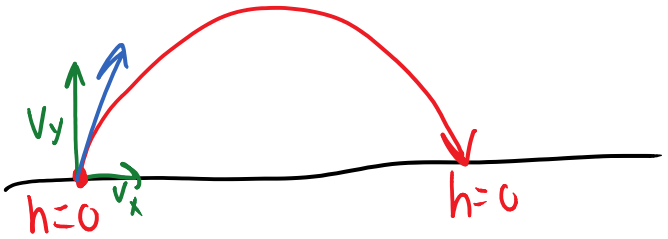
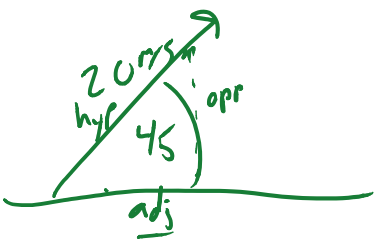
The Catapult and Trebuchet

Type I projectiles; we launched things starting out (ie: only an initial x-component). Now we can kick and launch a little more realistically! X and y will have starting velocities.



We use the same formulas and method to solve. We just have one pre-step. We need to take our initial velocity and break it into its 2 components (x,y components)

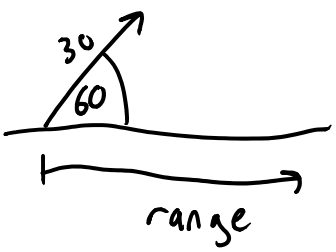


$V_{0x} = 20\cos(45)$

$V_{0y} = 20\sin(45)$

Gurk kicks soccer ball at 30m/s at an angle of 60° from the horizontal.

1) Find x,y components.
2) Find hang time (total time in air)
3) Find the range (distance travelled)



1) $V_x = 30\cos(60)$
$= 15$ m/s

$V_y = 30\sin(60)$
$= 26.0$ m/s

y

2) $d_y = V_{0y}t + \frac{at^2}{2}$

$0 = 26t - 4.9t^2$

$0 = t(26 - 4.9t)$

$0 = 26 - 4.9t$

$-26 = -4.9t$

$\frac{-26}{-4.9} = t = 5.3$ s.

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

$(5 + 10)$

$5(1+2)$

$\frac{-26}{-4.9} = t = 5.3\,s.$

3) $d = vt$
$= 15(5.3)$
$= 79.6\,m$

A golf ball is struck at 45m/s at an angle of 65° above the horizontal. How far does it travel (range)?

1) $V_x = 45\cos(65)$
$= 19$

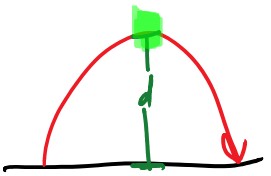
$V_y = 45\sin(65)$
$= 40.8$

$d = V_0 t + \frac{at^2}{2}$
$0 = 40.8t - 4.9t^2$
$0 = t(40.8 - 4.9t)$
$0 = 40.8 - 4.9t$
$\frac{-40.8}{-4.9} = t = 8.33\,s.$

$d = vt$
$= 19(8.33)$
$= 158\,m.$

What is the highest point that it reaches?

$V_f^2 = V_i^2 + 2ad$
$0 = 40.8^2 + 2(-9.8)d$
$-40.8^2 = -2(9.8)d$
$\frac{-40.8^2}{-2(9.8)} = d = 84.9\,m.$



At what time does it get there?

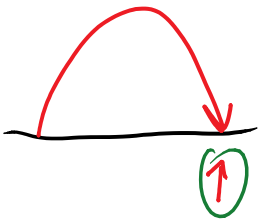
$V = at$
$V_f - V_i = at$
$0 - 40.8 = -9.8t$
$\frac{-40.8}{-9.8} = t = 4.16\,s$

4.16

What is v_x and v_y at this point?

$\rightarrow 19$ $\rightarrow 0$

What is v_f? at the end.

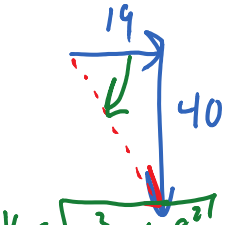


$v_{f_y}^2 = v_{i_y}^2 + 2ad$

$= 40.8^2 + 2(-9.8)(0)$

$v_{f_y}^2 = 40.8^2$

$v_{f_y} = -40.8$



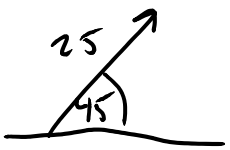
$v_f = \sqrt{19^2 + 40.8^2}$

$= 45 \text{ m/s}$

$\theta = \tan^{-1}\left[\frac{40.8}{19}\right]$

$\theta = 65°$

A catapult launches a watermelon at 25m/s at an angle of 45° from the horizontal. How far away can it hit the attacking zombie horde?



1) components

$V_x = 25\cos(45)$

$= 17.7$

$V_y = 25\cos(45)$

$= 17.7$

↓ $d = V_0 t + \frac{at^2}{2}$

$0 = 17.7t - 4.9t^2$

$0 = t(17.7 - 4.9t)$

$0 = 17.7 - 4.9t$

$\frac{-17.7}{-4.9} = t = 3.6\text{s}.$

x = range

$d = vt$

$= 17.7(3.6)$

$= 63.7\text{m}.$

You try:

Alley throws a ball at 12m/s at a 50° elevation.

A. hangtime?
B. range?
C. max height?

t=1.88s d_x=14.5m $d_{y\text{-}max}$=4.31m

Alternatively; you know how far away the approaching zombie army is, and you need to set up your trebuchet to hit them.

You are given a range, you must find θ,v_0. (many answers will work: a different answer for each valid θ.

The zombie horde is 1km away! Your trebuchet is set to launch at 50° elevation. What should we set v_0 to be?

Same problem: The zombie horde is 1km away, our trebuchet will launch at 250m/s. What θ should we select?