

College Physics 201

Projectile Motion

Materials: *Projectile launcher, ramps, target sheets, carbon paper, colored pencils or markers*

1 Purpose

The goal of this experiment is to test your new skills in calculating projectile motion by predicting where a projectile will land. First, each group will have to calibrate the muzzle velocity of their launcher.

2 Introduction

Projectiles are objects traveling in two dimensional free flight. Free flight is defined as motion under the influence of gravity only. Therefore, when we treat an object as a projectile we can ignore any frictional effects, launching effects, and landing effects. The equations of motion introduced in lecture (from Newton's laws and assuming a constant acceleration) will work only under these conditions so we are only interested in the time while in flight which occurs from the moment the projectile **leaves** the launcher until the moment **just before** it lands.

The launchers you will be using must be calibrated before you can use them to predict where the projectile will land. The value we need in the calibration is the velocity with which the projectile leaves the launcher. This is set by the spring in the launcher which varies considerably from launcher to launcher. Thus, you will first perform an experiment to calibrate the launchers initial launch velocity. In the second experiment, you will use the calibrated launch velocity to *predict* where the projectile will land for a given launch angle. Then your gunnery skills will be tested in front of the instructor.

3 Procedure and Analysis

This laboratory is broken into two separate experiments. You are to record all necessary information on paper in a **neat** and **orderly** manner. A diagram of the setup to clearly identify where relevant parameters are measured is generally a good idea. Work out all calculations in detail including all necessary steps. Make statements along the way that tell the instructor **exactly** what you were thinking and what you did. These types of problems are the same type you will see on any exam (except for the experimental part).

3.1 Calibrating the Projectile Launcher

- Set the launcher up on the table top with it pointed in a direction useful for the experiment.
- Make sure that the projectile will clear the edge of the table.
- Make sure the launcher is level and then mark the location of the feet of the launcher with small pieces of tape. You don't want it to move during the experiment.
- Make a list of all the variables you will need in order to calculate the initial horizontal launch velocity of the projectile.
- Test launch the projectile to get a general location of the landing zone. One lab partner should act as the "Safety" person keeping people out of the launch zone and tracking down the projectile. Use the provided cardboard boxes positioned beyond your target to contain the projectile.

- Center your target paper where the projectile will land. Place small pieces of tape on the corners to hold it in place (this tape needs to be COMPLETELY removed from the floor after your experiment – failure to remove your tape will cost you points).
- Place carbon paper over the target sheet and launch the projectile at least three times. Two or three spotters to watch and mark where the projectile lands is an acceptable alternative to carbon paper.
- Remove the carbon paper and measure the horizontal displacement from the pin to landing location for each of the trials. Average them together to get a single value.
- Measure the vertical drop from the pin to the floor.
- Now with all the necessary measured values, calculate the initial horizontal velocity of the projectile.
- Upon completion of this stage, contact your instructor so that they can prep your launcher for part 2 by moving it to the floor and setting an inclination angle of their choosing.

3.2 Testing Your Gunnery Skills

- After the instructor has moved your launcher and set the launch angle, measure the angle, launcher height (y-displacement) and use your previously determined initial velocity to predict where your projectile will land as measured from the launch position. **No practice shots are allowed! Points will be deducted if a practice shot is fired.**
- Double check your calculations and then inform the instructor you are ready to launch. The instructor will place a target at the position you choose.
- You will launch the projectile a minimum of three times (additional shots are allowed at the sole discretion of the instructor). The instructor will record the score scaled by the markings indicated on the target where the most accurate shot will earn the highest score.
- Measure and record the *actual* range of each trial launch.
- Calculate the average range of the three trials.

4 Questions

1. Calculate the percent difference between the predicted range and the average measured range in the gunnery test in section 3.2.
2. If your predicted range was significantly different than your measured range, review your calculations and measurements then, if appropriate, rectify the discrepancy by properly recalculating the predicted value (of course you should show all of your work). If the calculation and measurements were all correct but you had a large percent difference, then discuss the source of the observed difference. If your prediction was close (within $\sim 10\%$) then simply state that your prediction matches the experimental data within the expected experimental uncertainties.

5 References

- OpenStax, *Physics*, Chapter 3
- *Physics*, 8th edition, Cutnell and Johnson, Chapter 3.