Name:________________________ Group: ______________ Section:________

Lab 2: Phet Simulation – Projectile Motion
Phet simulations are simulations on all sorts of topics (not just physics) that come from the University of Colorado - Boulder

To find the simulation, either Google "Phet simulation projectile motion" or go directly to this link: http://phet.colorado.edu/en/simulation/projectile-motion

Click "Intro." When the simulation opens, hit the "Fire" button. ***Spend 5 minutes just playing with the simulation to see what it can do.***

Click the red button to fire the cannon. Click-and-drag on the target to move it horizontally to the impact point on the ground. Choose your favorite projectile…does it matter which one you choose?

Now draw a diagram of the situation in the box to the right, labeling all relevant quantities.

Finding *g*: Use these settings - an angle of 60° and an initial speed of 18 m/s. Come up with a strategy to verify what value the simulation is using for *g*. Note that the simulation has a helpful blue measurement tool which, when placed on one of the dots, tells you the time, horizontal position, and vertical position for that point on the trajectory. Describe your strategy here, detailing the steps:

Compare strategies with the other students in your group. Then verify the value the simulation is using for *g*. It's a good idea for each member of the group to do a calculation (maybe even different ways) so you can double-check your method. Show your work here.

For the rest of the lab, have the simulation in “Lab” mode.

Predict: What will happen to the range when you double the velocity?

<u>Range versus initial speed:</u> <u>Experiment 1:</u> How does the initial speed affect the range of the projectile? Set the angle to 60 degrees. Find the range for several different values of initial speed (make sure you get values over the whole range of initial speeds available). Fill out the table and make a plot:

v_i (m/s) (plot on x-axis)	Range (m) (plot on y-axis)
0	

Were you correct in your prediction? Explain.

How does the range vary with launch speed? It is a linear relationship?

Maximizing the range – You may want to hit the magnifying glass with the minus sign in it, a couple of times, to zoom out a little for this part. Predict what initial angle will produce maximum range (range is the total horizontal distance traveled by the projectile), in the case when the projectile lands at the same level it was launched from.

What is your predicted value of the initial angle? _____

Range versus launch angle - Experiment 2: Fix v_i to be constant and fill the table and plot the range for several values of θ. Again, get values from the whole range of angles available to you. You can use the measurement tool – place it on the impact point to read the range, height, and time for the projectile.

θ(deg.) (x-axis)	Range (m) (y-axis)

Was your prediction correct?

Reset the initial speed to 18 m/s and set the angle to 25 degrees. Move the target so the projectile lands on it. Make a prediction of a different launch angle that will also allow you to hit the target.

Predicted launch angle: _________
Briefly explain your prediction:

Check your prediction with the other members of your group. Come up with a group consensus on the value of the launch angle that will allow the projectile to hit the target.
What is your predicted value? ______

Did you successfully hit the target? [ ] Yes [ ] No

If not, repeat the process until you successfully predict a value of the launch angle that will allow you to hit the target.

Derive Range Equation: Now you're going to find an equation for the range (defined as the x displacement of the projectile when it reaches y=0) for a cannon firing from y=0. Leave everything as variables, such as v_i for the initial velocity, and θ for the launch angle. After you are confident in your equation you must be able to predict where the projectile will land on the first try.

1. Write out an equation that gives the horizontal position of the object as a function of time.

2. Is the total time the object spends in flight determined by what's going on horizontally or what's going on vertically? Come up with an expression for the total time the object spends in flight (the time it takes the object to return to the level from which it was launched), in terms of v_i and θ.

3. Substitute your expression from 2 into your equation in 1, which should produce what we call the range equation – an equation that tells you how far horizontally the object travels, in terms of v_i and θ. You may find the following relation useful: $\sin\theta\cos\theta = \frac{1}{2}\sin(2\theta)$.

4. In particular, how does the range depend on v_i? Does this match your results from the first experiment? Explain.

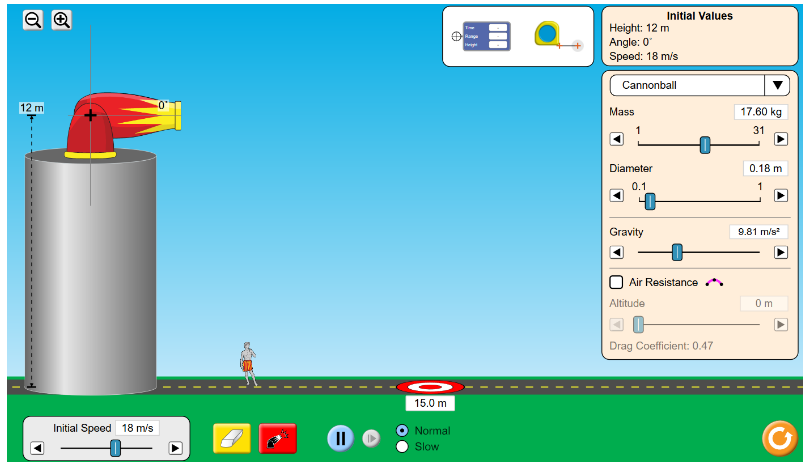
5. Does your equation agree with your results from the second experiment? Explain.

<u>Assessment:</u> Once you have completed this part, call an instructor over. They will set the angle and initial speed of the cannon. Using the equation you derived in the previous step, move the target so that the projectile hits it on the first try.

Did you succeed? [ ] Yes [ ] No

If not, what went wrong?

Varying Launch Height: Now, re-set the cannon so that it launches projectiles from much higher than the target. Click and drag on the support at the bottom left of the cannon, dragging it vertically upward and somewhat to the left, and then set the launch angle to 0°, so the projectile is launched horizontally. The simulation should now look something like this:



Using the measurement tool:

Measure the horizontal distance from the origin to the target: ___________

Measure the vertical distance from the origin to the target: ___________

Now, with the launch angle at 0°, predict what the initial speed should be so that the projectile hits the target. Show your work for this prediction here:

Check your prediction with the other members of your group. Come up with a group consensus on the value of the initial speed that will allow the projectile to hit the target. What is your *group* predicted value? ______

Now run the experiment. Did you successfully hit the target? [ ] Yes [ ] No

If not, repeat the process until you successfully predict a value of the initial velocity that will allow you to hit the target.

Experiment with different launch speeds. What is the significance of the small circles that the simulation places on the trajectory?

What do you notice about those symbols in this case, with the different launch speeds?

Now, set the launch angle to 30°, and again predict what the initial speed should be so that the projectile hits the target. Show your work for this prediction here:

Check your prediction with the other members of your group. Come up with a group consensus on the value of the initial speed that will allow the projectile to hit the target.

What is your *group* predicted value? _______

Did you successfully hit the target? [ ] Yes [ ] No

If not, repeat the process until you successfully predict a value of the initial velocity that will allow you to hit the target.

Maximizing the range for varying launch height – You may want to hit the magnifying glass with the minus sign in it, a couple of times, to zoom out a little for this part. Predict what initial angle will produce maximum range (range is the total horizontal distance traveled by the projectile), in the case when the projectile lands at a lower level from where it is launched. This angle is:

[ ] smaller than before [ ] same as before [ ] larger than before

Try it to see what happens, and explain the result you get.