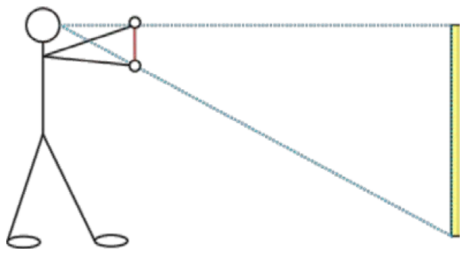
# Lab 1 - Measurements and Uncertainties

## Objectives

- To make measurements with uncertainty and down to the correct number of significant digits
- To understand how to recude uncertainties
- To use percent difference in the comparison of two measurements.

## Overview

Using the method of similar triangles, one is able to determine the dimensions of an object based on the dimensions of known values. For example, one is able to determine the length of a lawn by looking at a piece of string (red in the figure) and an object of a known size placed at the opposite end of the lawn (yellow in the figure) because the ratio of the distance between the eye and stick and the distance between the eye and string must be equal to the ratio of the length of the stick and the length of the string.



$$\frac{\text{Distance from eye to stick}}{\text{Distance from eye to string}} = \frac{\text{size of stick}}{\text{size of string}}$$

Measuring the size of an object through this indirect method can be useful for large and/or distant objects, however this method is much less precise and with greater uncertainty than a direct measurement.
You will apply this indirect method using the appropriate uncertainties, and compare the results with a direct measurement

# Background on measurements and uncertainty

In Module 0 in canvas, find the “basic data analysis” page. Read the sections “Measurement Uncertainties” and “Significant figures” for information on determining the uncertainty of a measurement and reporting measurements to the correct number of significant figures.

# Procedure

You will need three people in your lab team to complete this activity, partner A, partner B, and partner C.

- Go out to the lawn near the lab room.
- Partner A holds a 2-meter stick vertically on one edge of the lawn. (If a 2-meter stick isn’t available, then measure the height of the tallest person on your team (person A) and have them stand on one edge of the lawn.)
- While standing on the opposite edge of the lawn, partner B holds a string at arm’s length from their eye. Using the string, partner B measures how long the 2-meter stick appears to be from their position.

  **What is the apparent size of the stick with uncertainty?**

  //4.1 cm +\- 0.5 cm

Partner c measures the distance between the eye of partner B and the string when partner B measures the apparent size of the stick.

**What is the distance between the eye and the string with uncertainty?**

//50 cm +/- 0.5 cm

**Explain how partner B and partner C determined their uncertainties.**

//By including half of the smallest unit of measurement.

**Using the previous measurements, determine the length of the lawn by calculating the distance between partner A's 2-meter stick and partner B's eyes.**

//2500cm

**Add all the percent uncertainties in quadrature in order to determine the percent uncertainty on the size of the law. Show your work. ("Basic Data Analysis" in Module 0 may be useful.)**

//2% uncertainty

**What is the uncertainty on the size of the lawn?**

//+\- 0.5cm

**Do you think the actual size of the lawn falls within your range of estimated sizes? Explain.**

**//**yes because the measurements where checked twice.

**What factors most influenced your estimate of the size of the lawn? Explain.**

// accuracy of tape measure and the apparent length of the string viewed from the eye

Use the tape measure to measure the distance between partner A's 2-meter stick and the spot on the ground directly below partner B's eyes.

**What is the direct size of the lawn with uncertainty?**

//2300cm +\- 0.5cm

**How did you determine the uncertainty in the direct measurement?**

//by half the smallest unit of measurement

**Which measurement do you think is more reliable, the measurement made with the string or the measurement made with the measuring tape? Why?**

//the measurement made by the string b/c the exact position was lost after going inside and going back to the lawn.

**When comparing each measurement, is the measurement of length using the string consistent with the measurement of length using the measuring tape? That is, does one value agree with the other if each of their experimental uncertainties is taken into account?**

//yes the measurements are close in value.

**What is the percent difference between the length of the lawn measured using the string and the length of the lawn measured using the measuring tape?**

//8% difference

**If you were to repeat the experiment, will you get the same length for the lawn?**

//no because the measurements would be different in different spots.

Simulate this by going to each group and recording the length of the lawn that each group measured.

**Compare the length of the lawn you measured to the length measured by each of the other groups.**

**Average the length of the lawn measured by each group. This average is considered the best estimate for the actual length of the lawn.**

//22m

**Calculate the standard error on the average.**

// +\- 0.5 m

**Report the best estimate as average +/- standard error, down to the correct number of signficiant figures**

// 22m +\- 0.5m

**How close is your measured length of the lawn to the best estimate?**

// the measured length of the lawn is close to the estimate. By 100 cm.

**If you were to redo this experiment, how could you minimize your uncertainty?**

//by measuring twice and using well calibrated more precise tools.