Projectile Launcher Scramble!

Group A

Stage 1

In stage 1, your group is to perform an experiment aimed at determining Earth's surface gravity, g.

Obtain a tennis ball and drop it from at least 7 different heights between 0 meters and 5 meters (the height of the railing of the second floor), inclusive. Measure the time that each ball took reach the floor below.

In a Jupyter notebook, create a list of your height values. Then create a second list of your time values.

Then, plot your data as a series of scatter points with h on the horizontal axis. Physics tells us that these points should be related to g by the following equation:

$$\Delta t = \sqrt{\frac{2h}{g}}.$$

A number of experiments have shown that $g \approx 9.81\frac{\mathrm{m}}{\mathrm{s}^2}$. *On the same graph as your scatter plot*, plot the theoretically predicted curve given by the above equation with $g \approx 9.81\frac{\mathrm{m}}{\mathrm{s}^2}$.

Use the above equation to have Python determine g for each data point individually. Then use python to calculate the median and the mean of your values for g.

Then, add another line to your previous plot, which plots the function given by $\Delta t = \sqrt{\frac{2h}{g}}$ using your mean experimental value for g. Make sure there is a legend to distinguish these lines.

Use your mean experimental value for g to predict the time it would take for a ball dropped off the empire state building to reach the streets of NYC below.

Stage 2 — Both Groups

First, combine results from groups A and B into one master document. Send the other group your file from part 1 and then find a way to merge the two files. I think the easiest way might be to simply copy the contents from 1 file into the other file once you have both opened on your computer.

Now you are to launch a projectile from the railing of the second floor and predict where it will land. The horizontal distance is given by $\Delta x = v_i \Delta t$ with $\Delta t = \sqrt{\frac{2h}{g}}$. Use your experimentally determined values for v_i and g in this equation. You will also need to measure h of the railing before the launch. Use Python to solve for Δx for you.

Once you have your prediction, place a target at the predicted landing zone and launch away! Did you hit the target? Include a picture and a discussion of your result in a Markdown cell in your document. Also, measure the true horizontal distance that the ball traveled before it impacted the ground.

You are to launch more balls horizontally from a number of different heights...7 different heights in total. Measure the horizontal distance traveled before impact for each launch. Then make a scatter plot for this data with h (your independent variable) on one axis and Δx (your dependent variable) on the other axis. Plot your prediction $\Delta x(h)$ using your experimental values of v_i and g as a line that goes through the scatter points.

Please turn in your final document on Canvas. Use any remaining time to work on your project proposal in groups.

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Group B

Stage 1

In stage 1, your group is to perform an experiment aimed at determining the initial launching speed of a ball as it exits a projectile launcher on the "long-range"/"high-speed" setting.

Obtain a projectile launcher and load a ball on the "long-range"/"high-speed" setting. Launch a ball horizontally and measure the time it takes for the ball to travel 5 meters. Repeat this process for different distances until you have a total of 7 data points (different times for different distances).

In a Jupyter notebook, create a list of your distance values. Then create a second list of your time values.

Then, plot your data as a series of scatter points with Δx (distance traveled) on the vertical axis.

To find the average speed over a given time interval, we can use the following equation:

$$v_{avg} = \frac{\Delta x}{\Delta t} .$$

Use Python to calculate the average speed that the ball traveled with during each of your trials. Then, create a separate scatter plot with Δt on the horizontal axis and your calculated values of v on the horizontal axis.

Note that your average speeds should get lower as *Deltat* gets longer. This makes sense—the ball slows down slightly as it rolls! The y-intercept (which you of course do not have data for) would give the initial speed of the ball. *Guess* where the y-intercept should be (based on your other data), and then use Python to draw a small red circle around where you expect this y-intercept to be. Then, in a Markdown cell, present a numerical value for (and your justification for) the initial velocity of the launcher, v_i.

Use your experimental value for v_i to predict the time it would take for a launched ball to roll across the continental United States (if there was no friction or air resistance).

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