

PHY 251

Lab 3 – Projectile Motion

Objectives:

The objective of this lab 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. In this situation, the horizontal (perpendicular to gravity) acceleration is zero, and the vertical acceleration is **g** downward (9.80 m/s² downward on Earth).

To solve problems of projectile motion, we consider the horizontal (x direction) and vertical (y direction) components of motion separately. In the x direction, acceleration is a constant and is equal to zero ($a_x = 0$). In the y direction, acceleration is also a constant and is equal to $-g$ ($a_y = -9.8 \text{ m/s}^2$). The kinematic equations of motion are modified for projectile motion:

For horizontal motion

$$v_x = v_{x0}$$

$$x - x_0 = v_{x0}t$$

where v_x is the velocity of the projectile in the x direction at any particular point along the trajectory, v_{x0} 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

$$v_y = v_{y0} - gt$$

$$y - y_0 = v_{y0}t - \frac{1}{2}gt^2$$

where v_y is the velocity of the projectile in the y direction at any particular point along the trajectory, v_{y0} 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.

Apparatus:

Ballistic Pendulum
Meter sticks
Tilting Board
Protractor

Procedure:

1. The initial speed of the projectile is measured by means of measurements of range and fall. Therefore the pendulum is swung up onto the rack and hooked with the pawl so that it will not interfere with the free flight of the ball (it may be necessary instead to remove the pendulum and the rack from the apparatus; ask your instructor for help). 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. The ball is to be fired horizontally, and therefore the apparatus must be level. 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. This sheet of paper is your data.
3. Fire the ball five times and determine the range for each shot. The range is the horizontal position from the point of projection to the point of impact (the distance from the point where the ball is fired to the point where the ball hits the ground). Record each of these distances in your data table.
4. Compute the average range of the projectile
5. Measure the vertical distance of fall (the vertical distance of the point of projection above the floor). Calculate the time required for the ball to fall.
6. Compute the velocity of projection from the results obtained in calculations of procedures 4 and 5.
7. For angles of 5, 10, and 15 degrees,
 - a) Set up the spring gun and measure the new height from the bottom of the ball to the floor.
 - b) Use the projectile equations to predict where the ball will strike the floor and place a new sheet of paper at that location. Be sure to check again the horizontal position of the ball as it leaves the gun.
 - c) Perform Procedure 3, adjusting the paper if you initially miss it.
8. Compare the results of Procedures 7b and 7c, calculating percent errors.

Before leaving lab, record the number on the spring gun that you used. You will use this same apparatus in a later lab.