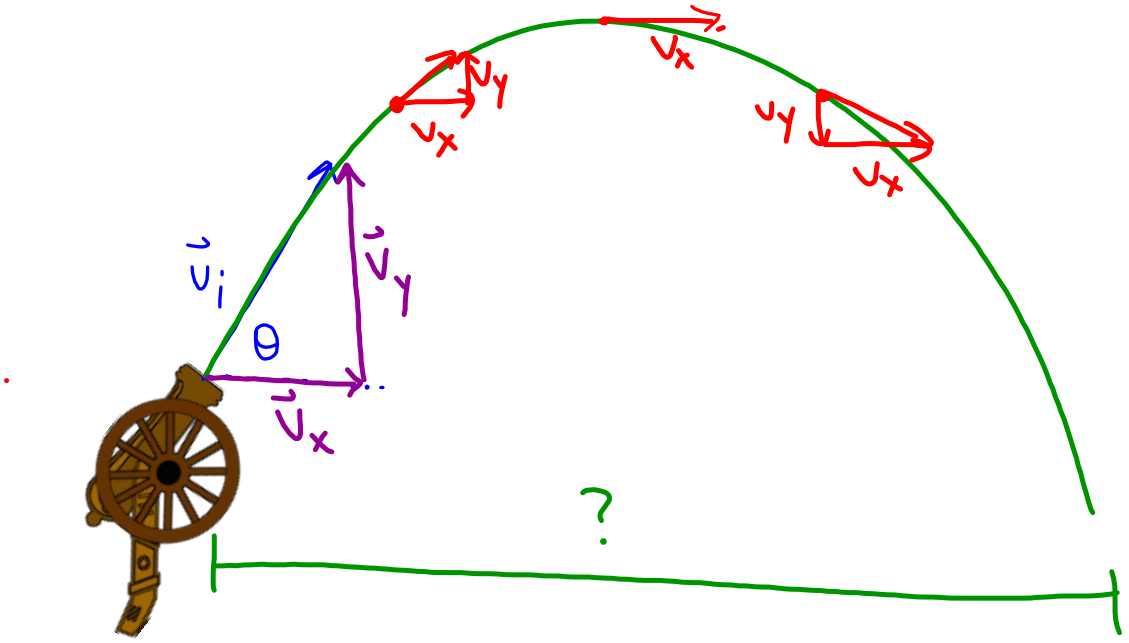
Projectile Motion

Launched at an Angle

Goal:

- to solve problems when objects are launched at angle



How far will the cannon ball land?

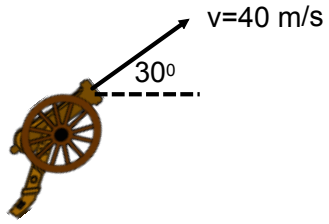
Depends on $\vec{v}_i$ and θ

Here the initial velocity now has both a horizontal and vertical component. Each component is needed to solve the problem.

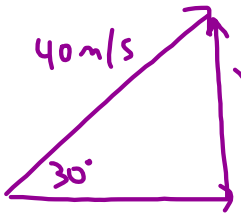
A cannon fires a shell with a speed of 40 m/s at an angle of 30^0.

How far away does the shell land if...

a) it lands at the same height?



Find components:



$v_y = 40\sin 30^\circ$

$= 20$ m/s

$v_x = 40\cos 30^\circ$

$= 34.64$ m/s

Vertical

$\vec{v}_i = 20$ m/s [up]

$\vec{a} = 9.8$ m/s^2 [down]

$\vec{\Delta d} = 0$ (same height)

$\Delta t = ?$

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

$0 = 20\Delta t + \frac{1}{2}(-9.8)\Delta t^2$

$0 = 20\Delta t - 4.9\Delta t^2$

$0 = \Delta t(20 - 4.9\Delta t)$

$\Delta t = 0$ $\quad 20 - 4.9\Delta t = 0$

$4.9\Delta t = 20$

$\Delta t = 4.08$

Horizontal

$\Delta t = 4.08$ s

$\vec{v} = 34.64$ m/s

$\vec{\Delta d} = ?$

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

$34.64 = \frac{\vec{\Delta d}}{4.08}$

$\vec{\Delta d} = 141.3$ m

b) it lands 10 m below the launch height?

only change is vertical displacement.

Vertical

$\vec{v}_i = 20\ m/s\ (up)$

$\vec{a} = 9.8\ m/s^2\ [down]$

$\vec{\Delta d} = 10\ m\ [down]$

$\Delta t = ?$

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

$$-10 = 20\Delta t - 4.9\Delta t^2$$

$$4.9\Delta t^2 - 20\Delta t - 10 = 0$$

$$\Delta t = \frac{20 \pm \sqrt{(-20)^2 - 4(4.9)(-10)}}{2(4.9)}$$

$\Delta t_1 = -0.45$ $\Delta t_2 = 4.53$

Horizontal

$\Delta t = 4.53\ s$

$\vec{v} = 34.64\ m/s$

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

$$= 34.64(4.53)$$

$$= 156.9\ m$$

A basketball is thrown so that is has an initial velocity of 10 m/s at an angle of 60^0. The ball strikes the net which is 6 m away. How high is the net?

Equations for projectile motion when $\Delta d_y=0$

$$t = \frac{2v_0 \sin\theta}{g}$$

$$H = \frac{{v_0}^2 \sin^2\theta}{2g}$$

$$R = \frac{{v_0}^2 \sin 2\theta}{g}$$

Firing a cannon