EXPLORATIONS

Activity 1

Cricket Thermometers

Objectives

- To investigate the relationship between temperature and the number of cricket chirps
- To find the *x* value of a function, given the *y* value
- To find the *y* value of a function, given the *x* value
- To use technology to find a linear regression
- To use technology to plot a set of ordered pairs

Materials

- TI-73 graphing device
- Cassette player
- Tape of crickets chirping

Introduction

Anyone who has ever been out in the country on a summer evening is familiar with the chirp of a cricket. Chirping patterns convey different messages and are different from species to species. Male crickets chirp in order to attract and court female crickets, and to stake a claim to their territory. The mature male cricket makes the sound by rubbing together his forewings, much like a violinist produces sound by rubbing a bow along the strings of his instrument.

Crickets are insects, and like other insects, they are ectothermic, which means that their body temperature rises or falls when the temperature of the environment rises or falls. The metabolism of an insect fluctuates with its body temperature.

Is a cricket's rate of metabolism reflected in the frequency of its chirps? In this activity, you will graphically analyze the relationship between cricket chirps and temperature.

Problem

How can you use the frequency of cricket chirping to predict the temperature of a habitat?

Collecting the data

1. Your teacher will play a tape of cricket chirps at different temperatures. The narrator will give the temperature and then you will listen to the cricket chirping. Your teacher will tell you when to start counting and when to stop.
2. Record the temperature and the number of chirps in 15-second intervals on the **Data Collection and Analysis** page.

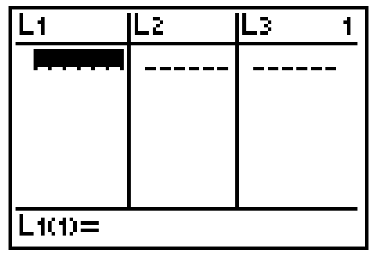
3. Your teacher will play a tape of three crickets, each chirping at *unknown* temperatures. Record the number of chirps in 15-second intervals and then multiply by 4 in order to determine the number of chirps per minute. Record the number of chirps on the **Data Collection and Analysis** page.

Setting up the TI-73

Before starting your data collection, make sure that the TI-73 has the STAT PLOTS turned OFF, Y= functions turned OFF or cleared, the MODE and FORMAT set to their defaults, and the lists cleared. See the Appendix for a detailed description of the general setup steps.

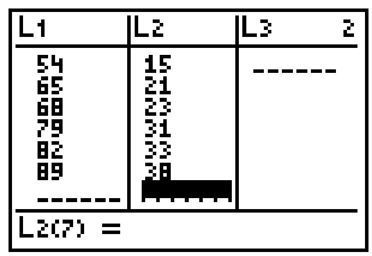
Entering the data in the TI-73

1. Press [LIST].

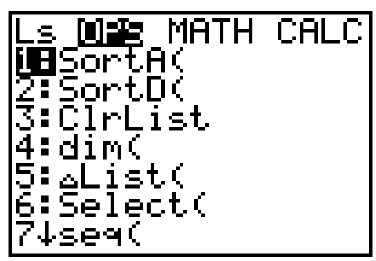


2. Enter the temperatures in **L1**.
3. Enter the number of chirps per 15-second intervals in **L2**. (Make sure your pairs of temperature and chirps match in each column.)

   ***Note**: Your cricket chirp count might differ from what is shown.*

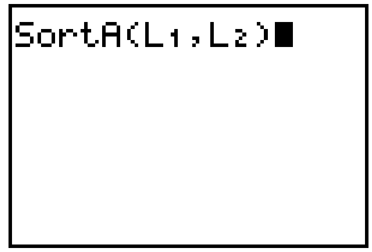


4. Press [2nd] [STAT] [▸] to move the cursor to the **OPS** menu.

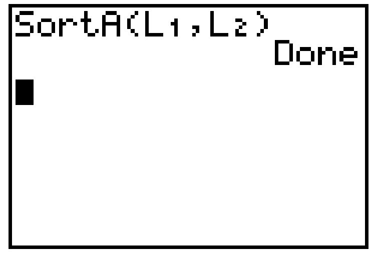


5. Select **1:SortA(** by pressing **1** or [ENTER].

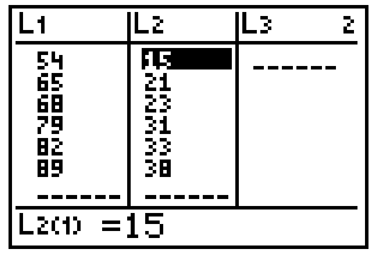
6. Press [2nd] [STAT] **1:L1** [,] [2nd] [STAT] **2:L2** [)].



7. Press [ENTER]. The lists are sorted.

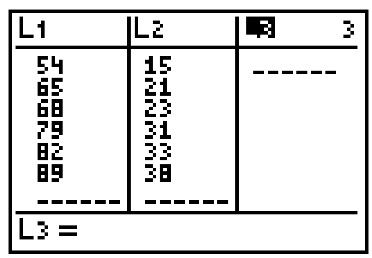


8. Press [LIST] to return to the data lists.

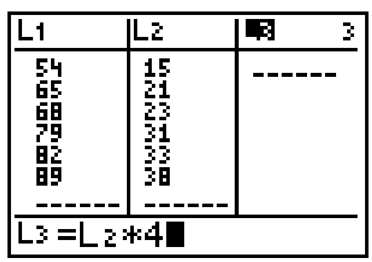


You counted the number of chirps in 15-second intervals, but you would like to plot the number of chirps per minute. In order to get the number of chirps per minute, you must multiply all the entries in **L2** by 4.

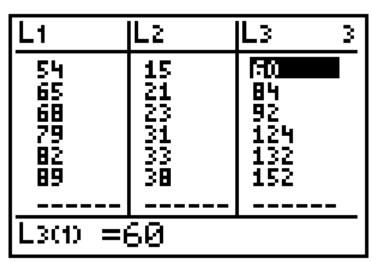
9. Press [▸] and [▴] to highlight **L3**.



10. Press [2nd] [STAT] **2:L2** [×] **4**.

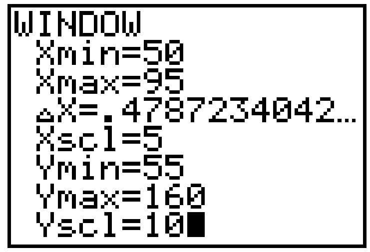


11. Press [ENTER] to see the calculation.



Setting up the window

1. Press [WINDOW] to set up the proper scale for the axes.



2. Set the **Xmin** value by identifying the minimum value in **L1**. Choose a number that is less than the minimum.

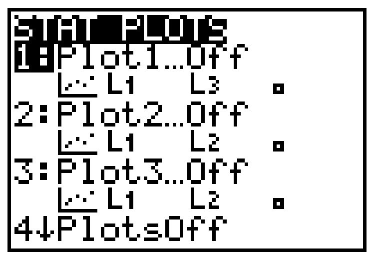
3. Set the **Xmax** value by identifying the maximum value in each list. Choose a number that is greater than the maximum. **Do Not Change the ΔX Value.** Set the **Xscl** to **5**.

4. Set the **Ymin** value by identifying the minimum value in **L3**. Choose a number that is less than the minimum.

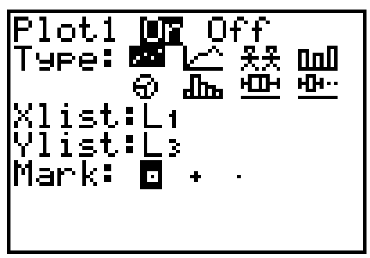
5. Set the **Ymax** value by identifying the maximum value in **L3**. Choose a number that is greater than the maximum. Set the **Yscl** to **10**.

Graphing the data: Setting up a scatter plot

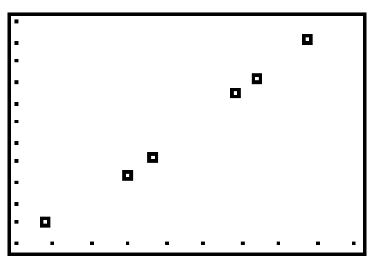
1. Press [2nd] [PLOT]. Select **1:Plot1** by pressing **1** or [ENTER].



2. Set up the plot as shown by pressing [ENTER] [▼] [ENTER] [▼] [2nd] [STAT] **1:L1** [▼] [2nd] [STAT] **3:L3** [▼] [ENTER].



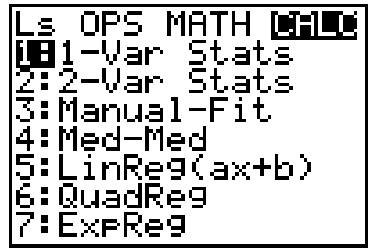
3. Press [GRAPH] to see the plot.



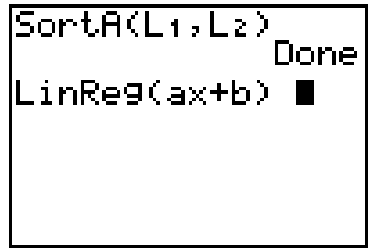
Analyzing the data

Finding a linear regression

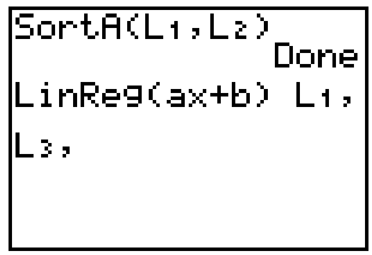
1. Press [2nd] [STAT]. Press [◄] to move the cursor to the **CALC** menu.



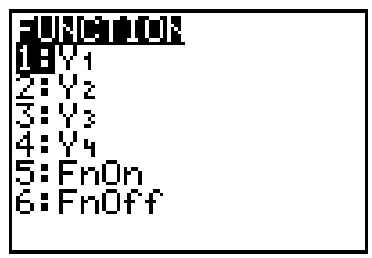
2. Select **5:LinReg(ax+b)** by pressing **5**.



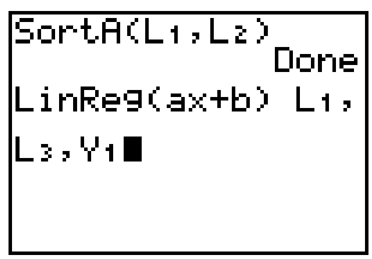
3. Press [2nd] [STAT] **1:L1** [,] [2nd] [STAT] **3:L3** [,].



4. Press [2nd] [VARS]. Select **2:Y-Vars** by pressing **2**.

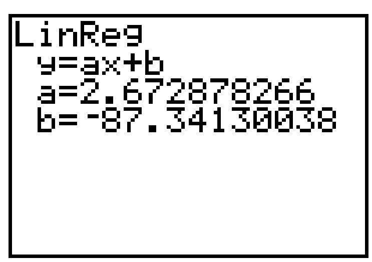


5. Select **1:Y1** by pressing **1** or [ENTER].

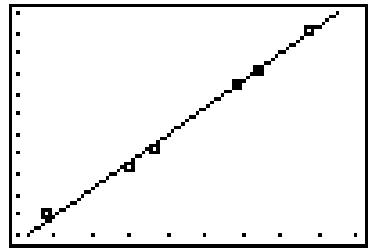


6. Press [ENTER] to calculate the linear regression. The function is pasted in **Y1**.

   ***Note**: Your values might differ from what is shown.*



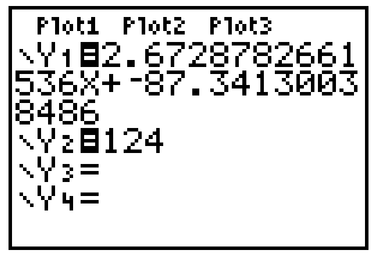
7. Press [GRAPH] to see the linear regression model.



Determining the temperature of a habitat

You can determine the temperature of a habitat based on the number of cricket chirps per minute. In the example shown below, the cricket chirped 124 times per minute. You will use the actual number of cricket chirps per minute for Unknown Number 2 based on the tape recording that **you** listened to, or data given to you by your instructor.

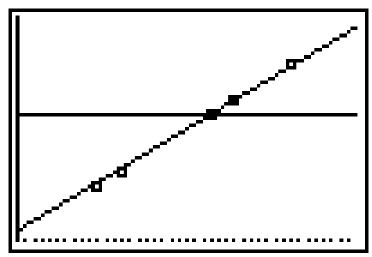
1. Press [Y=]. Press [▼] until you are at **Y2**. Enter the number of chirps per minute for your unknown (124 in our example).



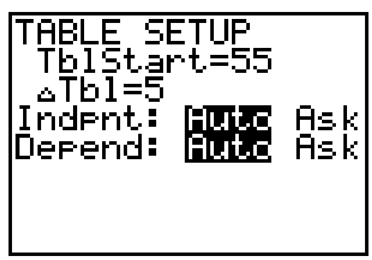
2. Press [GRAPH] to see the intersection of the two lines.

   The *x* value of the point where the two functions intersect is the temperature of the habitat where your *unknown* cricket was chirping.

   The table function of the TI-73 will be used to determine the coordinates of the point of intersection.

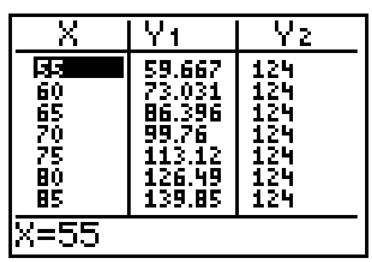


3. Press [2nd] [TBLSET]. Type in the lowest *x* value in **L1** (55 in the example). Press [▼] **5** to set the **ΔTbl** value.



4. Press [2nd] [TABLE]. If necessary, use [▼] and [▲] to scroll the table.

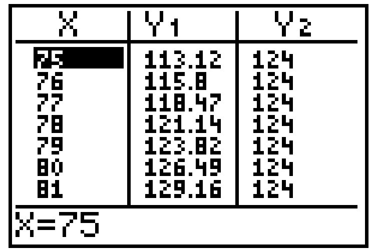
   Note: *For this example, in the Y1 column, 124 chirps per minute falls between 113.12 and 126.49, which corresponds to 75 and 80 degrees in the X column. Based on that information, the table will be readjusted.*



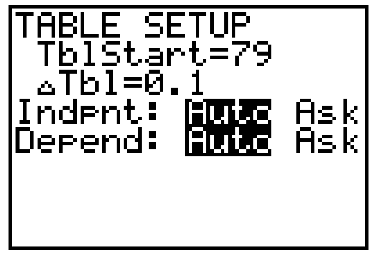
5. Press [2nd] [TBLSET]. Enter your results from Step 4 for **TblStart**. Press ▼ **1** to set the **ΔTbl** value.

6. Press [2nd] [TABLE]. If necessary, use ▼ and ▲ to scroll the table.

Note: For this example, in the Y1 column, 124 chirps per minute falls between 123.82 and 126.49, which corresponds to 79 and 80 degrees in the X column. Based on that information, the table will be readjusted again.

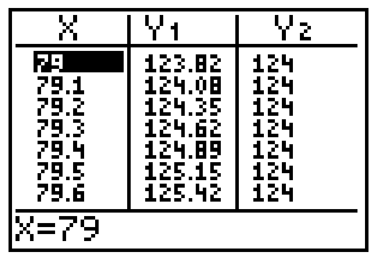


7. Press [2nd] [TBLSET]. Enter your results from Step 6 for **TblStart**. Press ▼ **0.1** to set the **ΔTbl** value.

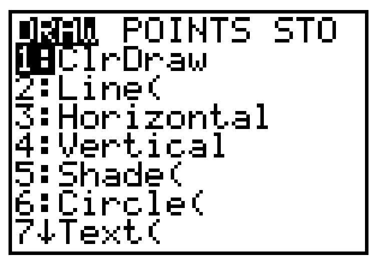


8. Press [2nd] [TABLE]. If necessary, use ▼ and ▲ to scroll the table.

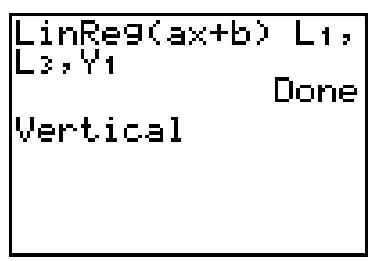
Note: The data used to construct the linear model had temperatures measured to the nearest degree. Therefore, the unknown is determined to the same level of precision. From the table, 124 chirps per minute falls between 123.82 and 124.08, which corresponds to 79 and 79.1 degrees. Rounding to the nearest degree, the intersection point will be (79, 124).



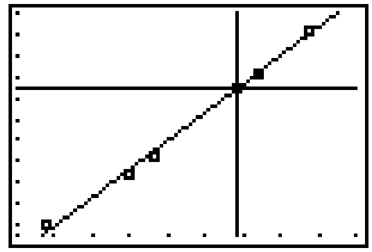
To verify the coordinates graphically, we will use the **DRAW** function. Press [DRAW].



9. Select **4:Vertical** by pressing **4**.

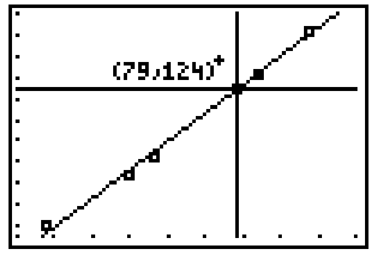


10. Type the results from Step 8. (In this example, 79.) Press [ENTER].



For this example, note that the coordinates of the point on the linear model where all of the lines intersect is defined by the vertical drawn at *x*=79 and the horizontal at *y*=124.

11. The coordinates of the intersection can be added onto your screen by pressing [DRAW] **7:Text**, moving the cursor near the point of intersect, and typing the results.



Note: *Text appears below and to the right of the cursor.*

12. Determine the temperatures of the habitats for all three unknown crickets.

Answer the questions on the **Data Collection and Analysis** page.

Data Collection and Analysis

Name ____________________________

Date ____________________________

Activity 1: Cricket Thermometers

Collecting the data

Temperature (°F)	**Number of chirps per 15 seconds**

	Temperature (°F)	**Number of chirps per 15 seconds**	**Number of chirps per minute**
Unknown Cricket Number 1			
Unknown Cricket Number 2			
Unknown Cricket Number 3			

Analyzing the data

1. Coordinates for the intersection of the two functions for Unknown Cricket Number 2:

x = __________ *y* = __________

2. The *slope* of the linear regression line is ______________________________

3. Explain what the *slope* represents in context with the data that you analyzed.

____

____

____

4. What does the *y* value of the intersection of the two functions represent?

____

____

5. What does the x value of the intersection of the two functions represent?

____

____

6. Determine the temperature of the habitat for unknown crickets 1 and 3. Repeat the procedure in the **Determining the temperature of a habitat** section.

   Note: *For Unknown Cricket Number 1, you will have to adjust the window.*

   Temperature of the habitat for Unknown Cricket Number 1: ____________

   Temperature of the habitat for Unknown Cricket Number 3: ____________

7. You had to interpolate to determine the temperature of the habitat for Unknown Crickets number 2 and 3. *Interpolation* means to make a prediction *within* the bounds of known data. The key word is *within*. You had to extrapolate to determine the temperature of the habitat for Unknown Cricket number 1. *Extrapolation* means to make a prediction that a trend will continue *outside* the bounds of known data. From a scientific standpoint which is riskier, interpolation or extrapolation? Explain.

____

____

____

____

Extensions

- Predict the number of cricket chirps if the temperature is known. Suppose that the temperature of a habitat is 70°F. Explore how to predict the number of cricket chirps per minute.

  How many chirps per minute did you predict when the temperature of the habitat is 70°F?

- Based on the data, how many chirps per minute would a cricket make if the temperature of the habitat were 32°F or 212°F? (Remember to adjust the window.)

- Based on common sense, would you give the same answer? Explain.

Teacher Notes

Activity 1

Cricket Thermometers

Objectives

- To investigate the relationship between temperature and the number of cricket chirps
- To find the *x* value of a function, given the *y* value
- To find the *y* value of a function, given the *x* value
- To use technology to find a linear regression
- To use technology to plot a set of ordered pairs

Materials

- TI-73 graphing device
- Cassette player
- Tape of crickets chirping
- Stopwatch (optional)

Preparation

- You can purchase the audiocassette tape for this activity by writing to:

  Robert Anderson, Ph.D.
  Department of Biological Sciences
  Idaho State University
  Pocatello, ID 83209

  Ask Dr. Anderson to send and bill you for *Myths and Science of Cricket Chirps*. The cassette comes with a booklet.

Management

- When playing the tape, play the beginning of Side B. There is approximately 25 – 30 seconds of chirping at each temperature. Play the tape for a few seconds. Tell the students to start timing the chirps. Mark time for 15 seconds and then tell the students to stop. You may want to use a stopwatch. Ask the students to record the data on the **Data Collection and Analysis** page. The students will learn to use the spreadsheet functions of the TI-73 to determine the number of chirps per minute.

  ***Note**: As of the time of printing, there is a slight error on the tape. The narrator does not say when unknown cricket number 2 starts, although there is suddenly a clear change in the frequency of cricket chirps.*

- You may want to have the students transfer this data to one of the computer graphing programs (such as TI InterActive!™ software) and then produce a hard copy of their graphed data.

Answers to Data Collection and Analysis questions

Collecting the data

Sample sorted data:

Temperature (°F)	Number of chirps per 15 seconds
54	15
65	21
68	23
79	31
82	33
89	38

	x-coordinate (temperature — °F)	*y*-coordinate (chirps per minute)
Unknown Cricket Number 1	49	44
Unknown Cricket Number 2	79	124
Unknown Cricket Number 3	73	108

Analyzing the data

1. *Answers will vary.*

2. The *slope* of the linear regression line is ___________.

   The slope of the linear regression line is 2.67.

3. Explain what the *slope* represents in context with the data that you analyzed.

   Slope is defined as rise over run. It represents how the number of chirps per minute changes as the temperature changes. In this problem, the slope is $\frac{2.67}{1}$ *or 2.67. This means that for every increase in temperature of one degree Fahrenheit, the number of cricket chirps per minute increases about 2.67.*

4. What does the *y* value of the intersection of the two functions represent?

   The y value represents the number of chirps per minute for the unknown cricket.

5. What does the *x* value of the intersection of the two functions represent?

   The x value represents the temperature that corresponds to the number of chirps per minute for the unknown cricket.

6. Determine the temperature of the habitat for unknown crickets 1 and 3. Repeat the procedure in the **Determining the temperature of a habitat** section.

   Note: *For Unknown Cricket Number 1 you will have to adjust the window.*

   For Unknown Cricket Number 1, the temperature is 49 degrees Fahrenheit.

   For Unknown Cricket Number 3, the temperature is 73 degrees Fahrenheit.

7. You had to interpolate to determine the temperature of the habitat for unknown crickets number 2 and 3. *Interpolation* means to make a prediction *within* the bounds of known data. The key word is *within*. You had to extrapolate to determine the temperature of the habitat for unknown cricket number 1. *Extrapolation* means to make a prediction that a trend will continue *outside* the bounds of known data. From a scientific standpoint, which is riskier, interpolation or extrapolation? Explain.

   Extrapolation is riskier as it assumes a trend will continue beyond the experimental data. See answers to ***Extensions*** *section.*

Answers to Extensions questions

- How many chirps per minute did you predict when the temperature of the habitat is 70°F?

  If the temperature is 70°F, then the cricket will chirp approximately 100 times per minute.

- Based on the data, how many chirps per minute would a cricket make if the temperature of the habitat were 32°F or 212°F? (Remember to adjust the window.)

  According to the graph, if the temperature were 32°F the cricket would chirp -1.8 times. If the temperature were 212°F, then the cricket would chirp 479 times. However, you know that frozen and boiled crickets do NOT chirp. The lesson here is that the graph is useful when you interpolate, for it is linear within the bounds of the known data. It is therefore reasonable to interpolate.

- Based on common sense, would you give the same answer? Explain.

  As common sense would dictate, extrapolation is another story. As the temperature is significantly increased or decreased, you move beyond the range of temperatures that the cricket could tolerate. The graph loses its linearity.