LAB 2
Hypothesis Testing

OBJECTIVES

1. Categorize the types of experimental uncertainty and reduced them using the average, standard deviation, and standard deviation of the mean.
2. Express experimental results and uncertainty so that someone reading your lab report will have an estimate of the reliability of your work.
3. To understand the difference between the standard deviation and standard deviation of the mean and reliability estimate the standard deviation of the mean.

EQUIPMENT

Ball Bearing shooters, black & white beans and Excel.

PROCEDURE

Part 1: Ball Bearing Shooters

You will be launching a ball bearing from a fixed height and measuring the horizontal range (x_1) that the ball travels. Repeat this launch again, but this time **double the height** of the ball bearing shooter and measure the range x_2. Now predict and measure the ratio of ranges (x_2/x_1).

a. With your group, come up with a **predicted** value for the ratio $(x_2/x_1)_{thy}$. Don't just guess, but try to have some reasoning behind it. If the group can't agree on a single theory, it's okay to have two competing theories.
b. Place the shooter on a wooden box and launch a ball bearing using the shooter and record the horizontal range x_1 in a data table (measure this to nearest mm). Repeat this a total of 15 times.
c. Raise the shooter to twice the initial height and repeat part (1b); define the horizontal range as x_2. In a new column, compute the ratio x_2/x_1 and take the average value ($\equiv (x_2/x_1)_{avg}$).
d. Answer the following questions:
   - Was your experimental average value equal to your predicted value?
   - If your experimental average didn't match your predicted value, does that mean that your theory was inconsistent ("wrong") with your data? Why or why not?
e. Based on these results, come up with what you think is a "reasonable spread of uncertainty" by answering the following questions:
   - If we perform this experiment many times we are pretty confident that the spread in the data values will be somewhere between ____ and ____.
   - If we did the experiment once more, our best guess for the ratio x_2/x_1 would be _____?
f. With the help of the instructor, make a histogram chart to display the results from part (1c). Add your values to the class histogram on the whiteboard. Notice that the curve is "bell shaped". What was the most common value on the class chart? Is your predicted value within the "reasonable spread" that you determined in part (1e)? Does it fall within the classes bell curve? Is your theory consistent with your experimental measurements? That is, what does this tell you about the correctness of your theory?

Part 2: From Probable to Certainty: measuring the number of white beans in a cup

a. With your group, come up with a **predicted** value $\mathbf{N_{thy}}$ for the number of white beans in the plastic bin. There is a prize for the group that is closest to the actual value.
b. Mix-up well the container of black and white beans and scoop-out a cup full beans (a random sample). Count the number of white beans per cup and record them in Excel. Repeat a total of 15 times. Create an addition column in Excel that multiples these 15 values by 52 (there are 52 cups of beans in the plastic bin). These are the estimated values for the number of white beans in the plastic bin.

c. Use Excel **calculate** the average number of white beans $\mathbf{N_{avg}}$ in the plastic bin and the standard deviation $\mathbf{S_N}$. Estimate the standard deviation of the mean using $\boldsymbol{\sigma_N} \approx S_N/\sqrt{N}$.
d. On the whiteboard, add your values N_{thy}, N_{avg} and σ_N to the table on the whiteboard.
e. Using your own data, **plot** a distribution curve for a $1\sigma_N$-confidence interval ($N_{avg} \pm 1S_N$). Determine the percentage of data points that land within the confidence interval – is it 68%?
f. Does the actual number of white beans (see instructor for the value) fall within your confidence interval $N_{avg} \pm 1\sigma_N$? If it falls within a $1\sigma_N$-confidence interval, we say that it is consistent; if it does not, it is inconsistent.
g. With the help of the instructor, compare the classes standard deviation of the mean $\boldsymbol{\sigma_{class}}$ to your estimated standard deviation of the mean σ_N using a percent difference. How do they compare?
h. Questions
    - What is the meaning of the value 68% in reference to the standard Deviation?
    - If the number of data points that land within a $1\sigma_N$-confidence interval is not 68%, is your data measurement in error?
    - What is the difference between the standard deviation S_N and standard deviation of the mean σ_N?