I. Background Information:

Weakest Link Rule and Uncertainties

The length, width and height of a box is measured: L = 10 cm, W = 20 cm, and H = 40 cm. Each measurement has an uncertainty of 1 cm. What is the uncertainty in the volume of the box? V = L x W x H = 8000 cm^3, the smallest possible volume is obtained by subtracting the uncertainty from each measurement: V(min) = L(min) x W(min) X H(min) = (9 x 19 x 39) cm^3 = 6669 cm^3, and the largest is obtained by adding: V(max) = L(max) x W(max) x H(max) = (11 x 21 x 41) cm^3 = 9471 cm^3. This method is correct, but very cumbersome.

Weakest link rule:

Instead of using the above method, we are going to use the weakest link rule to determine the uncertainty. Determine the percentage uncertainty of each measurement and select the largest percentage uncertainty as a good approximation. In the above example, the percentages are 1/10 = 10% for L, 1/20 = 5% for W, and 1/40 = 2.5% for H. The largest percentage is 10%, so that is what is used to determine the uncertainty in the volume. Volume uncertainty = 8000 cm^3 x 10% = 800 cm^3. Using the weakest link rule, V(min) = (8000 – 800)cm^3 = 7200 cm^3 and V(max) = (8000 + 800)cm^3 = 8800 cm^3. Notice that the approximate min and max values are close to the ones determined above.

II. Observation Experiment:

Determine a relationship between ramp angle and acceleration for a wooden block sliding down a wooden ramp

Any lettered section can be graded. Items which include a letter and a number in parentheses refer to a rubric ability. For example, (O3) refers to the observation experiment rubric ability 3. Items without such designation are given as additional guidance.

Purpose: Design an experiment to take appropriate data to find a relationship, construct a mathematical relationship from data, interpret the relationship and data to understand the differences between this relationship and the one found with a cart on a track.

You have a wooden block and a wooden ramp, meter sticks, and a motion detector. Determine a mathematical relationship between the angle of the ramp and the acceleration of the block, based on experimental data. The software will graph the velocity of the block. Perform a linear fit for velocity to determine the acceleration. There is a 'fit' button on the Logger Pro toolbar.

a. Draw a clearly labeled diagram of the experimental set-up. Make sure the important aspects of the experiment are included.
b. (O3) Decide what is to be measured and identify independent and dependent variables. Perform the experiment.

c. (O5) Describe what is observed without trying to explain, both in words and by means of a data table.
d. (O7) Graph the magnitude of the acceleration (on the vertical axis) vs. angle of incline (on the horizontal axis). You may use Excel or Logger Pro to graph and/or fit the data. Make the graph from 0 degrees to 90 degrees. Use the data and also use what you can assume for the

magnitude of the acceleration when the angle is 0 degrees and when the angle is 90 degrees. You can also think about what the graph would look like between 90 degrees and 180 degrees to help you understand the overall shape of the graph. Which function has a graph which looks like the one you just drew?.
e. (O8) Devise an explanation for the observed relationship.
f. (O9) Identify any assumptions made in devising the explanation, i.e. the relationship between the ramp angle and the acceleration of the block.
g. Make use of the weakest link rule to estimate the uncertainty in the relationship.
h. Contrast the mathematical relationship found in this experiment with the one found in the first lab between a cart and a metal track. If you did not get to this part, then ask your TA for the mathematical relationship that can be obtained from that experiment. What is similar between the two relationships? What is different? What about the experiments might contribute to a different relationship?

III. Testing Experiment:

Predict where two carts will collide

Any lettered section can be graded. Items which include a letter and a number in parentheses refer to a rubric ability. For example, (T3) refers to the testing experiment rubric ability 3. Items without such designation are given as additional guidance.

Purpose: Combining experimental data with problem solving to make predictions for the outcome of a new situation, considering factors that will impact the outcome of the situation, and smashing things together because it's fun!

The task is to place two carts at the correct initial positions in order for them to collide at the center point when released from rest at the same time on two ramps tilted at very different angles. The angular difference must be more than 15 degrees. Make sure the foam pad is between the two ramps at the base so the carts don't actually collide, but hit the foam pad simultaneously. This is a problem solving exercise. Use the equipment to take any necessary data, but do not perform the final test until the TA gives permission to do so and is ready to watch. Using trial and error is not allowed. The challenge is to predict the correct initial positions and test the prediction once as the TA watches.

Write the following:

a. Which quantities must be determined in order to predict the correct initial positions? Do any necessary experiments, measurements, and/or calculations to determine the values of those quantities. You may also refer to the results from lab 1.
b. (T4) Make a reasonable prediction based on the model developed in lab 1 and the kinematics model developed in lecture to predict where to initially place the carts such that they collide in the center.
c. Use the weakest link rule to estimate the uncertainty in the calculations. When the calculations are completed, show the results to the TA and then run the experiment.
d. Record the outcome of the experiment.
e. (T7) Decide whether or not the prediction and the outcome agree or disagree.
f. Reconcile any differences between the prediction and the outcome of the experiment. Be specific. For example, discuss how experimental uncertainties affected the outcome.