

Projectile Motion

Physics 114

Fall 2024

The goal of this informal lab is to have some fun testing the predictions of 2D kinematics. You will use a ball-bearing projectile launcher (see Figure 1) whose launch speed is measured optically.

Part 1: Initial Setup

Your instructor will explain to you the initial setup of the launcher. This includes:

1. Leveling the launcher and zeroing the angle scale,
2. Setting the initial launch angle,
3. Recording the important distances that define the starting position of the ball relative to the launcher case,
4. Hooking up the air pump (don't overtighten), and
5. How to hook up the launcher to the computer so you can measure the launch speed.

Part 2: Determining the initial velocity

The projectile launcher must be connected to the lab computer (or your own; but the instructor will have to supply you with the free Logger-Pro software). Once the computer is connected to the launcher, and you start Logger Pro, it should automatically sense the launcher and show a display for the initial velocity. In order to measure the velocity, you will have to push the start button (rightward facing arrow) at the top of the window.

The middle dial on the launcher adjusts the pressure from zero psi (pounds per square inch) to a maximum of about 70 psi. You will know the maximum pressure because as you engage the pump, you will see the gauge pressure increase, and at some point, you will hear air escaping — this is the signal you are up to the maximum pressure you dialed in with the center dial. Adjust the center knob so the pressure is somewhere between 20 and 70 psi.

For this part, you'll want to launch the ball repeatedly at the same pressure and compute the average speed, \bar{v}_0 , with its uncertainty, $\Delta\bar{v}_0$. It's best for the purposes of this lab to compute the uncertainty by



Figure 1: The Vernier Projectile Launcher.

using a worst-case analysis:

$$\Delta \bar{v}_0 = \frac{v_{\max} - v_{\min}}{2}$$

When you launch the ball, have a lab partner ready to collect it after it hits the floor. In order to fire the ball, you will have to simultaneously push the “Arm” and “Launch” buttons. After one trial, prepare for the next trial by gently placing the ball back into the launcher, pumping up the pressure, and pressing the start button on the LoggerPro screen. Take 10 trials in total.

Part 3: Predict the landing spot!

Now that you have your measured value for the launch velocity and its uncertainty, you will want to place the launcher on a table, measure the initial height (with an uncertainty!) and the launch angle (with an uncertainty!), then use these values to compute where the ball will land (the range)—and of course, you should compute an uncertainty on this quantity. This calculation will take some time. In your calculation, make sure to show:

- a sketch of the expected trajectory along with appropriately labeled distances, launch angle, and initial velocity,
- detailed calculations leading to your final predicted landing point along with its uncertainty. Use a worst-case scenario analysis to determine the uncertainty: calculate the largest and smallest possible values for the range using the largest and smallest possible launch velocity, initial height, and launch angle, consistent with the uncertainties on these values.

Once you have completed this, make a target by marking a spot on a piece of paper with an error bar (you could also use the rather narrow pressure sensitive tape). Place this on the floor so that the marked spot is on the floor exactly where you expect the ball to land. Then fire the ball repeatedly (again, take 10 trials) to test your prediction! Record the number of your trials in which the ball landed within the predicted area. If you consistently fail to hit the target area, you will need to check your measurements, calculations, and target placement, correct any mistakes you find, then try again.

Informal Lab Report Requirements

On a separate piece of paper, include the following in this order:

1. Your name, the title of the lab, and the names of your partners.

2. An organized table of the 10 measurements of v_0 from Part 2.
3. State your measurement of \bar{v}_0 with uncertainty in plus-minus notation.
4. Your measurements of the initial height and launch angle, with uncertainty, in plus-minus notation.
5. The detailed sketch and calculations of the expected range, with uncertainty propagation, that you did in Part 3. Be sure to state clearly the predicted range with its uncertainty in plus-minus notation.
6. Report the number of trials in which the ball landed within the predicted area.