EXPLORATIONS

Activity 1

Cricket Thermometers

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-83 Plus

Before starting your data collection, make sure that the TI-83 Plus 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.
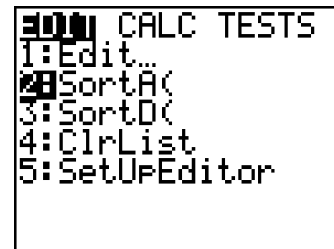
Entering the data in the TI-83 Plus

1. Press STAT and select **1:Edit** by pressing ENTER.
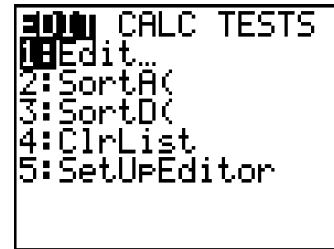
2. Enter the temperatures in **L1**.

3. Move the cursor to **L2** and enter the number of chirps per 15-second intervals. (Make sure your pairs of temperature and chirps match in each column.)

4. Press STAT and select **2:SortA(**.

5. Press ENTER.

6. Press 2nd [L1] , 2nd [L2]).

```
SortA(L1,L2)
```

7. Press ENTER. The lists are sorted.

```
SortA(L1,L2)
              Done
```

8. Press STAT and select **1:Edit** to return to the data lists.

```
EDIT CALC TESTS
1:Edit…
2:SortA(
3:SortD(
4:ClrList
5:SetUpEditor
```

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 ▶ ▲ to highlight **L3**.

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

```
L1     L2     L3     3
54     15     ------
65     21
68     23
79     31
82     33
89     38
------ ------
L3 =
```

10. Press 2nd [L2] × 4.

```
L1     L2     L3     3
54     15     ------
65     21
68     23
79     31
82     33
89     38
------ ------
L3 =L2*4
```

11. Press ENTER to see the calculation.

```
L1     L2     L3     3
54     15     60
65     21     84
68     23     92
79     31     124
82     33     132
89     38     152
------ ------ ------
L3(1)=60
```

Setting up the window

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

    ```
    WINDOW
     Xmin=50
     Xmax=95
     Xscl=5
     Ymin=50
     Ymax=160
     Yscl=10
     Xres=1
    ```

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. 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 [STAT PLOT] and select **1:Plot1** by pressing ENTER.

    ```
    STAT PLOTS
    1:Plot1…Off
       L1   L2
    2:Plot2…Off
       L3   L4   +
    3:Plot3…Off
       L5   L6   .
    4↓PlotsOff
    ```

2. Set up the plot as shown by pressing ENTER ▼ ENTER ▼ 2nd [L1] ENTER 2nd [L3] ENTER ENTER.

    Note: *Press* ▼ ▼ *if* **L1** *and* **L3** *are already displayed*.

    ```
    Plot1  Plot2  Plot3
    On  Off
    Type: ⊞  ⋌  ⊪
          ⊶  ⊷  ⟋
    Xlist:L1
    Ylist:L3
    Mark: □  +  .
    ```

3. Press GRAPH to see the plot.
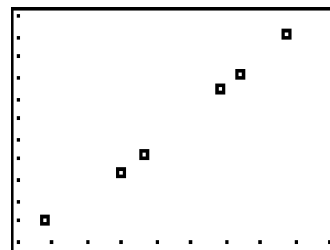
Analyzing the data

Finding a linear regression

1. Press [STAT] and move the cursor to the **CALC** menu.

```
EDIT CALC TESTS
1▮1-Var Stats
2:2-Var Stats
3:Med-Med
4:LinReg(ax+b)
5:QuadReg
6:CubicReg
7↓QuartReg
```

2. Select **4:LinReg(ax+b)** and press [ENTER].

```
EDIT CALC TESTS
1:1-Var Stats
2:2-Var Stats
3:Med-Med
4▮LinReg(ax+b)
5:QuadReg
6:CubicReg
7↓QuartReg
```

```
SortA(L₁,L₂)
           Done
LinReg(ax+b) ▮
```

3. Press [2nd] [L1] [,] [2nd] [L3] [,].

```
SortA(L₁,L₂)
           Done
LinReg(ax+b) L₁,
L₃,▮
```

4. Press [VARS] and move the cursor to the **Y-VARS** menu.

```
VARS Y-VARS
1▮Function…
2:Parametric…
3:Polar…
4:On/Off…
```

5. Select **1:Function** by pressing [ENTER].

```
FUNCTION
1▮Y₁
2:Y₂
3:Y₃
4:Y₄
5:Y₅
6:Y₆
7↓Y₇
```
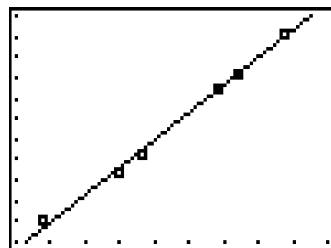
6.   Select **1:Y1** by pressing [ENTER].

```
SortA(L₁,L₂)
             Done
LinReg(ax+b) L₁,
L₃,Y₁
```

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

```
LinReg
 y=ax+b
 a=2.672878266
 b=-87.34130038
```

8.   Press [GRAPH] to see the linear regression.

Determining the temperature of a habitat

You can determine the temperature of a habitat based on the number of cricket chirps per minute.

1.   Press [Y=] and [▼] until you are at **Y2**. Enter the number of chirps per minute for your *second* unknown as shown.

```
Plot1 Plot2 Plot3
\Y₁■2.6728782661
536X+-87.3413003
8486
\Y₂■124
\Y₃=
\Y₄=
\Y₅=
```

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.
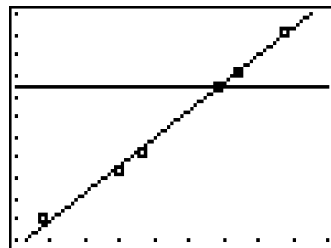
3.   Find the coordinates of the point of intersection of the two lines. Press [2nd] [CALC].

```
CALCULATE
1:value
2:zero
3:minimum
4:maximum
5:intersect
6:dy/dx
7:∫f(x)dx
```

4.   Select **5:intersect** and press ENTER.

```
CALCULATE
1:value
2:zero
3:minimum
4:maximum
5:intersect
6:dy/dx
7:∫f(x)dx
```
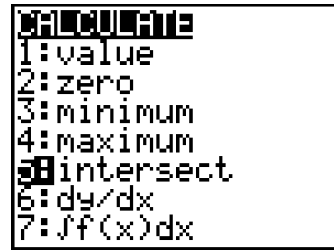
5.   The TI-83 Plus will prompt you for the *First curve*. Make sure the cursor is flashing on the regression line and then press ENTER.

   Note: *Use ▲ and ▼ to select the function. Once you have selected the regression line press* ENTER*.*

```
Y1=2.672872661536X+¯87._


First curve?
X=72.5    .  . Y=106.44237 .
```
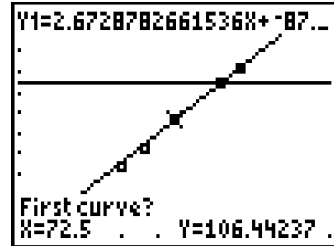
6.   The TI-83 Plus will prompt you for the *Second curve*. Make sure the cursor is flashing on the second line and then press ENTER.

   Note: *Use ▲ and ▼ to select the function. Once you have selected the regression line press* ENTER*.*

```
Y2=124


Second curve?
X=72.5    .  . Y=124 .   .  .
```
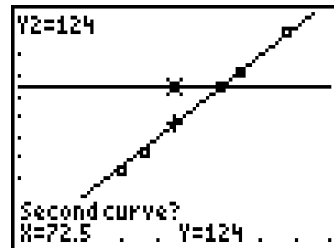
7.   The calculator will prompt you to *Guess*. Try to estimate the coordinates of the point of intersection.

```
Y2=124


Guess?
X=72.5    .  . Y=124 .   .  .
```
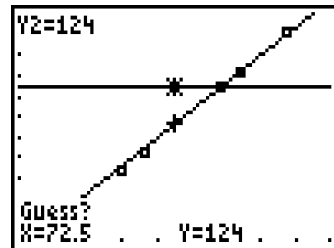
8.   Press ENTER to find the exact point of intersection. Record the point of intersection on the **Data Collection and Analysis** page.

```
Intersection
X=79.068809  Y=124 .   .  .
```
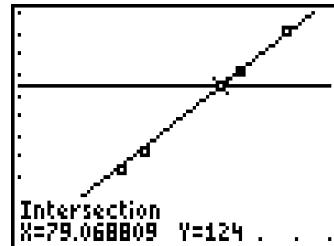
Answer the questions on the **Data Collection and Analysis** page.

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

A c t i v i t y   1

Cricket Thermometers

♦   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

♦   TI-83 Plus

♦   Cassette player

♦   Tape of crickets chirping

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-83 Plus 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!™) 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. The *slope* of the linear regression line is *2.67*.

2. 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.

3. 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.

4. 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.

5. 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.*

Data provided above.

6. 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

1. 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.

2. 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.

3. 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.