PROJECTILE MOTION LAB.

In this lab you will solve a projectile motion problem and then check your theoretical result against the result of the corresponding experiment.

The apparatus:

A ball launcher. To get the ball ready for launch, push the ball against the spring until it latches
Note: latch to the second position at least.

The lab has 3 parts:

1. Determine the initial velocity \( v_0 \) of the ball coming out of the launcher by launching it vertically and measuring the max height \( H \) of its trajectory.
2. Predict theoretically the range of that ball when it is launched horizontally with the initial velocity \( v_0 \) (part 1) from at a height \( H \) above the launch point (you will be launching the ball from your table top).
3. Grading the lab: position a sheet of paper on the floor that includes the range uncertainty and tape the paper at the predicted range. Put a sheet of carbon paper so that the impact of the ball will leave a mark on you taped sheet.

Part 1. Determination of \( v_0 \):

To determine \( v_0 \) launch the ball vertically 6 times and measure each time the maximum height \( H_i \) of the trajectory, using a meter stick.

1) From the generic equations of uniformly accelerated motion, determine the initial velocity \( v_0 \) of a ball launched vertically and reaching a max height \( H \) above the launch point.
2) Measure \( H \) 6 times. To launch the ball vertically, position the launcher on the floor close to a wall. You can use a piece of masking tape on the wall and draw a mark at the max height reached by the ball, then measure height from launch point. Think about the exact location when you can actually say that the ball is in free fall (moving only under the influence of gravity). Be careful about avoiding systematic errors in the reading of \( H \): For instance avoid parallax error (see Figure 1), by making sure that your eyes are roughly at the same height as your reading on the meter stick.
3) Enter you height measurements in Excel and determine for each the corresponding value of the initial velocity using the appropriate formula from 1.

Part 2. Range prediction (see figure 2):

1) Derive the expression for the predicted range of the ball assuming that the ball will be launched horizontally from the launcher located on the table top. Express you result in terms of \( v_0 \) and the measurement of the initial height of the ball above the ground.
2) Enter that expression in your Excel sheet, to compute a predicted range from the horizontal launch at a height \( d \) for each of the 10 \( v_0 \)’s from Part I. Use Excel functions to obtain the average and standard deviation of these values:

\[
R = <R> +/- \Delta R
\]
Part 3. Grading of the Lab:

1) Position the launcher on the table top and tape a piece of paper on the floor at the location of $<R>$ and indicate with two lines the interval +/- $\Delta R$ on the paper (figure 2).

2) **Do not launch the ball.** Call your prof over, and launch the ball. The impact of the ball must fall in the interval on the paper. The grading is as follows: A: The ball falls within the interval on the first try. B: You may elect to verify your calculations for mistakes and correct them if necessary. If you succeed in having the ball land within the interval of uncertainty on the second or third trial your grade is a B. If you need more than three trials to hit the predicted range, this lab hand out cannot do anything more for you. Go and seek mercy from your prof!

The generic equations in 2 dimensions:

\[
\begin{align*}
x &= \frac{1}{2} a_x t^2 + v_{ox} t + x_0 \\
v_x &= v_{ox} t + x_0 \\
y &= \frac{1}{2} a_y t^2 + v_{oy} t + y_0 \\
v_y &= v_{oy} t + y_0
\end{align*}
\]

Parallax error:

Due to poor “location” of eye!