Kinematics
2 Dimensional Motion
Projectile Virtual Lab

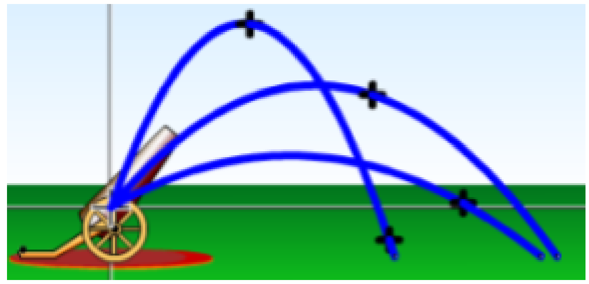
Name ___________________________

Period _____

Purpose – To investigate projectiles fired at angles.

An object is fired at a speed of 14 m/s at three different angles.

- **Label** the trajectories in the chart below on the diagram to the right as v_1, v_2 or v_3.
- **Resolve** each of the velocity vectors into horizontal and vertical components. (use trig)
- **Rank** the time of flight for each velocity on the diagram on the right (1 max time, 2, 3)



Velocity	Horizontal Component	Vertical Component	Time of Flight
v_1 = 14 m/s at 30°			
v_2 = 14 m/s at 50°			
v_3 = 14 m/s at 70°			

Launch the Projectile Motion simulation. http://phet.colorado.edu/en/simulation/projectile-motion

Choose the INTRO tab from the 1st screen
Adjust the cannon height by clicking on the + symbol on the cannon and dragging down until the height is 0 m.
Adjust the speed with the slider to 14 m/s then fire three projectiles at 30°, 50° and 70° (adjust angle by clicking on the cannon and dragging it to the correct angle). Keep all other initial conditions as given.

Circle either constant, changing or zero, draw an arrow in the direction of the velocity (if not zero) and give the value of the acceleration of the projectile while in the air. Ignore air resistance.
While the projectile is <u>ascending</u> its:

- horizontal velocity is constant/changing/zero and points _______ and the acceleration is _________
- vertical velocity is constant/changing/zero and points _________ and the acceleration is _________

When the projectile is at the <u>apex</u> its:

- horizontal velocity is constant/changing/zero and points _______ and the acceleration is _________
- vertical velocity is constant/changing/zero and points _________ and the acceleration is _________

While the projectile is <u>descending</u> its:

- horizontal velocity is constant/changing/zero and points _______ and the acceleration is _________
- vertical velocity is constant/changing/zero and points _________ and the acceleration is _________

Equation	Horizontal Motion	Vertical Motion
$v = \frac{\Delta d}{\Delta t}$		
$a = \frac{v_f - v_i}{\Delta t}$		
$\Delta d = v_i \Delta t + \frac{1}{2} a \Delta t^2$		
$a = \frac{v_f^2 - v_i^2}{2\Delta d}$		

In the chart above, check the box for the equations if they can be used in either horizontal or vertical motion.

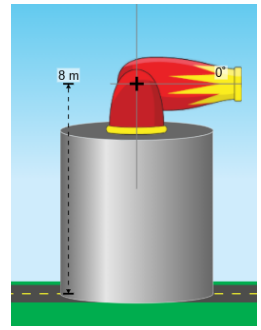
Which type of motion describes the horizontal equation(s) ___________________________

Which type of motion describes the vertical equation(s) ___________________________

What variable ties the horizontal and vertical equations of motion together? ______________________

Rewrite the equations below adding the subscripts "x" and "y" to the appropriate variables. Where appropriate replace the acceleration "a" with "g".

		Projectile Motion Equation	
Equation		Horizontal (X)	Vertical (Y)
$v = \frac{\Delta d}{\Delta t}$	becomes		
$a = \frac{v_f - v_i}{\Delta t}$	becomes		
$\Delta d = v_i \Delta t + \frac{1}{2} a \Delta t^2$	becomes		
$a = \frac{v_f^2 - v_i^2}{2\Delta d}$	becomes		



Launching a Projectile with a non-zero Starting Height and Horizontal
Make the angle of the cannon 0 degrees. Horizontal Projectile
Adjust the height to a few different heights and at each height try different speeds and observe the actions of a projectile that is not launched at ground level.

How does adding initial height with constant speed affect **flight time**? ___________

Why do you suppose this is? ____________________________________

____

What formula can we use that supports your explanation? ____________________

How does adding initial height with constant speed affect **maximum range**? _________________

Why do you suppose this is? ____

____

What formula can we use that supports your explanation? _______________________________

How does adding initial speed with constant height affect **flight time**? ______________________

Why do you suppose this is? ____

____

What formula can we use that supports your explanation? _______________________________

How does adding initial speed with constant height affect **maximum range**? _________________

Why do you suppose this is? ____

____

What formula can we use that supports your explanation? _______________________________

Consider this scenario and ignore air resistance. A pirate fires his cannon parallel to the water but 3.5 m above the water. The cannonball leaves the cannon with a velocity of 120 m/s. He misses his target and the cannon ball splashes into the briny deep. How far did the cannonball travel? *(please show work)*

	x	y
d		
v_0		
a		

t = ______

Launching a Projectile with a zero Starting Height and Angled velocity
Make the height of the cannon 0 meters.
Adjust the angle to a few different degrees and at each angle try different speeds and observe the actions of a projectile that is launched at ground level.

How does adding initial angle with constant speed affect **flight time**? ___________

Why do you suppose this is? ____________________________________

____

What formula can we use that supports your explanation? ____________________

How does adding initial angle with constant speed affect **maximum range**? _________________

Why do you suppose this is? ____

____

What formula can we use that supports your explanation? _______________________________

How does adding initial angle with constant speed affect **maximum height**? _________________

Why do you suppose this is? ____

____

What formula can we use that supports your explanation? _______________________________

How does adding initial speed with constant angle affect **flight time**? ______________________

Why do you suppose this is? ____

____

What formula can we use that supports your explanation? _______________________________

How does adding initial speed with constant angle affect **maximum range**? _________________

Why do you suppose this is? ____

____

What formula can we use that supports your explanation? _______________________________

How does adding initial speed with constant angle affect **maximum height**? _________________

Why do you suppose this is? ____

____

What formula can we use that supports your explanation? _______________________________

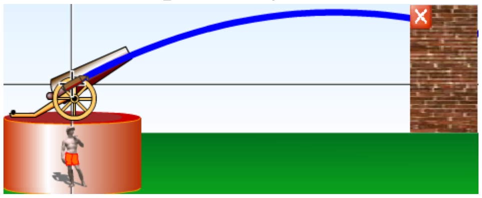
Symmetrical Trajectory (starting and ending height are the same)

A rival pirate fires his volley back at the same 3.5 m above the sea, but at an angle of 30^0. Coincidentally, this scurvy dog's cannon also fires at 120 m/s. This cannonball strikes the other boat at 3.5 m above the sea (so the vertical displacement is zero. How far did this cannonball travel? *(please show work and use the xy chart)*

	x	y
d		
v_0		
a		

t = ______

The Interrupted Projectile (that hits something on the way)



Many projectiles don't complete their entire travel to the ground. We may need to calculate the range of a projectile that lands on a hill above ground or the height when the projectile stuck its mark.

How would the flight time of a projectile that lands ABOVE the height it was launched compare to the flight time of a ground-to-ground projectile____

Why is this? ____

____

What formula can we use that supports your explanation? _________________________

OK, one last pirate scenario. A pirate 50.0 m away from a tall ship wants to shoot the crow's nest off this ship. She angles her cannon at 25^0 and fires; her cannonball leaving at only 68 m/s. Somehow, the lass pegs the crow's nest. How high was the crow's nest? *(please show work)*

	x	y
d		
v_0		
a		

t = ______