PHYSICS 133 Spring 2006 EXPERIMENT NO. 3 PROJECTILE MOTION

Introduction

This laboratory experiment presents the opportunity to study projectile motion, an example of motion in two dimensions. The motion can be described as accelerated motion in the vertical direction and uniform motion in the horizontal direction.

Equipment

- 1 Computer set,
- 1 Photogate,
- 1 interface box,
- 1 launching ramp with SALT (screw-actuated linear translator),
- 1 meter stick,
- 1 plumb bob with string,
- 1 steel ball-bearing

Method

The steel ball will be launched horizontally by being released from a certain height on the ramp. It will then roll down the ramp and fall to the floor, where it makes a mark on the landing paper. The horizontal distance from take-off to landing, x, is proportional to the initial horizontal velocity, v, of the ball. The distance, x, can be measured with the meter stick. By using the SALT, photogate and computer, the initial velocity v_0 of the ball (as it leaves the ramp) can be calculated.

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. You should be able to measure D_{eff} to high precision, since you can estimate fractions of a turn to +/- ¼ turn by eye.

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 not be disturbed after measuring the diameter of the ball. In order to measure the time that the ball is in the photogate, enter the GATE TIMING MODE from the Main Menu of the computer program. Select ONE GATE operation and use 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 starting positions of the ball on the launch ramp. The starting position may be adjusted by moving the spring-clip 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 initial velocity of the ball, for each different launch position, and plot x vs. 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. A theoretical formula relating x to v 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 g and your measured value for h, calculate the expected range of the ball for each of the measured velocities. On the same graph as in (6) above, make a mathematical plot of the theoretical formula (the formula yields a continuous line instead of a set of points since it is valid for any initial velocity).

Q2. Do your experimental data points from (6) agree with the theoretical line? Discuss.