Two Hot Two Cold

About the Lesson

How do we measure temperatures? In almost all countries of the world, the Celsius scale (formerly called the centigrade scale) is used in everyday life, science, and industry. This scale sets the freezing temperature of water at 0 and the boiling temperature at 100. The distance between these two points is divided into 100 equal intervals called degrees.

Vocabulary

- Celsius
- Fahrenheit
- Slope

Teacher Preparation and Notes

- Each group will need 5 cups with water of varying temperatures:
  - One cup of water should be room temperature or fresh out of the tap.
  - One should be very cold with many solid ice cubes in the cup.
  - One should have water that is cool with only a few cubes of ice that have just melted.
  - One should be considerably warmer than room temperature.
  - One should be either boiling water or very close to boiling.
- Run water through a coffee pot for hot water samples and keep ice in a small cooler for the cold water samples.

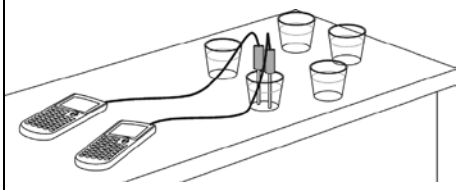
Activity Materials

- Compatible TI Technologies:

TI-84 Plus*
TI-84 Plus Silver Edition*
TI-84 Plus C Silver Edition
TI-84 Plus CE

***** *with the latest operating system (2.55MP) featuring MathPrint™ functionality.*

- Vernier EasyData® App
- 2 Vernier Easy Temps® Sensors
- 5 cups per student group, of water with varying temperatures
- Ice and boiling water)



Tech Tips:

- This activity includes screen captures taken from the TI-84 Plus CE. It is also appropriate for use with the rest of the TI-84 Plus family. Slight variations to these directions may be required if using other calculator models.
- Watch for additional Tech Tips throughout the activity for the specific technology you are using.
- Access free tutorials at http://education.ti.com/calculators/pd/US/Online-Learning/Tutorials
- Any required calculator files can be distributed to students via handheld-to-handheld transfer.

Lesson Files:

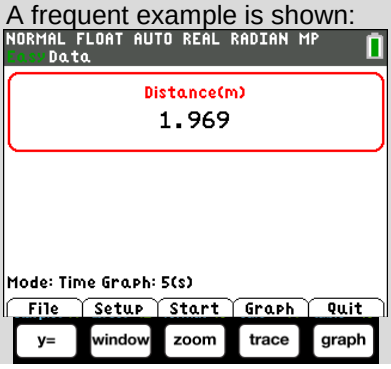
- Two_Hot_Two_Cold_Student.pdf
- Two_Hot_Two_Cold_Student.doc

Introduction

The United States uses the Fahrenheit scale. This scale employs a smaller degree unit than the Celsius scale and its freezing point is set to a different temperature. For the temperatures we commonly use and observe, Celsius readings are lower than Fahrenheit readings. You have probably noticed this if you have seen a thermometer that has both Celsius and Fahrenheit markings or if you have driven by signs at banks and other businesses that display time and dual temperatures.

In this experiment, students will collect data in both Celsius and Fahrenheit temperatures using two temperature probes in the same cups of water. Based on the data collected, students will develop an equation to convert Celsius temperatures to Fahrenheit temperatures.

Tech Tip: While using the Vernier EasyData® app, the tabs at the bottom of the screen indicate menus that are accessed by pressing the calculator key directly below it. A frequent example is shown:

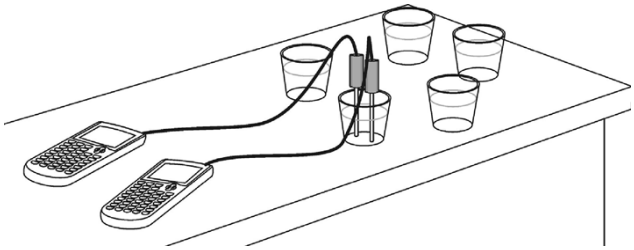


Collecting the Data

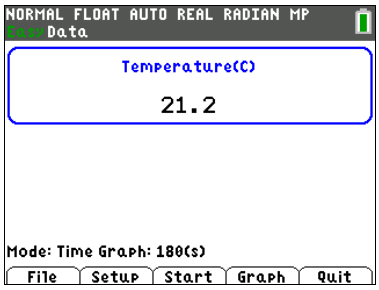
Have students work in groups of 3 or 4. Have them assign each group member a task.

- *Materials/setup person* (sets up the **EasyTemp** sensors and TI-84 Plus CE calculators; holds probes in sample during activity)
- *Tech people (2)* (each operates **EasyData App** and TI-84 Plus CE, one for Celsius readings and one for Fahrenheit readings)
- *Data Recorder* (reads and records the temperature readings for each sample on the worksheet chart)
- *Runner* (brings samples to group, holds cup to avoid spillage during activity, and returns samples after readings are taken)

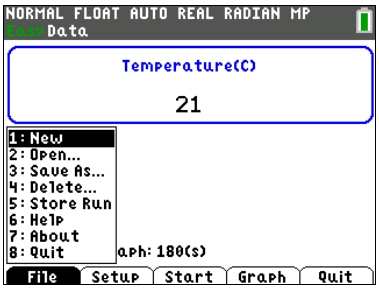
Link two **EasyTemp** probes to two different TI-84 Plus CE calculators. (You may also use the two **EasyLinks** with two of the older temperature probes or a combination of these two setups) Refer to the figure below:



1. When you connect the **EasyTemp** probe to your TI-84 Plus CE, the **EasyData App** will launch automatically. Connecting the **EasyLink** to your TI-84 Plus CE and connecting an older temperature sensor to the other end of the **EasyLink** will work just as well.



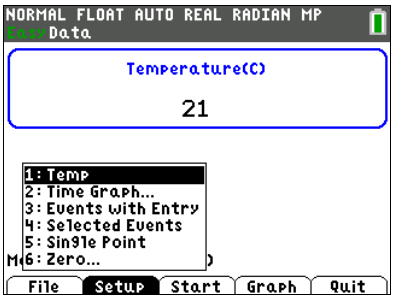
2. The **EasyData** information screen is displayed for about 3 seconds followed by the main screen. The **EasyData App** identifies the temperature sensor. The main screen of **EasyData** will display the current temperature across the top of the screen in degrees Celsius.



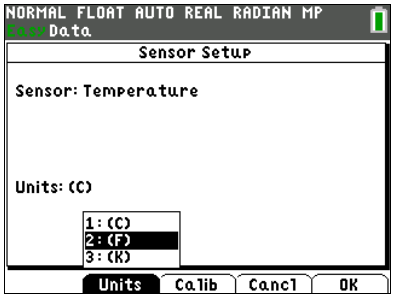
3. Press the [y=] key to access the **File** menu and select **1:New** by pressing [1] . Or, since **1:New** is highlighted, you can press [enter]. This resets the program and clears out old data.

Teacher Tip: The order the readings are taken is not important. An efficient way to test each cup is to have a few samples in one area of the room and let students carry one or two samples at a time from that area to the area where their group is working. After taking those readings, the samples can be returned. This will allow you to keep the water boiling for each temperature reading.

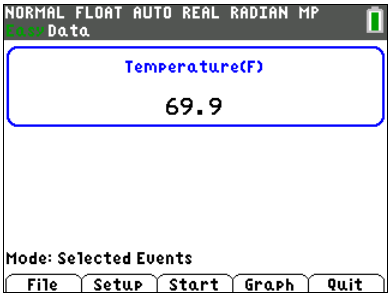
4. Leave one of the calculators with the Celsius setting but the other calculator will need to be changed to Fahrenheit. Press the window key to select **Setup** and choose **1:Temp** from the menu displayed.



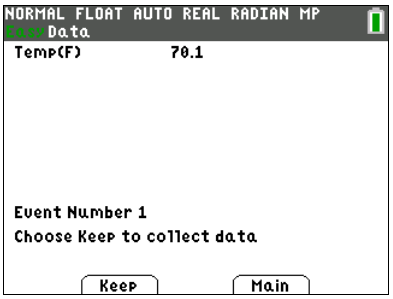
5. From the next screen, press the window key to select **Units**. Select **2:(F)** from the menu to change from Celsius to Fahrenheit.
6. When the screen appears confirming that your choice has been accepted, select **OK** by pressing graph.



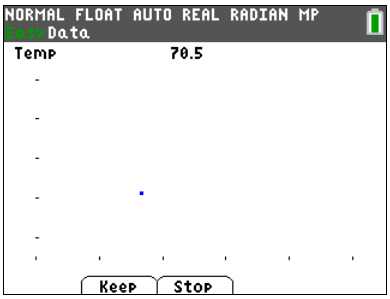
7. You will be returned to the main screen of the **App.** Select Setup on both calculators and select **4:Selected Events**.
8. You will be taken to a screen that displays the temperature reading in real time at the top of the screen.



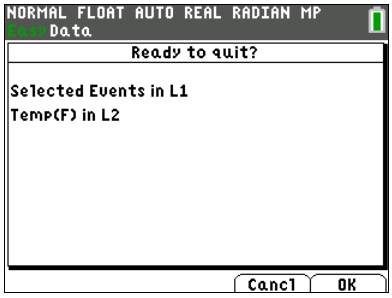
9. To begin collecting data, position the two probes next to each other but not touching. Select **Start** by pressing zoom. Let the first reading be the room temperature. To record the temperature of the first reading, select **Keep**.
10. Repeat the procedure until you have collected the six readings. This includes the air temperature and the five cups of water. Record the readings in the table on the worksheet. The important thing is to keep the two probes close together so they are measuring the same temperature. Select **Keep** at the same time on both calculators after the temperature readings have become relatively stable.



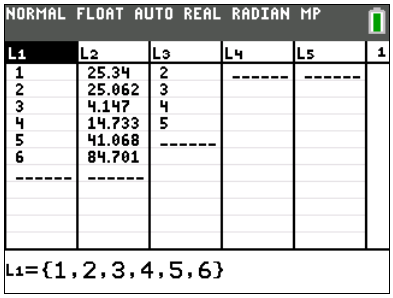
11. With each recorded value, a new data point will be displayed on the graph. When finished, select **Stop** by pressing zoom. The graph of all the data points will be displayed. At this point you can use the right and left arrow keys to view the coordinates of the points.

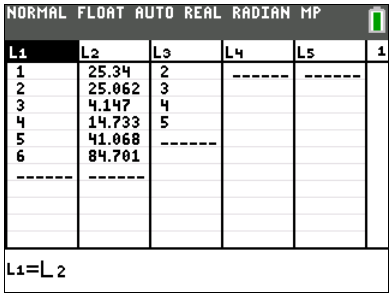


12. You will **NOT** analyze the data from within the **App**. Select **Main** by pressing graph and then **Quit** to exit the **App**.
13. The new screen will inform you that your data are in lists one and two. **L1** contains the numbers 1-6. The temperatures are stored in **L2**. The Celsius and Fahrenheit readings are stored in **L2** on two separate calculators. The lists need to be in both calculators so that the Celsius data is in **L1** and the Fahrenheit data is in **L2**. This allows you to examine the relationship between them.

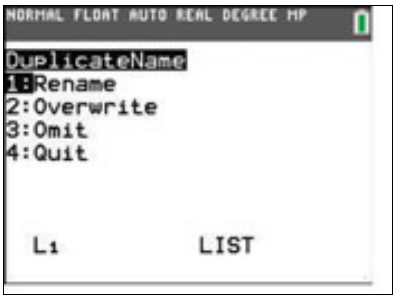


14. On the calculator that took the readings in the Celsius scale, press stat and select **1:Edit** to see the lists displayed. We need to replace **L1** with the values in **L2**.
15. Position the cursor so the name **L1** is highlighted. Press 2nd [list] to access **L2**. You will see **L2** at the bottom of the screen. Press enter.
16. **L1** should fill in with the data from **L2**.



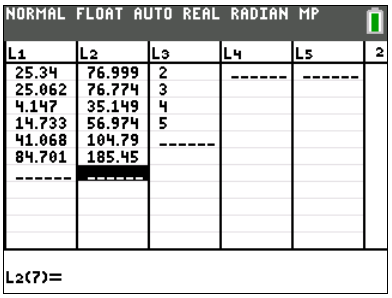


17. Link the two calculators together and pass **L1** from the Celsius calculator to the Fahrenheit calculator and the **L2** from the Fahrenheit calculator to the Celsius calculator. In both cases, because the receiving calculator already has data in the target list, your calculator will ask you if you would like to **2:Overwrite** the data.



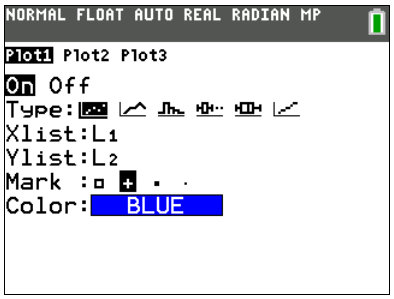
18. When the list is sent successfully, you will receive confirmation.

19. Press [stat] and select **1:Edit** to see the lists displayed on both calculators. Link both **L1** and **L2** to all students in the class.

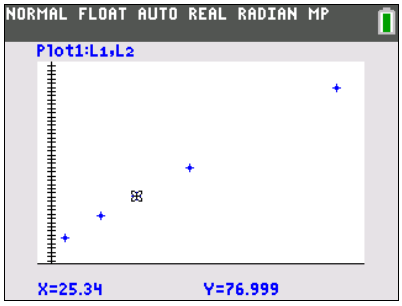


Data Analysis

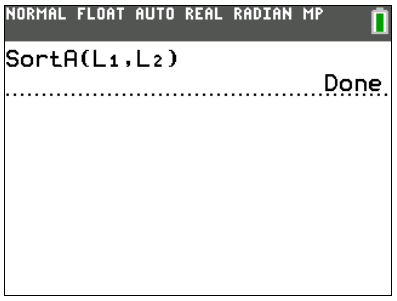
1. Set up a scatter plot with temperature in degrees Celsius as the independent variable (Xlist) and the corresponding temperature in degrees Fahrenheit as the dependent variable (Ylist).



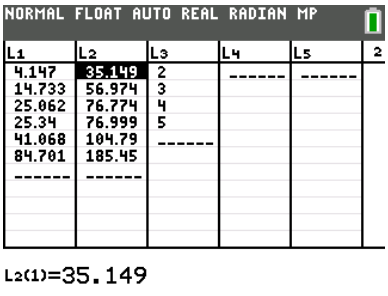
2. Press [zoom] and select **9:ZoomStat** to see the graph of the scatter plot. When [trace] is selected, you may have trouble scrolling through the points. When a scatter plot is traced using the right arrow key, the points are scrolled through in the order they were entered in the data list of the independent variable. Often this is the order in which they appear on the screen from left to right, but that is not what happened in this scatter plot. The right arrow will allow you to scroll through the points in the order they are listed in **L1** and **L2** regardless of where they appear on the screen.



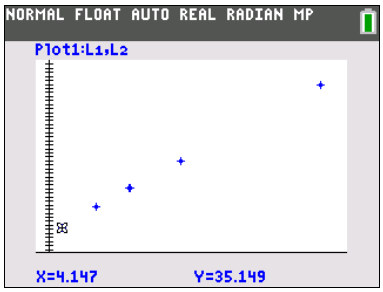
3. Sort the lists so that the data points are in order from smallest to largest. Use the calculator to sort the list for you. Press [stat] and select **2:SortA(** from the menu. This will sort the list in ascending order.
4. This takes you to the home screen. If you enter **L1**, the calculator will arrange the numbers in list one in order, but it will leave the numbers in **L2** alone. Because the numbers in **L2** are related to the numbers in **L1**, the entire row needs to be carried along with the lead entry from **L1**. To do this, type **SortA(L1, L2)**. Press [enter] to execute the command.



5. Press [stat] and select **1:Edit**.Your data has been sorted. Notice that the elements in **L1** have been listed in ascending order, as have their corresponding values in **L2**.

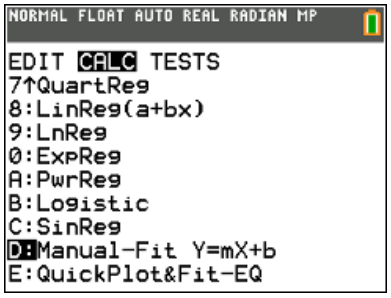


6. Now the points can be traced in order from left to right.

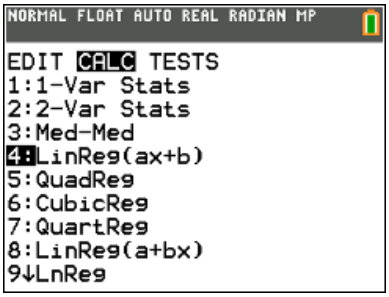


7. Next, find the trend line or the line of best fit. If your students have enough experience, you can discuss with them the different ways to find the regression equation.

   - One method is to estimate the slope and Y-intercept and enter it in **Y1**. Next, check to see how closely it matches the points and adjust the values until you are satisfied with the fit. This can be done manually or using the **Manual-Fit** option under the stat ▸ **CALC** menu.
   - Another method is to choose two ordered pairs on the graph and calculate the slope. Then, using the slope and Y-intercept (or any other point), find the equation of the line, graph the line, and see how well it fits the data points.
   - Using the built-in linear regression feature of the calculator is a quick and accurate method. stat ▸ **CALC** menu



Or:



Teacher Tip: Why would it be best to avoid using the built-in regression in this case? Consider the purpose of this activity. If the purpose is to find the function relating Celsius and Fahrenheit temperatures, then looking up the formula in a book is as quick and accurate as using the regression feature. Our purpose is more for the students to learn linearity, that linear data has a constant slope, and that if data has a constant slope it can be modeled with a line. Also, as students adjust the parameters to find a better fit, they cement in their minds the definitions of m and b and what effects these parameters have on the equation of a line. Learning a few keystrokes to find a regression line and calling that "the answer" limits the power of the activity to teach students about the equation of a line.

The goal of this lesson is to understand and highlight the algebra involved in building a mathematical model for a linear set of data. Additionally, the chance to help students become more familiar with the Celsius scale is a result. Here's a short poem that also helps. Try saying this poem and then adding these numbers to the X-values in the table to see their matching Fahrenheit values. See Figure 40.

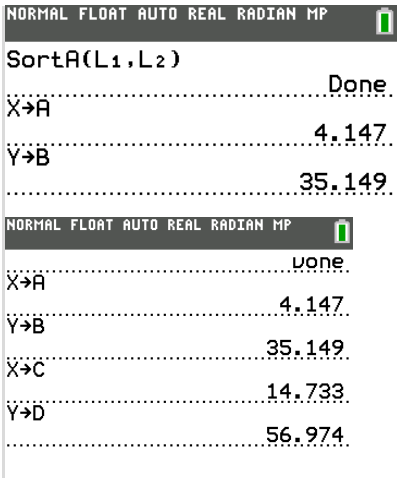
30's hot and 20's nice: 10 is cold and 0's ice!

An extension to this activity is to let the calculator find a regression equation for the data, put it in Y3, and then compare the various methods used in both the graph and the table views.

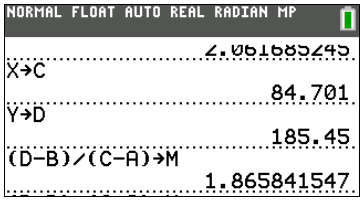
8. The calculator can help with the computation of the slope. After tracing to the first point, press [2nd] [mode] to [quit] and return to the home screen. Press [X,T,θ,n] [sto→] [alpha] A [enter]. This will store the X-value from the point you last traced on the graph screen to the variable **A**. Repeat this procedure to store the Y-value in **B**. Press [alpha] **Y** [sto→] [alpha] **B** [enter].

9. Press [graph] and then [trace] and use the right arrow key to move to the last point on the right. Once again, notice the X- and Y-values displayed at the bottom of the screen.

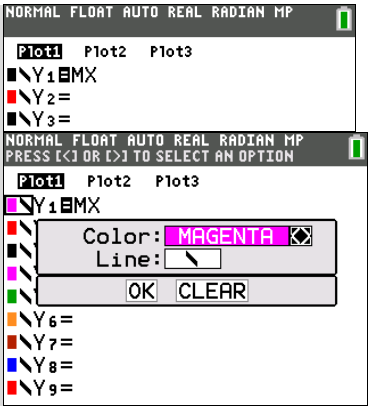
10. Repeat the procedure to store these values in **C** and **D**. Press [2nd] [mode] to access [quit] and return to the home screen. Press [X,T,θ,n] [sto→] [alpha] **C** [enter]. This will store the X-value from the last point to the variable **C**. Next, press [alpha] **Y** [sto→] [alpha] **D** [enter].



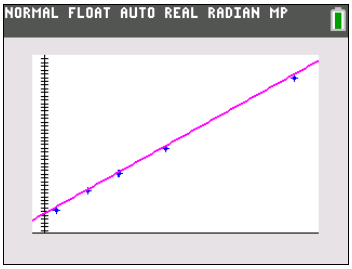
11. Using the slope definition, have the calculator find the slope and store the value in **M** as shown. Be sure to enclose both the numerator and denominator in parentheses. The keystroke sequence is (alpha **D** − alpha **B**) ÷ (alpha **C** − alpha **A**) sto→ alpha **M** enter.



12. Go to the y= window and press alpha **M** X,T,θ,n to type in **MX** behind **Y1**. To change the color of the line press ◄ ◄ to highlight the slash and color icon and press enter. Press ► or ◄ to scroll through the colors.

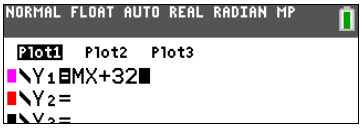


13. Press graph to see how closely this line fits the points. In the example shown, it looks like the slope is correct since the line is parallel to an imaginary line through the points. The vertical position of the line needs to be moved up by adjusting the Y-intercept.

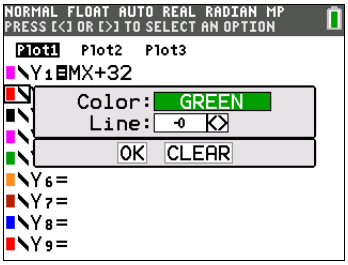


14. Determine how much your line is below where it needs to be. Add this value to the equation you entered in **Y1**. Think about the relationship between Celsius and Fahrenheit. What is 0 degrees Celsius in Fahrenheit?

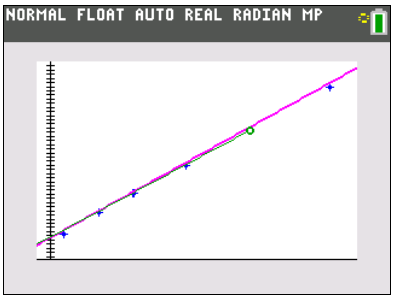
    Press graph to see how closely this fits the points.



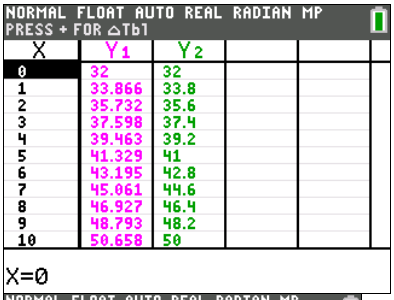
15. Look up the formula to convert Celsius to Fahrenheit and enter it in **Y2**. Press ◄ ◄ to highlight the slash and color icon and press enter in front of **Y2**. Press enter to change the color of the line and the symbol. Choose the symbol with the ball and the small line to the left of the ball. Then press ▼ and enter on **OK**.



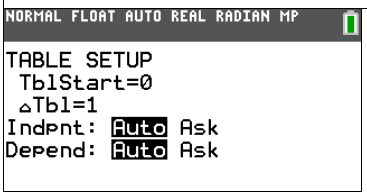
16. Press graph. **Y1** is graphed normally. A circular cursor traces the leading edge of the graph of **Y2** and helps emphasize how close the lines are to each other.



17. Press 2nd [table]. This will allow you to see how close your regression equation is to the formula. A numerical comparison rather than just the visual comparison on the graph screen can confirm that the two lines are very close to being the same line.

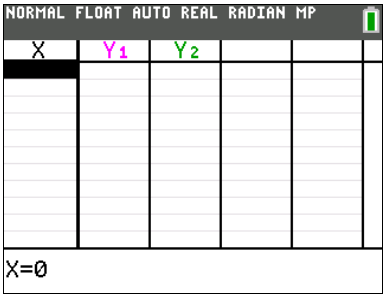


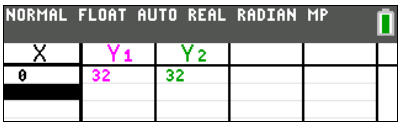
18. Press 2nd [tablset] to access the **TABLE SETUP** Menu. The defaults on the table are to start at zero, to count by one, and to automatically fill in all the values. With these settings, it could take a while to scroll and find specific values.



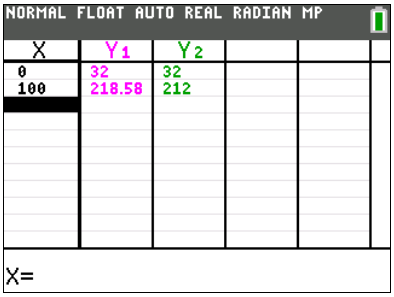
19. To take more control over what numbers the table displays, change the **Indpnt:** to **Ask** instead of **Auto**. Leave the **Depend:** set on **Auto**. Use the arrow keys to position the cursor on the word **Ask** and then press enter.

20. Press 2nd graph to access the **TABLE**. You will be taken to a blank table. Type **zero**. It will be entered beside the **X=** at the bottom of the screen. Pressing enter will fill in both **Y1** and **Y2**. Remember: you entered the Y-intercept from your knowledge of the fact that 0 degrees Celsius is 32 degrees Fahrenheit. So, this exact match is not an indicator for all points.





21. Another common set of values is the boiling point of water. Celsius is 100 degrees and Fahrenheit is 212. Type in **100** beside the **X=** and compare the value in **Y1** to the value in **Y2**.



Looking at the Results (Student Worksheet Answers)

1. Fill in the table with the data you collected.

   Student answers will vary.

2. Why is the order in which you collect the data not important?

   Student answers will vary.

   Sample Response: Because we were comparing the two temperature readings to each other.

3. You put the Celsius readings in **L1** and the Fahrenheit readings in **L2**. Why did you throw away the numbers 1-6 that were originally in **L1** after running the EasyData App?

   Student answers will vary.

   Sample Response: They had nothing to do with how the two temperature readings were related to each other.

4. You used two of these data points to find the slope of the regression equation. Would you get the same answer as if you used two different points? Explain.

   Student answers will vary.

   Sample Response: Maybe not exactly the same but VERY close.

5. What was your regression equation?

   Student answers will vary.

   Sample Response: Answers will vary but should be close to y= 1.8x + 32.

6. The definition of the slope of a line is the change in **Y** divided by the change in **X**. For this problem, that would be the change in Fahrenheit divided by the change in Celsius. Use your own words to state what that means in respect to this problem

   Student answers will vary.

   Sample Response: For every 1 degree change in Celsius, the Fahrenheit changes by 1.8 degrees.

7. What was the regression equation the calculator found?

   Student answers will vary.

   Sample Response: Answers will vary but should be close to y= 1.8x + 32.

Looking at the Results (continued)

8. What is a reasonable explanation for why the two regression equations are different from each other and also different from the formula?

   Student answers will vary.

   Sample Response: Small amount of human error and/or calibration of temperature probes.

9. If your equation is in **Y1**, the formula is in **Y2**, and the calculator's regression equation is in **Y3**, use the **Ask** feature on the table of the calculator and fill in this chart for the given temperatures.

   Student answers will vary.

   Sample Response: Y2 is from the formula; other answers will vary.

X°C	Y2
5	41
15	59
25	77
35	95
60	140
85	185