INTERACTIVE DEMONSTRATIONS - MEASUREMENTS -

OVERVIEW

Interactive demonstrations are practical exercises intended to facilitate your understanding of the topics in this course throughout the semester. They will complement the lecture sessions and will take place in a collaborative fashion, so you can reflect upon the issues as you explain your own conceptions to each other.

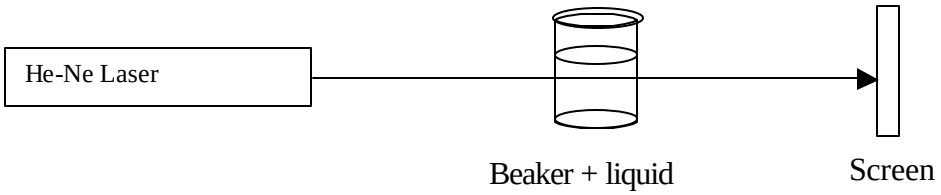
For each experiment, you should brainstorm with the group to predict the outcome, observe the results of the experience by executing the exercise, and finally analyze the results obtained by explaining any discrepancy or agreements between your predictions and the actual outcome of the measurement.

OBJECTIVES

- To get acquainted with experimental settings
- To discover the numerical and unit dimensions of experimental data
- To discover the limitation of measuring devices
- To appreciate the meaning of significant figures obtained in measurements
- To discover the uncertainty of measurements
- To perform graphical representation of relationships between variables using Excel
- To access chemical information using the electronic facilities of the chemistry library for undergraduates

Measuring Length

Equipment: Laser pointer, English ruler, millimetric scale screen, beaker, water, hexane, acetone, and methyl alcohol.



- Note the position of the laser beam on the millimetric screen as it enters the empty beaker off axis.

- Add water, ethyl alcohol, acetone, and hexane (respect the order) and each time note the new position of the beam on the screen. Clean the beaker each time you change the liquid

investigated. Measure the deviation of the laser beam both in inches and millimeters using the ruler provided. Write down your observations.

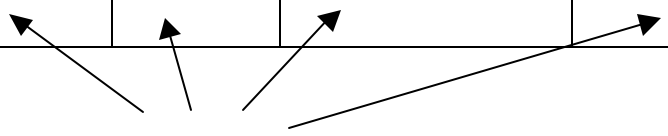
- Each member of the group must do a measurement of the deviation produced. Report the average deviation for each liquid both in inches and millimeters.
- Search the CRC index using the Undergraduate Web page of the chemistry library **http://www.columbia.edu/itc/chemistry/chem-tutorial/** for the values of the refractive index of the substances measured.
- Prepare a plot of refractive index vs. average deviation (two plots: one plot with the deviation in inches, and one with the deviation in mm.)
- Use the Undergraduate Web page of the chemistry library to find the definition of refraction of light and refractive index.
- Can you use this setup to measure the index of refraction of an unknown liquid? Describe how you would do the measurement.

Measuring electrical properties

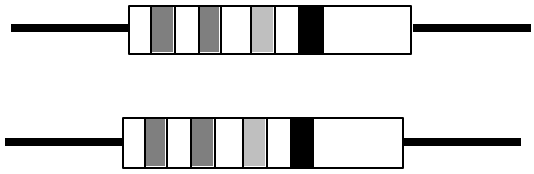
Equipment: Multimeter, resistors, and batteries

1. Measuring Resistance. The resistance value of commercial resistors is indicated by a universal color code that also indicates the uncertainty of the measurement according to the table below:

Color	**1st band**	**2nd. band**	**3rd. band (factor x)**	**Tolerance (Accuracy) (%)**
Black (B)	0	0	x 1	-
Brown (Br)	1	1	x 10	-
Red (R)	2	2	x 100	-
Orange (O)	3	3	x 1,000	-
Yellow (Y)	4	4	x 10,000	-
Green (G)	5	5	x 100,000	-
Blue (Bl)	6	6	x 1,000,000	-
Violet (V)	7	7	x 10,000,000	-
Gray (Gr)	8	8	x 100,000,000	-
White (W)	9	9	x 1,000,000,000	-
Gold (Go)	-	-	-	5
Silver (S)				10
No Color (No)				20



Example:



Y V O No

What is the value of the resistance of the resistor shown? Explain.

- Using the Multimeter measure the value of the given resistors. Each member of the group will make an individual measurement. Report the average of the value measured and compare it with the value given by the color system.
- Discuss the discrepancy of the values and write a definition of uncertainty in measurement.
- According to the color of the 4th. band, decide which resistors are more expensive? Explain.

2. Measuring Voltage:

- Using the Multimeter measure the voltage of the alkaline batteries provided. Use different scales of the Multimeter and compare the results. Each member of the group will do a measurement and the average voltage will be reported. What can you say about the uncertainty of the value reported?

Measuring Mass

Equipment: Triple beam balance, mechanical balance, coins, and 10mL volumetric flask.

- Using the triple beam and the mechanical balances provided, measure the mass of the ten pennies together, and then measure them separately taken two at a time.
- Is the sum of the masses of the pennies taken separately equal to the mass obtained when the pennies are measured together? Explain. Report the uncertainty.
- Which balance gives you a better match between the two measurements? Why?

Measuring Temperature

Equipment: Thermometer (0 - 360°C), (0 - 50°C), water bath, ice, salt.

- Using the two thermometers provided, measure the temperature of the warm water, iced water, and ice-salt water mixture. Each member of the group will make a measurement. Calculate the average temperature. Write down your conclusions.
- Convert the temperature readings to Fahrenheit and Kelvin. Report your results with the proper number of significant figures. Report the uncertainty.

Measuring Volume

- Fill the burette with water as indicated by the instructor.

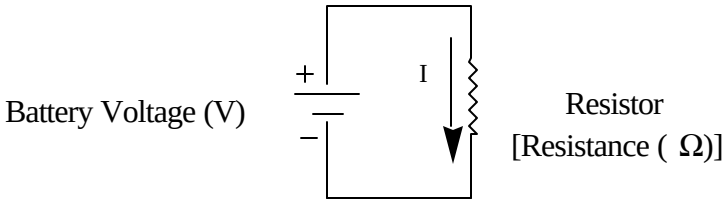
- Deliver 25mL of water on a 50mL beaker. Does the volume delivered match the volume inscribed on the beaker?
- Deliver 10 mL of water in a 10mL volumetric flask. Does the volume match the mark on the flask?
- Withdraw 10 mL of water with the graduated pipette and fill the 10mL volumetric flask with it. Do you note any difference between the measurement done with the burette and the one performed with the pipette? Explain.

Propagating uncertainty with calculations

(a) Current

Ohm's law is written as $V = I \times R$, where V is the voltage in volts, I the current in Amperes, and R is the resistance in ohms.

- Using the measured values for the voltage of the batteries and the resistors given, calculate the current that will circulate through the simple circuit shown. Propagate the uncertainty accordingly, and report the result with the appropriate number of significant figures



(b) Density

Using the most accurate thermometer, measure the temperature of the water measured in the volumetric flask, and using the most accurate balance measure the mass of the volumetric flask filled with water.

- How can you obtain the mass of water that was inside the volumetric flask?
- Once you figure that out, calculate the density of the water at the temperature measured. Report the correct number of significant figures, and the uncertainty that results from such calculation.
- Fill four 10mL volumetric flasks with water at four different temperatures.
- Measure the mass of each water sample. In the mass measurement exercise above, you were supposed to calculate the mass of water contained in the flask. Using the same strategy calculate the mass of water and the corresponding density.

- Search the CRC index using the Undergraduate Web page of the chemistry library http://www.columbia.edu/itc/chemistry/chem-tutorial/ for the values of the density of water at the temperatures measured. Tabulate the results as shown below.

T (°C)	d (g/mL) CRC	d (g/mL) Exp.

- Plot the results in one single graph using Excel.
- Explain any discrepancies between the experimental values and the theoretical ones.