

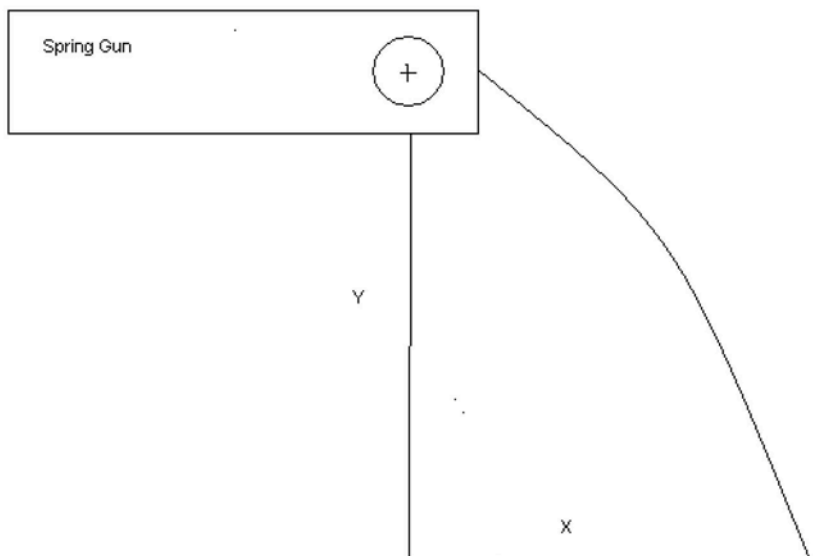
GENERAL SCIENCE LABORATORY 1110L Lab

Experiment 3: PROJECTILE MOTION

Objective: To understand the motion of a projectile in the earth's gravitational field and measure the muzzle velocity of the projectile as it leaves the end of the spring gun.

Apparatus: PASCO Spring Gun, Projectile (Yellow plastic ball), Plumb Bob, Meter stick, Target paper, Carbon paper, Tape.

Theory: When a projectile is shot out horizontally in the earth's gravitational field, its position as a function of time can be described by the following two equations



Y is the vertical distance fallen in meters, **t** is the time in seconds, and **g** is the acceleration of gravity m/s^2 .

$$Y = \frac{1}{2} g t^2 \quad (1)$$

We can re-arrange equation (1) to solve for t , which is our time of fall in the Y direction. Also the time of flight.

$$t = \sqrt{2 \frac{Y}{g}} \quad (2)$$

Where t is in seconds if Y is measured in (m) and $g = 9.80 \text{ m/s}^2$.
We have seen this equation before in the Human Response Time and Picket Fence Labs.

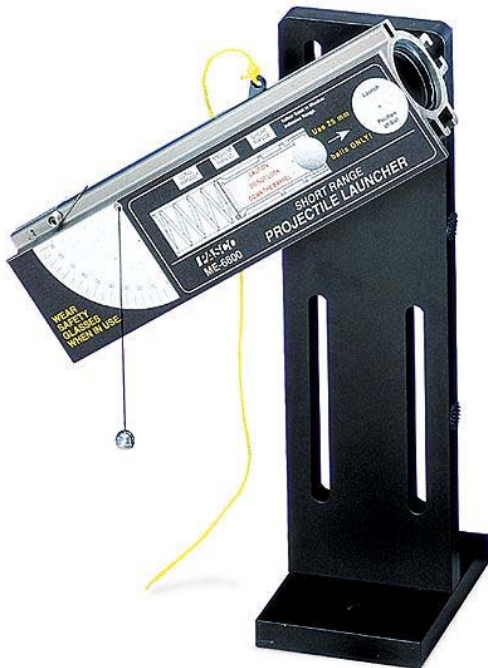


Figure 1: Spring Gun Projectile Launcher

The distance traveled in the Horizontal Direction is given

$$\mathbf{X=Vt} \quad \mathbf{(3)}$$

V is the muzzle velocity in (m/s) which remains constant throughout the flight. X and Y are respectively the horizontal and vertical distances the projectile travels. Note: the ball travels a distance X in the same time it takes to fall freely a vertical distance Y. This means that t is the same in both equations.

Procedure:

- 1.Using the C-clamp provided, clamp the Spring Gun to the end of the lab table so that the muzzle end (The end with the white circle.) of the gun points towards the opposite end of the lab table along the longer dimension.**
- 2, Loosen the two black knobs on the side of the spring gun opposite the side with the white circle on it.**
- 3. Place the Torpedo Level (See Below) or the level with the tape measure in it on the top of the Spring Gun on the flat side and adjust the spring gun until the center bubble of the level is within the two black marks.**



Figure 2: Torpedo Spirit Level

- 4. Tighten the two black knobs so that the spring gun will not move during firing**
- 5. Remove the Torpedo Level or other level. (You might want to check to see if the Spring Gun is still level after your test firings)**
- 6. The center of the white circle represents the center of the projectile as it leaves the Spring Gun.**
- 7. Hang the Plumb Bob so that its string goes through the center of the white circle (the center is marked by cross hairs) and the point of the bob is just barely above the table top.**



Figure 3: Plumb Bob and string

8. Place a piece of masking tape on the table under the point of the Plumb Bob and mark the point's position on the tape. (This is the point where we will start the measurements of the horizontal distances) We will call this X_0 .

9. Using your meter stick, measure the projectile's vertical height as it leaves the gun. (Measure to the bottom of the white circle instead of the center, because it is the bottom of the ball that hits the table) (This value should not change during the experiment as long as the gun is perfectly level each time you fire it). Record the Y value at the place provided at the top of your data table.

10. Place the sheet of cardboard provided in front of the computer monitor so the projectile will not hit the screen.

11. Place the yellow projectile into the mouth of the Spring Gun.

12. Using the Ram-Rod, cock the Spring Gun by pushing the projectile back into the gun. There are three possible settings for the Spring Gun; Short, Medium, and Long Range. ***We will be using the Short Range setting.*** You can tell what range you have the gun set to, by looking through the slots on the top of the gun. A yellow plastic indicator will line up with small white boxes on the side of the Spring Gun that say Short, Medium, and Long Range.

13. To fire the gun, ***pull gently straight up on the Yellow String.*** Note the approximate location where the ball lands on the table.

14. Tape the white target paper to the top of the table so that the center of the sheet is about where the ball landed.

15. Lay the carbon paper on top of the white target paper carbon (shiny) side down.

16. Check the Spring Gun and make sure it is level before you fire it again. Fire the Spring Gun.

17. Lift the Carbon Paper and note where the ball landed. (The ball leaves a small black circular mark on the white sheet) Mark the spots on the white sheet 1 through 6, so you will know which mark came from which trial.

18. Repeat steps 11 through 17, five more times.

19. Measure from Xo to the center of each black dot and record the six horizontal distances in your data table.

DATA ANALYSIS

- 1. Calculate the time of flight using equation (2).**
- 2. Calculate the average horizontal distance the projectile traveled $X_{average}$.**
- 3. Calculate the average muzzle velocity by substituting the average horizontal distance $X_{average}$ into equation (4).**

$$V_{average} = \frac{X_{average}}{\text{time of flight } t} \quad (4)$$

- 4. Repeat the calculation in step 3 with the maximum distance to get V_{max} .
 $V_{max} = X_{max} / t$ time of flight.**
- 5. Repeat the calculation in step 3 with the minimum distance to get $V_{minimum}$.**
- 6. The estimate of the statistical error of the muzzle velocity $V_{average}$ is found by calculating the Standard Deviation of V, ΔV .**

$$\Delta V = \frac{Range}{\sqrt{6}} \quad (5)$$

An alternate expression for ΔV .

$$\Delta V = \frac{V_{\max} - V_{\min}}{\sqrt{6}} \quad (6)$$

7. Calculate the % error in V.

$$\% \text{ error } V = (\Delta V / V_{\text{average}}) \times 100\% \quad (7)$$

Questions

1. What is the most important type of error in this experiment that we have discussed in previous classes? Give an example that applies to this experiment.
2. How would the muzzle velocity be different if the mass of the projectile was greater than that of the projectile used in the experiment? Less?

Format for Suggested Data Table in your lab notebook

| Y Height | |
|--------------|-----------------------------|
| (cm) | (m) |
| Trial Number | Horizontal distance Xi (cm) |
| 1 | |
| 2 | |
| 3 | |
| 4 | |
| 5 | |
| 6 | |

$X_{\text{avg}} =$ _____ (cm) = _____ (m)

$V_{\text{avg}} =$ _____ (cm/s) = _____ (m/s)

$V_{\text{max}} =$ _____ (cm/s) = _____ (m/s)

$V_{\text{min}} =$ _____ (cm/s) = _____ (m/s)

$\Delta V =$ _____ (cm/s) = _____ (m/s)

%error = _____ %

Lab Report Format:

Your lab report for this experiment should contain the following sections:

1. Title of experiment in center of the first page. Date to the left of the title. Experimenters name with partners name(s) under experimenters name to the right of the title.
2. Objective
3. Apparatus
4. Original Data: Neatly filled out data page.
5. Sample calculations: For this lab an example (ONE) needs to be shown for each of the following calculations: time of flight t , X_{average} , V_{average} , ΔV , and % error in V .
6. Results: State your results (in the form of **very short** sentences). Make sure the numerical results are properly rounded and have the correct number of significant digits. Report the muzzle velocity V and ΔV and % error in V .
7. Conclusions: Address the answers to the two discussion questions above.

PROPER MATERIALS, ETC. FOR YOUR REPORTS

1. ALL DATA IS TO BE RECORDED DIRECTLY IN YOUR LAB NOTEBOOK. **NO SCRATCH PAPER IS TO BE USED.**
2. YOU ARE TO USE BLUE OR BLACK INK ONLY FOR RECORDING DATA AND DOING YOUR REPORTS IN YOUR NOTEBOOK.
3. REMEMBER, ONLY THE FRONT OF THE PAGES IN YOUR LAB NOTEBOOK ARE TO BE USED FOR DOING YOUR LAB REPORT. I WILL NOT LOOK AT ANY INFORMATION ON THE BACKSIDE OF THE NOTEBOOK PAGES.
4. **DO NOT TEAR OUT ANY PAGES** FROM YOUR NOTBOOK.
5. DO NOT ERASE OR USE WHITEOUT FOR MISTAKES!!!!
All observations taken under the same experimental condition are equally valid and should be retained for analysis. Do not erase readings. If you must change a reading, draw a single line through it and then record the new measurement next to the old one.