

Projectile Motion (Intro) PhET Simulations Lab

Introduction:

Projectiles travel with two components of motion, X any Y. The acceleration and velocity in the Y direction is independent of the acceleration (if any) and velocity in the X direction. In this module, you will investigate the motion of a simple projectile. Realize that while gravity (acceleration) acts on the projectile in the _____ direction, it does not affect the velocity of the projectile in the _____ direction.

Procedure: (we will be ignoring air resistance during this lab)

- Run the PhET Projectile Simulation:
http://phet.colorado.edu/simulations/sims.php?sim=Projectile_Motion
- The cannon can be moved to add or remove initial Y position and X position.
- The cannon can be pivoted to change the firing angle, θ .
- The tape measure can be moved and dragged to measure range to target.
- To fire the cannon, .
- To erase the projectile's path, .



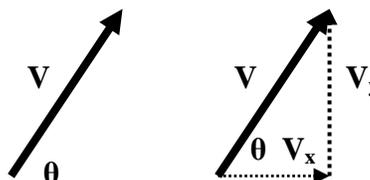
Be sure **air resistance is off** and spend some time firing various projectiles.

- Set the initial speed to a value between 10-15m/s. Choose your favorite projectile.
- Find the range of the projectile at various angles.

$\theta = \underline{30}$ Range (dx) = _____ m	$\theta = \underline{70}$ Range (dx) = _____ m
$\theta = \underline{40}$ Range (dx) = _____ m	$\theta = \underline{80}$ Range (dx) = _____ m
$\theta = \underline{50}$ Range (dx) = _____ m	Add two more \rightarrow
$\theta = \underline{60}$ Range (dx) = _____ m	$\theta = \underline{\quad}$ Range (dx) = _____ m

- Measure the distance from the cannon to the target using the tape measure.
- Move the target to 21.0 m from the cannon. Attempt to hit the target with three different angles by changing the firing angle and initial velocity.

Range (d_x) = 21.0m	$\theta = \underline{\quad}$	Vi = _____	
Range (d_x) = 21.0m	$\theta = \underline{\quad}$	Vi = _____	
Range (d_x) = 21.0m	$\theta = \underline{\quad}$	Vi = _____	



VERY IMPORTANT

- ❖ A projectile's velocity (v) has an X component (v_x) and a Y component (v_y). The X component (v_x) is found by multiplying the magnitude of the velocity by the *cosine* of the angle, θ .
- ❖ Similarly, the Y component of velocity is found by multiplying the magnitude of the velocity by the *sine* of the angle, θ .

$v_x = v \cos \theta$

$v_y = v \sin \theta$

So, a projectile fired at **20 m/s** at **65°** has an X-velocity of $v_x = 20 \cos 65$ or **8.5 m/s**.

The projectile would have a Y-velocity of $v_y = 20 \sin 65$ or **18 m/s**.

So, the projectile would fire as far as one fired horizontally at 8.5 m/s and as high as one fired straight up at 18 m/s.

A projectile fired at 30 degrees with a velocity of 15 m/s would have an x-velocity component of _____ m/s and a y-velocity component of _____ m/s.

Calculate the components of the following projectile's velocities:

- | | |
|---|---|
| 1. $v = 35 \text{ m/s}$ $\theta = 15^\circ$ $v_x = \underline{\hspace{1cm}}$ $v_y = \underline{\hspace{1cm}}$ | 4. $v = 35 \text{ m/s}$ $\theta = 60^\circ$ $v_x = \underline{\hspace{1cm}}$ $v_y = \underline{\hspace{1cm}}$ |
| 2. $v = 35 \text{ m/s}$ $\theta = 30^\circ$ $v_x = \underline{\hspace{1cm}}$ $v_y = \underline{\hspace{1cm}}$ | 5. $v = 35 \text{ m/s}$ $\theta = 75^\circ$ $v_x = \underline{\hspace{1cm}}$ $v_y = \underline{\hspace{1cm}}$ |
| 3. $v = 35 \text{ m/s}$ $\theta = 45^\circ$ $v_x = \underline{\hspace{1cm}}$ $v_y = \underline{\hspace{1cm}}$ | 6. $v = 35 \text{ m/s}$ $\theta = 90^\circ$ $v_x = \underline{\hspace{1cm}}$ $v_y = \underline{\hspace{1cm}}$ |

- ❖ We can reverse the process and combine the two components of velocity back into one velocity fired at an angle.
- ❖ The magnitude of velocity is found using the Pythagorean Theorem with v_x and v_y as the legs of a right triangle. For instance, the velocity of a projectile with an x-component of 7.2 and a y-component of 4.8 is $\sqrt{7.2^2 + 4.8^2} = 8.7 \text{ m/s}$.
- ❖ The angle above the horizontal is found using the inverse tangent (\tan^{-1}) of the legs v_y/v_x . For instance, the angle of the projectile described above would be $\tan^{-1}\left(\frac{4.8}{7.2}\right) = 34^\circ$.

Calculate the velocity magnitude and angle of the projectiles listed below:

- | | |
|---|--|
| 7. $v_x = 5.6$ $v_y = 6.4$ $v = \underline{\hspace{1cm}}$ $\theta = \underline{\hspace{1cm}}$ | 9. $v_x = 8.1$ $v_y = -7.2$ $v = \underline{\hspace{1cm}}$ $\theta = \underline{\hspace{1cm}}$ |
| 8. $v_x = 2.8$ $v_y = 4.9$ $v = \underline{\hspace{1cm}}$ $\theta = \underline{\hspace{1cm}}$ | 10. $v_x = -1.3$ $v_y = -5.2$ $v = \underline{\hspace{1cm}}$ $\theta = \underline{\hspace{1cm}}$ |

Conclusion Questions:

1. Without air resistance, the piano travels *further / the same distance* as the football. (circle)
2. This is due to the fact that velocity in the X-direction *increases / is constant / decreases* as projectiles travel.
3. The Y-component of velocity *increases / is constant / decreases* as projectiles travel.
4. The answers to #2 and #3 are due to the fact that gravity acts *only in the Y / both the X any Y* direction.
5. The path of a projectile is a *linear curve / round curve / parabolic curve*.
6. This is due to the fact that the time component in the free fall equation (dy) is _____.
7. Without air resistance, maximum range of a projectile is obtained with an angle of _____.
8. The same range can be obtained with angles of _____ and _____.
9. Firing a projectile at 25 m/s at an angle of 35° is similar to firing a projectile with a speed of _____ straight up and _____ horizontally.
10. A projectile with a horizontal component of 13 m/s and a vertical component of 18 m/s would have an overall velocity of _____ m/s at an angle of _____ above the horizontal.