Ex. You are riding your bike over a distance of 30m. You decide to raise your velocity to 6.2 m/s with an acceleration of 0.5 m/s^2.

A) What is your initial speed?

$d = 30m$
$a = 0.5 m/s^2$
$V_f = 6.2 m/s$
$V_i = ?$

$V_f^2 = V_i^2 + 2ad$

$\sqrt{V_f^2 - 2ad} = V_i$

$\sqrt{(6.2)^2 - 2(0.5)(30)} = V_i$

$V_i = 2.9 m/s$

B) How long did it take you to cover that distance

$t = ?$
$a = 0.5 m/s^2$
$d = 30 m$
$V_f = 6.2 m/s$
$V_i = 2.9 m/s$

$a = \frac{V_f - V_i}{t}$ $t = \frac{V_f - V_i}{a} = \frac{6.2 - 2.9}{0.5}$

$t = 6.6 sec$

Vertical Motion (Up & Down)

Need to account for gravity

Acceleration Due To Gravity: $g = 9.8 m/s^2$

$g\oplus$ going down (speeds up)

$g\ominus$ going up (slowing down)

$V_f = V_i + gt$

$V_f^2 = V_i^2 + 2gd$

$d = V_i t + \frac{1}{2} g t^2$

Ex. A penny is dropped from the top of the Empire State Building (443m). How long does it take to hit the ground?

$d = 443\,m$
$g = 9.8\,m/s^2$
$v_i = 0$
$t = ?$

$d = \cancel{v_i t}^{0} + \frac{1}{2}gt^2$

$\sqrt{\frac{2d}{g}} = t$

$\sqrt{\frac{2(443)}{9.8}} = t$

$t = 9.5\,s$

Ex. If the penny was thrown (straight down) from a window 125m high with an initial velocity of 18 m/s

i) How fast is the object hitting the ground?

ii) How fast would it hit the ground if it was thrown from the top of the Empire State Building with the same initial velocity? $(d = 443m)$

i) $d = 125\,m$
$g = 9.8\,m/s^2$
$v_i = 18\,m/s$
$v_f = ??$

$v_f^2 = v_i^2 + 2gd$

$v_f = \sqrt{v_i^2 + 2gd}$

$v_f = \sqrt{(18)^2 + 2(9.8)(125)}$

$v_f = 52.7\,m/s$

ii) $v_f^2 = v_i^2 + 2gd$

$v_f = \sqrt{(18)^2 + 2(9.8)(443)}$

$v_f = 94.9\,m/s \times \frac{1hr}{1000m} \times \frac{3600}{1hr}$

$341.64\,km/hr$

Ex. An object is thrown straight up with a velocity of 22 m/s.

A) How high did it go?

B) How long before you catch it back?

A) $v_i = 22\,m/s$
$g = -9.8\,m/s^2$
$v_f = 0$
$d = ?$

$\cancel{v_f^2}^{0} = v_i^2 + 2gd$

$\frac{-v_i^2}{} = d$

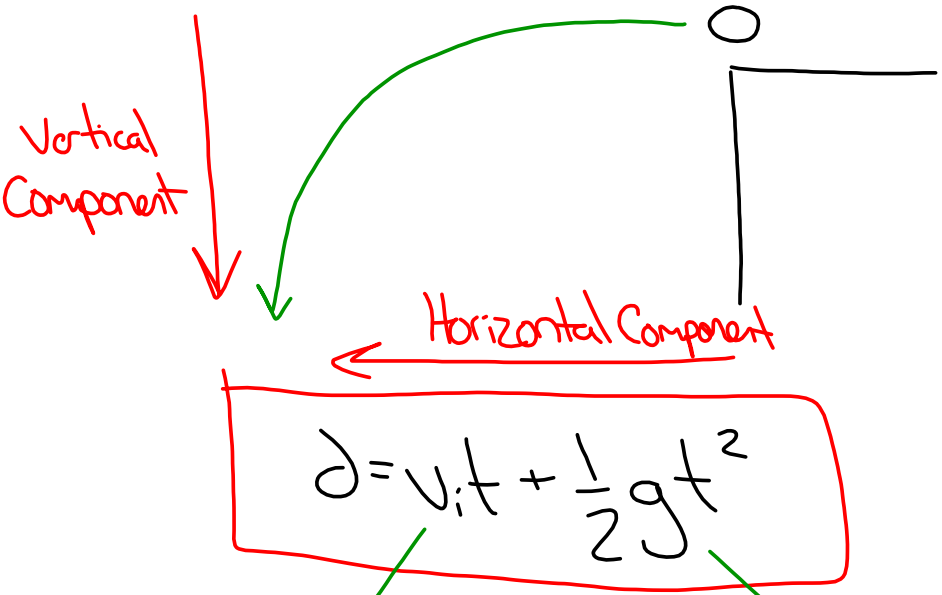
B) $v_f = v_i + gt$

$t = \frac{-v_i}{g} = \frac{-22}{-9.8}$

$t = 2.24\,s \times 2$

$t = 4.48\,s$

Throwing An Object Horizontally



$$d = v_i t + \frac{1}{2} g t^2$$

Horizontal

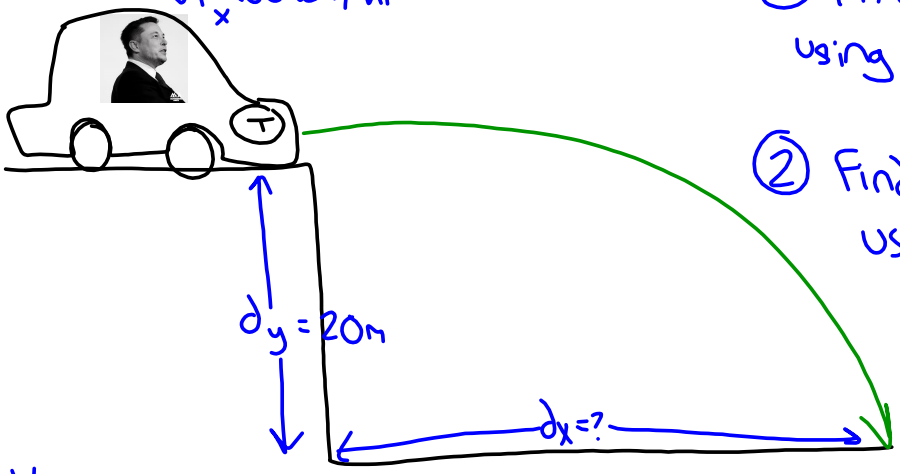
$d_x = v_{i_x} t$

Vertical

$d_y = \frac{1}{2} g t^2$

* Time is the same whether horizontal or vertical!

Ex. Elon Musk is driving his Tesla 100 km/hr over a cliff and (like his stock) the car continues to free fall until it crashes on the ground 20m below. (He shouldn't be using Twitter so much). How far from the base of the cliff did the car land?



① Find time (t) using vertical component

② Find d_x using horizontal component

$v_{ix} = 100\frac{km}{hr} \times \frac{1000m}{km} \times \frac{hr}{3600s}$

$v_{ix} = 27.8$ m/s

① $d_y = \frac{1}{2}gt^2$

$t = \sqrt{\frac{2d_y}{g}}$ $t = \sqrt{\frac{2(20)}{9.8}}$ $t = 2.02$s

② $d_x = v_x \cdot t$

$d_x = (27.8\text{ m/s})(2.02\text{ s})$

$d_x = 56.2$ m

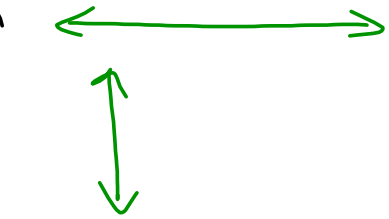
Recap: Kinematics

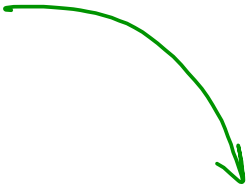
Horizontal Motion

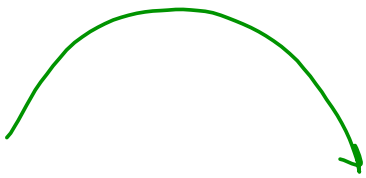
Vertical Motion

Throwing or Moving object from a height:

Projectile Motion







Projectiles

$$d = v_i t + \frac{1}{2} g t^2$$

Horizontal

$d_x = v_x \cdot t$

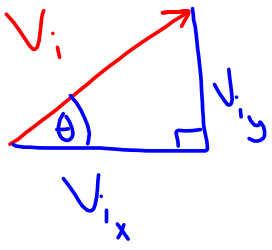
$t_x = t_y \rightarrow$ Time is constant

V_x stays constant

Vertical

$d_y = \frac{1}{2} g t^2$

For projectiles: An object will be launched at an angle
→ Vectors can be used!



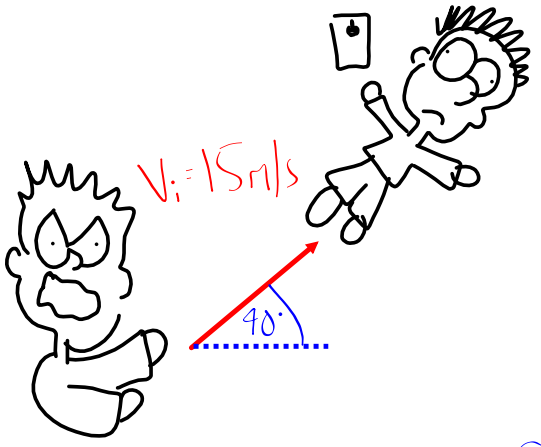
$\sin\theta = \frac{V_{i_y}}{V_i}$

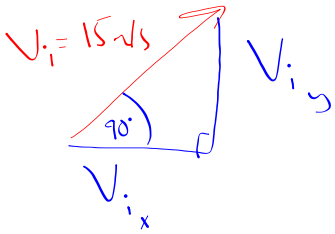
$V_{i_y} = V_i \cdot \sin\theta$

$\cos\theta = \frac{V_{i_x}}{V_i}$

$V_{i_x} = V_i \cdot \cos\theta$

Ex. A student was caught watching Snapchat videos on their phone while in Physics class and was thrown out of class at a speed of 15 m/s with an angle of elevation of 40 degrees. Calculate the horizontal and vertical velocities.





$V_{i_y} = V_i \cdot \sin\theta$

$= 15 \sin 40$

$V_{i_y} = 9.6 m/s$

$V_{i_x} = V_i \cdot \cos\theta$

$= 15 \cos 40$

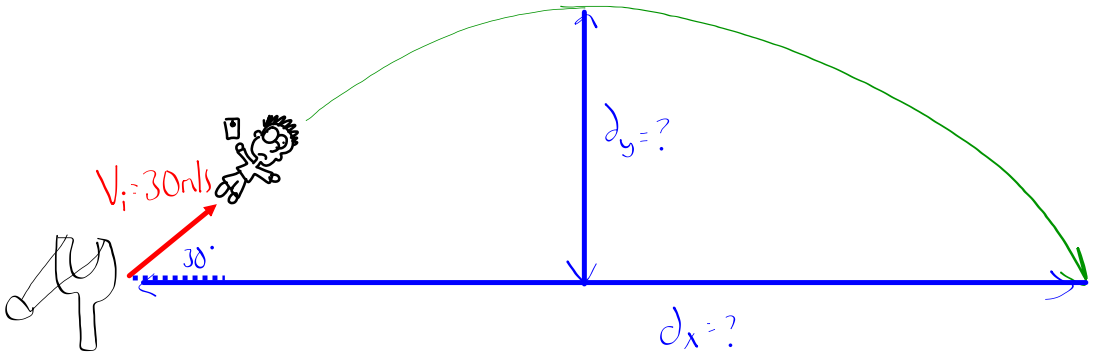
$V_{i_x} = 11.5 m/s$

Ex. A Giant slingshot fires the same student at a velocity of 30m/s at an angle of 30 degrees.

i) How high did the student go? ∂_y

ii) How long does it take to reach the max height? $t_{1/2}$

iii) What is the range of the student? ∂_x



$V_i = 30 m/s$, 30°

$V_{iy} = V_i \sin 30$

$V_{iy} = 15 m/s$

$V_{ix} = V_i \cdot \cos 30$

$V_{ix} = 25.98 m/s$

i) $\partial_y = ?$

$V_{iy} = 15 m/s$

$V_{fy} = 0$

$g = -9.8 m/s^2$

$V_f^2 = V_i^2 + 2g\partial$

$\frac{V_f^2 - V_i^2}{2g} = \partial$

$\frac{-(15)^2}{2(-9.8)} = \partial_y$

$\partial_y = 11.5 m$

ii) $V_f = V_i + gt_{1/2}$

$\frac{V_f - V_i}{g} = t_{1/2}$

$\frac{-15}{-9.8} = t_{1/2}$

$t_{1/2} = 1.53 s$

iii) $t_{total} = 1.53 \times 2$

$= 3.06 s$

$V_{ix} = 25.98 m/s$

$\partial_x = V_{ix} \cdot t$

$\therefore \partial_x = (25.98 m/s)(3.06 s)$

$\partial_x = 79.5 m$