PY 105

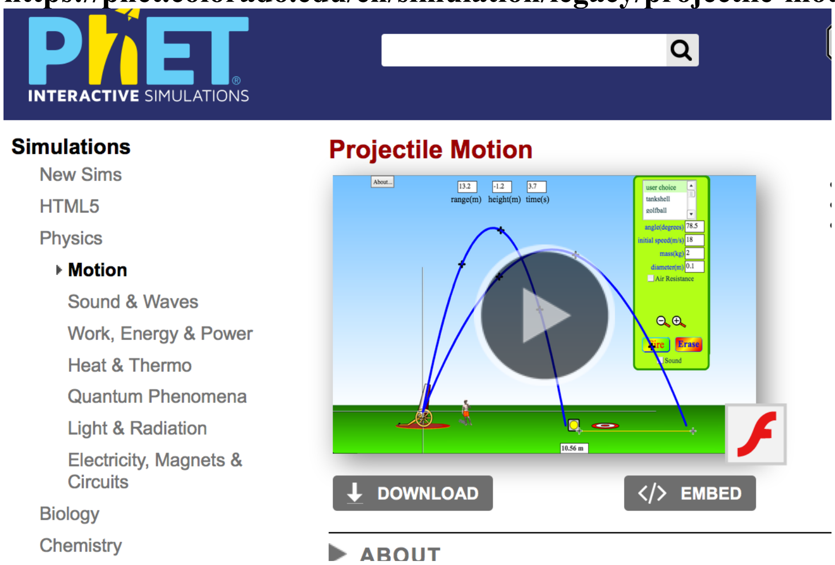
Lab 3: 2-D Kinematics

Section: Name: ___________________________________ BU ID: ________________ .

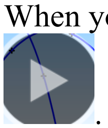
Partner: Name: ___________________________________ BU ID: ________________ .

Part I: Playing with a projectile.

In this part you will use a Java applet to reinforce some concepts related to a projectile motion.
Enter into your web browser on the link below (the copy of the link is in file py105labweblinks.doc)
https://phet.colorado.edu/en/simulation/legacy/projectile-motion



When you see the Phet home page with the picture of a Projectile Motion App, click on the Play button



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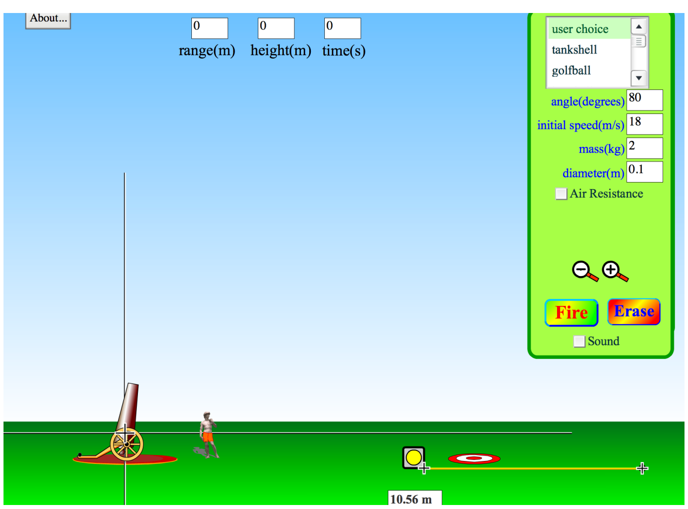
You will see a screenshot similar to the one below.



Do not make any changes yet, just make a shot by clicking on

button to check that your PC has working Java.

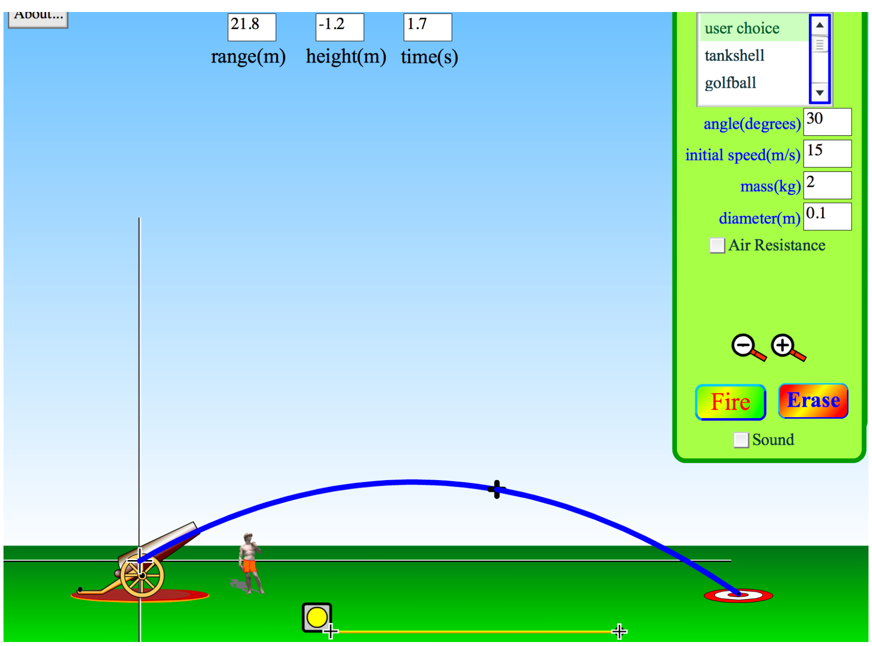
If you see the trajectory, you are all set, otherwise you should call your TF and ask for a different PC.

1. Set the launch angel to 90 degrees, the initial speed to 15 m/s, the mass to 1 kg, the diameter to 0.1 m. Note that the ball starts its motion 1.2 m above the ground. For the given values of the parameters (and g = 9.81 m/s^2), calculate the total time of the ball.

Now make a shot and compare calculated time with the one on the screen (at the top edge of the applet).

Comment. ____

Change the values on the right, make angle = 30^0, initial speed = 15 m/s, mass = 2 kg, diameter = 0.1 m, and make a shot again. Then drag the target to the right to the landing point of the ball (see the picture below).



Click  to erase the trajectory.

2. Predict: if you change the mass of the ball, will it affect the trajectory?

[ ] yes [ ] no [ ] it might depend on other parameters__________________________

Change the mass of the ball and check your prediction. Comment___________________________

3. Predict: if you change the the initial speed of the ball to 10 m/s, how will it affect the trajectory (where will the cannon ball fall, how high will it go above the ground)?

____

Change the initial speed of the ball and check your prediction. Comment___________________________

4. Set the initial speed back to 15 m/s and change the angle to 40^0. Predict, if you make a shot now, where will the cannon ball fall, and will its maximum height be affected?

____

Change the settings as required and check your prediction. Comment___________________________

5. Keep the launch angle set to 40^0. Calculate the new launch speed required to hit the target (note, you also can use a measuring tape and reading at the top of the applet to get more data).

v_0 = ____

Change the settings as required and check your prediction. Comment___________________________

Part II: Projectile Motion experiment

Attention! Please be very careful with using spring guns and long meter sticks: do not jab your fingers in a spring gun, do not shoot when people are close to the trajectory of a ball, do not accidentally hit people with a meter stick.

APPARATUS

❑ Spring gun set-up ❑ Spring gun ball
❑ Gun mounted on frame w/ protractor ❑ Bar level
❑ Hook collar w/ pointer ❑ Two-meter stick
❑ 2 Bench clamps ❑ Plumb-bob
❑ 2 Aluminum bar supports w/ wing nut ❑ Masking tape
❑ Short rod ❑ Paper

EXPERIMENT

The experiment consists of measuring the range R of a small ball fired from a spring gun at various angles from the vertical. The apparatus (see Fig. 1) allows both the angle of projection and the initial velocity to be varied. (Note: Do not load or fire the spring gun until its use has been described and demonstrated by your instructor) The angle of projection is measured with a protractor, and the initial velocity can be varied by adjusting the tension on the spring with the adjusting knob on the back of the gun (the spring tension should be set so that the range, when fired horizontally, is between one and two meters; do NOT change the spring tension: if you need to do it, call your TF). After the instructor has demonstrated the use of the gun, load it and fire a few practice shots. Practice firing the gun the same way each time to minimize the variation in initial velocity.

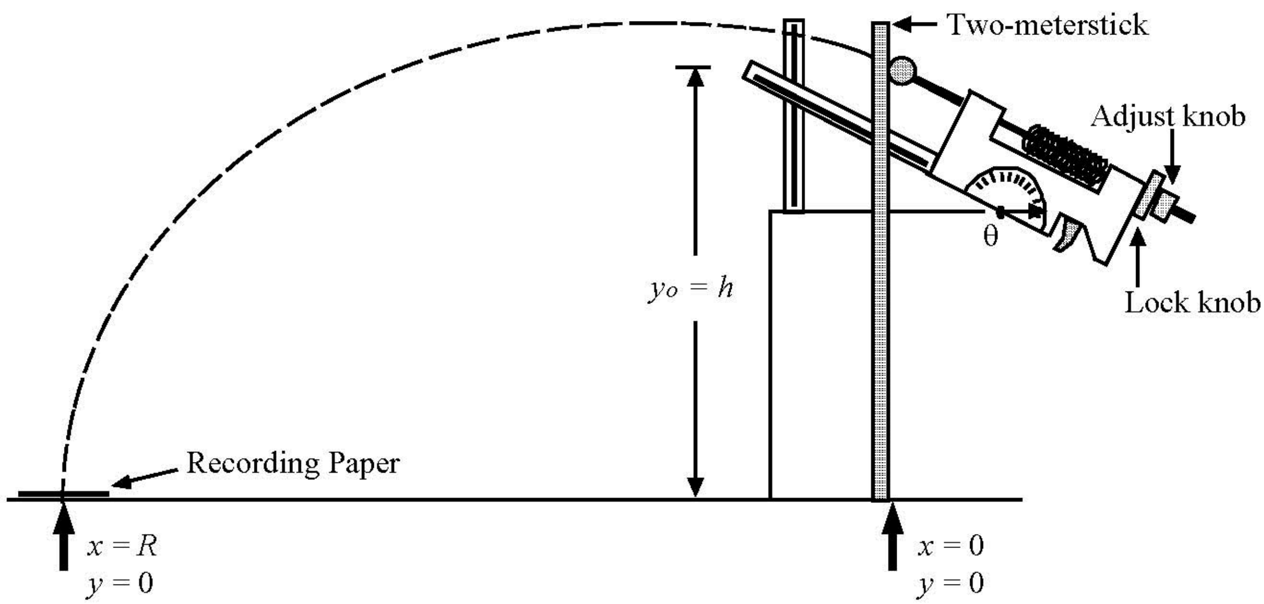


Figure 1: The spring gun setup.

PROCEDURE

A. Determining the initial speed of the ball.

1. Set the gun into the horizontal position. Level the gun using the level provided. Tighten the knurled brass screw. Now adjust the pointer so that it indicates 0°. Leave the gun in this position and be sure all screws and clamps are tight.

2. Use a plumb bob to locate the point on the floor directly under the point where the ball leaves the gun. Mark this point on a piece of paper or tape fastened to the floor. Measure the height h of the ball from the floor. Note that this point and this height change as the angle is varied.

3. Determine the approximate range of the ball by firing the gun a couple of times (place a backstop beyond the landing point to protect innocent passersby). In order to measure the position at which the ball strikes the floor, tape a sheet of paper to the floor such that the ball strikes the paper approximately in the center.

4. Fire ten shots; circle and number the impact positions on the sheet on the floor. If the positions are spread so much that they do not all hit the paper, check that everything is tight and that each time you use the same technique to project the ball. If one range is far from others, do not write it down, exclude this measurement as having some unexpected error.

5. Determine the range, R, by measuring the distance from the spot under the gun (x = 0 and y = 0) to the marks on the recording sheet. Calculate the average value of the range.

#	1	2	3	4	5	6	7	8	9	10	Ave
R											

6. Use your data to calculate the initial speed of the ball (apply our general problem-solving strategy).

$g =$ $h =$ $R_{ave} =$

$v_0 =$ ________

B. Study of the dependence of the range on the launch angle.

Before taking more data, vary the angle of launch and try to find the angle which gives the maximum range. You may want to try predicting it first. Make just a couple of shots at each angle.

Your goal is to predict and then to check your prediction of the range for two angles (20° and 40°).

First, you need to derive an equation which will let you to calculate the range for given values of initial speed, height, and angle. Use the space below and our general problem-solving strategy to derive that equation.

Set the gun to an appropriate angle. Measure the new initial height. Calculate the new range. Repeat steps 2 through 5 from part A (for each angle measure the range five times). Be certain not to turn the spring adjusting knob during this procedure or you will change the initial velocity. Be sure to mark the new initial position (both x_o and y_o) as the angle changes. Calculate the percent difference between the theoretical and experimental values of the range. Comment.

$\vartheta =$ $h =$ $v_0 =$ $R_{calculated} =$

$\vartheta = 20^0$ $h =$	#	1	2	3	4	5	Ave
	R						

$\vartheta =$ $h =$ $v_0 =$ $R_{calculated} =$

$\vartheta = 40^0$ $h =$	#	1	2	3	4	5	Ave
	R						

Equipment

Lab 3:
Part I (12 tables): a computer with Java;
Part II (12 tables): Projectile Motion apparatus, two-meter stick, paper, masking tape.

Unit layout

L3: 160 min

PI: 80 min

PII: 80 min

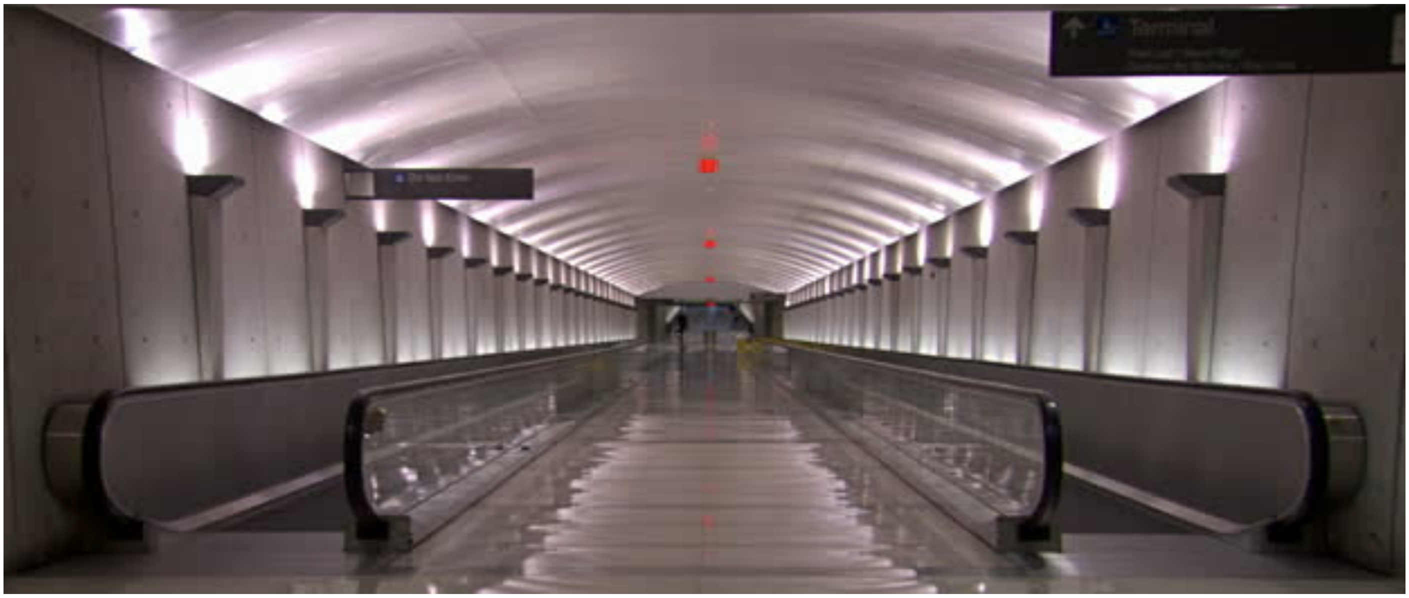
PE3: 40 minutes

Breaks when needed

Section: Name: BU ID: .

Practice Exercise 3

Two friends, Bob and Ben, are at the Logan international Airport. To “kill” some time, they decided to race each other making a roundtrip of the same length.



The first time they both ran on the floor between two parallel moving walkways: they started at the beginning of the walkways, and turned back when the walkway ended. Turned out they were equally fast, so the race was a tie (a.k.a. a draw). So they decided to make the race more fun. This time Ben was running on the floor by a walkway, but Bob was running on the moving walkway – both ways.

1. Predict, who won the race this time. Prove your prediction.

2. Assume that in the first race Bob and Ben both ran at 10 km/h; the walkway is 300 m long, and its speed is 3 km/h. Calculate how much time the “winner” ran less than the “looser”.