

# TEMPERATURE SCALES AND FREEZING POINT DEPRESSION

## LAB PP 6.PALM

### INTRODUCTION

**Temperature tells us the relative warmth or coolness of a substance. This warmth or coolness is actually our sensation of the average energy of the motion of the molecules in the substance.** The scale we use to measure temperatures tells us what those temperatures are relative to. People rely on temperature measurements in a variety of ways. Sometimes we use our bodies to estimate the temperature of other things, like when we stick our toe in a swimming pool to see how cold it is, or when we put our hand on someone's forehead to check if they have a fever. When the situation requires a more accurate temperature measurement, we use thermometers. Thermometers vary, of course, depending on the temperature scale on which they are based

**Figure 1: Common Temperatures in Celsius and Fahrenheit**

Description	°C	°F
Freezing water temperature	0	32
Boiling water temperature	100	212
Comfortable room temperature	22	72
Normal body temperature	37	98.6
Better tap water temperature (2-min burn)	51.7	125
“Too hot” tap water temperature (6-s burn)	60	140

In the United States, we commonly use the Fahrenheit scale to measure temperature, but the Celsius scale is used in scientific measurements and for practically all temperature measurements in most other countries. This lab activity introduces the Celsius temperature scale and compares measurements made in Celsius and Fahrenheit. Figure 1 compares common temperatures measured in Celsius and Fahrenheit. (Much scientific work actually uses the Kelvin scale which is directly related to the Celsius scale (uses the same “size” degrees but a different “0” point.)

This lab activity also introduces the concept of freezing point depression. The uses of salt to melt ice and snow on roads and to help make homemade ice cream are common applications of processes related to freezing point depression.

### PURPOSE

The purpose of this activity is two-fold:

1. to introduce and increase familiarity with the Celsius temperature scale.
2. to observe and measure an example of freezing point depression.

## **EQUIPMENT/MATERIALS**

Palm OS device with DataPro software	Ice cubes
LabPro interface with AC adapter and Palm cable	Paper towels
2 Temperature Probes	Liquids at various temperatures
Packets (or other supply) of common table salt	

## **SAFETY**

- Always wear an apron and goggles in the lab.
  - Use caution handling hot liquids.
  - Do not eat or drink in the laboratory.
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## **PROCEDURE**

1. Connect the two temperature probes to the LabPro CH1 and CH2 ports.
2. Ensure that the LabPro is connected to the Palm device.
3. Connect the power supply to the LabPro and plug it into a nearby electrical outlet or power strip.
4. Turn ON the Palm and select the DataPro Application from the Home screen. If it is already running, “quit” and restart DataPro from the Home screen.
5. On the DataPro screen, you will see the temperatures being measured and reported by the two probes. Hold the metal part of the CH1 probe in your hand. What happens to the temperature that is displayed? When it reaches a steady state, record the temperature and your observations in Table 1 on the Data Sheet.
6. Obtain an ice cube and place it on a paper towel in your group’s workspace.
7. Gently press the tip of the probe against the top of the ice cube. What temperature is now displayed? Record the final steady temperature displayed and your observations of the process in Table 1 on the Data Sheet.
8. Once the temperature has stabilized, pour the contents of a small packet of salt (or its equivalent, as directed by your teacher) onto the top of the ice cube.
9. Once again, gently press the tip of the probe against the top of the ice cube and keep it there until a nearly steady temperature is reached. What is the temperature now? What is happening to the ice cube? Record the temperature displayed and your observations in Table 1 on the Data Sheet.

10. Set up the second temperature probe to measure temperature in °F as follows:
  - a. **Activate DataPro “Setup”:** with DataPro running, tap <Setup> at the bottom of the DataPro main screen
  - b. **Activate the sensor selection screen:** On the “DataPro - Setup” screen, tap <CH2: TEMP(C)>
  - c. Scroll down to “TEMPERATURE TMP(F)” and select it (tap it) with the stylus
  - d. The Setup screen should now show the second sensor as CH2: TEMP(F)
  - e. Tap <OK>
  - f. Measure temperatures of different cold, warm and hot liquids with both probes to see the temperature in °C and °F. Record the liquids used and the temperatures observed in Celsius and Fahrenheit in Table 2 of the Data Sheet.
11. **FINISHED?** If you are sure you are done using the Palm device (**not doing an “optional” page**), if the <Quit> option is not at the bottom of your screen, press <OK> as many times as it takes to display a <Quit> option. When you tap on <Quit>, you will be told that using <Quit> will erase your data—that’s okay—tap <Quit> on the popup screen, then when you see the main Palm OS screen, simply turn off the Palm device.

(Optional—do this page and the companion calculation page if instructed to by your teacher)

12. Use the Palm, LabPro, and sensors to create a graph of °F vs. °C
  - a. Create a data set
    - i) At the DataPro initial screen, choose Setup, then
      - (1) You should (still) have CH1: TEMP(C) and CH2: TEMP(F)  
(If you don't, through this setup screen make sure you do.)
      - (2) Mode: Time graph
      - (3) Settings (set to these values if you see something different):
        - (a) 1 second/sample
        - (b) 60 samples
        - (c) graph options: autoscale
        - (d) triggering: none...then exit "settings" by tapping <OK>
      - (4) exit "setup" by tapping <OK>
    - ii) Hold both temperature probes together on a cool surface or in a beaker or glass of cool water, and tap **Start**
    - iii) Move the temperature probes together into the palm of your hand or dunk them evenly and together into a beaker or glass warm or hot water
  - b. **Display a graph of °F vs. °C** (you probably are viewing a graph of Temp vs. Time or All... versus )
    - i) Tap on the y-axis label and select CH2: TEMP(F)
    - ii) Tap on the x-axis label and select CH1: TEMP(C) (the correct scatter-graph should appear)
12. The LabPro software can tell you the equation of the line
  - a. Tap on "Curve Fit" to bring up the "Curve Fit" screen
  - b. Ensure that the "Data to Fit" box says **CH2: TEMP(F)**
  - c. Ensure that the "Fit Equation" box shows **Linear**
  - d. Answer/solve/fill in, as required, on the calculation page labeled "(Optional) Conversion Equation by Calculation and by Palm"
13. **View the equation:** When you are done recording the equation values, tap <OK> to back up one screen and see the straight line plotted over the data points.
14. **FINISHED?** When you are done using the Palm device, press <OK> as many times as it takes to display a Quit option. You will be told that using Quit will erase your data—that's okay—tap Quit on the popup screen, then when you see the main Palm OS screen, simply turn off the Palm device.

**DATA SHEET**

Name \_\_\_\_\_

Name \_\_\_\_\_

Period \_\_\_\_\_ Class \_\_\_\_\_

Date \_\_\_\_\_

**TEMPERATURE SCALES AND FREEZING POINT DEPRESSION**

**DATA TABLES**

**TABLE 1**

<b>Probe Conditions</b>	<b>Temp. (°C)</b>	<b>Observations</b>
In hand		
On ice cube		
On ice cube with salt		

**TABLE 2**

<b>Description of Liquid</b>	<b>°C</b>	<b>°F</b>

(Optional) °C → °F Conversion Equation by Calculation and by Palm

Interpretation of line constants:

- A. Slope—the ratio of the size of a Celsius degree to that of a Fahrenheit degree:
- B. “y”-intercept—the number of Fahrenheit degrees above zero at which water normally freezes (When Celsius temperature is 0°, Fahrenheit is ...?)
- C. The equation you’ll be working on:  $y = \mathbf{a} \cdot x + \mathbf{b}$  (a.k.a. Celsius to Fahrenheit conversion equation →  $F = \mathbf{a} \cdot C + \mathbf{b}$ )

(You have probably seen this written as  $y = \mathbf{m} \cdot x + \mathbf{b}$  in a math class?)

1. Knowing two points (C, F)—water’s freezing point (0, 32) and boiling point (100, 212), determine the equation in slope-intercept ( $y = m \cdot x + b$  *or*  $F = m \cdot C + b$ ) form and write the slope and intercept values here: (the “expected” values)

$$F = \underline{\hspace{2cm}} \cdot C + \underline{\hspace{2cm}}$$

2. Write the values for slope and intercept given by the Curve Fit method of your Palm device: (the “observed” values)

$$F = \underline{\hspace{2cm}} \cdot C + \underline{\hspace{2cm}}$$

3. How well do the numbers compare? Show your calculations of the percent error for each.

$$\% \text{ error} = (\text{observed value} - \text{expected value}) / (\text{expected value}) * 100\%$$

- A. Slope: Compute the percent error of the experimentally-determined slope value, showing your calculations and results here:

- B. Intercept: Compute the percent error of the experimentally-determined intercept value the same way. Show your calculations and results here: