
PHYSICS 125 EXPERIMENT NO. 3

PROJECTILE MOTION

Introduction

This laboratory experiment presents the opportunity to study motion in two dimensions, projectile motion, which can be described as accelerated motion in the vertical direction and motion at a uniform velocity in the horizontal direction.

Equipment

One computer set one photogate, one interface box, one launching ramp with screw-actuated linear translator (SALT), carbon and landing paper, One plumb bob with string, one meter stick, one steel ball.

Method

The steel ball will be launched horizontally by being released at a certain height on the ramp. It will then fall to the floor and make a mark on the landing paper. The horizontal distance from take-off to landing x is proportional to the horizontal velocity V : of the ball. Using the SALT, photogate and computer, this velocity can be calculated, and the distance x can be measured with the meter stick.

Procedure

1. Measure the height h of the launch point (i.e. the end of the ramp above the floor).
2. Measure the "effective diameter" D_{eff} of the ball. This may be accomplished by translating (moving in a straight line) the photogate from the front to the back of the steel ball on the launching ramp. The front and back are indicated by where the photogate is blocked or unblocked as seen by the LED (light emitting diode) installed in the side of the photogate. The SALT will advance the photogate by $1/28$ of an inch per rotation of the knob, i.e., turn the knob 28 times and the photogate will move 1 inch. In addition, the knob is marked with 1() numbers. You should be able to measure D_{eff} to high precision.
3. The launch velocity of the ball will be calculated from its effective diameter and the time it spends in the light path of the photogate. **It is very important that the photogate is not disturbed after measuring the diameter of the ball.** In order to measure the time the ball is in the photogate, enter the "GATE TIMING MODE" from the Main Menu of the computer program. Select "ONE GATE" operation and either normal or large digits. Be sure that the interface box is in "SET" condition.

4. Each time the ball passes through the photogate, the elapsed time will appear on the screen. The time and distance x should be recorded for 5 different initial positions of the ball. The starting position may be adjusted by moving the screw clamp on the ramp. Repeat the experiment several times for each of these adjustments in order to obtain the average value and uncertainty of the distance x and time. Include the uncertainties in your calculations.
5. Exit the program by hitting "ENTER".
6. Calculate v , the horizontal velocity of the ball, for each different height, and plot x versus v in your lab book. Include horizontal and vertical error bars in your plot. Recall how you determined v and measured x and you will be able to generate the error bars.
7. The theoretical formula relating x to v for this case is $x = v\sqrt{2h/g}$. Derive this relationship. This equation predicts the range x of the projectile for every possible value of initial velocity. Using the accepted value for the gravitational constant g and your measured value for it, calculate the expected range of the ball for each of the measured velocities. On the same graph as in (6) above, make a plot of the theoretical formula (the formula yields a continuous line instead a set of points since it is valid for any initial velocity).
8. Using your measurements and/or the theoretical prediction, determine your best guess for the range of the ball when released from a height which you have not previously measured. Have the TA sheet on the floor centered at your predicted range. If the projectile lands in the center you are done. If not reconsider your estimate and make a new estimate for a different height of release. Repeat the steps until you come up with a prediction that you can verify experimentally.

Questions:

1. *To what precision can you measure D_{eff} ? Explain briefly and include the error in your lab book.*
2. *Do your experimental data points from (6) agree with the theoretical line? Discuss.*