Physics 101 Fall 2009 Lab 3: Projectile Motion

Group Members (Please circle your own name):

Goals:

As Leonardo da Vinci once said, "To understand motion is to understand nature." The understanding of something in science, ultimately leads to a prediction. So we would like to make predictions about objects, such as a rocket, being shot into space, in terms of how long it will stay in space, how far it will go into space, etc.

Background:

Neglecting air resistance, an object set in motion near the surface of the Earth over short ranges experiences no acceleration along the horizontal direction and constant acceleration due to gravity along the vertical direction. So the equations for the displacement of an object thrown near the surface of the Earth are

$$x = x_i + v_{ix}(\Delta t) \tag{1}$$

$$y = y_i + v_{iy}(\Delta t) - \frac{1}{2}g(\Delta t)^2, \tag{2}$$

where v_{ix} and v_{iy} are the x and y components of the initial velocity respectively. Also, g is our beloved acceleration due to gravity. The minus sign indicates that we are choosing our origin to be somewhere on the ground to that moving upward increases the displacement in the y direction. *Question:* There are also two equations for the velocity in the x direction and the velocity in the y direction. What are they?

Question: If you are given the initial speed of the object, or the magnitude of the initial velocity, how do you find v_{ix} and v_{iy}?

Materials:

Air-powered rockets with launcher, meter stick, protactor, stopwatch, distance marker, and laundry detergent bottle.

Activity:

(1) Go outside on the quad and find a nice, open spot near the Physics Building. Adjust the laucher so that the rocket goes straight up into space. Stomp on the launching pad and see how high you can shoot off the rocket just for fun.
(2) Now we are going to perform our first measurement. Take the laundry detergent bottle and place it about waist high, or even a little higher. Measure that height with the meter stick and record it. From now on you will always place the laundry detergent bottle at that same height.

(3) Drop the laundry detergent bottle onto the launch pad and measure the time it takes for the rocket to be launched into the air and come back down again. Do this several time and record your time measurement. By how much does the measurement vary?

When launched into the air vertically, the rocket has some initial velocity in the positive y direction. How can you compute that initial velocity knowing the "time of flight" of the rocket? Hint, at what time is the rocket at its highest and what is the instantaneous velocity at that point? Also, assume the magnitude of g is $9.8m/s^2$.

Now that you have computed the initial speed, what is the maximum height of the rocket?

(4) Instead of having the rocket shoot directly upwards, now position the launcher to be at some

angle with respect to the horizontal. Place the launcher at 20 degrees with respect to the horizontal. Use your protractor to do this.
Place the laundry detergent bottle at the same height as before and drop it onto the launching pad in the same manner as before. Have one person measure where the rocket lands and one person measure the rocket's time of flight. Record both. Repeat these measurements for the angles listed in the table below and record them.

Angle (degrees)	Time (sec)	Horizontal Distance (m)
20		
25		
35		
45		
55		
65		

(5) Make a graph of the horizontal distance travelled, i.e. the range, versus the angle. What shape does it have? At what angle is the range maximum?

(6) At the beginning of your studio today your TA should have discussed the range equation with you. Do you remember the form of the range equation? If so, what is it? If not, ask your TA to help you jog your memory.

(7) Input the initial velocity computed above in the vertical projectile experiment. Does the range equation "work"? Can you predict the range when the rocket is launched at an angle of 75 degrees? Check your prediction.

(8) What about the time of flight recordings? What formula describes them? Are they accurate?

(9) If the range equation is not an accurate description of what you have measured, what is going on? Can we really neglect air resistance, etc.?