Experiment 1A

MEASUREMENTS AND DATA TREATMENT

MATERIALS:

600 mL beaker, ring stand, Bunsen burner, digital thermometer, thermometer clamp, stirring rod, string with attached mass, meter stick, timer, ruler.

ADDITIONAL READING: Before coming to lab, read Appendices B, C, and D.

PURPOSE: In this experiment, the student will learn how to do the following.

1. Collect and record experimental data.
2. Report data with the proper number of significant figures.
3. Manipulate and analyze data using a spreadsheet program.

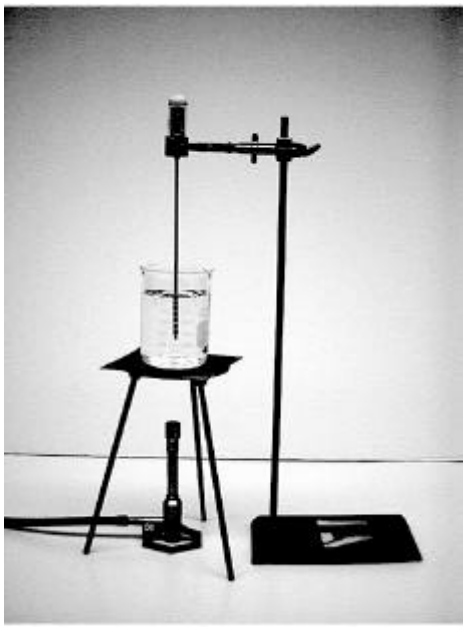
PROCEDURE:

Unless otherwise indicated by your instructor, express all data with the proper number of significant figures and units.

Part A. *Relationship between Fahrenheit and Celsius Temperature Scales.*

Fill the 600 mL beaker with an ice/water mixture and place it on the ring stand. Clamp the digital thermometer to the ring stand and immerse it half way into the beaker (*Fig. 1*).

Figure 1

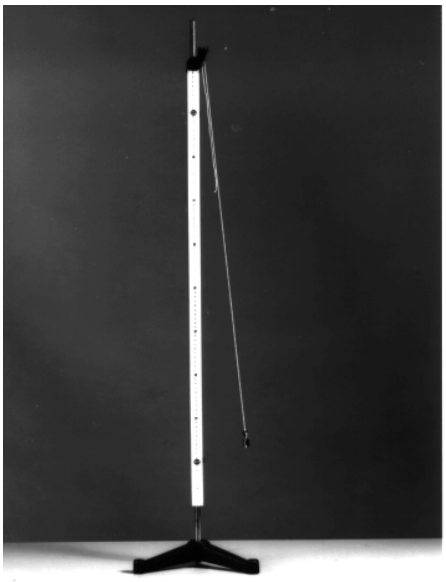


The digital thermometer will be used to measure the temperature both in degrees Fahrenheit (°F) and degrees Celsius (°C). When the temperature readings have stabilized, record them in the *Data Section* using the *proper number of significant figures and units*. Remove all of the ice and refill the beaker with tap water. Re-immerse the thermometer and record the temperature in °F and °C when stabilized. Using a Bunsen burner, slowly raise the temperature of the water 12 to 15°C. Record the °C temperature and the corresponding °F temperature. Gentle stirring with a stirring rod should help to equilibrate the temperature. Repeat the warming process in 12 to 15°C increments until the water is boiling. Record the temperature readings after each heating.

Part B. *Measurements of the Period of a Pendulum.*

A string with an attached mass is suspended from a post on a ring stand (*Fig. 2*).

Figure 2



Carefully measure the length (in cm) of the string from its end to the center of the mass. Record the length in the *Data Section* using the *proper number of significant figures and units*. While keeping the string taut, displace the mass by about 15° (*Fig. 2*) and release it. The time it takes for the mass to return to its (approximate) original position is defined as one cycle of the pendulum. Record the time (in seconds) required for <u>twenty</u> <u>cycles</u> of the pendulum.. Repeat the experiment using another length of string and record the data. Collect data for at least 6 different string lengths ranging between 20 cm and 1 meter. For best results, the string lengths should be evenly spaced over the entire range of 20 cm to 1 m. Make sure to displace the mass by about 15° each time for consistency.

Name _____ Section _____

Partner _____ Date _____

DATA SECTION
Experiment 1A

Part A. *Relationship between Fahrenheit and Celsius Temperature Scales.*

Record the temperature values in the spaces provided using the proper number of *significant figures and units*.

Fahrenheit	Celsius
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

Part B. *Measurements of the Period of a Pendulum*.

Record the length and time values in the spaces provided using the proper number of *significant figures and units*.

Length of Pendulum	Time for 20 Cycles
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

DATA TREATMENT
Experiment 1A

Unless otherwise indicated by your instructor, all data in this experiment will be analyzed using a spreadsheet program.

Part A. *Relationship between Fahrenheit and Celsius Temperature Scales.*

(A.1) Enter your experimental data from Part A into a spreadsheet. To determine the relationship between the Fahrenheit and Celsius temperatures, plot a graph of temperature in °F versus temperature in °C. (Note, it does not matter which variable is designated as the dependent variable; for simplicity, the temperature in °F has been chosen as the dependent variable and the temperature in °C as the independent variable). Label the axes appropriately. Note, experimentally determined data are only shown as points or markers on the graph.

(A.2) Due to scatter in these data, it may be difficult to determine whether there is a linear relationship between the temperature in °F and temperature in °C. The equation for a straight line has the form

$$y = m\,x + b$$

where y is the dependent variable, x is the independent variable, m represents the slope of the line, and b represents the y-intercept of the line. An unambiguous way to determine if there is a linear relationship between the dependent and independent variables is to perform a linear regression on these data. From the linear regression output, the correlation value, $R^{2,}$ can be determined; the closer the value of R^2 is to 1.0, the more linear these data. Perform a linear regression on these temperature data to obtain values for R^2, the slope, and the y-intercept for the line that best fits your experimental data (i.e., the best-fit line). Record these values below with the proper number of *significant figures and units*.

R^2 = _____

m = _____

b = _____

(A.3) For each value of the independent variable in your spreadsheet, use the values for the slope and the y-intercept to determine the corresponding value of the dependent variable that lies on the best-fit line. Using the calculated values of the dependent variable, plot the best-fit line on your graph along with your experimental data. Note, points or markers should not be visible in the linear regression line.

(A.4) Because the R^2 value is close to 1.0, these data are linearly related and the relationship between the temperature in °F and temperature in °C can be expressed as °F = m (°C) + b. Using your values of m and b, write out the mathematical relationship between Fahrenheit and Celsius temperatures below.

_____

Part B. *Measurements of the Period of a Pendulum*.

(B.1) Enter your experimental data from Part B into a spreadsheet. Use the spreadsheet program to calculate the period of the pendulum (time required for one cycle of the pendulum), the logarithm of the period of the pendulum, and the logarithm of the length of the pendulum. Label the columns in the spreadsheet appropriately.

(B.2) Construct a plot of the period of the pendulum versus the length of the pendulum. Preform a linear regression analysis on these data. Record the R^2 value below.

R^2 = _____

(B.3) If the period and length of the pendulum are not linearly related, they might be fit by the equation $y = a\,x^m$ where the exponent m can be an integer or a fraction. Alternatively, by taking the logarithm of both sides of this equation it can be expressed as

$$\log y = m \log x + \log a.$$

Construct a plot of the log of the period versus log of the length. Perform a linear regression on these data. Plot the best-fit line through the experimental data points. Record the values for R^2, the slope, and the y-intercept with the proper number of *significant figures and units*.

R^2 = _____

m = _____

b = _____

(B.4) From your results, write out the mathematical relationship between the log of the period and the log of the length.

_____

What is the numerical value for the "a" term? a = _____

QUESTIONS
Experiment 1A

Part A. *Relationship between Fahrenheit and Celsius Temperature Scales.*

(A.1) Using your experimentally established relationship from *Part A* of this experiment, determine the Fahrenheit temperature that corresponds to a temperature of 275°C.

(A.2) The correct equation for the relationship between the temperatures in °F and °C is give by, °F = 1.8 (°C) + 32. Using this equation, calculate the Fahrenheit temperature that corresponds to a temperature of 275°C.

(A.3) Calculate the % error for your experimentally determined value obtained in part (A.1) from the theoretical value determined in part (A.2).

(A.4) What experimental sources of error might exist in *Part A* of this experiment?

Part B. *Measurements of the Period of a Pendulum*.

(B.1) Explain why it is more accurate to measure the time for many cycles of the pendulum to pass rather than the time for one cycle to pass.

(B.2) Based on your experimental data from *Part B* of this experiment, calculate the period of a 32.4 cm pendulum.

(B.3) What experimental sources of error might exist in *Part B* of this experiment?