PHY 151/251

Lab 2 - Projectile Motion

Objectives:

The objective of this experiment is to study the motion of a projectile when fired from a ballistic pendulum, specifically by analytically determining the range, time of fall, and velocity of the projectile and comparing these calculations to experimental observations.

Theory:

Objects near the surface of the earth which move under the influence of only gravity are said to follow a path of projectile motion. To solve problems of this type, we consider the horizontal and vertical components of motion separately. In this situation, the horizontal acceleration is equal to zero, and the vertical acceleration has a magnitude of g (9.80 m/s^2 on Earth) and points downward. In both cases, the acceleration is constant so we can adapt the kinematic equations to describe both components of the motion.

For horizontal motion

$$v_x = v_{xo}$$

$$x - x_o = v_{xo} t$$

where v_x is the velocity of the projectile in the x direction at any particular point along the trajectory, v_{xo} is the initial velocity of the projectile in the x direction, and $x-x_0$ is the horizontal distance (range) of the projectile.

For vertical motion

$$v_y = v_{yo} - gt$$

$$y - y_o = v_{yo} t - \tfrac{1}{2} g t^2$$

where v_y is the velocity of the projectile in the y direction at any particular point along the trajectory, v_{yo} is the initial velocity of the projectile in the y direction, and $y-y_0$ is the vertical distance the projectile travels.

The apparatus used in this experiment is a combination of a ballistic pendulum and a spring gun. The pendulum bob will not be used in this experiment.

Procedure Part I:

1. The initial speed of the projectile is measured by means of measurements of range and fall. The apparatus should be set up on a table near the corner of the lab table. The gun is cocked by pushing against the ball and compressing the spring until the trigger is engaged. As a preliminary run, fire the ball and approximate the location of impact on the floor (several shots may be necessary to make this estimate). Be sure to check the placement of the apparatus before each shot. Have a catcher located in a place where he or she can catch the ball after one bounce on the floor.

2. Tape a sheet of white paper to the floor at the location determined in Procedure 1. When the ball strikes the paper, it will leave a mark on it. In this way, an exact record can be obtained of the spot where the ball strikes the floor.

3. Fire the ball five times and measure the range for each shot. The range is the horizontal distance from the point where the ball leaves the spring to the point where the ball hits the ground.

4. Measure the vertical distance of fall (this will be your $y-y_o$ value). (Note: if we let the point of fire be our origin, then $y-y_o$ should be recorded as being negative).

Procedure Part II:

5. Set up the spring gun at an inclination angle of approximately 15 degrees and measure the new height from the bottom of the ball to the floor. (Note: as before, if we let the point of fire be our origin, then $y-y_o$ should be recorded as being negative).

6. Fire the ball five times and measure the range for each shot.

Calculations from Procedure Part I:

1. From the data collected in Procedure Step 3, determine the average range ($x-x_o$) of the projectile.

2. From the data collected in Procedure Step 4, determine the total time required for the ball to hit the ground.

3. Calculate the horizontal and vertical components of initial velocity (v_{xo} and v_{yo}).

4. Calculate the magnitude of the initial velocity vector (v_o).

Calculations from Procedure Part II:

5. Calculate the new horizontal and vertical components of initial velocity when the spring gun is inclined at an angle of 15°.

6. From the data collected in Procedure Step 6, determine the average range of the projectile.

7. Calculate the total time required for the ball to hit the ground.

8. Calculate the horizontal and vertical components of the ball just before it strikes the ground.

9. Calculate the magnitude and direction of the velocity of the ball just before it hits the ground.