Lab 1: Warm-Up Round

- I. Pick at least five to **estimate**. Record your logic in notebook.

(1) Estimate the volume of this classroom.

(2) Estimate the height of a penny, in millimeters.

(3) Estimate how long it would take to get to the moon by boat.

(4) Estimate the monetary value of one month of human life.

(5) Estimate the weight of optimus prime, in kilograms.

(6) Estimate how tall mount everest would be if the world shrunk proportionately to the size of a baseball.

(7) Estimate which is more, the total distance lance armstrong has cycled in his life, or the distance from earth to the moon.

(8) Estimate the maximum amount of acceleration that a human body can survive, in units of g-forces.

(9) Estimate usain bolt's top speed and michael phelps's top swim speed.

(10) Estimate the speed of a medium-fast fish.

(11) Estimate the number of quarters to make a stack 67cm high.

- II. Do this **uncertainty and measurement** activity.

(1) Draw a big rectangle by hand.

(2) Use your ruler to measure the width and height of your rectangle. Multiply the width and height to get the area. Is that its area? How close do you think it is?

(3) Measure width and height again. For each, get a maximum, minimum, and average measurement. What is the area of the rectangle?

(4) What is your best guess of its exact area? As a percentage, what is your amount of uncertainty? Use notation like $A = 8\text{cm}^2 \pm 3\%$ to answer.

(5) What factor most limited your ability to precisely measure the rectangle's area?

- III. Learn to use **photogate timer**.

(1) Figure out how to use the photogate timer in **gate mode** to measure an object's speed.

(2) SHOWDOWN: With the timer screen covered so you can't see, try to block the photogate for *exactly* five seconds. Who can get closer? Keep trying until you succeed twice in a row to within 5% accuracy. Photograph yourself with the victorious timer screen to show off to your friends.

(3) Take a pen and try to pass it through the photogate at a constant speed of exactly 1 cm/s. Keep trying until you succeed twice in row to within 5%. Now try to pass the pen through at exactly 20cm/s, 60cm/s, 120cm/s, and 800cm/s. Get each within 10% twice in a row.

(4) Measure the speed of the pendulum at its bottom point when dropped from 10^o and 70^o.

(5) Take a long object like a piece of paper or ruler (the long way), and try to pass it through the photogate at 10cm/s. What's the problem? Think instantaneous versus average velocity.

(6) Figure out what the timer's **memory functions** do (use the silver lever).

(7) Put the timer in **pulse mode**. What does this do? Also, ask me what the little number on that sticker means.

- IV. Analyze **uncertainty and inaccuracy in a pendulum measurement**.

(1) Drop the pendulum bob from 20^o a few times in a row and measure its speed at the bottom point. Do you get the same thing every time? About how much uncertainty is there?

(2) What factor is most strongly affecting your ability to get a consistent measurement?

(3) Calculate the predicted value of the pendulum's speed at its bottom point for this experiment. What is the percent uncertainty in this predicted value?

(4) Take an average pendulum speed measurement over 10 trials. Be efficient: First get set up—then quickly knock out all 10 trials. No need to convert each trial to a speed, just average the times then convert.

(5) Are you more confident in the accuracy of your 10 trial average measurement than in the result of the individual trials? That is because statistically, if the uncertainty in a single trial is some amount U, then the uncertainty of the average value over N trials is $u = U/\sqrt{N}$, due to the way that random errors cancel each other out. Your brain calculates this for you automatically. (*Optional*: Actually calculate σ and σ_N along with v_{avg} for your data, then write your final result as $v_m = v_{avg} \pm X\%$, where $X\% = \sigma_N/v_{avg} \times 100\%$).

(6) On the other hand, systematic errors that are not random will not cancel each other out in the average. As an example, "accidentally" move the photogate sideways so that it intercepts the pendulum before the bottom point. Drop the bob a few times from the same angle as before. You are now measuring the wrong speed, and averaging won't help.

(7) Compare the predicted value of the experiment to your measured average value. What is the percentage difference? Do they match to within the expected margins of uncertainty? Reflect wistfully.

- Go home!