

**Activity - Length Measurement**

**Purpose:** To practice measuring and estimating length in English and SI units; to learn about precision, uncertainty, and error propagation.

**Materials:** ruler, grad. cylinder, balance, digital scale, beaker, (calculator)

**Discussion:** In any experimental procedure taking measurements is a necessary part of the experiment. When taking measurements one must first decide which units to use (ie. inches, meters, pounds, etc...). Most of us are used to the *English System* of units. In this system the standard units of measure for length are inches. For smaller measures one might use fractions of the inch or microns; for larger measures one might use yards or miles. Using the English system can be tricky when you wish to convert units from, say, inches to feet because there are twelve inches in a foot and twelve is not an easy number to divide by. To simplify things--and to bring consistency around the scientific world--the *SI System* was developed. That system is based on tens which are easy to multiply and divide by (just move the decimal). The standard units for length in the SI system are meters. For smaller measures one might use millimeters or nanometers; for larger measures one might use kilometers or light years.

**Procedure:** **Estimating length**

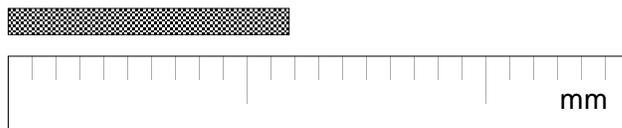
- Pick three objects in the room of varying sizes. Choose an appropriate English unit to measure length in. **Estimate** the length in that unit. Record. Do the same thing again but this time use a *metric* unit.
- Now measure the exact dimensions with a meter stick or ruler. Determine your percent of error (for the metric part only). Which system of measurement are you more comfortable with?

Object	<----- ENGLISH ----->			<----- SI ----->		
	estimate	actual	%error	estimate	actual	%error

**Determining a tool's precision and uncertainty**

When using a tool in the lab it is important to know the *uncertainty* of that tool. To make an appropriate measurement you should always stay within the certainty of the tool being used. In general you should measure to the greatest precision afforded by the tool then estimate one place further. For example, when

using a meter stick with millimeters being the smallest unit you should measure to the nearest millimeter then estimate one place further. In the picture above the object is not quite 12 mm long. You would record the length as 11 mm then estimate the next digit, say, 11.8 mm.



What are the precision and uncertainty of the following tools?

- a.) triple beam balance:       $\pm$  \_\_\_\_\_       $\pm$  \_\_\_\_\_
- b.) 100 mL grad. cylinder:     $\pm$  \_\_\_\_\_       $\pm$  \_\_\_\_\_
- c.) 200 mL beaker:             $\pm$  \_\_\_\_\_       $\pm$  \_\_\_\_\_
- d.) ruler (English):             $\pm$  \_\_\_\_\_       $\pm$  \_\_\_\_\_
- e.) ruler (SI):                     $\pm$  \_\_\_\_\_       $\pm$  \_\_\_\_\_
- f.) electronic balance          $\pm$  \_\_\_\_\_       $\pm$  \_\_\_\_\_

Use each tool above to make a measurement. Record the item measured and the measurement with the correct uncertainty:

Item	Quantity	Tool Used	Measurement
<i>Book cover</i>	<i>length</i>	<i>SI Ruler</i>	<i>25.42 + .01 cm</i>

### The Effects of Uncertainty on Calculations

•Estimate the dimensions of a rectangular object in SI units. Use those estimates to find its area and volume. Measure the exact values with a ruler and again find the calculate the actual area and the actual volume (be careful with units!).

Determine your percent error in each case.

Estimated		Actual		% Error
length		length		
width		width		
height		height		
area		area		
volume		volume		

**Calculations:**

**Questions:** (answer on a separate sheet of paper)

1. Why do scientists use the SI system?
  
2. Why is it necessary to choose an *appropriate* unit to measure with instead of just measuring with any old units (say, measuring the Eiffel Tower in millimeters)?
  
3. Which system of units were you more comfortable with? Why?
  
4. How does your % error for area and volume compare to that of the individual measurements? Compare your findings with classmates. Can you draw any conclusions from this?
  
5. What is the difference between *uncertainty* and *precision* of a measurement device?
  
6. Determine the %uncertainty of the following measurements (percent uncertainty is equal to the uncertainty of the device divided by the magnitude of the measurement.
  - a.) 25.502g using a triple beam balance \_\_\_\_\_
  - b.) 13.22cm using a metric ruler \_\_\_\_\_
  - c.) 1.32cm using a metric ruler \_\_\_\_\_

Why does the %uncertainty change in b) and c) above when the same tool is used???

7. **Estimate** the following in English or SI units:
  - a.) the length of a football field: \_\_\_\_\_ .
  - b.) the diameter of a hole made by a 3 hole punch: \_\_\_\_\_ .
  - c.) the height of the Saline water tower: \_\_\_\_\_ .
  - d.) the volume of a basketball: \_\_\_\_\_ .
  - e.) the area of one brick in the classroom wall: \_\_\_\_\_ .

**Conclusion:** What did you accomplish? What were the main concepts studied or discovered?