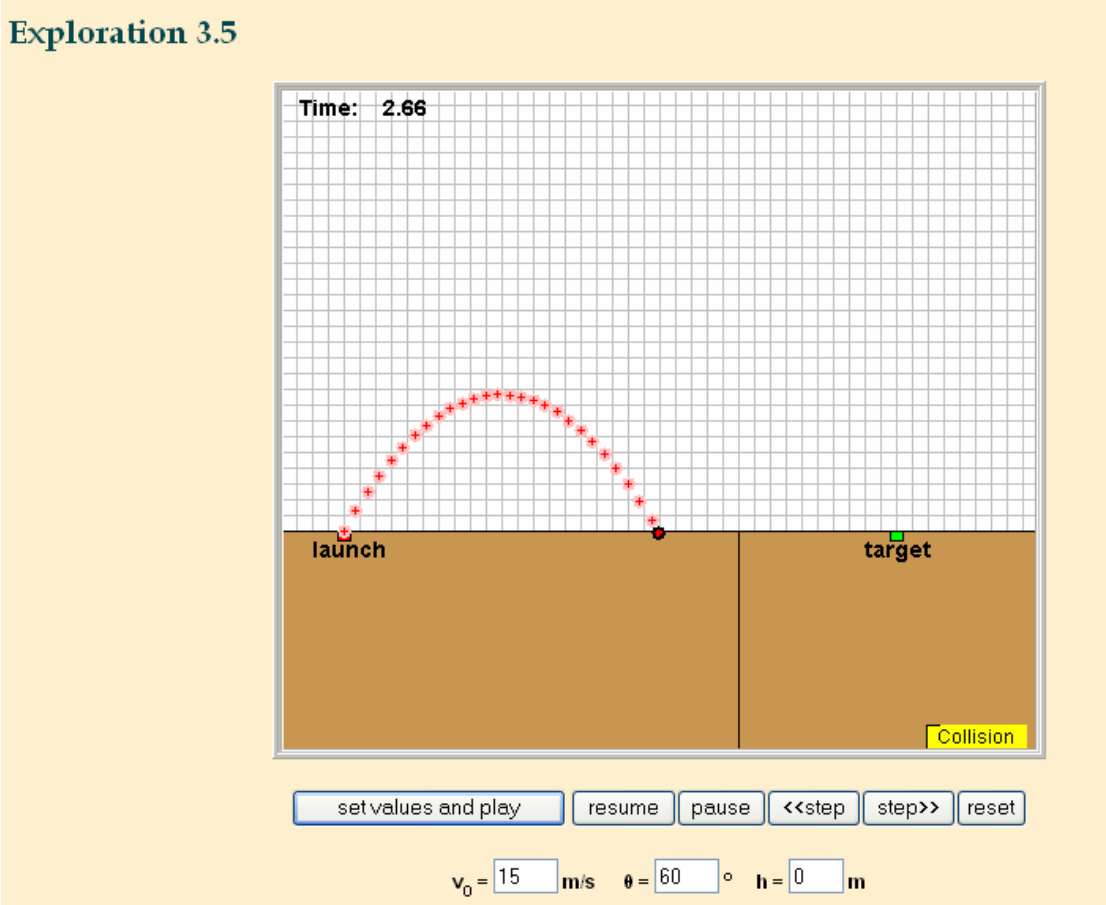
Worksheet for Exploration 3.5: Uphill and Downhill Projectile Motion



A projectile is launched at t = 0 s (**position is given in meters and time is given in seconds**). You may change the projectile's launch angle and initial speed and the height of the hill by using the text boxes and clicking the "set values and play" button. Restart.

For h = 0 m, vary the projectile's launch angle and initial speed and consider the following questions.

a. For a given initial speed, what launch angle will provide the maximum range of the projectile?

   i. The angle you are finding is the angle of the initial velocity vector. On the above figure sketch the direction of the initial velocity vector and indicate the angle.

   ii. Indicate velocity vectors at other times on the figure (say at the peak). What is the angle of the velocity vector when the object is at the peak?

   iii. Draw a position vector for the object at the peak. Does this have the same angle, magnitude, or units as the others?

iv. Now you should be ready to play with changing the angle of the initial velocity vector.

measured $\theta_{v \text{ initial max range}}$=_____

v. You should be able to determine how to find this angle using equations from your text or instructor. Do so. If you use a "canned" formula called the range formula you should know how this derives from the basic kinematic equations. Find and write out the range formula (only valid for h=0, where h means a change in height here).

Range formula:

vi. To find the angle for the initial velocity vector that gives the maximum range consider the trig functions you see in this formula. What is the maximum value it has, and at what angle (careful)?

Theoretical $\theta_{v \text{ initial max range}}$=_____
from range
formula

b. For the value of launch angle in (a), what is the value of the initial speed that will hit the target?

i. In the animation measure the range from launch to the target (horizontal displacement) using the mouse click measurements.

Range=_____

ii. Now use the range formula to predict your initial launch speed.

Predicted v_o=

iii. Try out your prediction. Does it work?

c. What other value(s) of the projectile's launch angle and initial speed will enable the projectile to hit the target?

i. Use the range formula to try several values of initial launch speed and launch angle. Make a short table of predictions.

v_o	$\theta_{v\ initial}$	Check if measurement agrees

d. Are these values unique?

e. What is the general relationship between launch angle and initial speed?

i. Hint: You should know this from the above investigations.

For h = 10 m, vary the projectile's launch angle and initial speed and consider the following questions.

f. For a given initial speed, what launch angle will provide the maximum horizontal displacement of the projectile?

g. What value(s) of the projectile's launch angle and initial speed will enable the projectile to hit the target?

h. Are these values unique?

i. Are these values the same as in (c)?

For h = -10 m, vary the projectile's launch angle and initial speed and consider the following questions.

j. For a given initial speed, what launch angle will provide the maximum horizontal displacement of the projectile?

k. What value(s) of the projectile's launch angle and initial speed will enable the projectile to hit the target?

l. Are these values unique?

m. Are these values the same as in (c) and (g)?