Projectile Motion

Equipment

- Computer with spreadsheet software
- Download of https://phet.colorado.edu/sims/html/projectile-motion/latest/projectile-motion_en.html

Objectives

- *To investigate how the launch angle affects the range of a projectile.*

Introduction

In this experiment, you will study how the range of a projectile changes as the angle at which it is fired is changed. A plastic ball fired from a spring gun is the projectile. The gun is placed on a floor, and the ball is fired into the air at different angles, striking the floor. To help locate the point of impact on the floor, use a carbon paper and a white paper. Ask your instructor for any other simple devices and instruments. Vary the angles by as great a range as possible.

The experiment will proceed in two stages. First, we will use a horizontal shot to establish the launch speed of the ball. Then, we will launch the ball at angles above horizontal to observe the effect on the range.

Our basic assumption is that a flying object has an acceleration of 9.8 m/s² downward. The basic formulas of kinematics apply. When we put them together with the initial velocity and height, we can derive Eq. 1. (This comes from the basic Projectile Motion equations, in Sec 4.3 of Serway/Jewett 9th Edition, or Sec 3.4 of Serway/Vuille 10th Edition. You can feel free to solve the basic equations instead of using Eq. 1.)

We will use a comparison between experimentally measured ranges x and the same ranges calculated using Eq. 1 as the criteria for the success of the experiment.

$$x = v_0 cos\theta \; \frac{v_0 sin\theta + \sqrt{2gh + (v_0 sin\theta)^2}}{g} \qquad (1)$$

Part #1. Investigation of the effect of the projected angle on the range.

1. Go to: https://phet.colorado.edu/sims/html/projectile-motion/latest/projectile-motion_en.html and open the simulation by clicking on ⊳ .

2. Move the canon up the height, $h = 5m$, and set the initial speed of the projectile to 10 m/s.

3. Fire the cannon at increasing angles, ranging from 10° to 80°, in increments of 10°. Add an extra data point at 45°.

4. For each run, use a ruler (upper right corner) to measure the range from the launcher. The initial horizontal position of the projectile is marked by a vertical line from the starting point marked by a cross on the surface of the launcher.

5. Enter the measure values collected by each lab partner to Table 1 and average the results.

6. Plot a series of values as a scatter plot of Average Range vs. Angle. (Remember, the *FIRST* variable is the *VERTICAL* axis.)

7. Fit the series into polynomial function and display the trend line equation on the graph.

Angle (°)	Measured Range (m)			
	Partner 1	Partner 2	Partner 3	**Average**
0				
10				
20				
30				
40				
45				
50				
60				
70				
80				

Table 1. Recorded data for angled launches of the projectile.

Part #2. Calculation of the initial velocity of the projectile.

1. ***Use the average range for zero angle*** (horizontal launch) to calculate the initial velocity of the cannon.
    - Set up Y(t) equation where initial position is h, final position is zero, initial velocity is zero, and the acceleration is -9.81m/s², and then solve it for time.
    - Set up X(t) equation where the initial position is zero and the final position is average range for horizontal launch; plug in the value of time to find initial velocity.
2. Calculate % difference between the calculated and set initial speed of a projectile.

Height, h (m)	**Average** Range (m)	Calculated Initial Speed, V_0 (m/s)	Actual Initial Speed, V_0 (m/s)	% Difference

Table 2. Recorded data for calculation of the initial velocity of the projectile.

Requirements for the Formal Report (also consult the rubric):

Save your Excel files through your Blackboard Group File Exchange

- The **Main Body** of the report must address the following:
    - The **introduction** must present a projectile and the two quantities investigated in the experiment along with predicted relationship between the two.
    - The **methods** must explain:
        1. What simulator was used to collect data?
        2. How the data was collected for Table 1: the setting and measuring the initial elevation, the measurement of the landing range (what tools were used and how they were used).
        3. How the angle was adjusted from zero to 80 degrees to collect data for Table 1 and what features of the software were used.
        4. How the initial velocity of the projectile was calculated (what formula(s) and values were used in the calculation).
        5. How the data from Table 1 was graphed to analyze the trend in the range

    - The **discussion** must be quantitative and reference numerical values of ranges and corresponding angles detrimental for the description of the trend (As the angle increases from zero to ... degrees, the value of the range ....), the trendline equation, and the observed correlation between measured and calculated curves.
    - The **conclusion** must include a summary statement on the experimental findings: how the variations in angle affected the landing range of the projectile.

- The **data section** must include
    - 1 Tables (labeled and captioned)
    - 1 Graph with averaged landing range plotted on it (titled, axis labels, units, labeled and captioned)