = 130m$

$\Delta x_{ver} = v_{0y} t + \frac{1}{2} a t^2$

$= 50 \sin 30 \cdot 3 + \frac{1}{2} \cdot {-9.8} \cdot 3^2 = 30.9$

A ball is thrown horizontally from the top of a 60.0-m building and lands 100.0 m from the base of the building. Ignore air resistance.




x components
$x = 100\,m$
$v_{ix} = ?$
$t = ? = 3.49$
$a = 0\,m/s^2$

y components
$y = -60\,m$
$v_{iy} = 0$
$v_{fy} = ?$
$a = -9.8\,m/s^2$
$t = ?$

(a) How long is the ball in the air?

$\Delta y = v_{iy}t + \frac{1}{2} g t^2$

$\sqrt{\frac{2 \cdot \Delta y}{g}} = t = \sqrt{\frac{2 \cdot -60}{-9.8}} = 3.49\,s$

(b) What must have been the initial horizontal component of the velocity?

(b) $v_{ox} = ?$ $t = 3.49$

$\Delta x = v_{ix} t + \frac{1}{2} a t^2$

$v_{ix} = \frac{\Delta x}{t} = \frac{100}{3.49} = 28.7$

(c) What is the vertical component of the velocity just before the ball hits the ground?

(c) $v_y = ?$

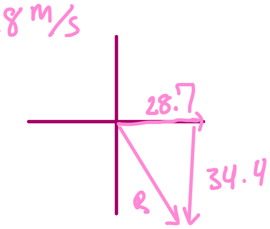
$\sqrt{v_y^2} = \sqrt{v_i^2 + 2g\,\Delta y}$

$v_y = 2g\Delta y = 2 \cdot -9.8 \cdot -60 = -34.4\,m/s$

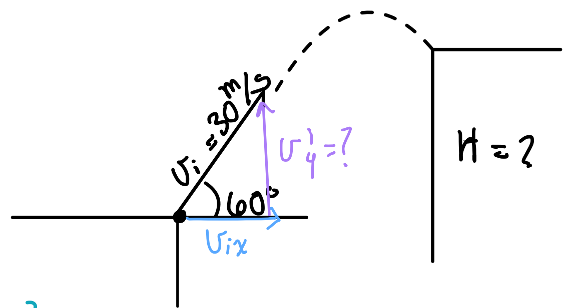
(d) What is the velocity (including both the horizontal and vertical components) of the ball just before it hits the ground?

(d) $\vec{R} = ?$

$R = \sqrt{x^2 + y^2} = \sqrt{28.7^2 + (-34.4)^2} = 44.8\,m/s$



An arrow is shot from a height of 1.5 m toward a cliff of height H. It is shot with a velocity of 30 m/s at an angle of 60° above the horizontal. It lands on the top edge of the cliff 4.0 s later.




(a) What is the height of the cliff?

ⓐ $y = v_{oy}t + \frac{1}{2}a_y t^2$

$\sin\theta = \frac{o}{h}$

$y = 30\sin 60 \cdot 4 + \frac{1}{2} \cdot -9.8 \cdot 4^2$

$y \approx 26\ m$

$\sin 60 = \frac{v_{iy}}{30}$

$v_{iy} = 30 \cdot \sin 60$

$H = 26_m + 1.5 = 27.5\ m = 28\ m$

(b) What is the maximum height reached by the arrow along its trajectory?

ⓑ $H_{max} = \frac{v'^2}{2g} = \frac{26^2}{2 \cdot 9.8} = 34.5 \approx 35\ m$

(c) What is the arrow's impact speed just before hitting the cliff.

ⓒ $\cos\theta = \frac{a}{h}$

$v'_y = 30 \cos(60°) = 15\ m/s$

$v_{fx} = v_{ix} = 15\ m/s$

$v_{fy} = v_{iy} + at$

$v_{fy} = 26 + -9.8 \cdot 4$

$v_{fy} = -13\ m/s$

$R = \sqrt{-13^2 + 15^2} = 20\ m/s$