Experiment 1C

MEASUREMENTS, DATA TREATMENT, AND INTRODUCTION TO SPREADSHEETING

MATERIALS:

10 mL graduated cylinder, weighing bottle, 50 mL buret, buret stand, buret clamp, string (one meter in length), 10 g mass, meter stick and pendulum stand, thermometer, 100 mL or larger beaker.

INTRODUCTION:

There are three parts to this experiment which can be performed in any order (as determined by your instructor). All values obtained in this experiment will ultimately be entered into a spreadsheet and all calculations and graphing will be done using the spreadsheet program. While all of the data will be gathered in a single laboratory session, the data reduction and spreadsheet instruction may extend over two or three weeks as determined by your instructor.

PROCEDURE: (work in pairs)

All original data is to be recorded neatly in ink on the data page for this experiment.

Part A. Determination of the Density of Water Using a Graduated Cylinder and Top Loader Balance:

Fill a 10 mL graduated cylinder to the 10.0 mL mark with distilled water. Weigh the filled graduated cylinder on a top-loading balance. Then empty the cylinder and again weigh the cylinder. Record the mass to 0.01 g and be sure to include units. Finally, using a thermometer and beaker, measure and record the distilled water temperature to one decimal place. Find the accepted density of water at this temperature from an appropriate source, such as the CRC Handbook of Chemistry and Physics found in the balance room.

Part B. Determination of the Density of Water Using a Buret and an Analytical Balance:

Using a buret, add about 1 to 2 mL of distilled water to a weighing bottle. Record the actual volume of water that was added. Weigh the weighing bottle with its lid on an analytical balance[1] and record the mass. Include units! Add an additional 1 to 2 mL to the weighing bottle and again determine the mass[2]. Record the <u>total</u> volume and <u>total</u> mass. Repeat this process until you have a minimum of 5 volume-mass data pairs. On the Part B data sheet, record the same temperature that was measured in Part A.

Part C. Period of a Pendulum:

A string with a 10 g mass on the end is suspended from a stand. Measure the length of string carefully[3]. Displace the mass by about 15° and let it swing. Measure the time required for 20 cycles of the pendulum. Record the length in centimeters to one decimal place, and record the time in seconds to the nearest second. Move to another length of the string and repeat. Do this until a minimum of 6 length-time data pairs have been recorded.

---

[1] The mass of the empty weighing bottle is not needed or desired.

[2] The amount of water that you add each time is not important. However, you must accurately record the actual <u>total</u> volume and <u>total</u> mass after each addition.

[3] Pick a convenient point on the 10 g mass for measuring the string length. Use the same point for all length measurements.

Calculations:

Introduction: You must have carried out all of the exercises in the Quattro Tutorial on the Chemistry Department homepage (www.nadn.navy.mil/ChemDept) before embarking upon the calculations required for this experiment. You may not use a calculator in the preparation of reports for this experiment; all calculations must be performed using functionality included in Quattro!

Part A. Determination of the Density of Water Using a Graduated Cylinder and Top Loader Balance:
Give some thought to how you lay out your spreadsheet. The following is a suggestion only:

	A	B	C
1	Experiment 1C-Part A		
2	Density of Water Using a Graduated		
3	Cylinder and a Top-Loading Balance		
4			
5	Volume of Water	10.00	mL
6	Mass of Full Cylinder	48.82	g
7	Mass of Empty Cylinder	38.73	g
8			
9	Mass of Water	10.09	g
10			
11	Calculated Density	1.009	g/mL
12			
13	Literature Density	0.99756	g/mL at 22.1 degree C
14			
15	Percent Error	1.15	%

The A-column is used to label the values, while the C-column is used for units, which are entered as left-aligned labels. The mass of water that is displayed in cell B9 results from the formula that is entered in this cell. The formula can be entered as +B6-B7 or as (B6-B7). Remember that the leading "+" or "(" is necessary so that Quattro interprets what follows as a formula and not as a label. The density displayed in cell B11 is the result of the formula +B9/B5 which is entered in that cell.

The literature value of the density is obtained by looking it up in an appropriate handbook. By definition, percent error is:

$$\frac{(\text{Experimental value}) - (\text{True Value})}{(\text{True Value})} x100$$

The formula entered in cell B15 in the example might be +100*(B11-B13)/B13.

You will need to format cells and adjust column widths. For example the graduated cylinder can be read to 0.01 mL. Consequently the volume of water should be displayed as 10.00 mL rather than 10 mL. Make sure that all of the quantities are appropriately labeled, so that when your instructor grades the printout of your spreadsheet, he/she will have no difficulty in identifying the various quantities. It is better to err on the side of over labeling than the other way around. If you have not produced a hard copy of a spreadsheet before, you may need to explore the options you have available for printing.

Your Part A report consists of a hard copy of the spreadsheet.

Part B. Determination of the Density of Water Using a Buret and an Analytical Balance:

You are to use Quattro to plot mass versus volume. That means volume is to be taken as the independent variable and plotted along the horizontal or X-axis. Mass is the dependent variable and plotted along the vertical or Y-axis.

Make sure the settings in Quattro are such that you can extrapolate a straight line through the data points to the Y-axis. You may need to attend an instruction session on how to do this. Your instructor will insist that the graph include a 1) title, 2) X-axis label and units, and 3) Y-axis label and units.

Using your graph: 1) determine the slope of the line (which is the density of water in g/mL); and 2) the Y-intercept (which is the mass of the empty weighing bottle in g). In Part C, you will be required to have Quattro Pro determine the value of the slope of a straight line, but in this part, you may extract the slope by any method you choose. Enter the values for slope and intercept into a blank area of the same spreadsheet you used to generate the graph. Finally, enter the literature value of the density into the spreadsheet. Calculation must be done by entering a formula and not on a calculator! Complete your spreadsheet by making sure all quantities are correctly labeled, have units, and that the numbers are formatted to a reasonable number of decimal places. If you have difficulty, seek help.

Your Part B report consists of hard copy of the spreadsheet and the graph.

Part C. Period of a Pendulum:

You are required to use the Linear Regression function in Quattro. You also need to know how to make Quattro draw in the best fit straight line through a field of discrete experimental data points. Both of these items are covered in the Quattro Tutorial mentioned previously. You may need to perform this exercise before proceeding!

Enter your experimental data in a spreadsheet. You may organize your spreadsheet any way you wish, but you will need to create the following additional columns: 1) period of pendulum (or time for a single cycle); 2) logarithm of period; 3) logarithm of length. Enter a formula in the first cell of each column and use the copy command to copy the formula into the remaining cells of the column. Note that Quattro Pro has both a natural log function (@LN) and a base 10 log function (@LOG). While either will work in this calculation, for sake of consistency, use the base 10 (@LOG) function. You should end up with a total of five columns in your spreadsheet.

Make a plot of Period versus Length. Display the points as open squares with no line connecting the points. If your data was reasonably good, the graph should display some curvature or nonlinear behavior. While it is possible to have Quattro draw a smooth curve through the points, this is a bit complicated and you are not expected to do this. Add titles, labels and units.

The behavior of the pendulum can be described by the exponential function:

$$\text{Period} = C(\text{Length})^A$$

where A and C are constants. Taking the logarithm of both sides we obtain the equation:

$$\log(\text{Period}) = A \log(\text{Length}) + \log(C)$$

which compares to the equation of a straight line, $y = mx + B$, where $y = \log(\text{Period})$, $x = \log(\text{Length})$, and $B = \log(C)$. Consequently if we plot log(Period) versus log(Length), we should obtain a linear plot with the slope equal to A, and the intercept equal to log(C).

Make a new graph using Quattro of log(Period) vs log(Length) displaying the log (Period)-log(Length) pairs with discrete open squares. Then use the Linear Regression function to obtain the best fit straight line and add this to the graph. Review the tutorial if necessary to accomplish this. Be sure to title the graph and label the axes. As logarithms do not have units, do not add units to the axis labels.

The ideal pendulum would yield a slope of 1/2 or 0.5 exactly. Enter this value into the spreadsheet and label it. Again, using a spreadsheet formula, calculate the percent deviation of your experimental (Linear Regression) slope from the ideal value.

Your Part C report consists of hard copy of the spreadsheet and the two graphs. The entire lab report consists of the original data sheet, separate spreadsheets for parts A, B, and C, each followed by the respective graph or graphs called for, if any.

Name _____ Section _____

Partner _____ Date _____

DATA SECTION
Experiment 1C

Part A: Measured volume of water in cylinder _____

Mass of cylinder and water _____

Mass of empty cylinder _____

Temperature of water _____

Literature density of water at expt. temp _____

Part B: Total volume water delivered Total mass water delivered

_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

Temperature of water _____

Part C: Length of pendulum Time for 20 cycles

_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

Instructor's initials: _____