Name _____

Date _____

PhET Vector and Projectile Motion Inquiry Activity

Introduction – You will use a computer simulation today to reinforce your ideas of vectors, acceleration and velocity. You will also start to investigate what projectile motion is. Since this is "inquiry based", you're not supposed to know everything going in, but learn as we walk through the lesson. **You must read all instructions carefully to get full credit.**   Let's get started!

Website : https://phet.colorado.edu/en/simulation/projectile-motion

Click on the "play" icon, then double click on "Vectors"
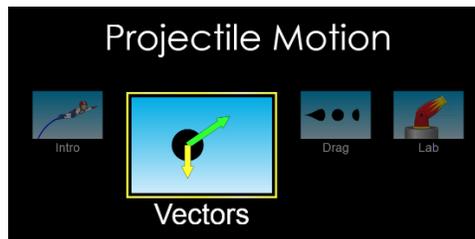
Initial setup and explanation

You'll see a cannon on the left of your screen. To fire the cannon, click the red button at the bottom of the screen. To reset the cannon, click the yellow "erase" button at the bottom of the screen.

You can change the angle of the cannon, and adjust its initial speed. We'll get to this in a few minutes.

Initial setup and investigating gravity

1. Uncheck the "air resistance box". Set the following: diameter = 0.8m, mass 5 kg, initial speed = 18 m/s and the cannon angle = 45º. Click the "slow" button at the bottom to watch the simulation more carefully.

2. Click the box that says "acceleration vectors"

3. Fire the cannon. You will see the cannonball leave the cannon, with an acceleration vector.

4. What is the direction of the vector?

5. What does this vector represent?

6. What do you observe about the length of the vector throughout its flight?

7. What does this tell you about the **direction and magnitude** of the acceleration acting on the cannonball throughout its duration of flight?

8. What do you predict will happen to the acceleration vector if we change the angle of the cannon?   Why do you think that?

Change the angle of the cannon to 65⁰. Fire the cannon at this new angle. Keep everything else the same. (Remember, click on the "slow" button to slow the simulation down)

9. What did you notice about the acceleration vector at this new angle?

10. What was different about the vector (if anything) compared to the 45⁰ angle. Move the cannon back to 45⁰ if you need to check or verify

11. Was your prediction correct about the acceleration vector at this new angle?

Change the angle of the cannon to 90⁰. Fire the cannon at this new angle. Keep everything else the same. (Remember, click on the "slow" button to slow the simulation down)

12. What did you notice about the acceleration vector at this new angle?

13. What was different about the vector (if anything) compared to the 45⁰ or 60⁰ angle? Move the cannon back to 45⁰ or 60⁰ if you need to check or verify anything.

14. Summary: What have you discovered about the acceleration due to gravity of an object in flight with regards to the angle of launch?

Change the angle of the cannon to 45º. Click the "slow" button. Fire the cannon and observe the acceleration vector. Now change the initial launch speed to 25 m/s. Fire the cannon again.

15. What did you observe about the acceleration vector when you fired it at the new speed? Was it any different from the initial speed?

Click the yellow erase button and unclick the acceleration vectors box. Click the "velocity vectors" box. Click on "components" just above it. This will track velocity in both the x and y directions.

Set the cannon to 60º and the initial velocity to 15 m/s. Click "slow" if you haven't already. Fire the cannon. Click erase and fire multiple times if necessary.

16. What do you notice about the velocity vector in the y direction? Describe what happens to its length and direction throughout the flight? Be specific

17. At what point does it seem like there is no velocity vector in the y direction?

18. Describe in your own words what is happening to the velocity in the y direction as the cannonball leaves the cannon and flies through the air.

19. What do you notice about the velocity in the x direction?

20. Why do you think this isn't changing? (Hint: What is affecting the velocity in the y direction, but not the x direction?)

Predicting and calculating

Imagine a cannon was shooting at an initial velocity of 20 m/s at 75⁰ above the horizontal. We are going to predict its range and check with the simulation.

Draw the scenario below:

<u>Using the sin and cosine functions, calculate V_x and V_y. Show all work</u>

<u>We will use the following formula to calculate the time to the top of the flight path:</u>

$V_f = V_y + at$

Since at the top of the flight, the $V_f = 0$, we have

$0 = V_y + at$

$-V_y = at$

$t = - (V_y / a)$ (Remember, a = -9.81 m/s^2)

Using the bold formula above, acceleration due to gravity = -9.81 m/s^2, and your v_y that you calculated above, solve for (t). Show all work.

The value you just solved for is *half* of the time the ball is in the air. (Remember, it's just to the top of the flight path). So take your time and **double** it. Show below:

Now, you solved for the total time in flight. Next, we'll solve for distance in the x direction. We'll use the following formula:

$v_x = d_x / t$

Rearranging for distance we get:

$d_x = v_x * t$

Using your v_x that you calculated above, and the TOTAL flight time (the one you doubled), calculate the distance in the x direction. Show work below:

Checking your prediction:

Set the cannon up to 20 m/s at 75⁰. Move the red and white target to your predicted distance in the x direction. Fire the cannon.

Did you hit the target?

Complete the calculations again using an initial launch speed of 30 m/s and an initial launch angle of 85⁰. Check your results with the simulation. Show all work below