2-D Motion: Projectile Motion

Physics 110 Laboratory

Introduction:

In this lab, we will study the motion of small steel balls fired from a spring-powered projectile launcher. You will use two different methods to find the velocity of the balls as they leave the launcher, and use that velocity, together with the equations governing projectile motion, to predict the range of a projectile fired at an arbitrary angle. As a test of your prediction, you will be asked to use the prediction to place a target on the floor at the spot where the ball will land.

Along the way, you will also investigate some new techniques of error analysis, and the differences between systematic and random errors.

Procedure:

The apparatus for this lab consists of a spring-powered projectile launcher which will fire a small plastic ball into the air. The goal of the lab is to determine the velocity of the ball leaving the launcher, and use that velocity to predict the flight of the ball when the launcher is used to fire the ball across the room.

For the first part of the experiment, the launcher will be fired straight up into the air. Place the launcher on the floor, and make sure the protractor reads 90º, and that the screws holding the launcher to the mount are tightened down. Make sure that the launcher is not aimed at a light (launchers which are mistakenly fired on the “high” setting will fire a ball into the ceiling hard enough to shatter light bulbs and make a mess), set the launcher to the “medium” setting (the second notch down), and fire the ball by tugging sharply on the launch cord. When firing the launcher, be sure to hold it down with your free hand.

Part 1: Muzzle velocity from the time of flight

a. One method you can use to find the velocity of a ball leaving the launcher is to measure the time that the ball spends in the air. Fire the ball from the launcher straight up, and use a stopwatch to measure the time between the firing of the launcher and the highest point the ball reaches. Repeat this measurement 10 times. Each member of your group should measure flight times. Record your measurements in the table below.

Trial	Time (s)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
Avg	
St. Dev.	

b. Using the equations governing projectile motion (which you should have discussed in class), and the average value of the time of flight you obtained, calculate the initial velocity and uncertainty in the velocity of the ball ($v_i \pm \Delta v_i$) when it left the launcher. Show your work and answer in the space below.

Part 2: Muzzle velocity from maximum height

a. A second method of measuring the initial velocity is to measure the maximum height reached by the ball. Clamp one of the two-meter sticks provided to the edge of the lab table, and use this to measure the maximum height of the ball. You may need to stand on the table in order to read the height. Take a few practice shots to determine the best way to read the ball's height from the meter stick, then each member of your group should record ten values of the maximum height reached in the table below.

Trial	y_f (m)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
Avg	
St. Dev.	

b. Using the equations governing projectile motion, and the average value of the maximum height, calculate the initial velocity and uncertainty in the velocity of the ball ($v_i \pm \Delta v_i$) when it left the launcher. Show your work and answer in the space below.

c. Do the muzzle velocities determined in Parts 1 and 2 agree within experimental uncertainties? If, not, explain why. Which value do you have more confidence in and why?

Part 3: Projectile motion

a. For the final part of the lab, your instructor will randomly assign each group an angle between $0^0 \le \theta \le 45^0$. Your job will be to calculate the total horizontal distance (± the uncertainty in the distance) that the ball will travel. Derive the expression for the horizontal distance measured from the launcher that the ball will land when launched at angle θ. Show you work in the space below including your expression for the horizontal distance. Calculate the horizontal distance using the angle you were assigned.

b. Launch the steel ball across the room at the angle you were given by your instructor. How well do your results agree with the predicted distance, taking into account the uncertainty? Explain any discrepancies.