Angle-Launched Projectiles

Goal: To understand the conceptual nature of the motion of an angle-launched projectile.

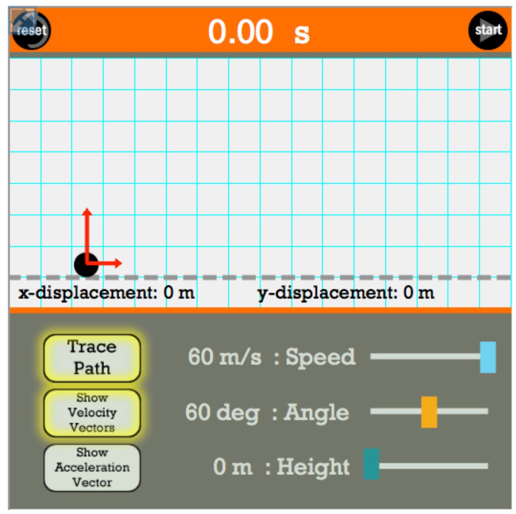
Background: A projectile is an object that is projected or launched into the air and then moves through the air under the sole influence of gravity. In this sense, a projectile is a free-falling object that experiences a downward acceleration of 9.8 m/s/s.

Getting Ready: Navigate to the Projectile Simulator in the Physics Interactives section of The Physics Classroom website:

http://www.physicsclassroom.com/Physics-Interactives/Vectors-and-Projectiles/Projectile-Simulator

Path:
physicsclassroom.com => Physics Interactives => Vectors and Projectiles => Projectile Launcher

Once the Interactive opens, resize it to whatever size you wish. Then set the **Speed** to 60 m/s. Set the **Angle** to 60 degrees. Set the **Height** to 0 m. Enable **Show Velocity Vectors** and **Trace Path**; they should be highlighted in yellow.



Directions and Questions:

1. **Horizontal and Vertical Velocity**
   Click the **Start** button and observe the simulation. The red arrows are velocity vectors. They are indicators of how fast the object is moving horizontally and vertically. The length of the arrow indicates how fast the object is moving in that direction. Describe the horizontal and the vertical velocity:

   The horizontal velocity (v_x) is ____________________ (constant, changing) and the vertical velocity (v_y) is ____________________ (constant, changing).

2. **Vertical Velocity at Peak**
   Carefully observe the vertical velocity vector as the projectile approaches the highest point (i.e., the *peak*). At its highest point, the vertical velocity is ______.
   a. zero   b. large and downward   c. large and upward   d. the same size as at t=0.0 s

3. **Time to Rise and Time to Fall**
   As the simulation runs, the time is displayed at the top of the Interactive. If the **Pause** button is pressed, arrows appear next to the time to step the simulation forward or backward. Use these controls to measure the time it takes to rise to the peak, the total time in the air, and the time it takes to fall from the peak. Record to the first decimal place.

   t_{rising} = __________ s t_{total} = __________ s $t_{falling}$ = __________ s

   Analyze these measurements and make a generalized statement about t_{rising} and $t_{falling}$.

4. Anna Litical makes the following claim:

   The vertical velocity (v_y) 1.0 second before reaching the peak is the same size as the vertical velocity (v_y) 1.0 second after reaching the peak. The same is true of the $\mathbf{v_y}$ values 2.0 seconds before and after the peak.

   Do you agree or disagree with Anna's claim? _______________ Perform some trials and support your answer the evidence and reasoning.

5. **Size and Direction of the Acceleration**
   Enable the **Show Acceleration Vector** option and run the simulation several times in order to answer the following three statements:

   The acceleration of a projectile is _______. Circle all that apply.
   a. constant b. changing c. decreasing as it rise d. increasing as it falls

   The direction of a projectile's acceleration is always ______.
   a. in the direction that it is moving b. opposite the direction it is moving c. downward

   When at its highest point, the acceleration is ______.
   a. zero b. large and downward c. large and upward d. the same size as at t=0.0 s

6. **Angle for Maximum Range**
   Vary the launch angle, make measurements and answer the following two questions.

   What launch angle results in the greatest *range*?

   State a rule that describes what pair of launch angles could be expected to result in the same x-displacement or range.

Angle (°)	x-displacement (m)
15	
25	
35	
40	
45	
50	
55	
65	
75	