Teachers Teaching with Technology™
Professional Development from Texas Instruments

Exploring Data Collection with the TI-84 Plus in High School Mathematics and Science

Materials for Workshop Participant*

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Pass the Ball

TEACHER NOTES

TI PROFESSIONAL DEVELOPMENT

Activity Overview

Many things in everyday life follow patterns. Mathematics can be used to examine the patterns that occur in a specific scenario and then predict future events for that scenario. This activity includes two examples of such patterns. The data collected is the time it takes to complete a task. The data will be used to make predictions about how long it will take to repeat that same task a certain number of times. The timed task is passing a ball. The basic concept has relevance to many areas of math, science, and everyday life.

Materials

- TI-84 Plus graphing calculator family
- Stopwatch
- Small bouncing ball (tennis/racquet balls work well)

1. For this activity, begin by having four students stand in a circle.
   - The starter will bounce, catch, and pass the ball to the next person.
   - Continue bouncing, catching, and passing the ball until it is back to the one who started.
   - Explain to students the importance of working at a consistent pace rather than working too quickly.

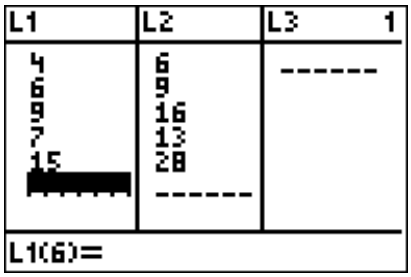
2. Time how long it takes the ball to get all the way around the circle.
   - Start and stop with the same person.
   - Have students record three trials of this process on their worksheets and calculate the average time.
   - Have them record the average in the chart on their worksheet.

Activity Sample Data	
Number of People	**Average Time in Seconds**
4	6
6	9
9	16
7	13
15	28

3. Complete the table for five different sets of students.
   - There should be a different number of students for each set.
   - To maximize participation, do not allow the same student to be in more than one group.

4. For the last row in each table, have everyone in the room participate.
   - Before timing this trial, have students predict how long they think it will take and write it on their worksheet.
   - Ask them to share their predictions.
   - Then time the trial for the entire class.

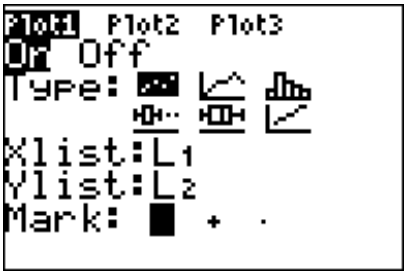
5. Press [STAT] [ENTER] to access the Stat List Editor window.



- Have all students enter the data in L1 and L2. Do NOT include the data for the trial that included the entire class.
- Have one student enter the data on the overhead calculator.

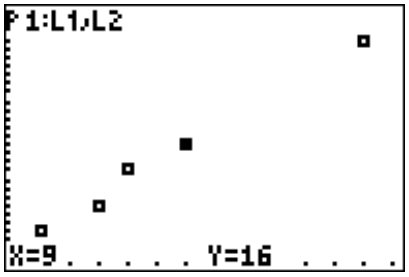
Data Analysis

6. Create a scatter plot.



- Press [2nd] [Y=] to access the [STAT PLOT] menu.
- **1: Plot 1** will be highlighted.
- Press [ENTER].
- Use the arrow keys to highlight the On choice, and press [ENTER] to select **On**.
- Continue using the arrow keys to navigate through this screen and adjust it as shown in the screen shot.

7. Press [ZOOM], and select **9:ZoomStat** by pressing [9] or by scrolling down until it is highlighted and pressing [ENTER].

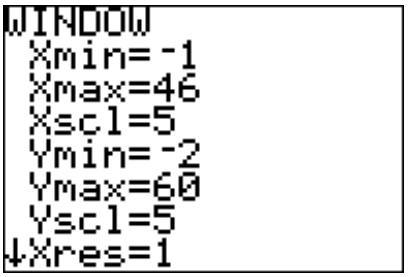


- This feature automatically adjusts the size of the graph window to include all the data points.
- When the scatter plot is displayed, press [TRACE], and scroll right and left to see the coordinates of each point displayed below the graph.
- Notice the **P1** in the upper left corner.
- This tells you it is tracing the points from **Plot1**, and displays the lists that are the coordinates of the plot.

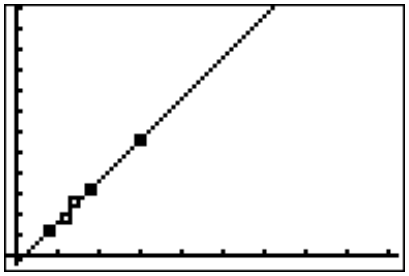
8. Have students fit the data with a function rule. There are several ways you can do this depending on your students' understanding of linear functions and features of the calculator. Below are three suggestions. Choose the one most appropriate for your students. Linear Regression and Manual-Fit Features are taught in subsequent lessons.

- Use the Linear Regression feature of the calculator.
- Use Manual-Fit feature of the calculator.
- Use paper and pencil to sketch a line of best fit, and find its equation.

The directions here will be for this last option.

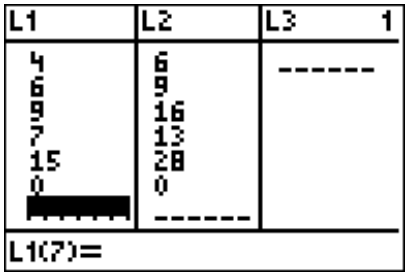


a. It may be helpful to take control of the window settings rather than staying with the **9:ZoomStat** setting.
   - You can assure yourself of "friendly" numbers (without a lot of places after the decimal point) when you scroll if the spread on the *x*-values is a multiple of 47 as shown.
   - Expand the *y*-values to include the approximation of the time you expect the entire class will take to pass the ball.



b. Have students sketch their points in the screen provided on their worksheet.
   - Next, have them sketch their approximation of the line of best fit.

c. After sketching the line on their worksheet, direct students to find an equation and enter it in Y1 of the [Y=] window.
   - To do this, have them identify two points and use their *x*- and *y*-values to determine the slope of the line.



d. Discuss with your students why the point (0, 0) would be a point that should be included with this data.
   - How many minutes did it take for no students to pass the ball?
   - Add the (0, 0) point to your data lists.
   - Since it is likely that the points do not lie in a straight line, have students work in groups and have each group choose two points from the lists.
   - Have each group choose a different set of points. One possible answer is (28–6)/(15–4) = 2.

e. Using this slope, have students write the equation of the line in Y1 and compare their lines with each other.
   - Have them graph the line to determine if their lines fit the plotted points.

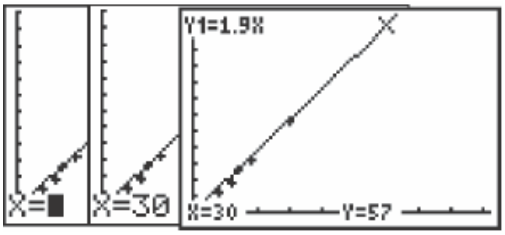
9. Have students use either the trace or table feature to predict how long they would expect it to take the entire class to complete the activity.
   - Discuss how close their predictions were to the actual time it took the whole class and possible reasons for any discrepancy.

10. Another option for predicting the time it took the entire class to pass the ball is to have the calculator find the *y*-value for a given *x*-value.

- From the graph screen, press 2nd TRACE to access the [CALC] menu.
- **1:Value** is highlighted already, so just press ENTER.
- An X= is displayed in the bottom left-hand corner.
- Enter the value for the total number of students in the class, and press ENTER.

Note: The value you enter must be included in the domain that was set in the WINDOW screen.

- The corresponding *y*-value will be displayed, and a cursor will mark the ordered pair on the graph.



Extension Activity

1. Repeat the process, but this time pass the ball without first bouncing it. A list of sample data is shown.

Extension Sample Data	
Number of People	Average Time in Seconds
5	3.98
7	4.91
9	6.42
11	
15	

2. After finding the regression equation and entering it into **Y1**, solve a problem that requires a prediction for values that are beyond the values in the recorded data.
   - For example, "If it took 50 seconds, how many people were there?"
3. The equation of the line for the sample question would be 50 = *mx*. If the slope was found to be 0.787, the equation becomes 50 = 0.787*x* and $x \approx 64$ people.

Discussion Notes

- Guide your students toward an understanding of the concept that a change in the *x*-values will cause a change in the *y*-values.
- Point out that if they were able to all pass the ball at exactly the same pace, they would be simulating a constant rate of change in the *x*-values that would bring about a constant and predictable change in the *y*-values.
- The fact that the estimation from the line of best fit is not an exact match to the actual time measured for the entire class is easily explained by human inconsistencies.
- The approximation from the line of best fit was not exact, but it should have been close enough to allow students to understand how this type of model building and reasoning could be used to predict future events with some reasonable degree of accuracy.

Worksheet Answers

The answers to the questions on the worksheet will vary depending on the data collected.

Pass the Ball
Student Activity

Name _____

Class _____

Objectives

- Graph scatter plots
- Graph linear functions
- Analyze proportional relations
- Interpret, predict, and analyze data and graphs

Materials

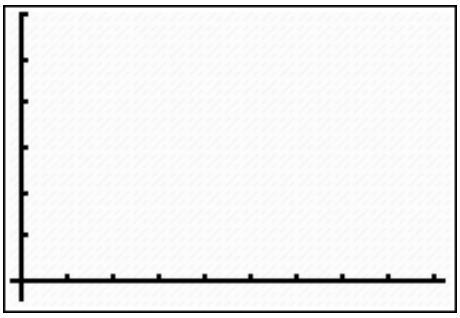
- TI-84 Plus graphing calculator family
- Stopwatch
- Small bouncing ball (tennis/racquet balls work well)

Number of People	Trial 1	Trial 2	Trial 3	Average Time in Seconds
4				

1. Fill in the table above.

2. Estimate how long you think it will take to do this activity with everyone in the room participating.

3. Enter the number of people in the group in **L1** and the time for that group to pass the ball in **L2**.
   - Turn on the [STAT PLOT] for **L1** and **L2** using the **9:ZoomStat** feature from the [ZOOM] menu to scale your window.
   - Make a sketch of these data points in the graph to the right.

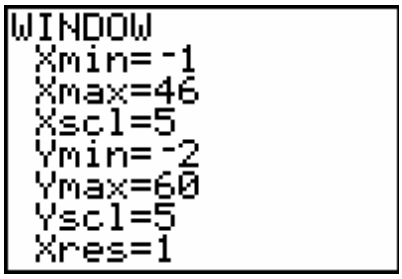


4. Draw what you consider to be the line of best fit.

Pass the Ball Name _____
Student Activity Class _____

5. Select two points through which your line passes and use them to find the slope of your line.
   - Write the equation of your line here_____, enter it into the calculator beside **Y1 =**, and then press GRAPH.
   - Examine how closely the line you drew matches the line on your calculator.

6. It may be helpful to take control of the window settings rather than staying with the **9:ZoomStat** setting.
   - Press WINDOW.
   - Adjust the spread on the *x*-values to be a multiple of 47 as shown here to assure yourself of "friendly" numbers when you scroll.
   - Next, adjust the *y*-values to include the approximation of the time you expect the entire class will take to pass the ball.



7. Press TRACE, and use the down arrow key to scroll along the line entered in **Y1**, not the data points.
   - Scroll to the right until your *x*-value matches the total number of students in your class.
   - Record your *y*-value of that point here and explain what it represents.

y =_____

8. Turn off **Plot 1**, and clear **Y1** before beginning the Extension activity.

Extension Activity

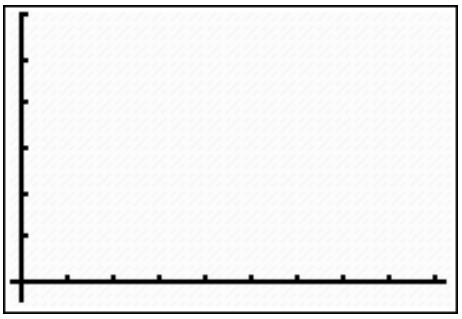
1. Fill in the table below.

Number of People	Trial 1	Trial 2	Trial 3	Average Time in Seconds
4				

Pass the Ball Name _____
Student Activity Class _____

2. Estimate how long you think it will take to do this activity with everyone in the room participating.

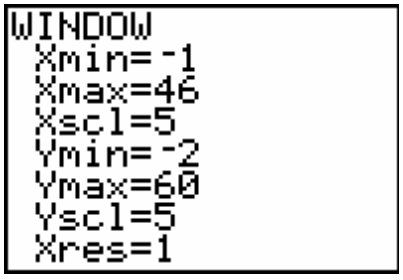
3. Enter the number of people in **L3** and the time for passing the ball in **L4.**
   - Turn on the [STAT PLOT] for **L3** and **L4**.
   - Use the **9:ZoomStat** feature from the [ZOOM] menu to scale your window.
   - Make a sketch of these data points in the graph to the right.



4. Draw what you consider to be the line of best fit.

5. Select two points through which your line passes and use them to find the slope of your line.
   - Write the equation of your line here_____, enter it into the calculator beside **Y1 =**, and then press [GRAPH].
   - Examine how closely the line you drew matches the line on your calculator.

6. It may be helpful to take control of the window settings rather than staying with the **9:ZoomStat** setting.
   - Press [WINDOW].
   - Adjust the spread on the *x*-values to be a multiple of 47 as shown here to assure yourself of "friendly" numbers when you scroll.
   - Next, adjust the *y*-values to include the approximation of the time you expect the entire class will take to pass the ball.



7. Press [TRACE], and use the down arrow key to scroll along the line entered in **Y1,** not the data points.
   - Scroll to the right until your *x*-value matches the total number of students in your class.
   - Record your *y*-value of that point here and explain what it represents.

   y =_____

8. Was your approximation for the time it took the entire class an exact match to the time you recorded from actually doing the activity?

   What could be the cause of any discrepancy?

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Mass Guessing

TI PROFESSIONAL DEVELOPMENT

Activity Overview

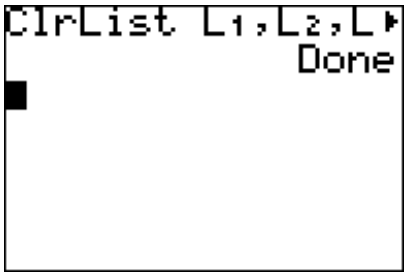
In this activity, you will guess the mass of various items, enter their estimated and actual masses into lists, and graph the results in a scatter plot.

Materials

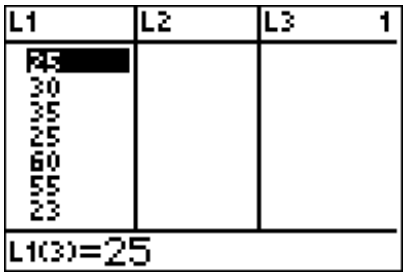
- TI-84 Plus graphing calculator family
- Half a dozen items with different masses

1. Have the participants enter the data editor, and clear all default lists by pressing [STAT] and choosing **ClrList**. Then press [2nd] [1], [2nd] [2], [2nd] [3], [2nd] [4], [2nd] [5], [2nd] [6] [ENTER].

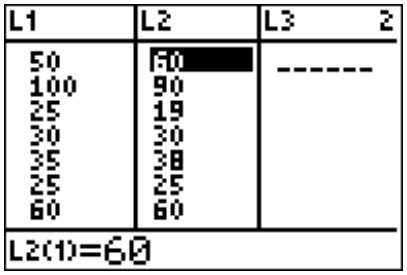
   All lists can also be cleared by pressing [2nd] [+] (for [MEM]) and choose clear all lists.



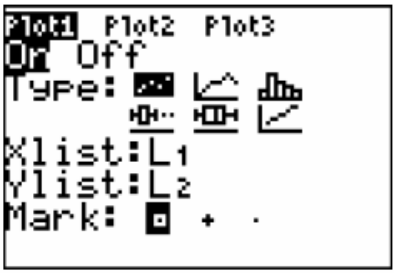
2. Pick up several objects and guess their mass.
   - Record the information on the data sheet. Press [STAT] and choose **Edit** to get to the table.
   - Transfer your predicted mass into in L1. Be sure to enter them in order by assigned number.



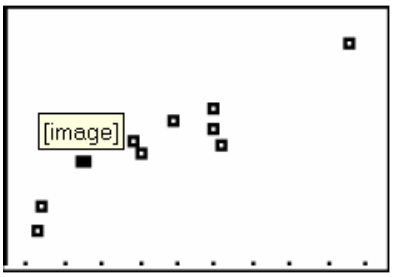
3. Now, mass all of the objects and record the results in L2. Be sure to match up items.



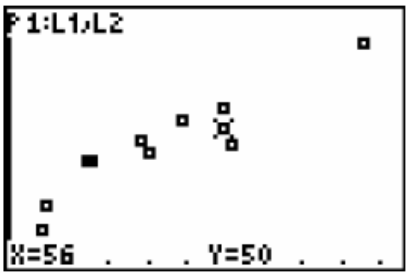
4. Have the participants create a scatter plot with the *x*-list (L1) and *y*-list (L2) by pressing [STAT PLOT] and setting the parameters as shown.



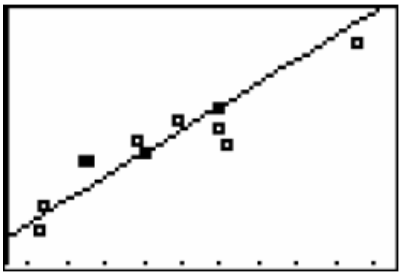
5. Make sure the Y= are clear, and use ZoomStat to show the relationship.



Press TRACE, and discuss the ordered pair.



6. Graph $y = x$ by pressing Y=. Show the graph by pressing GRAPH. What is the relationship between the scatterplot and line?



Data Table

Object Number or Description	Predicted Mass	Actual Mass

Grandma Ruth

TI PROFESSIONAL DEVELOPMENT

Activity Overview

As I grew up, I had the pleasure and misfortune of having my grandparents live close by. I enjoyed their company, and their constant desire to spoil their grandchildren by buying us things throughout the year. The downside of these shopping trips occurred in late summer when they would take me shopping for school clothes.

Grandma Ruth would insist in buying me several new outfits for school. These outfits would include everything from shirts and pants to shoes and underwear. There was something about buying underwear with your grandmother as a 14 year-old male that made the trip uncomfortable.

To make matters worse, Grandma Ruth had this strange notion that you could determine if a sock would fit your feet by wrapping it around your fist. So there I stood in the department store, wrapping socks around my fist to see if they were going to fit my feet. Grandma Ruth is gone now, and mixed in my fond memories of her is still the question of whether she was a little crazy in her notion of trying on your socks by using your fist rather than your feet.

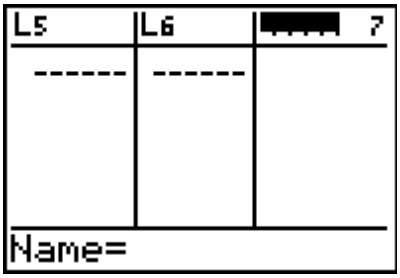
Materials

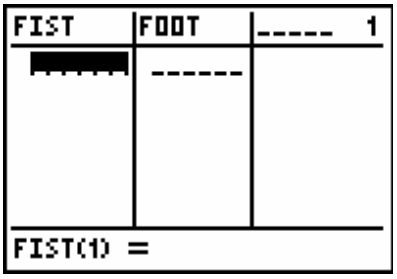
- TI-84 Plus graphing calculator family
- Tape measure

Plan

1. This is your question to answer so that my faith in my Grandma's sanity can be settled. To settle this, you are to use all that you know about the scientific method. The question has been asked, "Does the diameter of your fist determine your foot size?"
2. Your team needs to develop your test, conduct the experiment, analyze the data, and reach a conclusion supported by the data.
3. Include the collection of fist and foot data.
4. Share your team's plan with the class.
5. During the discussion, the class should determine the exact methodology of the investigation. All teams will then conduct the experiment the same way.

Execute





1. The teams will conduct the accepted experiment as prescribed and modified by the class. Data should be collected and entered into the TI-84 Plus graphing calculator.
2. Place the data for the diameter of the fist (FIST) as the independent variable and the length of the foot (FOOT) in the list editor. Press [STAT], and select **Edit** to see the list.
3. Highlight the name of a list, and arrow over to the right or left until you get the first unnamed list.
4. Enter the names **FIST** and **FOOT** in the first and second columns as shown. Now enter the data collected into your newly named lists.

Conclude

1. What did the data indicate? How were you sure? Did all of the variables you listed stay constant or controlled except for the FIST and FOOT?

2. What was your sample size? Was it large enough, how do you know?

3. How did your results compare with other team members?

4. What was the range of the data? Why would that matter?

5. How would you modify the experiment if repeated? Why?

6. Where was the science? What mathematic concepts were involved?

7. What questions come to your mind when you study the data?

Bungee Jumping Barbie

TI PROFESSIONAL DEVELOPMENT

TEACHER NOTES

Activity Overview

This activity involves a simulation of bungee jumping. The distance a person falls while attached to a bungee cord depends on their weight and the length of the cord. We will keep the person's weight constant by using the same object for the entire experiment. Our goal is to discover how far a person (represented by the doll) will fall based on how long the bungee cord is. Then we will predict how long a cord will be needed to fall from a known height without hitting the ground.

Materials

- TI-84 Plus graphing calculator family
- Dolls suitable for the experiment
- Boxes of sturdy rubber bands (must be the same size)
- Tape measures or meter sticks

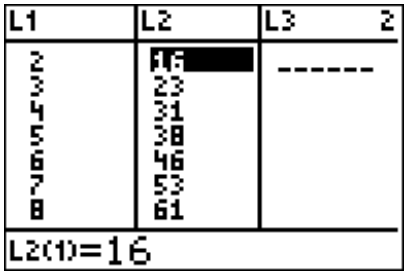
Data Collection

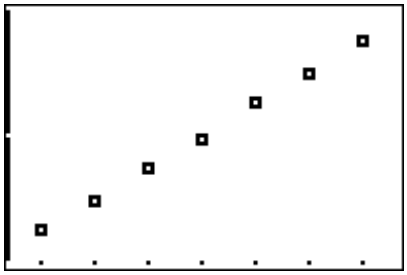
1. Collect a doll and eight identical rubber bands.
2. Attach the first band to the ankle of the doll.
3. Attach the free end of the chain at a fixed point from which a tape measure is attached.
4. Release the doll from the fixed point and record the distance it falls. Repeat the experiment several times.
5. Carefully add bands one at a time and test the drop until the length is eight bands. Be uniform in the way these are joined. Use student work sheet to record results.

Data Entry

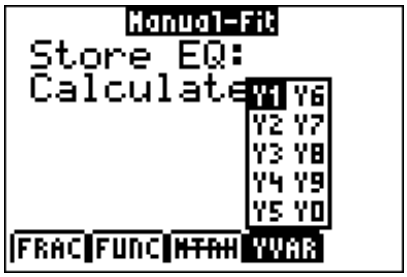
Enter the number of rubber bands in L_1 and the distances in L_2.

Create a scatter plot of L_1 versus L_2.

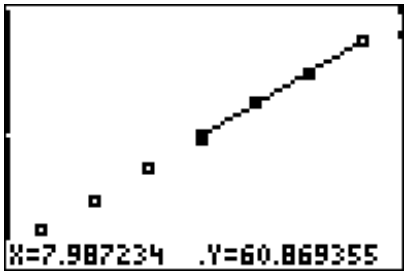




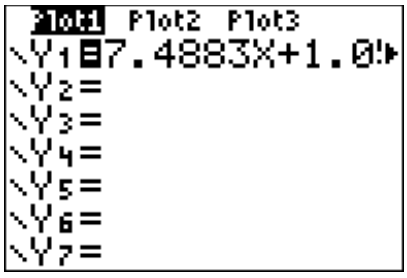
Analysis



1. Perform a manual fit on this data.
   - Press [STAT] and choose CALC then scroll to Manual Fit and press [ENTER].
   - Press [ALPHA][F4] to choose Y1 to store the equation as Y1.



2. When you get the next screen, press [ENTER] to choose the first point.
   - Press the arrow keys to create a line, and press [ENTER] to set the end point. The graph will appear.
   - Change *m* and *b* until you are happy with the fit. Then press [2nd][QUIT].



3. The equation is on the screen and can also be seen by pressing [Y=]. Record it here _____.
   - Using the resulting equation, predict how many rubber bands you will need to drop the doll from a new height given by the instructor.
   - Test your prediction.

Bungee Jumping Barbie

Student Activity

Name _____

Class _____

Activity Overview

This activity involves a simulation of bungee jumping. The distance a person falls while attached to a bungee cord depends on their weight and the length of the cord. We will keep the person's weight constant by using the same object for the entire experiment. Our goal is to discover how far a person (represented by the doll) will fall based on how long the bungee cord is. Then we will predict how long a cord will be needed to fall from a known height without hitting the ground.

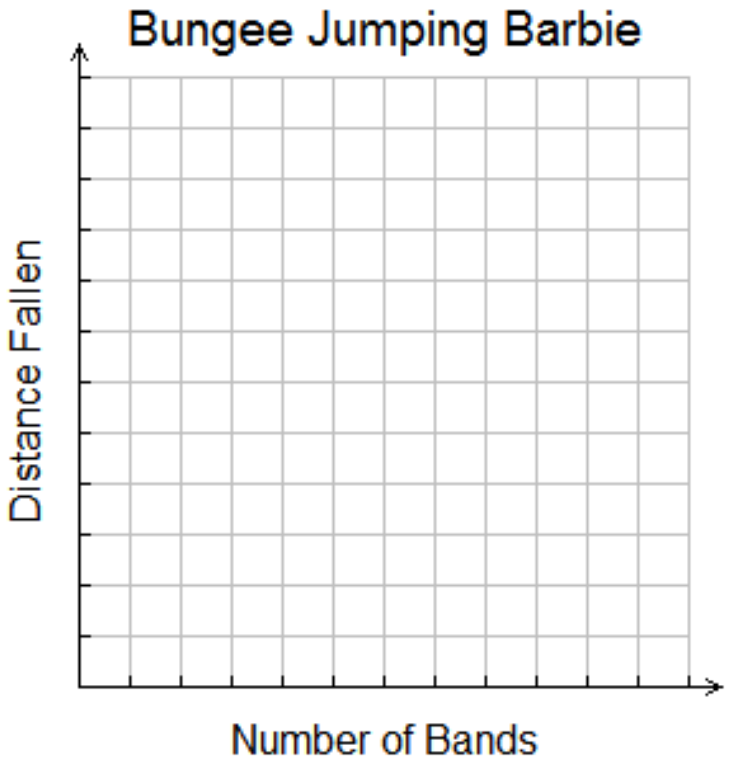
1. What variable do we control? This is the *independent variable*, or the *domain*.

2. What variable is not under our control? This is the *dependent variable*, or the *range*.

3. Make a rubber band chain attached to the ankle of the doll.
   - Begin with two rubber bands and drop it.
   - Add bands, one by one, and repeat until you get to eight rubber bands.

Number of Bands	Average Distance Fallen (cm)
2	
3	
4	
5	
6	
7	
8	

4. Graph the data on the grid provided below:



5. Find a mathematical model using Manual Fit. What equation did you get?

6. Now use your model to predict the number of bands needed to come as close as possible (to get the maximum rush) without hitting from a given distance.

7. What is the given distance provided to you?

8. Using your equation, what is the number of bands you will need? Show work.

Activity Overview

Students will measure their bones and determine the relationships between the various bone sizes.

Materials

- TI-84 Plus graphing calculator family
- Meter stick
- Dry spaghetti

Introduction

Scientists do not always find all of the bones needed to make real measurements of dinosaurs. They may find a leg bone, or a skull, or a few ribs. By calculating the relationship between the lengths of the bones found, they can estimate the size of the animal.

In this activity, you will measure some bones in your body; and then determine what type of relationship exists between those bones.

Procedure

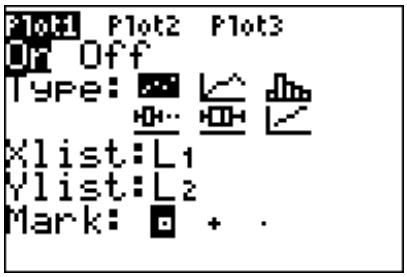
1. Each member of the group should measure the length of their shoe using a tape measure or meter stick. Record each measurement in the data table.
2. Each member of the group will measure their forearm from the bend at the wrist to the elbow using the tape measure or meter stick. Record each measurement in the data table.
3. Obtain data measurements from other groups to total 12 data sets (shoe length, forearm length), and record them in them.

From Elbow to Wrist

From Heel to Toe

Use the following steps to enter your data into the TI-84 Plus graphing calculator:

1. Press STAT, and then press ENTER to access the List editor.
2. If L1 is not empty, press ▲ to move the cursor to the top of the list, and then press CLEAR, ENTER to clear L1.
3. Press ▲ to move to the top of L2, and repeat step 2 to clear L2.
4. Move to the first position in L1 [L1 (1)], enter the first value in the shoe length column, and press ENTER. Continue this process until all values in the shoe length column are entered.
5. Press ▲ to move to the first position in L2 [L2 (1)], and enter the first value in the forearm length column. Continue this process until all values in the forearm length column are entered.
6. Press 2nd Y= to access [STAT PLOT] and press ENTER to access the screen shown.
   - Adjust the settings to match those shown.
   - Use the arrow keys to move around the screen, and press ENTER to select the settings.
   - Press ZOOM 9 to set up the window.
   - Press GRAPH to see a plot of forearm length versus shoe length.
7. Make a sketch of the data as it appears on the screen. Be sure to label the axes.



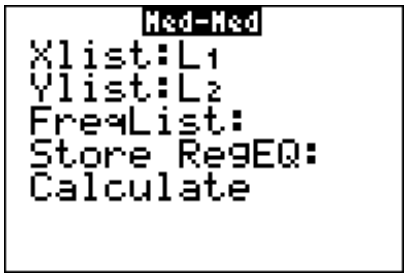
Analysis

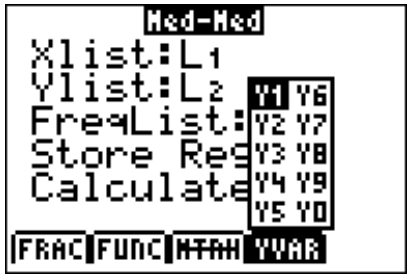
1. Break off a piece of spaghetti approximately as long as the width of the TI-84 Plus graphing calculator screen.
2. Then place the spaghetti on the screen of your calculator, and move it around until it best follows the pattern of your points.
3. The spaghetti represents a graph of a line that would predict the relationship between the length of your forearm and the length of your shoe.
4. Sketch your line of placement for the spaghetti on the graph in Question 7 above.
5. One way the TI-84 Plus can determine this line is by calculating the median-median fit.

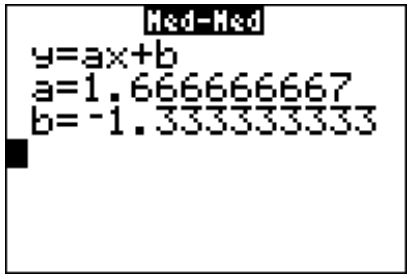
6. Use the following steps to find the median-median fit for your data points using your TI-84 Plus:
   - Press [STAT] [▶] to get the CALC Menu on your calculator for regression calculation.
   - Select option **3:Med-Med**.
   - Use arrow keys to go to **StoreReq**.
   - Press [ALPHA] [F4] to select the storage location and press [ENTER]. Arrow to Calculate and press [ENTER] again.
   - Copy the equation on the line below:

     _____

   - Press [GRAPH] to view the graph of the median- median line determined by the TI-84 Plus.
   - How does this compare to your original sketch of the graph?







Conclusion

1. Look at the graph. What does the line tell you about the relationship between the length of the forearm and the length of the shoe?
2. Suppose you and your friend are arm wrestling. You notice that your friend's forearm is longer than yours. What does this tell you about your friend's foot?

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Them Bones Name _____

Student Activity Class _____

Record your data here:

Student Name	Shoe Length (cm)	Forearm Length (cm)

1. Break off a piece of spaghetti approximately as long as the width of the TI-84 Plus graphing calculator screen.
2. Then place the spaghetti on the screen of your calculator, and move it around until it best follows the pattern of your points.
3. The spaghetti represents a graph of a line that would predict the relationship between the length of your forearm and the length of your shoe.
4. Your regression equation _____.
5. What does the line tell you about the relationship between the length of the forearm and the length of the shoe?

6. Suppose you and your friend are arm wrestling. You notice that your friend's forearm is longer than yours. What does this tell you about your friend's foot?

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ACTIVITY 5

Match the Graph

Math Objectives:

- Examine rate of change
- Analyze and interpret the graph of a function

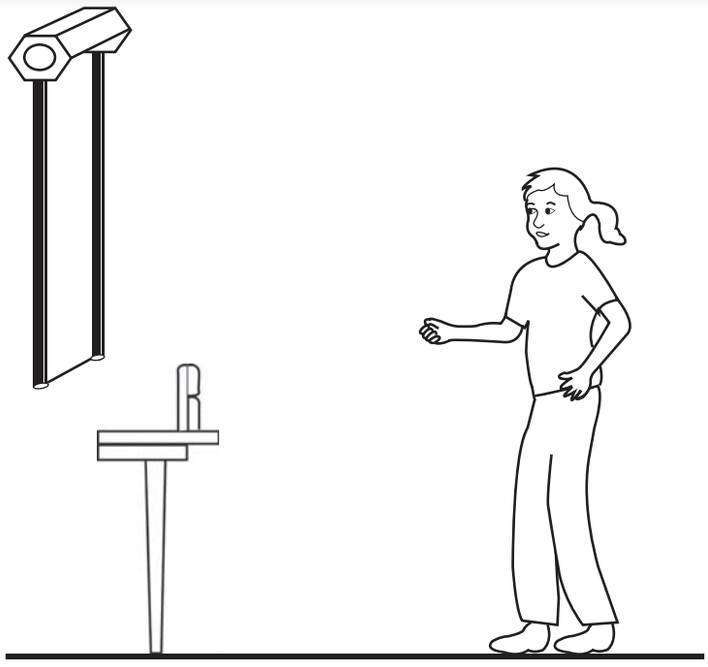
Materials: (Per Group)

- TI-83/TI-84 Plus Family
- Calculator-Based Ranger™ (CBR 2™)
- Vernier EasyData™ Application

OVERVIEW

Participants will work in groups to gain experience using the CBR 2 and EasyData App as they practice walking to match a distance/time graph.

Have several students do the *Match the Graph* activity in the front of the class as a demonstration before having students work in their own groups. The room should be set up with an aisle down the middle. Set up a CBR 2 and point it down the aisle. Connect it to a TI ViewScreen calculator so the class can see both the participant walking down the aisle and the data projected from the TI-84 Plus.



SETUP

1. Set up the activity as shown in the picture above.
2. Link the CBR 2 motion detector directly to the TI-84 Plus. You can use either the I/O Unit-to-Unit cable or the mini-USB cable.
3. The EasyData App will launch automatically if the mini-USB cable is used. If you are using the I/O unit-to-unit cable, you will need to press the APPS key, scroll down to highlight the EasyData App and press ENTER to launch the App.

4. Press [Y=] to access the **File** menu and select **1:New**. This resets the program and clears out old data. (In general, the "soft keys" at the bottom of the screen are accessed by pressing the top row of keys on the calculator.) **See Figure 1.**

Figure 1

5. The default unit of measurement on the EasyData App is meters. This activity will be done in feet. To change the units of measurement, select the **Setup** menu soft key by pressing the [WINDOW] key on the top row of the calculator. From the **Setup** menu, choose **1:Dist** by pressing [1] or [ENTER] since **1** is highlighted. **See Figure 2.**

Figure 2

6. From the Units menu, select **2:(ft)** by pressing [2] or scroll down until the **2** is highlighted and press [ENTER]. Then select **OK**. **See Figure 3.**

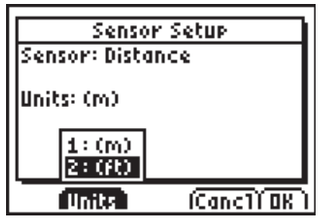


Figure 3

DATA COLLECTION

1. You will be returned to the main screen of the EasyData App. The App senses the CBR 2 and starts giving a distance reading across the top of the screen. Select **Setup** and choose **3:Distance Match. See Figure 4.**

Figure 4

2. Select **Start** (by pressing [ZOOM]) and follow the instructions on the screen. **Distance Match** automatically takes care of the settings. **See Figure 5.**

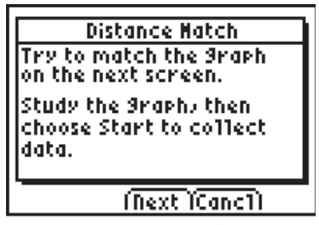


Figure 5

3. Select **Next** (by pressing [ZOOM]) to display the graph that is to be matched for this activity. Take a moment to study the graph with your students. Have them answer questions 1–5 on their worksheet. **See Figure 6.**

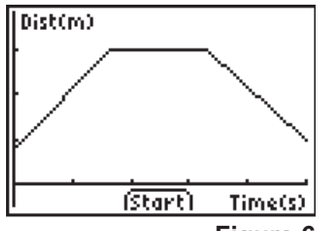


Figure 6

4. Select **Start** to begin the activity. As the walker starts to move, a trace of the walker's path will be displayed in real time along with the original graph. **See Figure 7.**

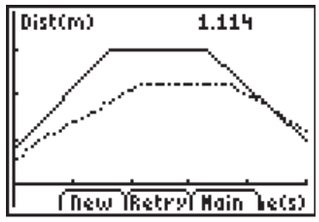


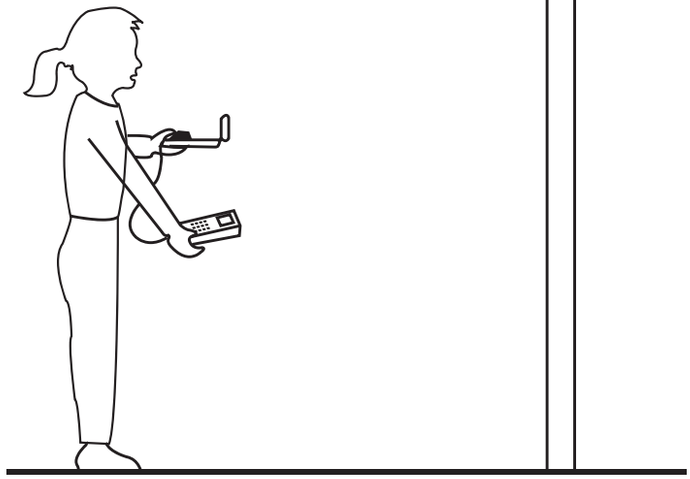
Figure 7

5. Choose a student or two to do a brief demo of the graph match application for the entire class. Select **Retry** to display the same graph again and select **New** to display a new graph. Take a moment to study one of the walks. Have students answer questions 6–9 on their worksheets. **See Figure 7.**

6. Outline the directions to be used for this activity.

   - Students earn up to five points in each of five areas: starting point, direction, rate, deviation, and teamwork.
   - "Starting point" points are earned for being close to the actual starting point.
   - In the "Direction" section, students earn points by going the correct direction.
   - "Rate" points are earned for walking the same rate as that in the graph, resulting in the same or parallel lines.
   - Students get "Overall Fit" points for not deviating from the graph.
   - For working as a team and helping the walker, the students earn "Teamwork" points.

7. If you have enough CBR 2 units, allow students to practice with their group for 5–10 minutes. An alternative setup is to have the student hold the calculator and CBR 2 while pointing the CBR 2 at the wall as shown below. Students should take turns in their groups having each participant gain experience using the CBR 2 and in walking to match the graph.



8. If you only have one CBR 2, have one student from each group take a practice "walk" in front of the entire class while their progress is viewed on the overhead. Their team members may offer advice.

9. After the practice "walk," randomly pick a team to match a graph. Then follow with the other teams in succession. For example, if you randomly pick team 4, the teams will follow in this order: 5, 6, 1, 2, 3, 4. Let the first team make a second attempt at the end. Give each team one minute or less to discuss the match.

10. Solicit scores for the group by a show of hands. Record the score given by most students rather than trying to average the scores. Let each student use the table on the worksheet to keep track of the scores.

WORKSHEET ANSWERS

1. Time
2. Seconds, 1 second
3. Distance
4. Could be feet or meters, depending on your settings; 1 foot or 1 meter
5. Depends on first graph that is displayed for the class demo
6. Depends on first graph that is displayed for the class demo
7. Backward. If the line slopes up, as the **X-**values (time) increase, so must the distances from the CBR 2 represented by the change in the **Y-**values. To increase these distances the walker needs to move farther away.
8. Forward. If the line slopes down, as the **X-**values (time) increase, the distances from the CBR 2 represented by the change in the **Y-**values must decrease. To decrease these distances the walker needs to move closer to the CBR 2.
9. Stand still. If the line is flat, the slope is zero. This means that as the time increases the distances remain the same.

ACTIVITY 5

Name: _____

Match the Graph

Math Objectives:

- Examine rate of change
- Analyze and interpret the graph of a function

Materials: (Per Group)

- TI-83/TI-84 Plus Family
- Calculator-Based Ranger™ (CBR 2™)
- Vernier EasyData™ Application

1. What physical property is represented along the **X-**axis? _____
2. What are the units? How far apart are the tick marks? _____
3. What physical property is represented along the **Y-**axis? _____
4. What are the units? How far apart are the tick marks? _____
5. For the first sample graph your teacher displays, how far from the CBR 2 motion detector do you think the walker should stand to begin? _____
6. Did the walker begin too close, too far, or just right? _____
7. Should you walk forward or backward for a segment that slopes up? _____

   Why? _____
8. Should you walk forward or backward for a segment that slopes down? _____

   Why? _____
9. What should you do for a segment that is flat? _____

   Why? _____

SCORING DIRECTIONS FOR GRAPH MATCH

Give each team a score from 1–5 based on the following criteria. (1 is lowest, 5 is highest.)

	Starting Point	Direction	Rate	Overall Fit	Team Work	Total
Group 1						
Group 2						
Group 3						
Group 4						
Group 5						
Group 6						

NOTES

ACTIVITY 4

Measure Up

Math Objectives:

- Graph and interpret box plots
- Graph and interpret histograms
- Generate a five-number summary of single variable data
- Analyze and interpret data and graphs

Materials:

- TI-83/TI-84 Plus Family
- Calculator-Based Ranger™ (CBR 2™)
- Vernier EasyData™ Application
- Firm piece of cardboard/wood (refer to picture)

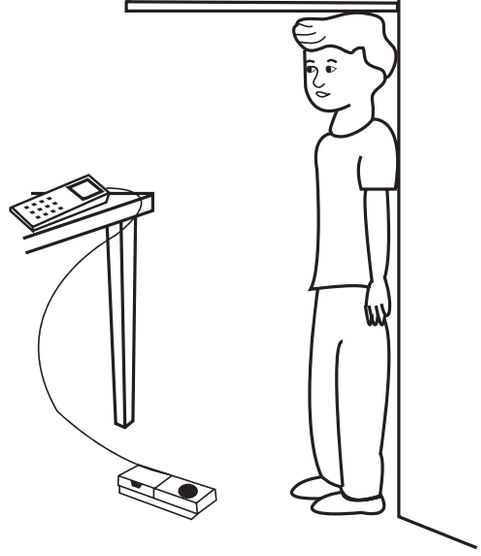
OVERVIEW

What is the average height of the students in your class? How does your height compare? How does your teacher's height compare? You can use statistics to answer these questions and describe the general characteristics of a set of measurements.

In this activity you will:

- Collect data of the heights of 12 students and the teacher in your class.
- Create a plot showing the heights of 12 students and the teacher in your class.
- Calculate the extreme values and median for the height data.
- Construct a box-and-whisker plot to summarize the height statistics.

SETUP



1. Set up the activity as shown in the picture. The CBR 2 should be positioned directly under the end of the board. The board should be long enough so that the CBR 2 can take a reading of the height of the board without the student blocking the path between the CBR 2 and the board.
2. Link the CBR 2 motion detector directly to the TI-84 Plus. You can use either the black link (I/O Unit-to-Unit) cable or the mini-USB cable.
3. The EasyData App will launch automatically if you use the mini-USB cable. If you are using the I/O cable or an older CBR, you will need to manually launch the App. To do this, press the APPS key, scroll down until the EasyData App is selected, and then press ENTER.
4. Measure the height of the teacher and the heights of 12 students. Take turns getting measured by using the board and the CBR 2. While one student is being measured, another student needs to hold the piece of cardboard or wood so that it is flat against the first student's head and level to the floor. A third student needs to run the calculator and CBR 2. They will take readings using the **Events with Entry** feature. The student holding the board must also be careful to stand out of the path of the CBR 2. Be sure to include the teacher's height because it might make a long whisker and a good topic for discussion.

DATA COLLECTION

1. When the EasyData App launches, you will see a title screen for a few seconds and then you will be taken to the home screen of the App. Notice the choices along the bottom of the screen: **File, Setup, Start, Graph,** and **Quit.** These are called "soft keys" and are accessed by pressing the top row of keys on the calculator, e.g., the [Y=] key corresponds to the **File** soft key, the [WINDOW] key will access the **Setup** soft key. **See Figure 1.**

Figure 1

2. Begin each lesson by choosing **New** from the **File** menu. This will reset the App and clear out any old data. The default **Mode: Time Graph** will be displayed near the bottom of the screen. The CBR 2 will click as it begins to measure the distance to the nearest object in its path. Notice the reading at the top of the screen. **See Figure 2.**

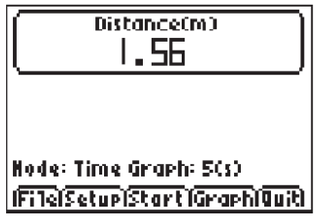


Figure 2

3. The default unit of measurement for the CBR 2 is meters. This activity works better in feet since students are more familiar with their height in feet and inches. To change the units of measurement, select the **Setup** menu by pressing the [WINDOW] key on the top row of the calculator. From the **Setup** menu, choose **1:Dist** by pressing [1] or [ENTER] since 1 is highlighted. **See Figure 3.**

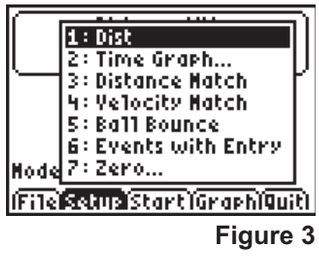


Figure 3

4. Press the [WINDOW] key to access the **Units** menu. Select **2:(ft)** by pressing [2] or by scrolling down until the **2** is highlighted and pressing [ENTER]. Then select **OK. See Figure 4.**

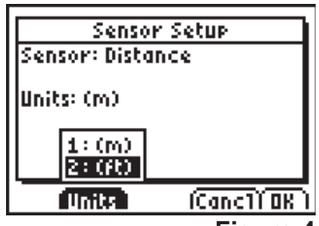


Figure 4

5. You will be returned to the main screen of the EasyData App. Select the **Setup** menu again, and then select **6: Events with Entry.** This will allow you to control when data is recorded by pressing a key on the calculator. **See Figure 5.**

6. Select **Start** (by pressing the [ZOOM] key) to begin collecting data.

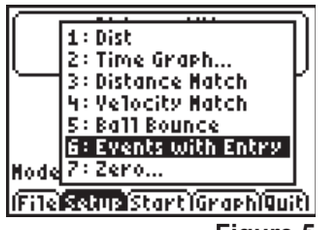


Figure 5

7. You will be taken to a screen that displays the distance being recorded by the CBR 2 in real time at the top of the screen. Have the first student stand below the board as shown in the picture. To record the distance for the first student's height, select **Keep**. **See Figure 6.**

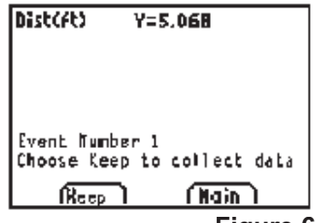


Figure 6

8. The next screen shown allows you to match a value with the distance you just recorded. Since this is the first person, type **1** and then select **OK**. **See Figure 7.**

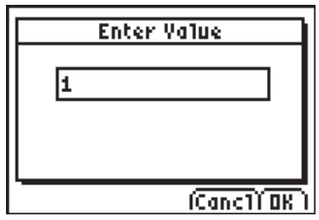


Figure 7

9. Repeat steps 7 and 8 until you have collected the heights of all 12 students and the teacher. When the **Enter Value** screen appears, increase the value each time to represent which person's height you are recording. With each recorded value, a new data point will be displayed on the graph. When finished, select **Stop. See Figure 8.**

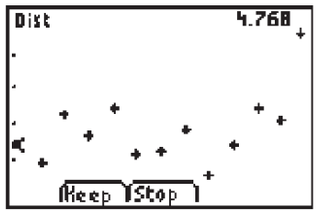


Figure 8

10. The graph of all the data points will be displayed. You can use the right and left arrow keys to view the coordinates of the points. **See Figure 9.** Before continuing, take a minute for students to ***sketch*** this graph on their worksheet.

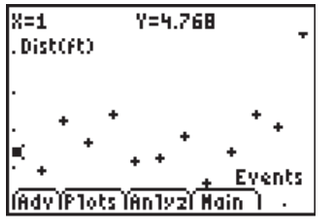


Figure 9

11. To confirm a description of the plots, select **Plots.** You will see that the plots are **Distance vs. Events**. **See Figure 10.** This is a good place to review vocabulary associated with this type of activity. Make sure the students understand the **Events**, although mentioned last, stand for the independent variable and the **Distance** represents the dependent variable.

Figure 10

12. Select **Main** and then **Quit** on the next screen. The screen on the right will be displayed. It will confirm the lists where your data is stored. Select **OK** to exit the App. **See Figure 11.**

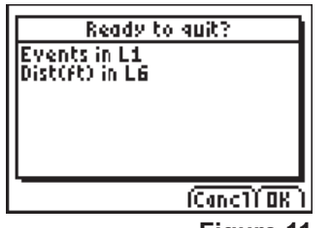


Figure 11

13. The data values you recorded, as stated in the exit screen, are in lists **L1** and **L6.** Press [2nd] [Y=] to access the [STAT PLOT] menu and to see **Plot 1** is still turned on with the window set to display all the points collected. **See Figure 12.**

14. Each student needs to have this data in his/her own calculator for the Data Analysis. This is an opportunity to have the students link the data from the calculator that collected it to the rest of the class. If linking gets to be standard operating procedure, thirty students can link in less than three minutes. When one calculator links to one other, then two link to four, four to eight, eight to sixteen, etc., it goes very quickly. This leads to the entire class staying on task until everyone is ready.

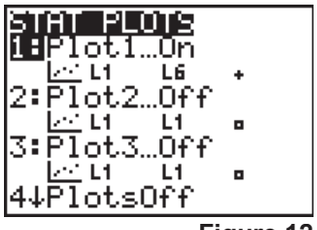


Figure 12

★ **NOTE** *For help linking calculators, see Appendix J.*

15. Ask each student to save all the data in **L6.**

DATA ANALYSIS

1. Sort **L6** to make analyzing the data easier. Press [STAT] and choose **2:SortA(** to sort in ascending order. As with any menu, you can press the down arrow until **2:SortA(** is highlighted and then press [ENTER], or you can just press [2]. **See Figure 13.**

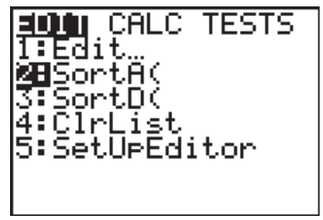


Figure 13

2. You will be returned to the home screen. Press [2nd] [6] to enter **L6.** Press [)] to close the parenthesis and then press [ENTER] to execute the command. **See Figure 14.**

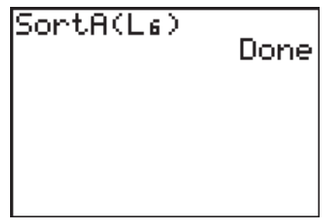


Figure 14

3. To confirm the list has been sorted, press [STAT] [ENTER] and scroll right until you can see **L6. See Figure 15.**

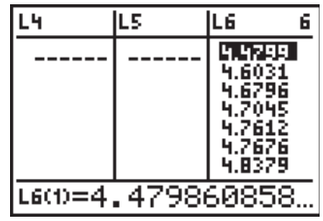
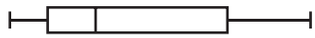


Figure 15

4. Make sure the students understand that the order of the numbers in **L1** is not important. Have them fill in the chart on their worksheet. Adjust your explanation of boxplots to fit your students' experience with them.

BOXPLOT EXPLANATION



A box-and-whisker plot, also called a boxplot, is a data representation that divides a data set into four regions with equal numbers of data points. The boxplot allows you to focus your attention on a few important features without the clutter that results when all data values are displayed. The median, or second quartile, separates the set into two halves. The first quartile is the median of the lower half and the third quartile is the median of the upper half. If you have an even number of data points, the median is found by calculating the average (mean) value of the two data points in the middle. One half of the data falls between the first and third quartiles.

The 1st quartile (Q1) value tells you that 25% of the values (in this case, the heights) are equal to or lower than Q1. The 3rd quartile (Q3) value is the point where 75% of the values are equal to or lower than Q3. This means that 50% of the class data is between Q1 and Q3. A shorter box means that the data is clustered and a longer box means that the data is more spread out. When the median line is in the center of the box, the data in the middle is symmetrically distributed.

The whiskers also give you information about how the data is distributed. If you have one whisker significantly longer than the other, the data is skewed in the direction of the longer whisker. This means the data is clustered near the shorter whisker.

5. Have your students follow the directions on their worksheet to sort the data in **L6** and then create their own box-and-whisker plot. Help them line up the data on the number line provided and identify the median by "counting in from both ends."

6. Repeat the idea of counting in from the ends for both the lower half and upper half of the data. Because you have 13 pieces of data, the median will be the 7th number in from either end. There will be six pieces of data in both the upper and lower halves. The median of each will be the average of the two middle pieces of data, the 3rd and 4th piece of data for each section. Guide the students in completing the plot in the space provided on their worksheet. Your students' level of experience with box-and-whisker plots should determine how much guidance you provide.

7. After their boxplot is drawn, have them use the one-variable stat feature on the calculator to see if the calculator's answers agree with the answers they have on the worksheet. Press [STAT], scroll right to the **CALC** menu, and then select **1:1-Var Stats. See Figure 16.**

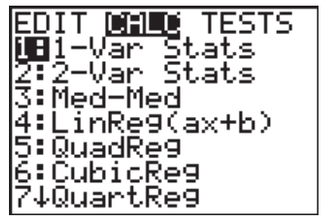


Figure 16

8. Press [2nd] [6] to enter **L6** in the home screen. Press [ENTER] to execute the command. **See Figure 17.**

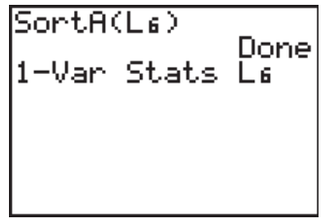


Figure 17

9. Have students scroll through the screen to see if the calculator agrees with the answers they entered into the chart. Instruct them to use the down arrow key to view all the lines of the statistics screen. Have them fill in their chart with these numbers and compare them to the numbers they found on their own. **See Figure 18.**

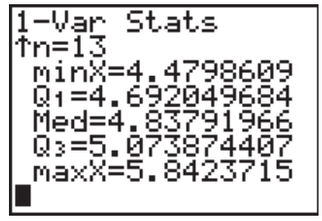


Figure 18

10. For further comparison, show them how to have the calculator create a box-and-whisker plot. Press [2nd] [Y=] to access the [STAT PLOT] menu. Press [ENTER] to set up **Plot 1**. **See Figure 19.**

11. If the plot is **Off,** use the arrow keys to highlight **On** and then press [ENTER] to select it. Use the right arrow key to scroll through the various types until  is highlighted and then press [ENTER]. Remember the heights are in **L6,** so press [2nd] [6] to type **L6** for the **Xlist.** The **Freq:** should be set at **1** since there was one height recorded for each student. **See Figure 20.** Press [ZOOM] and choose **9:ZoomStat** to view the new graph. Have students sketch the box-and-whisker plot in the space provided on the second page of their worksheet.

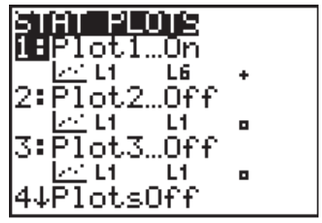


Figure 19

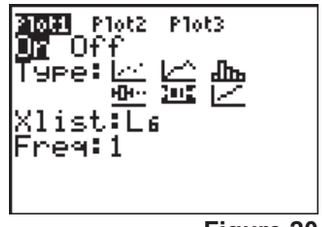


Figure 20

12. Press [TRACE] and use the right and left arrow keys to scroll through the plot. Notice the data at the bottom of the screen. Have students place the screen data in the appropriate place on the plot they sketch. For easy display, have them round numbers to the nearest hundredth before recording this information on their graph. **See Figures 21 a–e.**

13. Lead your students in a discussion about observations based on the length of both the whiskers and the boxes. The boxplot created by the calculator should closely match the boxplot the students sketched.

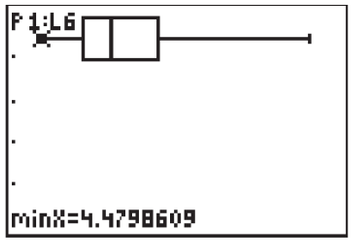


Figure 21a

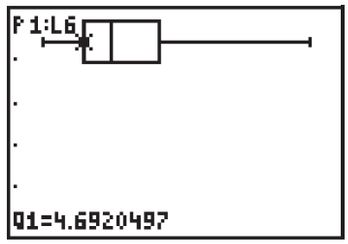


Figure 21b

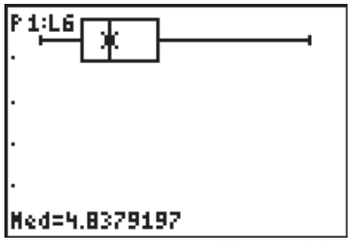


Figure 21c

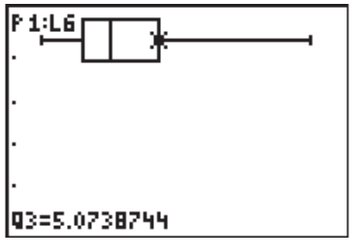


Figure 21d

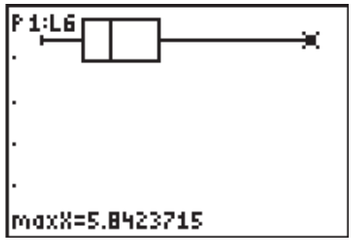


Figure 21e

EXPLORATION

1. Guide students in presenting the data in a histogram. Adjust the **Plot1** setting as shown here. Scroll until ▁▃▅▁ is highlighted and then press [ENTER]. **See Figure 22.** Press [ZOOM] and choose **9:ZoomStat** to view the new graph. **See Figure 23.**

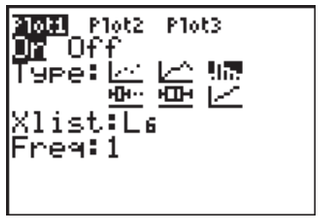


Figure 22

2. Students often have a hard time setting up a scale for a graph. They very quickly get in the habit of relying exclusively on the **9:ZoomStat** feature. Histograms often require adjustments. Press [TRACE] and scroll through the bars. Make sure they see that the **n** at the bottom of the window is the number of items in the bar marked by the cursor. **See Figure 23.** Encourage students to adjust the window settings to allow the graph to display the data in a more useful way. The **Xscl** determines the width of each bar starting at **Xmin.**

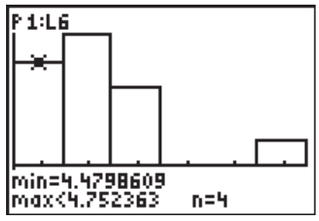


Figure 23

3. The numbers came from the CBR 2 and are very long. Round all the numbers to two decimal places for a cleaner display. Press [MODE], position the cursor on the **2** beside **FLOAT**, and then press [ENTER]. **See Figure 24.**

Figure 24

4. Press [WINDOW] and inspect the settings made by the calculator. This inspection can help students choose a logical selection for more appropriate settings. In the example, the current settings only show 4 bars for the histogram. Ask students to adjust the window to show more bars so that they display how many students are in smaller groupings. **See Figure 25.**

5. This problem will also give students an understanding of the shortcomings of the English measuring system. Units in feet and inches do not provide as many "friendly" numbers as those generated in the metric system.

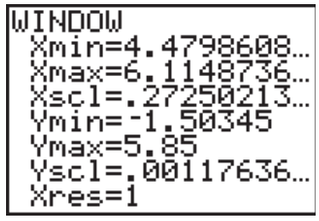


Figure 25

EXTENSION

1. An extension to this activity is to use the list feature to turn the data into inches rather than feet. This will make it much easier to create a more useful histogram. Ask the students how many inches are in one foot. One half of a foot? $\frac{3}{4}$ of a foot? Ask how they arrived at their answers. Make sure they see it as a multiplication problem. $\frac{1}{2}$ of a foot = $\frac{1}{2}$ x 12 inches = 6 inches.

2. Lead students to how many inches are in 4.5 feet. Then move to 4.2 feet. More importantly, lead them to a formula that will convert 4.2 feet to inches. Emphasize the concept that whether feet are given as a whole number or a fraction, they should multiply by 12 to convert feet to inches.

3. Let the list features of the calculator do this computation. Press [STAT] [ENTER] and position your cursor so the name of **L5** is highlighted. This will allow you to give a command for the entire list. Type in **L6 x 12**. **See Figure 26.**

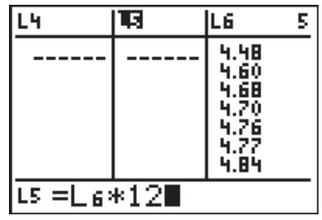


Figure 26

4. Press [ENTER] and watch **L5** fill in with the desired number of inches. The measurements are all rounded to the nearest hundredth. **See Figure 27.**

5. Next, round to the nearest whole number. Go back to the [MODE] key, position the cursor on the **0** beside the word **FLOAT,** and then press [ENTER].

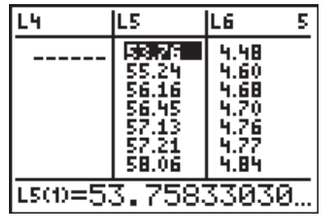


Figure 27

6. Press [STAT] [ENTER] to return to the Stat List Editor. Notice that all the numbers in **L5** are rounded to the nearest whole inch. **See Figure 28.**

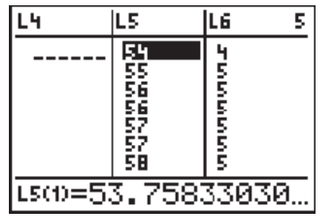


Figure 28

7. Press [2nd] [Y=] to go back to the [STAT PLOT] menu. Press [ENTER] to edit the setup of **Plot 1** and press [2nd] [5] to put **L5** in for the **Xlist. See Figure 29.** Press [ZOOM] and choose **9:ZoomStat** to view the new graph. The window will automatically adjust to include the data points that are now in inches.

8. The histogram will look just as it had before. Press [WINDOW] to see the current settings.

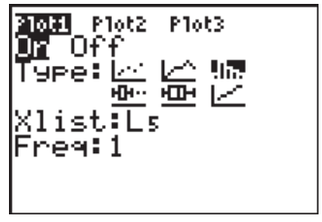


Figure 29

9. Adjust the window settings and use integers. This will allow the graph to make more sense to the students. Let the **Xmin** be the first integer smaller than the current **Xmin.** To edit these numbers, position the cursor on the first digit beside the equal sign and begin typing the number you wish to enter. The current digits will be erased as you type. Press either the down arrow key or [ENTER] to move to the next line. **See Figure 30.**

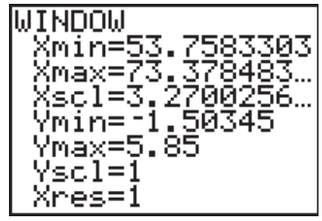


Figure 30

10. Set the **Xmax** to be the first integer greater than the current **Xmax**. Try adjusting the **Xscl** to 2 as in the example. More adjusting may be needed depending on the spread of your data. **See Figure 31.**

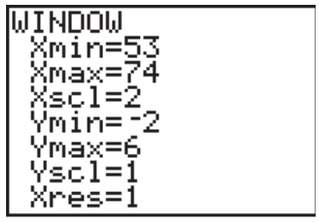


Figure 31

11. The **Ymin** is given a negative value so when you trace the histogram, the values displayed at the bottom of the screen will not be blocking the graph itself. Encourage students to see the relationship between this display and the box-and-whisker plot. A tall teacher led to a long right whisker in the boxplot and to the single box to the far right in the histogram. **See Figure 32.**

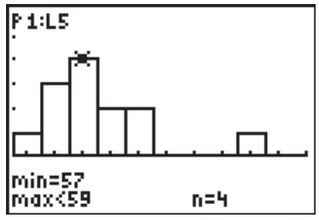


Figure 32

12. Assign the **Going Further** section for homework to check for understanding of the day's activities.

WORKSHEET ANSWERS

The answers to many of the questions on the worksheet will vary depending on the data collected. Answers that will not vary are provided here.

2. They should match.

5. 25%, 25%

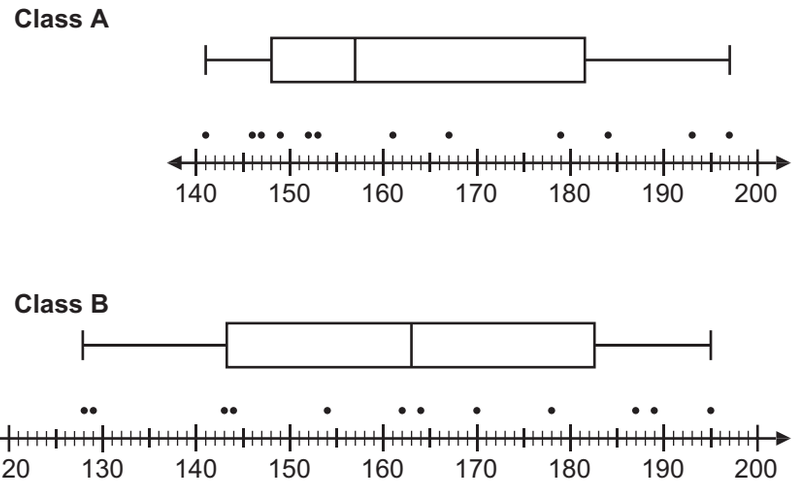
8. It would not change. The new numbers are just different representations of the same data so the graph, which basically shows how the data is distributed, would be the same shape.

GOING FURTHER

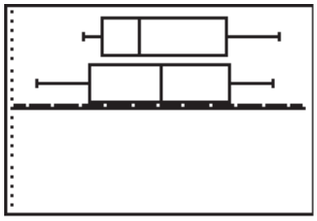
1. No

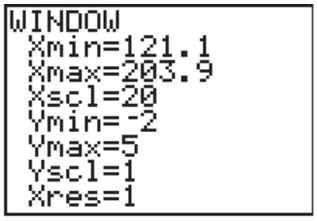
2. The right whisker is longer.

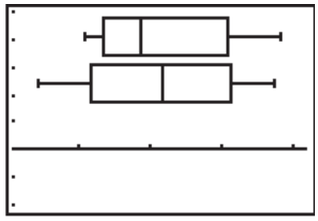
3.



4. Pressing ZOOM and choosing **9:ZoomStat** may give a less than "friendly" window. Help students adjust the window settings as shown here to produce a more readable graph.







ACTIVITY 4

Name: _____

Measure Up

Math Objectives:

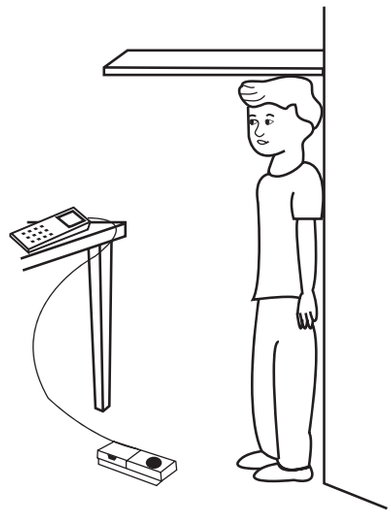
- Graph and interpret box plots
- Graph and interpret histograms
- Generate a five-number summary of single variable data
- Analyze and interpret data and graphs

Materials:

- TI-83/TI-84 Plus Family
- Calculator-Based Ranger™ (CBR 2™)
- Vernier EasyData™ Application
- Firm piece of cardboard/wood (refer to picture)

OVERVIEW

What is the average height of the students in your class? How does your height compare? How does your teacher's height compare? Use statistics to answer these questions and describe the general characteristics of a set of measurements.



In this activity you will:

- Collect data of the heights of 12 students and the teacher in your class.
- Create a plot showing the heights of 12 students and the teacher in your class.
- Calculate the extreme values and median for the height data.
- Construct a box-and-whisker plot to summarize the height statistics.

Follow your teacher's instructions to use the CBR 2 and the EasyData App to collect the heights of 12 students and your teacher. Link that data into each student's calculator in **L6**. Sort the list and fill in the chart below.

1. A special type of plot called a box-and-whisker plot shows a statistical picture of the data by graphically representing the lower extreme, lower quartile, median, upper quartile, and upper extreme. To create a box-and-whisker plot for the height data you collected, follow these steps:

a) On the number line on the next page, use a dot to mark each of the heights you collected. Follow your teacher's instructions to find the numbers to fill in this chart.

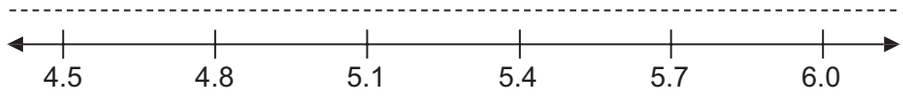
	Your answers	TI-84's answers
minX (the minimum height)		
Q1 (the first quartile)		
Med (the median value)		
Q3 (the third quartile)		
maxX (the maximum height)		

b) On the dotted line above the number line on the next page, use dots to mark the lower extreme (shortest), and the upper extreme (tallest). The median is the middle number when all the data is arranged in order. When the number of data items is even, the median is the average of the two middle values.

c) Draw a vertical line through the median.

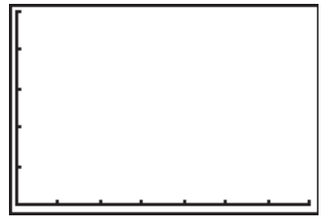
d) The lower quartile, Q1, is the median of the lower half of the data; the upper quartile, Q3, is the median of the upper half. Draw vertical lines through the lower quartile (Q1) and the upper quartile (Q3).

e) Draw a box from the lower quartile to the upper quartile, using the vertical lines through Q1 and Q3 as sides. Draw line segments (whiskers) from the box to the extremes.



2. Press [STAT] and scroll over to the **CALC** menu and select **1:1-Var Stats.** On the home screen, press [2nd] [6] to enter **L6.** Press [ENTER] to execute the command. Scroll down the screen and find the numbers to fill in the second column of the chart. Did the calculator's answers agree with the answers you put in the chart at the beginning of the worksheet? _____

3. Follow your teacher's instructions to have the calculator create a box-and-whisker plot for the data and make a sketch of it here.



4. Press the [TRACE] key and use the right and left arrow keys to scroll through the plot, paying attention to the data at the bottom of the screen. Place the screen data in the appropriate place on your sketch. For easy display, round numbers to the nearest hundredth before recording this information on the screen.

5. Approximately what percentage of the heights is greater than the upper quartile? _____ About what percentage is less than the lower quartile? _____

6. Notice that the box part of the plot represents the middle 50 percent of the data set. The size and location of the box tell you certain things about the data. A wider box indicates that the data is spread out and a smaller box means the data is clustered. Discuss the size and location of the box part of your plot. Describe how it relates to the measured heights. _____

_____

_____

7. The length of the whiskers on the boxplot gives a hint as to the distribution of the data. If one whisker is significantly longer than the other, the data is skewed in the direction of the longer whisker. This means that the data is bunched together near the shorter whisker. Describe the whiskers on your plot. What do the whisker lengths tell you about the heights? _____

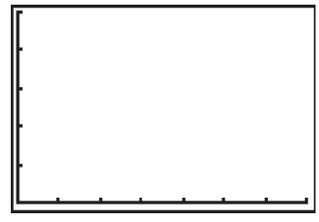
_____

_____

8. If the heights in this activity were measured in centimeters rather than feet, how would your boxplot be affected? Explain your reasoning. _____

_____

9. Follow your teacher's instructions to create a list of your data converted to inches. Create a histogram of this list and sketch it here. Use the information from the trace feature to mark each bar with the total number for that interval. Compare the information displayed in the histogram to the boxplot. What do the two have in common? Which do you prefer? Explain. _____



_____

ACTIVITY 4

Name: _____

Going Further

Math Objectives:

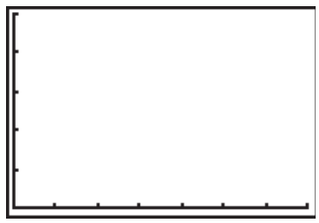
- Graph and interpret scatter and box plots
- Analyze and interpret data and graphs

Materials:

- TI-83/TI-84 Plus Family
- Calculator-Based Ranger™ (CBR 2™)
- Vernier EasyData™ Application
- Firm piece of cardboard/wood (refer to picture)

1. The nature of a box-and-whisker plot can sometimes be distorted by data values known as *outliers*. An outlier is a value that is set apart from the rest of the data set because it is significantly lower or higher than any other number in the set. Describe how your box-and-whisker plot would be affected if the tallest person measured were replaced with a professional basketball player. Would the median, lower quartile, and upper quartile values change? _____

2. Replace the tallest person in your **L5** with 7 feet to represent a tall basketball player and redraw the box-and-whisker plot here. How does it compare to the plot for the original data? _____



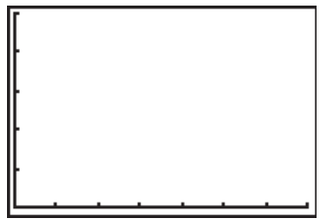
3. Suppose that this activity is repeated with two different classes. The average heights, in centimeters, are listed below. Arrange the numbers along the number line provided below each data set. Above the number lines, construct box-and-whisker plots for the heights in these two classes.

Class A: 193, 141, 161, 152, 179, 153, 167, 146, 184, 197, 147, 149

Class B: 195, 128, 164, 189, 162, 129, 178, 143, 154, 144, 187, 170

4. Use the built-in feature of the calculator to create a box-and-whisker plot for each class. Sketch them on the same axes here.

5. Based on these plots, write three statements comparing the heights in the two classes. _____



ACTIVITY 7

Hooke's Law

Math Objectives:

- Graph scatter plots
- Analyze and graph linear functions
- Calculate and model slope

Materials:

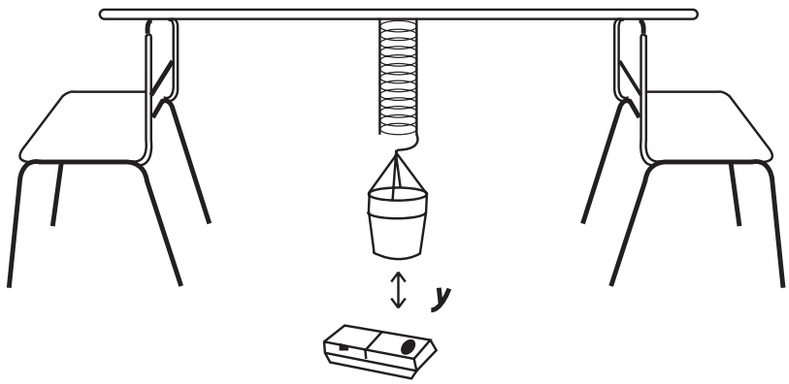
- TI-83/TI-84 Plus Family
- Calculator-Based Ranger™ (CBR 2™)
- Vernier EasyData™ Application
- Small spring cut in half (a Slinky® works well)
- Empty 4 oz plastic/paper cup (flat bottom)
- Two large paper clips or string
- Meter stick or other long stick
- Second meter/yard stick or ruler
- 30 Candies (M&Ms® and almonds work well)

OVERVIEW

Hooke's Law, explained in its simplest form for beginning algebra students, states that the stretch on a spring is directly proportional to the force applied to the end of the spring. In this activity, the force is the weight of an increasing amount of candy added to a cup. This force is applied to the end of a spring. **See the diagram below.** The data will be collected using the CBR 2 and the EasyData App. This experiment will produce linear behavior. You will analyze the data, determine an equation of the line of best fit, and interpret the meaning of the slope. The coordinates of the graph are the distance from the cup to the floor vs. the number of candies. You will interpret the values used in your model and apply the properties of this linear model to predict future behavior/events.

NOTE The following activity, **Activity 8: Hooke's Law, The Rest of the Story,** uses the data collected in this activity for further investigations into linear functions. Unless you have an extended lab period or block scheduling, it is unlikely you could complete them both in an average class period. This lesson can be done without doing Activity 8, but if you plan to do Activity 8, have your students save the data into named lists for easy retrieval. Also make sure students have their worksheet from Activity 7.

NOTE *For more help in saving data to named lists, see Appendix E.*



SETUP

Briefly demonstrate and discuss the data collection procedure with the class. Have students collect the data in groups of 3 or 4. Each group should do the following:

1. Place a meter stick or other long stick on the back of two chairs as shown in the diagram on the previous page.
2. Hang the spring from the stick. (A plastic Slinky® cut in half works well.)
3. Poke holes in the cup and put string or paper clips through the holes to form a handle. (You can also use an empty cream cheese or margarine container. The container you choose needs to have a flat bottom so the CBR 2 can take a reading of it. You can save valuable class time by having the handles already attached before the experiment.) Hang the cup/container on the spring with the string/paper clip handle. Make sure it is at least 18–24 inches off the floor when empty.
4. Before starting, have students measure the distance, in inches, from the top of the stick to the floor and record this on their worksheet. This measurement will be used if you choose to do **Activity 8: Hooke's Law, The Rest of the Story.**
5. Position the CBR 2 on the floor directly under the empty cup/container so you can measure the distance from the floor to the bottom of the container. Link the CBR 2 directly to the TI-84 Plus. You can use either the I/O unit-to-unit cable or the mini-USB cable.
6. The EasyData App will launch automatically if you are using the mini-USB cable. If you are using the I/O unit-to-unit cable, you will need to press the [APPS] key, scroll down to highlight the EasyData App, and then press [ENTER] in order to launch the App.

DATA COLLECTION

1. Press the [Y=] key to access the **File** menu and select **1:New** by pressing [1] or since **1:New** is highlighted, you can just press [ENTER]. This resets the program and clears out old data. **See Figure 1.**

Figure 1

2. The default unit of measurement on the EasyData App is meters. You will do this activity in feet. To change the units of measurement, press the [WINDOW] key on the top row of the calculator to select the **Setup** menu soft key. From the **Setup** menu, choose **1:Dist** by pressing [1] or [ENTER] since **1** is highlighted. **See Figure 2.**

Figure 2

3. From the **Units** menu, select **2:(ft)** by pressing [2] or by pressing the down arrow key until the **2** is highlighted and pressing [ENTER]. **See Figure 3.** When you have confirmation that you will be using feet, select **OK**. **See Figure 4.**

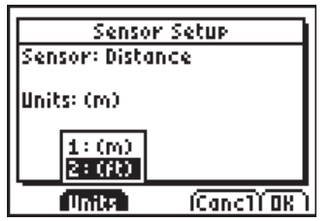


Figure 3

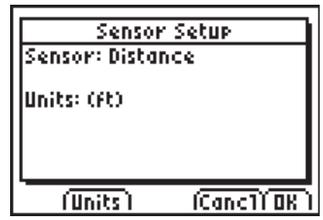


Figure 4

4. You will be returned to the main screen of the EasyData App. From the **Setup** menu, select **6: Events with Entry**. This will allow you to control when data is recorded by pressing a key on the calculator. **See Figure 5.**

Figure 5

5. This takes you back to the main screen. Select **Start**. You will hear the CBR 2 clicking as the reading is displayed at the top of the screen of the calculator. Select **Keep** to record this first data reading. It is the distance from the bottom of the empty container to the CBR 2. **See Figure 6.**

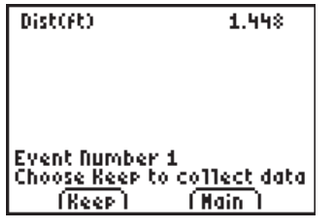


Figure 6

6. When the **Enter Value** screen appears, press [0], for no candies. **See Figure 7.**

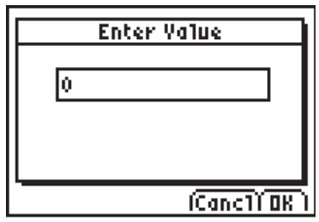


Figure 7

7. Slowly add 3 candies. Try to minimize the swing of the container. When the container is steady and the distance displayed at the top of the screen is stable, select **Keep** again. This time enter 3 in the **Enter Value** screen to represent the 3 candies in the cup. **See Figure 8.**

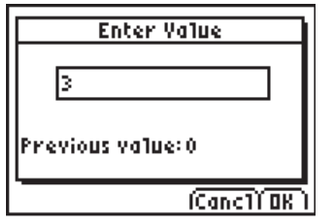


Figure 8

8. Continue for a total of 10 trials. Each time the **Enter Value** screen appears, enter the value of 3 more candies than the previous trial. With each recorded value, a new data point will be displayed on the graph along with the option to **Keep** or **Stop** the data collection. **See Figure 9.**

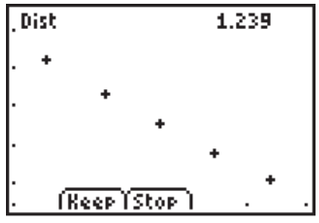


Figure 9

9. When finished with the trials, select **Stop**. A graph of your data points will be displayed. Use the right and left arrow keys to view the values of the points. **See Figure 10.**

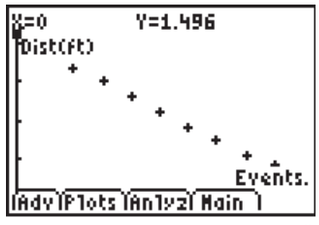


Figure 10

10. To confirm a description of the plots, press WINDOW to select the **Plots** soft key. This is a good time to review the vocabulary with your students. Identfy the **Events** as the independent variable and the **Distances** as the dependent variable. **See Figure 11.**

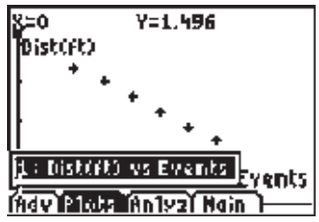


Figure 11

11. Select **Anlyz** and choose **2:Linear Fit** from the menu.**See Figure 12.**

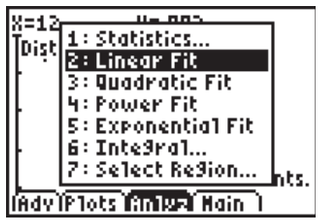


Figure 12

12. When **2:Linear Fit** is chosen, the calculator will display an equation for the line of best fit. Select **OK. See Figure 13.**

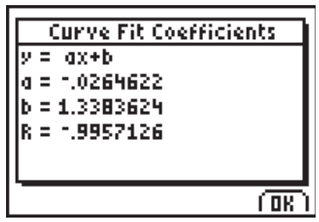


Figure 13

13. You will see the line of best fit being drawn on the screen with the data points. You can still use the right and left arrow keys to scroll through the data points. Use either the up or down arrow key to trace along the line rather than on the individual points. **See Figure 14.**

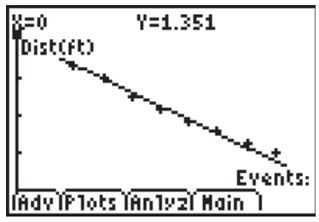


Figure 14

14. Select **Main** and then **Quit** on the next screen. The confirmation screen will be displayed telling you the lists where your data is stored. Select **OK** to exit the App. **See Figure 15.**

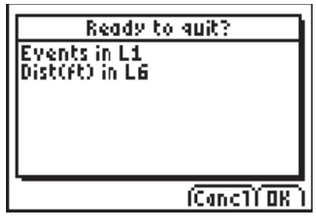


Figure 15

DATA ANALYSIS

1. Rather than having the calculator do all the work of finding the regression equation, consider having the students use the definition of slope and their understanding of linear equations to write their own equation for the line of best fit. An additional step would be to find the equation using both methods and then compare the answers. The following directions use a combination of the knowledge of formulas and calculator computations to graph an equation of a line. The students need to know the formula for deriving the slope when given the coordinates of two points and how to use the calculator for quicker and more accurate computations. This activity is meant to build the students' understanding of slope while showing them some lesser used features of the calculator.

2. The exit screen of the App verified that the data values you recorded are in lists **L1** and **L6**. Under the [STAT PLOT] menu, the **Plot1** is turned on with the window set to display all the points collected. **Y1** is turned off, but the regression equation found by the App is still displayed there. You can tell when the **Y1** is turned off because the equals sign is no longer highlighted. This indicates that the equation's graph will not be displayed in the [GRAPH] window. **See Figure 16.**

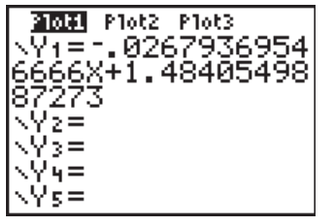


Figure 16

3. If you have already completed some of the previous lessons in this book, this may be a good time for participants to practice on their own and/or in groups. You could circulate the room and help where needed as students find their own line of best fit and compare it to the regression equation found by the calculator. You can decide how to proceed from here based on your students' knowledge and what your goals are for this lesson. Have the students link **L1**, **L6**, and **Y1**. This will allow each student to do his/her own data analysis.

★ **NOTE** *For help with linking calculators, see Appendix J.*

NOTE The following is a slightly different method of finding the slope of the regression equation. This method uses some of the features under the list menu. During this procedure, the student's knowledge of the definition of slope will be reinforced even though they will use technology to perform the otherwise time-consuming calculations. You may find it easiest to have the students work in groups to collect and link the data. Then they can come back together as a class while you direct them. They may need your direction because the features used in the next steps could be new to them.

4. It will be helpful to have **L1** and **L6** next to each other in the display. To accomplish this, press [STAT] [ENTER] to access the Stat List Editor and position the cursor so the name **L2** is highlighted. Press [2nd] [DEL] to access the [INS] (insert) command. **See Figure 17.**

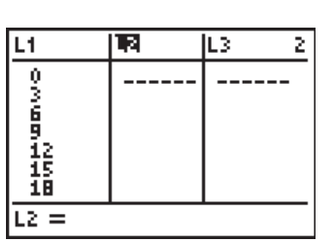


Figure 17

5. A blank column will be inserted to the right of **L1**. Press [2nd] [6] to have **L6** appear at the bottom of the screen. **See Figure 18a.** Press [ENTER] to see **L6** fill in the blank column. **See Figure 18b.**

★ **NOTE** *For more help rearranging the order of the lists displayed, see Appendix B, section 4.*

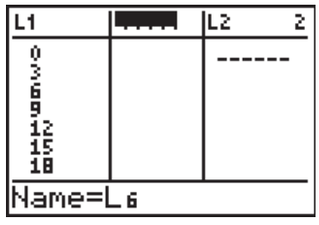


Figure 18a

6. We already know the differences in the **X**-values of any two consecutive points is three because the number of candies increased by three for each trial. The goal for this next set of calculator commands is to use the calculator to determine the differences in the **Y**-values of the data points collected in the activity and then use that difference to find the slope.

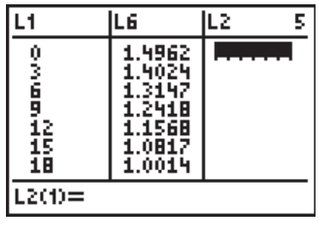


Figure 18b

7. Give **L2** a command that will calculate the difference between two consecutive values in **L6** and put that difference in **L2**. To do this, use the up arrow key to highlight **L2**. Press [2nd] [STAT] to access the [LIST] menu and arrow over to the **OPS** menu. Select **7: ΔList. See Figure 19.**

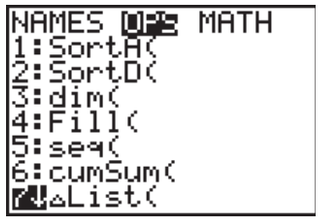


Figure 19

8. You will see this command displayed at the bottom of the Stat List Editor window. Press [2nd] [6] to type in **L6** and close the parenthesis. **See Figure 20.**

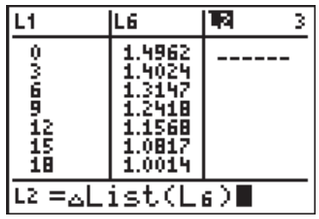


Figure 20

9. This will give the differences in the **Y**-values of your data points that were stored in **L6**. Press [ENTER] to see **L2** filled in with these differences. **See Figure 21.**

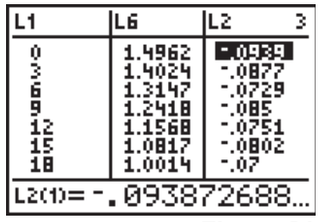


Figure 21

10. Because the change in the **X**-values is always three, you can divide each difference by three to find the slope for the individual segments between any two consecutive points listed in **L6**. Position the cursor to highlight **L3** and define it to be **L2/3**. **See Figure 22.**

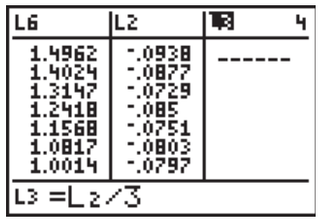


Figure 22

11. Press [ENTER] to see **L3** filled in with these slopes. **See Figure 23.** Discuss with your students why these differences, although very close, are not exactly the same. This is a good time to discuss the difference between theoretical events and actual data collection. Point out how human error affects data collection and that the CBR 2 helps to cut down on that type of error. Discuss the factors that could contribute to human error if the measurements were taken by hand with a yard or meter stick. Examine how much variation there is between any two entries in **L3**. Is .005 of a foot a significant error?

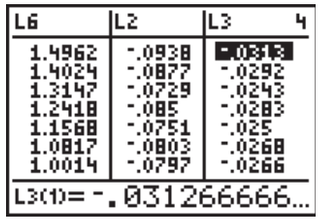


Figure 23

12. Guide the students to the understanding that the average of **L3** would serve as a close approximation for the slope of the line of best fit for all the points in the plot. Press [2nd] [MODE] to access [QUIT] and return to the home screen. Have the calculator find this average and store it in **M**. To do this, press [2nd] [LIST] and arrow over until **MATH** is highlighted. Select **3:mean(** from the list. **See Figure 24.**

Figure 24

13. Press [2nd] [3] to access **L3**. Complete the command by typing [)] [STO▶] [ALPHA] **M** [ENTER]. **See Figure 25.**

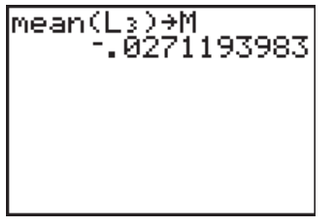


Figure 25

14. Next, identify the **Y**-intercept. Return to the graph and trace to the first data point. **See Figure 26.**

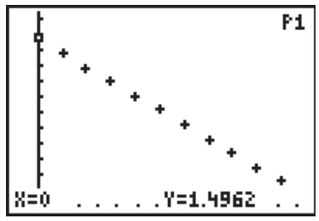


Figure 26

15. Press [2nd] [MODE] to [QUIT] and return to the home screen. The calculator keeps the **X**- and **Y**-values from the last point you traced in its memory until you trace to a new point. Store the **Y**-value from first data point in the **B** variable. The keystrokes are as follows: [ALPHA] **Y** [STO▶] [ALPHA] **B** [ENTER].
See Figure 27.

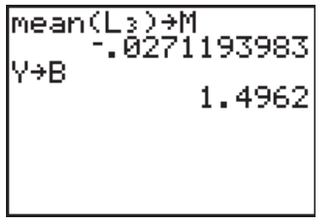


Figure 27

16. Next, check to see if these values for **M** and **B** are a close fit to the data. Go to the [Y=] window and press [ALPHA] **M** [X,T,Θ,n] [+] [ALPHA] **B** to type in **MX+B** next to **Y2. See Figure 28.**

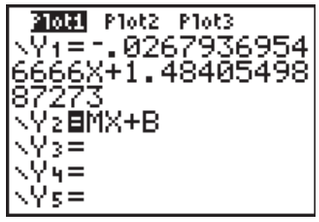


Figure 28

17. Press [GRAPH] to see how closely this equation fits the points. In the example shown, it looks like a great fit. Press [TRACE] and use the left and right arrow keys to scroll through the data points. **See Figure 29.**

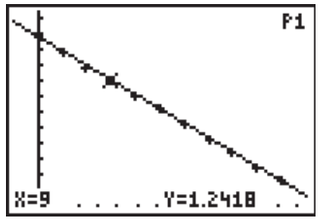


Figure 29

18. Next, press the up arrow. Your cursor will jump to the middle of the line and display the coordinates of the points on the line of the regression equation instead of the individual points from the lists. The upper left corner of the screen tells you the location of the equation you are tracing. In this example, it is tracing **Y2**. **See Figure 30.**

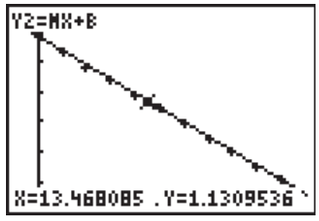


Figure 30

19. To compare how closely the regression equation you found matches the one the calculator found, graph them both at the same time. To distinguish between the two lines, use different graph styles. Go back to the [Y=] window and turn on **Y1** by positioning the cursor on the equal sign and pressing [ENTER] to highlight it. Leave **Y1** with the default style, but use the left arrow key to highlight the slash icon in front of **Y2**. Repeatedly press [ENTER] until you see the symbol shown in the screenshot on the right. The symbol looks like a ball with a line to its left. **See Figure 31.**

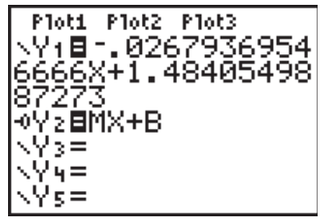


Figure 31

20. Press [GRAPH]. **Y1** is graphed using the default graph style. After **Y1** is completely graphed, you will see a small ball marking the trail as **Y2** is graphed. This feature makes it easy to see how closely your graph matches the graph found by the calculator. **See Figure 32.**

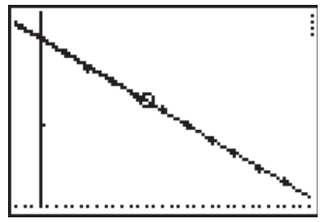


Figure 32

21. If you will be doing Activity 8, it is a good idea to save the data from **L1**, **L2**, and **L6** into named lists. Running the EasyData App will overwrite any data that was saved in unnamed lists as will many other Apps and programs. Name **L1**, **HSEQ**; **L2**, **HDIF**; **and L6**, **HOOKS**. **See Figure 33.**

★ **NOTE** *For help with naming lists, see Appendix E.*

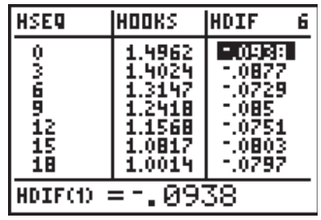


Figure 33

NOTE If you run the EasyData App again to collect another set of data, the previous data is overwritten. The EasyData App will run with no probe connected if you want to use it to view your graph. A screen confirming that no interface is connected will be displayed. Select **None** to continue without a probe. **See Figure 34.**

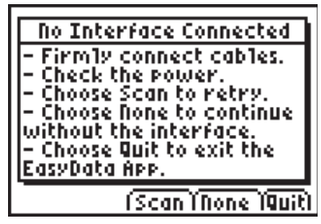


Figure 34

22. When the main screen is displayed, select **Graph** to view the plot from the last time data was collected. **See Figure 35.**

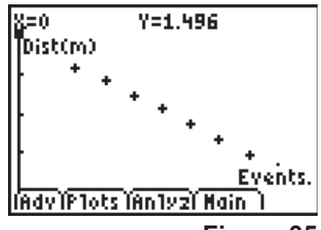


Figure 35

WORKSHEET ANSWERS

Answers will vary on problems not listed.

2. Number of candies

3. Distance from CBR 2

4. Difference

5. Difference between 2 consecutive elements in **L6**.

6. **L2/3** calculates the slopes of each segment and the average is a close approximation for slope of the whole line.

7. Negative; As the number of candies increases, the distance decreases.

8. Less change. . . so less steep

11. Answers will vary, but they should match the slope in 9 or 10 when multiplied by 3.

13. The change in distance per change in candies.

15. **a)** y = m (10) + b
b) 12 = mx + b

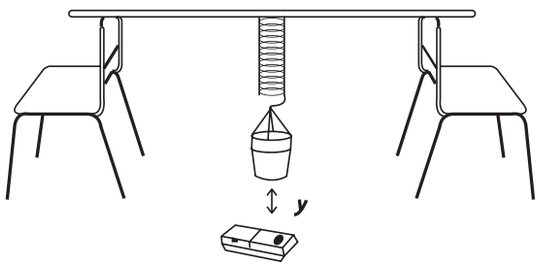
ACTIVITY 7

Name: _____

Hooke's Law

Math Objectives:

- Graph scatter plots
- Analyze and graph linear functions
- Calculate and model slope



Materials:

- TI-83/TI-84 Plus Family
- Calculator-Based Ranger™ (CBR 2™)
- Vernier EasyData™ Application
- Small spring cut in half (a Slinky® works well)
- Empty 4 oz plastic/paper cup (flat bottom)
- Two large paper clips or string
- Meter stick or other long stick
- Second meter/yard stick or ruler
- 30 Candies (M&Ms® and almonds work well)

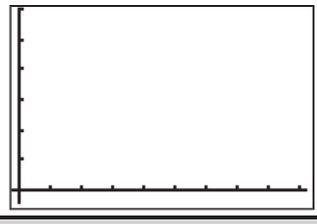
OVERVIEW

In this activity, you will create a situation that produces linear behavior by observing a spring being stretched as you add candies to a cup attached to the spring. You will then apply the properties of a linear function to develop a model for your motion. Finally, you will interpret the values used in your model. Your teacher will outline the procedure for you. Use the results of the activity to fill in the blanks below.

SETUP

Work in groups of 3 or 4 to do the following:

1. Place a meter stick or other long stick on the back of two chairs as shown in the diagram.
2. Hang the spring from the meter stick.
3. Hang the cup/container on the bottom of the spring. Make sure that when the cup is empty, it is at least 18–24 inches off the floor.
4. Use a ruler or a second yardstick to measure the distance, in inches, from the top of the stick to the floor and record it here. _____ This measurement will be used if you choose to do Activity 8.
5. Position the CBR 2 on the floor directly under the empty cup/container so you can measure the distance from the floor to the bottom of the container. Link the CBR 2 directly to the TI-84 Plus. You can use either the I/O unit-to-unit cable or the mini-USB cable.
6. The EasyData App will launch automatically if you are using the mini-USB cable. If you are using the I/O unit-to-unit cable, you will need to press the [APPS] key, scroll down to highlight the EasyData App and then press [ENTER] in order to launch the App. Follow the procedure outlined by your Teacher.
7. While still in the EasyData App, select **Anlyz** and select **2:Linear Fit**. Record that equation here. _____
8. Link **L1**, **L6**, and **Y1** into each student's calculator.
9. Set up a scatter plot in **Plot1** with **L1** and **L6** and sketch the graph of your data points here.



10. Before continuing, name three new lists in which to store and protect your data for use later. Store **L1** in a list named **HSEQ**, **L2** in a list named **HDIF**, and **L6** in a list named **HOOKS**.

Number of Candies, L1	Distance from the bottom of the cup to the floor/CBR 2, L6
0	
3	
6	
9	
12	
15	
18	
21	
24	
27	
30	

For recording purposes, round all decimals to the nearest hundredth.

1. Fill in the chart with the numbers from your calculator. Follow your teacher's directions to find your own regression equation.

2. What physical property is represented along the **X**-axis of the graph? _____

3. What physical property is represented along the **Y**-axis? _____

4. What is the mathematical meaning of the symbol delta, ∆? _____

5. Fill **L2** by using the command **∆List(L6)**. Describe the meaning of the values this formula will generate and put into **L2**. _____

6. Define **L3** to be **L2** divided by 3 and then calculate the average/mean of the numbers in **L3**. Explain why. _____

7. Consider your trend line for the distance to the floor vs. the number of candies.
Is the slope positive or negative? _____ Why? _____
_____

8. What kind of slope would you predict for a stiffer spring than the one you used? _____
_____

9. What is the regression equation you found to fit the data? _____

10. What was the regression equation found by the calculator? _____

11. For every set of three objects you put in the container, the distance from the CBR 2 decreased by _____.

12. What is the mathematical definition of slope? _____

13. Describe, in your own words, the meaning of slope in relation to this activity. _____
_____

14. Use the TRACE or TABLE buttons to find the following:

a. How far from the floor would the cup be if 10 candies were used? _____

b. How many candies are in the can if it is 12 inches from the floor? _____

c. How many objects would it take until the container hits the floor? _____

15. Write the equations that you used to answer questions 14 a–c.

a) _____ **b)** _____ **c)** _____

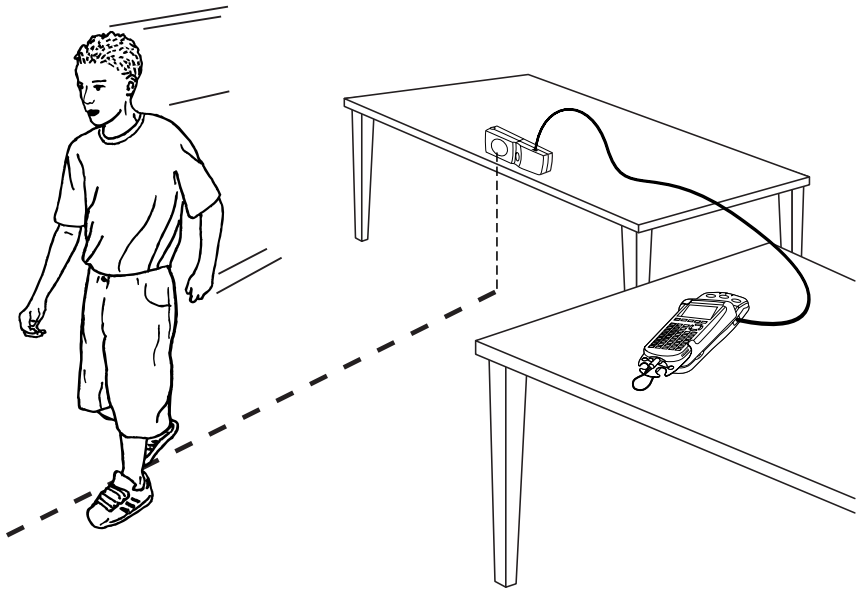
NOTE You will need this worksheet to do Activity 8.

Activity
1

Walk the Line: Straight Line Distance Graphs

When one quantity changes at a constant rate with respect to another, we say they are *linearly related*. Mathematically, we describe this relationship by defining a linear equation. In real-world applications, some quantities are linearly related and can be represented by using a straight-line graph.

In this activity, you will create straight-line, or constant-speed, distance versus time plots using a Motion Detector, and then develop linear equations to describe these plots mathematically.



OBJECTIVES

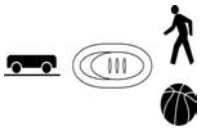
- Record distance versus time data for a person walking at a uniform rate.
- Analyze the data to extract slope and intercept information.
- Interpret the slope and intercept information for physical meaning.

MATERIALS

TI-83 Plus or TI-84 Plus graphing calculator
EasyData application
CBR 2 or Go! Motion and direct calculator cable
or Motion Detector and data-collection interface

PROCEDURE

1. Set up the Motion Detector and calculator.



   a. Open the pivoting head of the Motion Detector. If your Motion Detector has a sensitivity switch, set it to Normal as shown.
   b. Turn on the calculator and make sure it is on the home screen. Connect it to the Motion Detector. (This may require the use of a data-collection interface.)

2. Position the Motion Detector on a table or chair so that the head is pointing horizontally out into an open area where you can walk. There should be no chairs or tables nearby.

3. Set up EasyData for data collection.
   a. Start the EasyData application, if it is not already running.
   b. Select [File] from the Main screen, and then select **New** to reset the application.

4. Stand about a meter from the Motion Detector. When you are ready to collect data, select [Start] from the Main screen. Walk away from the Motion Detector at a slow and steady pace. You will have five seconds to collect data.

5. When data collection is complete, a graph of distance versus time will be displayed. Examine the graph. It should show a nearly linearly increasing function with no spikes or flat regions. If you need to repeat data collection, select [Main] and repeat Step 4.

6. Once you are satisfied with the graph, select [Main] to return to the Main screen. Exit EasyData by selecting [Quit] from the Main screen and then selecting [OK].

ANALYSIS

1. Redisplay the graph outside of EasyData.
   a. Press 2nd [STAT PLOT].
   b. Press ENTER to select Plot1 and press ENTER again to select On.
   c. Press ZOOM.
   d. Press ▼ until ZoomStat is highlighted; press ENTER to display a graph with the *x* and *y* ranges set to fill the screen with data.
   e. Press TRACE to determine the coordinates of a point on the graph using the cursor keys.

2. The slope-intercept form of a linear equation is $y = mx + b$, where m is the slope of the line and b is the y-intercept value. The independent variable is x, which represents time, and y is the dependent variable, which represents distance in this activity. Trace across the graph to the left edge to read the y-intercept. Record this value as b in the Data Table on the *Data Collection and Analysis* sheet.

3. One way to determine the slope of the distance versus time graph is to guess a value and then check it by viewing a graph of the line with your data. To do this, enter an equation into the calculator, and then enter a value for the y-intercept and store it as variable B.
   a. Press Y=.
   b. Press CLEAR to remove any existing equation.
   c. Enter the equation M*X + B in the Y1 field.

d. Press ◀ until the icon to the left of Y1 is blinking. Press ENTER until a bold diagonal line is shown in order to display your model with a thick line.

e. Press 2nd [QUIT] to return to the home screen.

f. Enter your value for the *y*-intercept and then press STO▶ B ENTER to store the value in the variable B.

4. Now set a value for the slope *m*, and then look at the resulting graph. To obtain a good fit, you will need to try several values for the slope. Use the steps below to store different values to the variable M. Start with M = 1. Experiment until you find one that provides a good fit.

   a. Enter a value for the slope *m* and press STO▶ M ENTER to store the value in the variable M.

   b. Press GRAPH to see the data with the model graph superimposed.

   c. Press 2nd [QUIT] to return to the home screen.

5. Record the optimized value for the slope in the Data Table on the *Data Collection and Analysis* sheet. Use the values of the slope and intercept to write the equation of the line that best fits the distance versus time data.

6. Another way to determine the slope of a line to fit your data is to use two well-separated data points. Use the cursor keys to move along the data points. Choose two points (x_1, y_1) and (x_2, y_2) that are not close to each other and record them in the Data Table on the *Data Collection and Analysis* sheet.

7. Use the points in the table to compute the slope, *m*, of the distance versus time graph.

$$m = \frac{y_2 - y_1}{x_2 - x_1} =$$

⇒ Calculate the slope and answer Question 1 on the *Data Collection and Analysis* sheet.

8. You can also use the calculator to automatically determine an optimized slope and intercept.

   a. Press STAT and use the cursor keys to highlight CALC.

   b. Press the number adjacent to LinReg(ax+b) to copy the command to the home screen.

   c. Press 2nd [L1] , 2nd [L6] , to enter the lists containing your data.

   d. Press VARS and use the cursor keys to highlight Y-VARS.

   e. Select Function by pressing ENTER.

   f. Press ENTER to copy Y1 to the expression.

      On the home screen, you will now see the entry LinReg(ax+b) L1, L6, Y1. This command will perform a linear regression using the *x*-values in L1 as and the *y*-values in L6. The resulting regression line will be stored in equation variable Y1.

   g. Press ENTER to perform the linear regression. Use the parameters a and b to write the equation of the calculator's best-fit line, and record it in the Data Table.

   h. Press GRAPH to see the graph.

⇒ Answer Questions 2–5 on the *Data Collection and Analysis* sheet.

Activity
1

DATA COLLECTION AND ANALYSIS

Name _____

Date _____

DATA TABLE

y*-intercept *b	
optimized slope *m*	
optimized line equation	
x_1, y_1	
x_2, y_2	
regression line equation	

QUESTIONS

1. How does this value compare with the slope you found by trial and error?

2. How do the values of the slope and intercept as determined by the calculator compare to your earlier values? Would you expect them to be exactly the same?

3. Slope is defined as change in *y*-values divided by change in *x*-values. Complete the following statement about slope for the linear data set you collected.

   In this activity, slope represents a change in _____ divided by a change in _____.

4. Based on this statement, what are the units of measurement for slope in this activity?

5. The *y*-intercept can be interpreted as the starting position or the starting distance from the Motion Detector. What does the slope represent physically?
   Hint: Consider the units of measurement for the slope you described in the previous question.

ACTIVITY 12

Bouncing Ball

Math Objectives:

- Graph scatter plots
- Graph and interpret a quadratic function
- Apply the vertex form of a quadratic equation
- Calculate the maximum value of a parabola

Materials:

- TI-83/TI-84 Plus Family
- Calculator-Based Ranger™ (CBR 2™)
- Vernier EasyData™ Application
- Bouncing ball

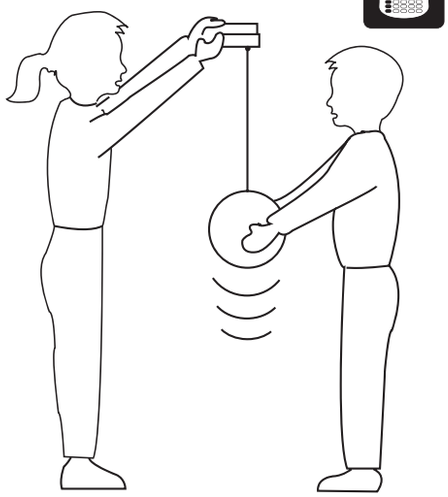
OVERVIEW

The next activity, **Activity 13: How High Will It Bounce?**, uses the data collected in this activity for investigations into the rebound height of a bouncing ball. Unless you have an extended lab period or block scheduling, it is unlikely you could complete them both in an average class period. Although this lesson can be done alone, if you plan to do Activity 13, be sure to have your students pay special attention to the directions about saving the data into named lists for easy retrieval.

Real-world concepts such as free-falling and bouncing objects, gravity, and constant acceleration are examples of parabolic functions. This activity investigates the values of height, time, and the coefficient *A* in the quadratic equation, $Y = A(X - H)^2 + K$, which describes the behavior of a bouncing ball.

NOTE *For help with saving data to named lists, see Appendix E.*

NOTE Demo the activity using the overhead calculator so the entire class can see the process. If you only have one CBR 2, after running the activity link the data lists to each student's calculator. If you have enough CBR 2 units, have students work in small groups.



SETUP

1. Avoid using a soft or felt-covered ball such as a tennis ball, since pulses from the CBR 2 tend to be absorbed by these surfaces.
2. Racquetballs work well. If you have trouble, try using a bigger ball like a basketball or smooth playground ball.
3. This activity is best performed with at least three students: one to hold the CBR 2 and press the trigger, one to release the ball, and one to run the calculator.
4. Set the sensitivity on the CBR 2 to Normal.
5. Link the CBR 2 directly to the TI-84 Plus. You can use either the I/O unit-to-unit cable or the mini-USB cable.

6. The EasyData App will launch automatically if using the mini-USB cable. If using the I/O unit-to-unit cable you will need to press the APPS key, scroll down to highlight the EasyData App, and press ENTER in order to launch the App.
7. Position the CBR 2 motion detector at least 15 centimeters above the ball (50 cm if you are using the older CBR). Hold the sensor directly over the ball and make sure that there is nothing in the ***Clear Zone***. Information about the ***Clear Zone*** can be found in the Helpful Hints section in the front of the book.
8. For best results, hold the sides of the ball and then quickly move your hands outward to release the ball.
9. Begin with a test bounce. Drop the ball (do not throw it).

DATA COLLECTION

1. Press the Y= key to access the **File** menu and select **1:New** by pressing 1 or since **1:New** is highlighted, you can just press ENTER. This resets the program and clears out old data. **See Figure 1.**

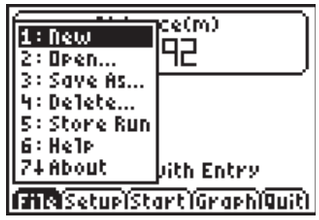


Figure 1

2. The default unit of measurement on the EasyData App is meters. You may want to do this activity in feet. To change the units of measurement, select the **Setup** menu soft key by pressing the WINDOW key on the top row of the calculator. From the **Setup** menu, choose **1:Dist** by pressing 1 or ENTER since 1 is highlighted. **See Figure 2.**

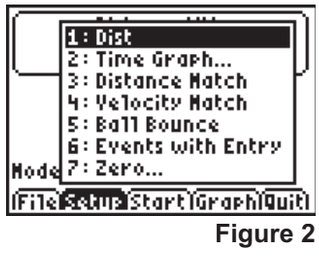


Figure 2

3. You may choose to do this activity in either meters or feet. The sample data is in meters. Press the WINDOW key on the top row of the calculator to access the **Units** menu. From the **Units** menu, select **1:(m)** or **2:(ft)** by pressing 1 or 2 or by scrolling until your choice is highlighted and pressing ENTER. Then press the GRAPH key on the top row of the calculator to select **OK**. **See Figure 3.**

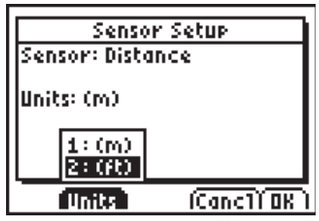


Figure 3

4. You will be returned to the main screen of the EasyData App. From the **Setup** menu, select **5:Ball Bounce** and then select **Start**. Follow the general instructions displayed. **Ball Bounce** automatically takes care of the settings. **See Figure 4.**

Figure 4

5. Have one person hold the CBR 2 motion detector, while another person holds the ball at least 15 centimeters beneath the sensor (50 cm if you are using an older CBR). Select **Next**. **See Figure 5.**

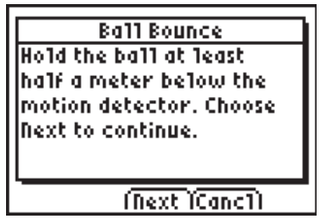


Figure 5

6. Follow the on-screen directions. At this time you may disconnect the CBR 2 from the calculator or you may leave it connected. Whether you leave it connected or not, you will need to press the **TRIGGER** on the CBR 2 motion detector to begin collecting data. **See Figure 6.**

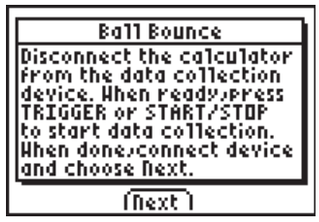


Figure 6

7. When the CBR 2 begins clicking, release the ball, and then step back. The program will collect data for 5 seconds. (If the ball bounces to the side, move to keep the CBR 2 directly above the ball, but be careful **not** to change the height of the CBR 2 motion detector.) When the clicking stops, re-connect the CBR 2 to the calculator and select **Next** on the calculator screen. The collected data is transferred to the calculator. A screen displays a notice to wait as it is transferred.

8. As soon as the data is sent, the calculator displays the distance vs. time graph from within the program. The plot should look like a bouncing ball. If it does not, repeat the sample, ensuring that the CBR 2 motion detector is aimed squarely at the ball. **See Figure 7.**

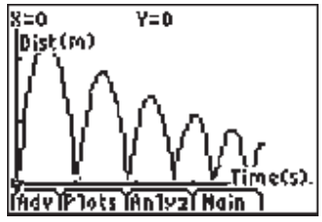


Figure 7

9. To repeat the sample, select **Main**, **Start**, and repeat the process. You will get a warning screen telling you the new data will overwrite any previous data. Select **OK. See Figure 8.**

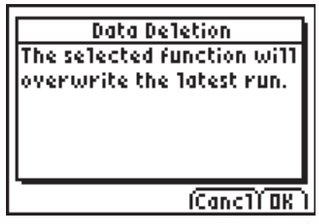


Figure 8

10. When you are satisfied with your data, study the plot. Select **Plots** to confirm a description of the graph as **1: Dist vs Time**. **See Figure 9.**

11. Guide your students in a discussion to help them realize that when the ball is at its highest point, its distance from the CBR 2 is the smallest. Observe that the **Ball Bounce** feature automatically flipped the distance data so the graph's appearance resembles the up and down movement of the ball.

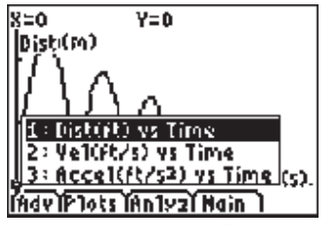


Figure 9

12. At this time, you can use the right and left arrow keys (not the TRACE key) to view the coordinates of the points. Pressing TRACE at this point will take you out to the Main screen of the EasyData App. If the students do that by accident, they can select **Graph** to return to the Graph screen. Have the students stop here and answer questions 1–7 on their worksheets.

DATA ANALYSIS

You have several options for analyzing the data. Three options will be shown here. Select the one most appropriate for your students or do all three and compare the answers. There is value in showing students different ways to accomplish any task. Consider going through option C together and then have the students repeat the process on their own in the "**Going Further**" section of their worksheet. The three methods are as follows:

A. Analyze the data from within the App. (Students will need to work in groups for the whole process as there will be only one calculator with the data.)

B. Exit the App and let the calculator identify a regression equation. (Link **L1** and **L6** so each student has his/her own set of data.)

C. Exit the App and use the vertex form of the quadratic to allow students to more thoroughly examine the relationship between quadratic equations and their parabolas. (Link **L1** and **L6** so each student has his/her own set of data.)

A. Analyze the data from wthin the App

1) Select **Anlyz** and choose **7:Select Region**. **See Figure 10.**

Figure 10

2) A warning screen is displayed. You will lose your original data. If you want to keep the original data, exit the App at this point and go to choice B or C described below. **See Figure 11.**

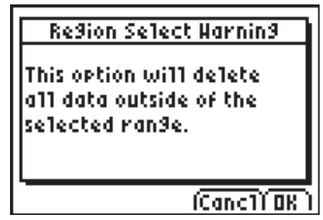


Figure 11

3) If you continue with this option, your graph is displayed and the calculator is asking you to **Set a Left Bound** for the region you wish to examine. You may want to have different groups select different regions. The example will select the second parabola. Arrow to the left end of the second parabola and select **OK**. **See Figure 12a.**

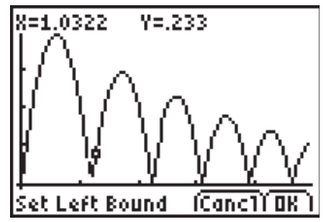


Figure 12a

CAUTION Students are familiar with pressing the ENTER key to make a selection on a graph screen. Remind them that from within this App, they need to press the GRAPH key on the top row of the calculator to access the soft key for the **OK**.

4) You will see a vertical line drawn at that point and the sentence at the bottom of the screen has changed and is asking you to **Set a Right Bound**. The cursor now appears on the far right side of the screen. Use the left arrow key to scroll to the right end of the second parabola and select **OK**. **See Figure 12b.**

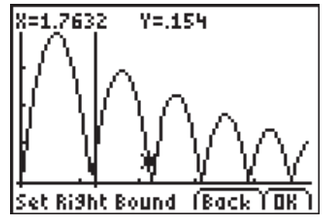


Figure 12b

5) The region you selected is drawn on the screen alone. It is clearly a parabola. **See Figure 13.**

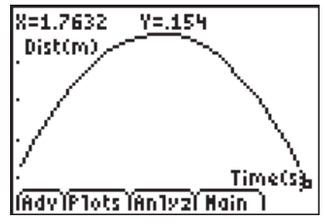


Figure 13

6) Select **Anlyz** and choose **3:Quadratic Fit** from the menu. **See Figure 14.**

Figure 14

7) The regression equation is displayed. **See Figure 15.**

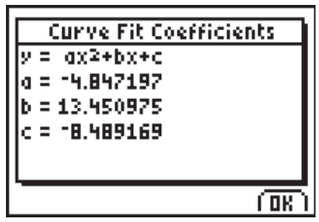


Figure 15

8) Select **OK** to see how closely the equation fits the data. The graph style has been adjusted to see the ball tracking the path. The plots have been displayed with the little crosses rather than the plain dots. **See Figure 16.**

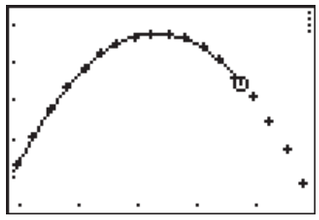


Figure 16

9) The advantage to this method is a quick and accurate answer. The disadvantage is the original data outside the selected region was lost and there was not much done in the way of concept development. **See Figure 17.**

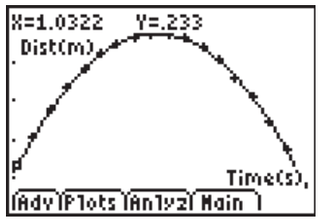


Figure 17

B. Exit the App and let the calculator identify a regression equation.

1) Once you see the data graphed, select **Main** and then **Quit**. **See Figure 18.**

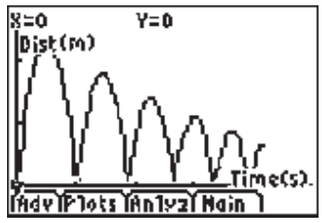


Figure 18

2) The App will display a screen telling you where the data is. For **Ball Bounce**, the time is in **L1**, the distance in **L6**, velocity in **L7**, and acceleration in **L8**. **See Figure 19.**

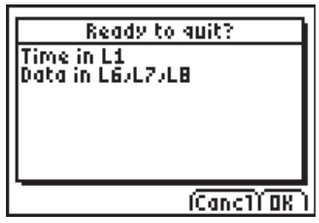


Figure 19

3) If you press [2nd] [STAT PLOT] you will see that the **Plot1** is turned on with **L1** and **L6** in the **Xlist** and **Ylist,** respectively. **See Figure 20.**

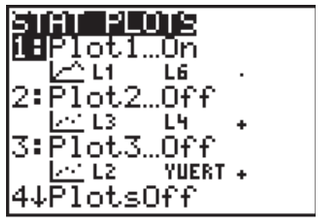


Figure 20

4) Press [GRAPH] and you will see your data displayed in the same window as when it was in the App. You can go through the same process that the App did in option A. Select a region and find a regression equation for it. **See Figure 21.**

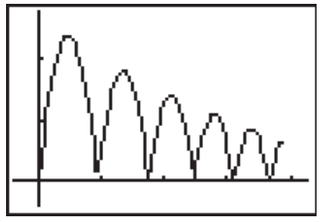


Figure 21

5) The **Select** feature on the calculator allows you to select a region from a Stat Plot you have turned on as a **Scatter** plot or **xyLine** plot. It will allow you to leave the original data in place and put the selected data in whichever lists you choose. To do this, press [2nd] [LIST] and arrow over to **OPS**, down to **8:Select** and press [ENTER]. **See Figure 22.**

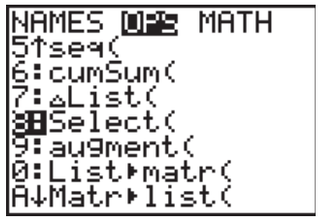


Figure 22

6) On the home screen, press [2nd] [2] [,] [2nd] [3] [)] to enter **L2** and **L3** as the arguments for the **Select** command. This is where the data points from the region you select will be stored. The nice part about doing it this way, as opposed to being inside the App, is that the original data remains intact in case you want to go back to it. This requires the new lists to have different names from the lists in which the original data is stored. Press [ENTER]. **See Figure 23.**

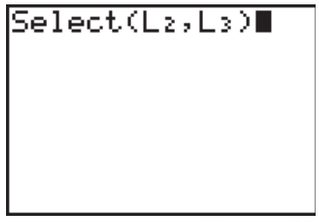


Figure 23

7) You will be taken to the graph screen and asked to select a **Left Bound**. In the example, the second parabola is being selected. Use the right arrow key to scroll over to the far left of the chosen parabola and press [ENTER]. **See Figure 24.**

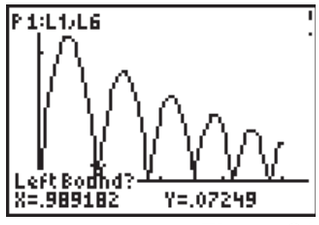


Figure 24

8) That boundary will be marked with an arrow at the top of the screen and the question at the bottom of the screen will now ask for a **Right Bound**. The cursor remains in the position where you left it. Use the right arrow key again to scroll to the far right side of the parabola and press [ENTER]. **See Figure 25.**

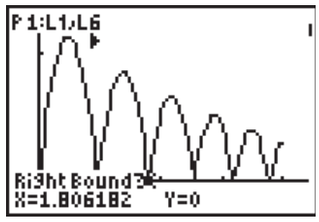


Figure 25

9) A new graph, with just the selected area, will be drawn. Press [TRACE] and look in the upper left corner of the screen to see that your data is in **L2** and **L3** and they have been used as the **Xlist** and the **Ylist** of **Plot1**. The selected data is always put in the same **Stat Plot** as the plot of the original data. **See Figure 26.**

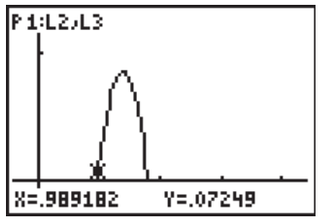


Figure 26

10) Press [STAT], arrow over to **CALC**, and select **5:QuadReg**. **See Figure 27.**

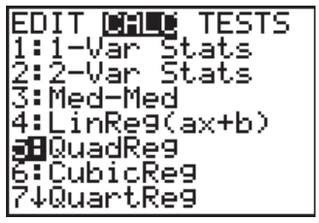


Figure 27

11) You will be taken to the home screen to enter the list names and where you want the equation pasted. Press [2nd] [2] [,] [2nd] [3] to enter **L2**, **L3**. Press the comma key again and then press [VARS] [▸] to access **Y-VARS** and select **1:Function**. From the list displayed, select **1:Y1**. Press [ENTER] to execute the command. **See Figure 28.**

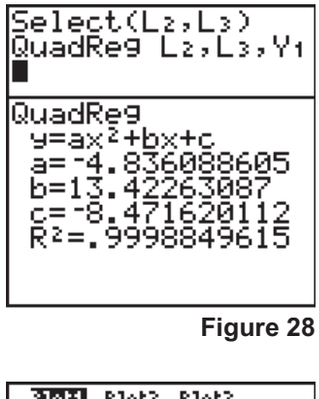


Figure 28

12) Go to [Y=] and move the cursor in front of **Y1** to highlight the slash icon. This controls the style of the line used to graph the equation. Press [ENTER] repeatedly until the graph style is the ball tracker as shown on the right here, the one with the ball and the small line to the left of the ball. **See Figure 29.**

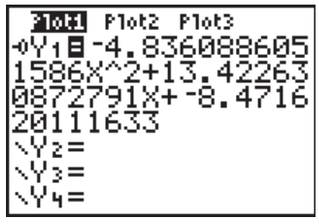


Figure 29

13) Press [GRAPH] to see the regression equation match the plots. **See Figure 30.**

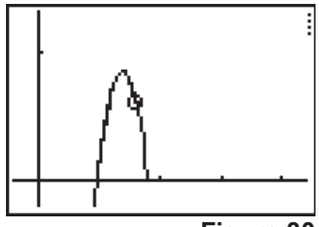


Figure 30

NOTE Think about your goals for the lesson. Both of the previous ways of obtaining the regression equation involve knowing the right keystrokes to get "the answer." They are quick and accurate but involve very little concept development. The following method will do more for helping students learn the vertex form of a quadratic equation. It will not only help them learn where the **X**- and **Y**-values of the vertex are found in the equation, but it will also help them see how the value of A affects the shape of the parabola.

C. Exit the App and use the vertex form of the quadratic to allow students to more thoroughly examine the relationship between quadratic equations and their parabolas.

1) Begin this method the same as the method above for steps one through nine. This will have the single parabola plotted in **Plot1** with the data coordinates stored in **L2** and **L3**. Press GRAPH. **See Figure 31.**

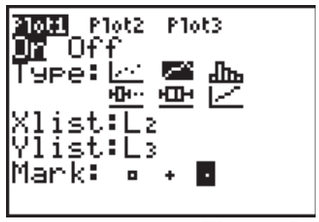


Figure 31

2) When the data is displayed in the graph window, press TRACE and scroll to the vertex. The **X**- and **Y**-coordinates displayed at the bottom of the screen will remain in the memory of the calculator until you trace to a new point or store new values in **X** and **Y**. **See Figure 32.**

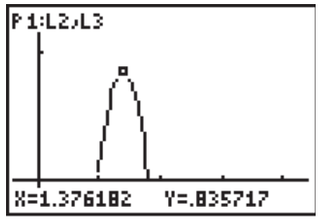


Figure 32

3) Press 2nd MODE to access [QUIT] and return to the home screen. Store the coordinates from the vertex in the standard variables, **H** and **K**. Select an initial value for **A**. Hopefully your students are familiar enough with parabolas before you start this activity to know that **A** must be negative. In this case, -1 is a good place to start. The keystroke sequence is X,T,Θ,n STO▸ ALPHA **H** ENTER, then ALPHA **Y** STO▸ ALPHA **K** ENTER, and then -1 STO▸ ALPHA **A** ENTER. **See Figure 33.**

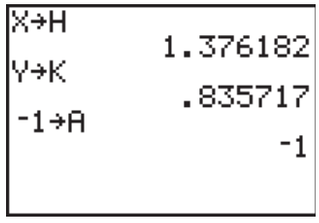


Figure 33

4) Press Y= and type in **A(X–H)²+K** for **Y1**. **See Figure 34.**

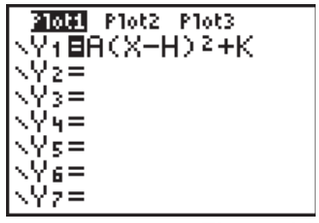


Figure 34

5) Press GRAPH to see how closely your equation fits the data. This step allows the students to see the vertex is in place and just the **A**-value needs adjusting. Allow them to try several values on their own as they search for a good fit. **See Figure 35.**

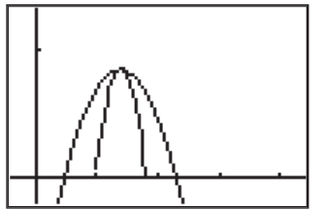


Figure 35

6) Examine the values that the students decide are a good fit for **A**. Lead them into a discussion about the acceleration of falling objects due to gravity. Remember, the ball was not thrown; it was dropped. After an object is released, it is acted upon by gravity (neglecting air resistance). So **A** depends on the acceleration due to gravity, -9.8 meters/second^2 or -32 feet/second^2. The negative sign indicates that the acceleration is downward. The value of **A** is approximately one-half the acceleration due to gravity, or -4.9 meters/second^2 or -16 feet/second^2. Depending on their knowledge of physics, decide how far you want to take this discussion. **See Figures 36a–b.**

7) Have the students store the appropriate value in **A** and press GRAPH to examine the fit.

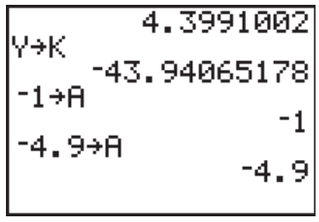


Figure 36a

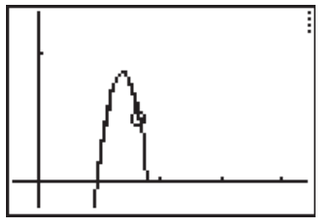


Figure 36b

NOTE You will need this data for Activity 13. To protect it from being accidentally thrown away, store **L1** and **L6** in new lists with unique names. Store **L1** in a list called **BTIME** (Ball Time) and **L6** in a list called **BDIST** (Ball Distance).

NOTE *For help with naming lists, see Appendix E.*

WORKSHEET ANSWERS

Answers will vary for problems 8, 9, 10, 12 and 20.

1. Time

2. Seconds

3. Distance/height

4. Feet or meters

5. Height of first bounce

6. The floor

7. Time was increasing. The **X**-axis is time, not distance. As time increases and you move across the **X**-axis, the ball goes up and down.

11. Approximately -4.9 if using meters, or -16 if using feet

13. + opens up,
– opens down

14. Increasing |A| will make it steeper.

15. Decreasing |A| will make it wider.

16. Different vertex

17. Same; student explanations will vary depending on their previous experiences.

18. Same or very close

19. The value of **A** is relative to gravity and therefore the same for any ball.

21. y = -4.9(x – 7) + 0.48

22. No, it would only affect the vertices of the bounces.

ACTIVITY 12

Name: _____

Bouncing Ball

Math Objectives:

- Graph scatter plots
- Graph and interpret a quadratic function
- Apply the vertex form of a quadratic equation
- Calculate the maximum value of a parabola

Materials:

- TI-83/TI-84 Plus Family
- Calculator-Based Ranger™ (CBR 2™)
- Vernier EasyData™ Application
- Bouncing ball

In this experiment, you will collect the height vs. time data of a bouncing ball by using the CBR 2 and the EasyData App. Your teacher will explain the procedure. When you see the EasyData App graph the ball data, complete questions 1–7.

1. What physical property is represented along the **X**-axis? _____

2. What are the units? _____

3. What physical property is represented along the **Y**-axis? _____

4. What are the units? _____

5. What does the highest point on the plot represent? _____

6. What does the lowest point represent? _____

7. Why does the plot look like the ball bounced <u>*across*</u> the floor. _____

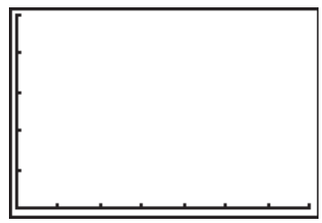
After exiting the App, use the **Select** feature on your calculator to isolate any one bounce you choose. Have the selected data put in **L2** and **L3**. For any one bounce, a plot of height vs. time has a parabolic shape. The equation that describes this motion is quadratic: $Y = A(X - H)^2 + K$ where A affects the width of the *parabola* and (H, K) is the *vertex* of the parabola.

8. This equation is called the *vertex form* of the quadratic equation. Trace along your height vs. time plot. Identify the vertex of the bounce you chose and record the **X**- and **Y**-coordinates as H and K here. H = _____ K = _____

Go back to the home screen and store these values in H and K on the calculator. The keystroke sequence is [X,T,Θ,n] [STO▸] [ALPHA] **H** [ENTER] and then [ALPHA] **Y** [STO▸] [ALPHA] **K** [ENTER]. Also store –1 in the variable A by pressing **–1** [STO▸] [ALPHA] **A** [ENTER].

9. Press [Y=] and enter the expression $\mathbf{A(X - H)^2 + K}$ for **Y1** and press [GRAPH]. Sketch both your selected plot and the graph of the equation when A = –1 on the coordinate axes provided here.

10. State which bounce you worked with. _____



11. To find the equation of the parabola, use a guess-and-check method to find the value of A. Starting with an initial guess of A = –1 from above, adjust A by storing new values in A on the home screen. For each new value of A that you test, press [GRAPH] to view the new parabola. Experiment until you find one that provides a good fit for the data. Record the value of A that works best in the space here. A = _____

12. Using this value of A and the H and K values found in question 1, write the vertex form of the quadratic equation here. Y = _____

13. What effect does the sign (positive or negative) of A have on the parabola? _____

14. What effect does increasing the size of |A| have on the shape of the parabola? _____

15. What effect does decreasing the size of |A| have on the shape of the parabola? _____

16. How would the equation change, if at all, with a different bounce of the parabola? _____

17. Would you expect your classmates to have the same value of A for their trials or do you think the A value would vary? Explain your answer. _____

18. Find out the value of A from the other groups of students in your class. How do these values compare to your value of A? _____

19. What conclusion can you make about the value of A of a quadratic equation for a bouncing ball? _____

Going Further *Answer these questions. Show all work.*

20. Re-plot **L1** and **L6** and repeat the procedure for one of the other bounces of the original data. When you use the **Select** feature, choose **L4** and **L5** to store your data. Find the equation of this new bounce. Then, type it in **Y2** of the Y= window and graph it to see how well it matches the scatter plot and write it here.

21. Using what you discovered about the value of A in a quadratic equation for a bouncing ball, write the equation of a parabolic ball bounce with a vertex of (7, 0.48). Assume the data was measured in meters.

22. If a ball that was more or less bouncy was used this time, would it affect the value of A in the equation? If so, describe how.

NOTE You will need this data for Activity 13. To protect it from being accidentally thrown away, store **L1** and **L6** in new lists with unique names. Store **L1** in a list called **BTIME** (Ball Time) and **L6** in a list called **BDIST** (Ball Distance).

NOTES

Getting Started with the TI Connect™ Software

TI PROFESSIONAL DEVELOPMENT

Activity Overview

Teachers and students need a way to back up their graphing calculator, take screen captures, and easily update the operating system. The TI Connect™ software application makes exchanging information between the TI-84 graphing calculator family and your computer quick and easy. Use TI Connect software to create and access calculator content, transfer and backup files, take screen captures, and update the operating system of your graphing calculator. TI Connect software includes TI DeviceExplorer, TI ScreenCapture, Backup, Restore, TI DataEditor, Explore My TI Data, and Send to TI Device. In this activity, you will explore the basic features of the TI Connect software.

Materials

- TI Connect software (version 4.0)
- TI-84 graphing calculator family
- Silver Link or standard A to mini-B USB black cable.

Note: Although this activity frequently references the TI-84 Plus C Silver Edition graphing calculator, most functions work with the TI-84 Plus and TI-84 Plus Silver Edition graphing calculators.

Part One – Getting Started

Step 1:

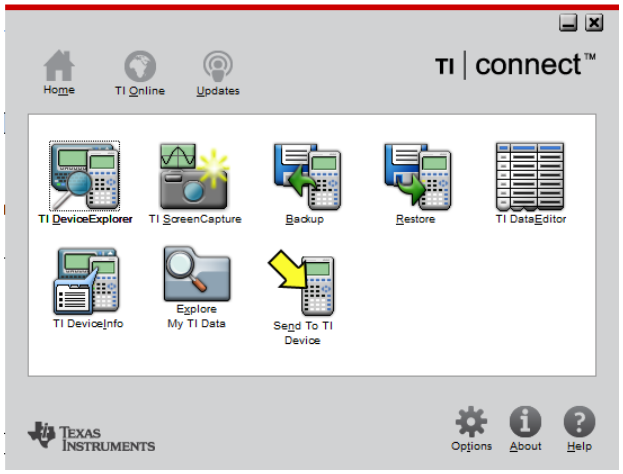
To open the TI Connect software:

- Connect the TI-84 Plus C Silver Edition to the computer using the Silver Link cable or Standard A to Mini-B USB black cable.
- Turn on the graphing calculator.
- Double-click on the TI Connect icon on your computer.

Step 2:

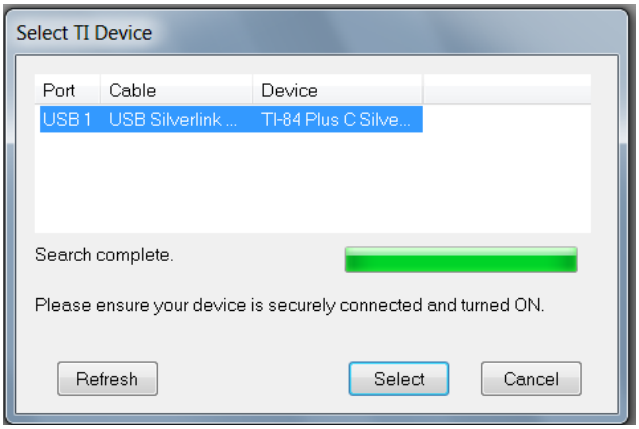
The TI Connect Home Screen will open up to display a list of actions.

Select an appropriate action by clicking on the icon.



Step 3:

The TI Connect software will open communication with the TI-84 Plus and find the attached calculator. Press the Select button when the graphing calculator is 'found', and you can begin.



Step 4:

With the addition of the TI-84 Plus C Silver Edition to the TI-84 family, the TI Connect software has been updated. What has changed?

New feature:

- Send to TI Device has been made more easily accessible by placing an icon on the TI Connect Home Screen.

Updated features:

- TI Device Explorer has been updated to work with the addition of color and backgrounds.
- TI ScreenCapture has been updated to include color and image capabilities.

Unchanged features:

- Backup
- Restore
- TI DataEditor
- TI DeviceInfo
- Explore My TI Data

In the following sections, each of these features will be discussed.

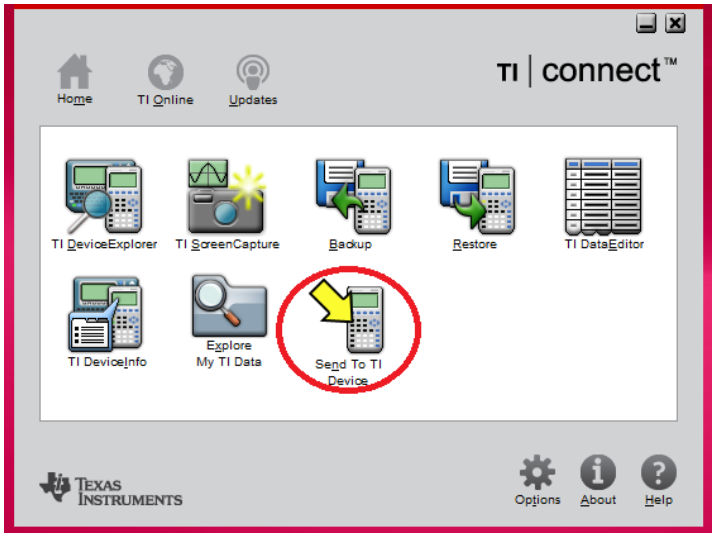
Note: The steps and directions given here are for a PC. If you are using a Mac, many of the processes that are described are the same. However, if you need help, remember to access the Help Menu from the various TI Connect screens.

Part Two – Send to TI Device

The Send to TI Device feature allows the student or teacher to send calculator files from the computer to the TI-84 Plus C Silver Edition.

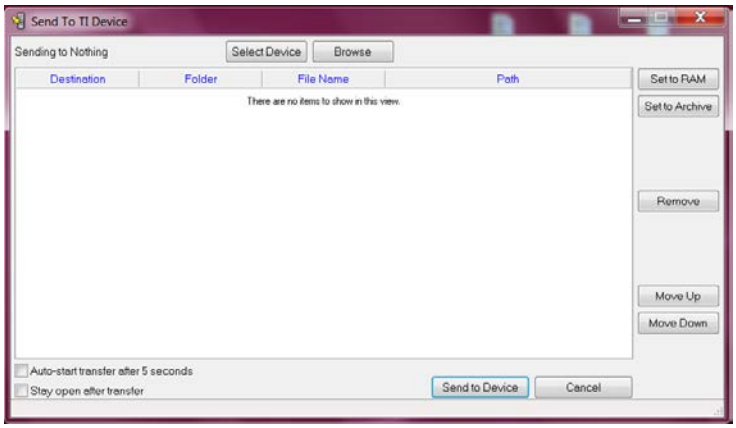
Step 1:

Click the Send to TI Device icon.



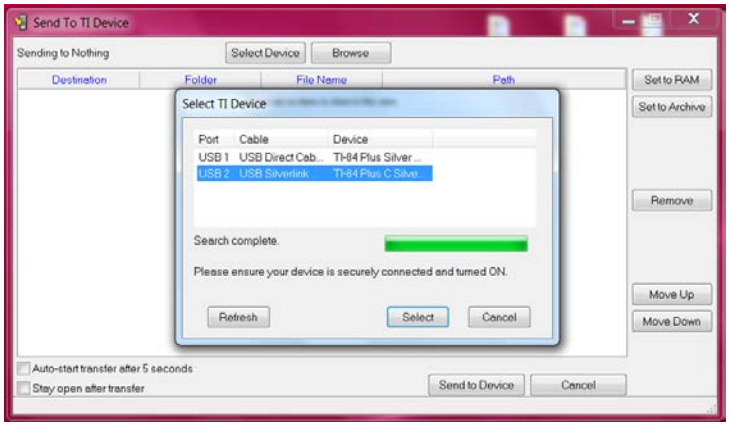
Step 2:

The Send to TI Device Window will open. Press on the Select Device button.



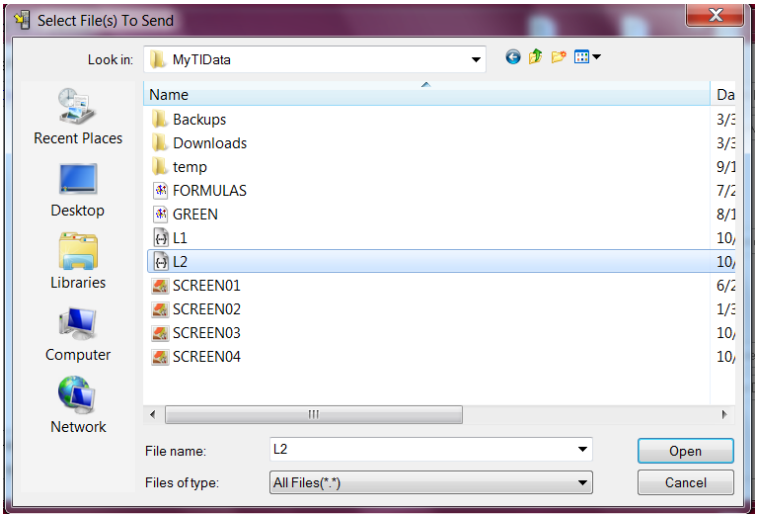
Step 3:

The TI Connect software establishes connectivity with the graphing calculator. Press the Select button.



Step 4:

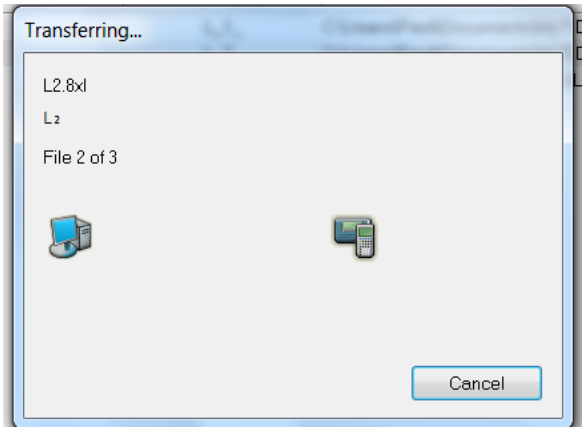
Next press the Browse button, and locate the file(s) you want to send. Press Open.



Step 5:

When your selections are finished, press the Send to Device button.

- A Transferring… Window opens. You might get a transfer warning about files already existing. Follow the prompts.
- When transfers are complete, the Send to TI Device window closes.
- You can now access the sent files on the TI-84 Plus C Silver Edition.



Keep in Mind:

- Sending files lets you share your files with others and still maintain a copy on both your computer and your own graphing calculator.
- Files stored on the computer can be sent to the RAM or Flash/Archived memory of the connected graphing calculator.
- If multiple calculators are connected to the computer, you can only choose to send to one of them at a time.
- Do not unplug TI connectivity cables while using Send to TI Device.

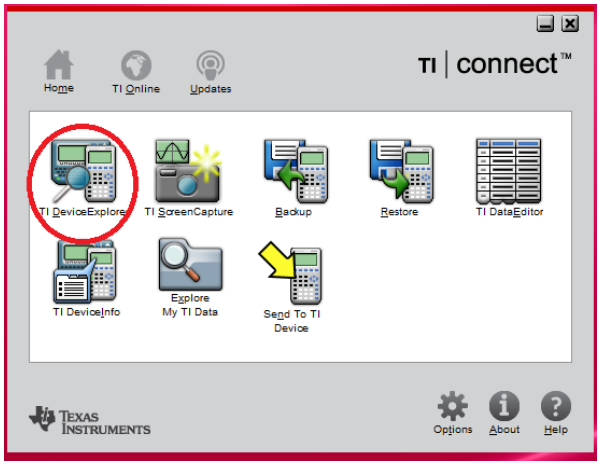
Part Three – TI Device Explorer

The TI DeviceExplorer feature allows the teacher or student an easy way to work with the files on the TI-84 Plus C Silver edition. The TI Device Explorer key features are:

- Viewing the contents of the graphing calculator
- Copying calculator files to your computer
- Copying computer files to a connected graphing calculator
- Deleting calculator files
- Backing up and restoring calculator files
- Updating calculator files

Step 1:

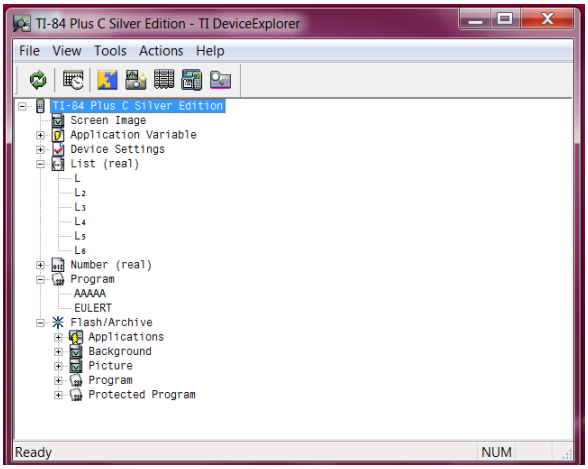
Click the TI DeviceExplorer icon.



Step 2:

When TI Connect establishes connectivity with the TI-84 Plus C Silver Edition, press the Select button.

- The TI DeviceExplorer window will open.
- Click on a "**+**" next to any icon to view the contents of that folder.



Step 3:

Drag and drop computer files into the TI DeviceExplorer as an alternative to using the Send to TI Device. Drag and drop calculator files from the TI DeviceExplorer into a computer folder for backup or later use. Right-click on a calculator file in Device explorer and choose delete.

Note: You can transfer/send files to your TI-84 Plus without opening TI Connect. Just drag a file on your computer to the TI Connect desktop icon for a quick transfer to your connected calculator.

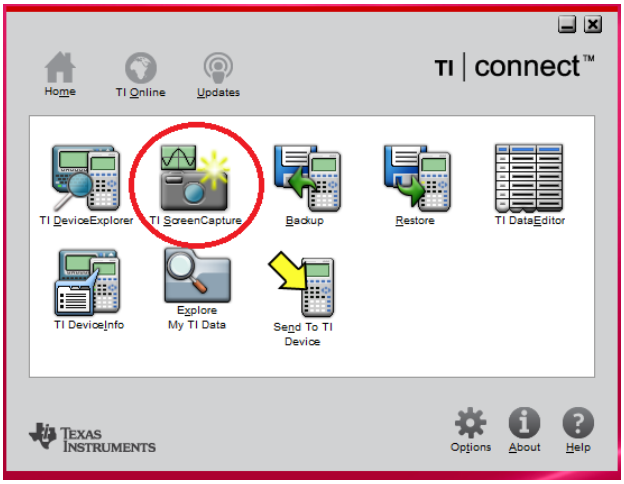
Part Four – TI Screen Capture

The TI ScreenCapture feature gives the teacher or student an easy way to capture the screen images of the TI-84 Plus C Silver Edition. Features of TI ScreenCapture include:

- Capturing the calculator screen as an image.
- Editing the images.
- Transferring images between the calculator and another computer application.
- Saving images in various file formats.
- Converting an image to the TI-84 Plus C file format for use as a background.
- Printing the screen capture.

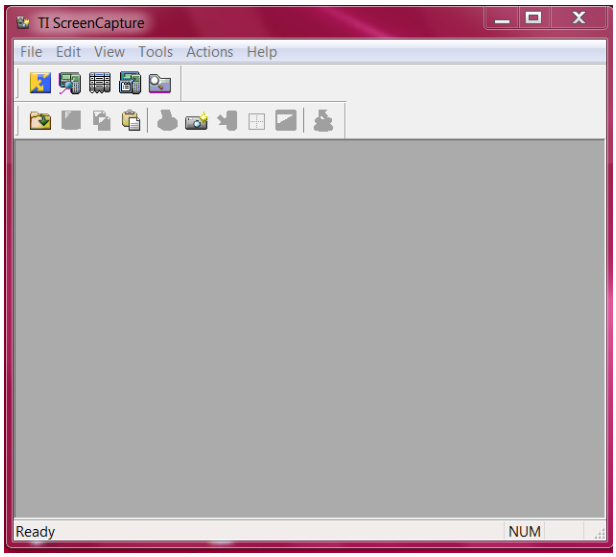
Step 1:

Click the TI ScreenCapture icon.



Step 2:

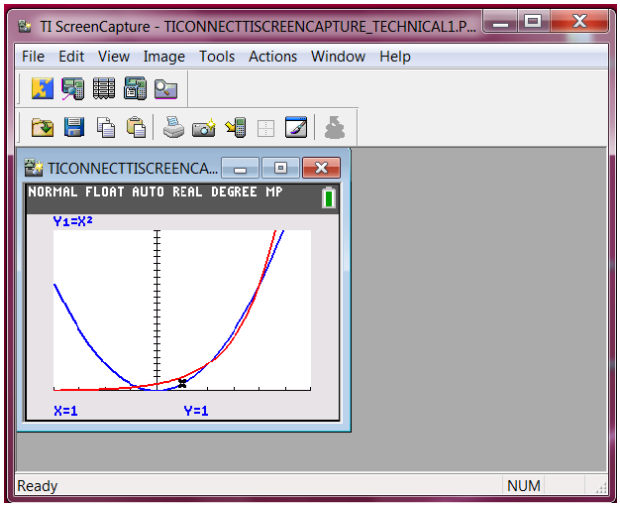
The TI ScreenCapture window will open.



Step 3:

Click the camera icon.

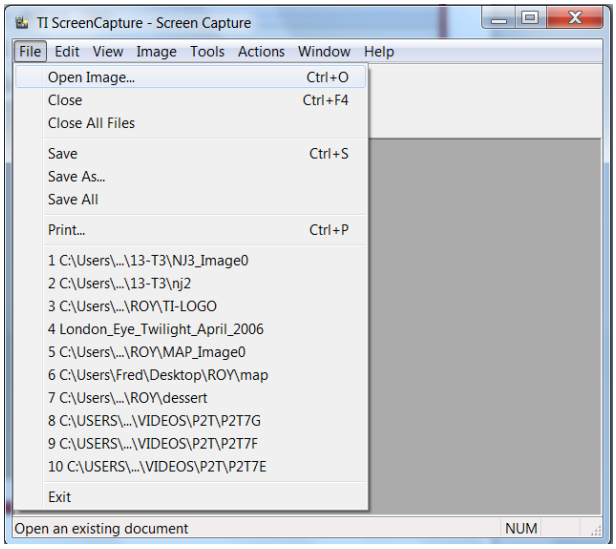
- The TI Connect software will establish connectivity with the TI-84 Plus C Silver Edition with a screen capture.
- Capture additional screens by clicking the camera icon.
- TI Screen Capture can be used to send a background image to the calculator, or it can be saved and loaded into the TI SmartView Software.



Step 4:

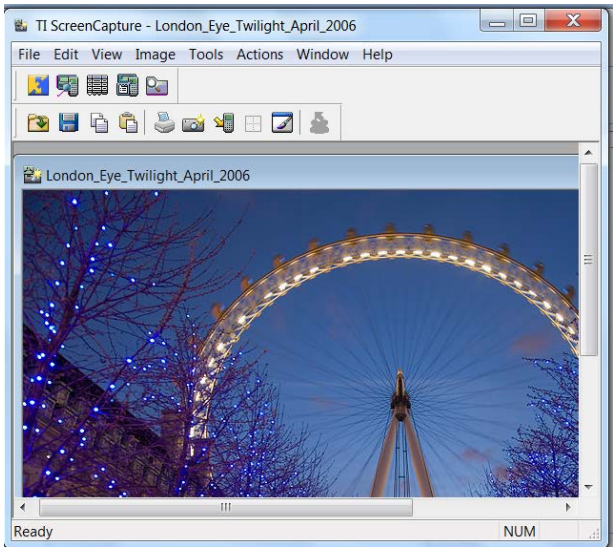
From the **File** menu, click **Open Image**.

Note: Any image in *.jpg, *.bmp, *.tif, *.png, *.gif, or existing TI picture formats can be opened in TI ScreenCapture.



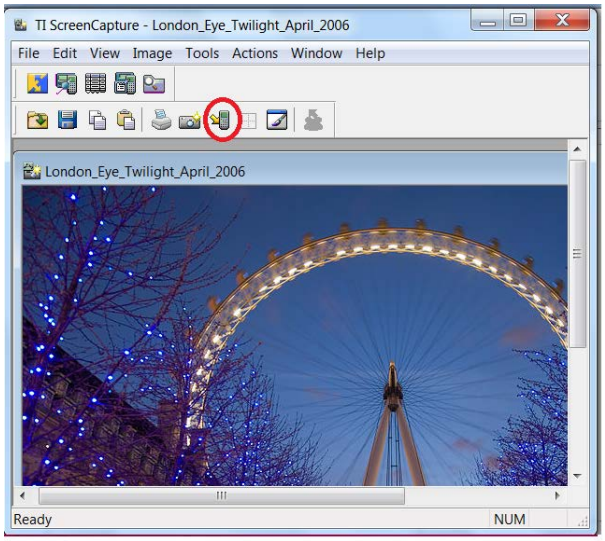
Step 5:

The image will open in the TI Connect Screen Capture Window.



Step 6:

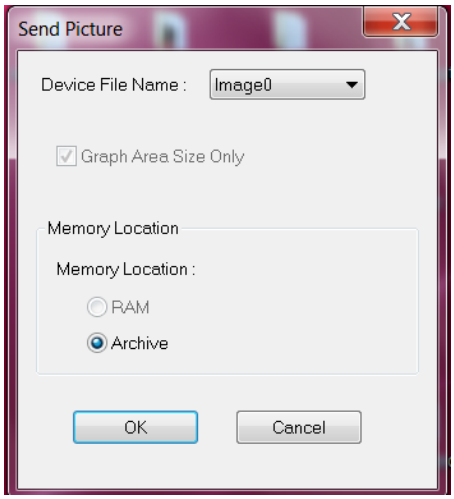
Click on the Send to Calculator Icon to send the image to your connected TI 84 Plus C Silver Edition.



Step 7:

A Send Picture Window will open. Select the image variable number you want to use for your image.

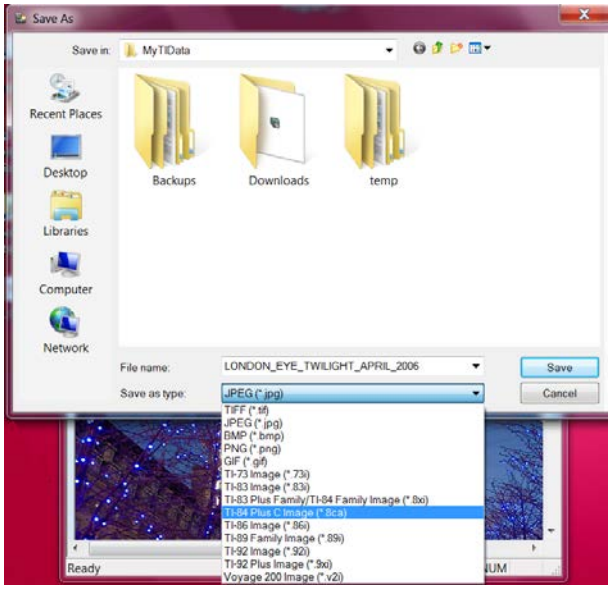
- Remember Images 1-5 are preloaded on the TI-84 Plus C Silver Edition.
- Follow the on screen prompts. When transferring is complete, the image file can be accessed on the TI-84 Plus C Silver Edition.



Step 8:

To save the picture as an image for use with the TI SmartView emulator software or as a backup:

- Select **File** > **Save As** > **Save as type**
- Select **TI-84 Plus C Image (*.8ca)**
- Click **Save.**
- The background image is now ready to **Load** into the TI SmartView software.



Part Five – The Backup and Restore Features

The Backup and Restore feature in the TI Connect™ software provides an easy way for students and teachers to back-up the files on their graphing calculator and restore them at a later time.

With the Backup tool you can:

- Back up the calculator's RAM
- Back up the calculator's Archive
- Back up the calculator's Apps

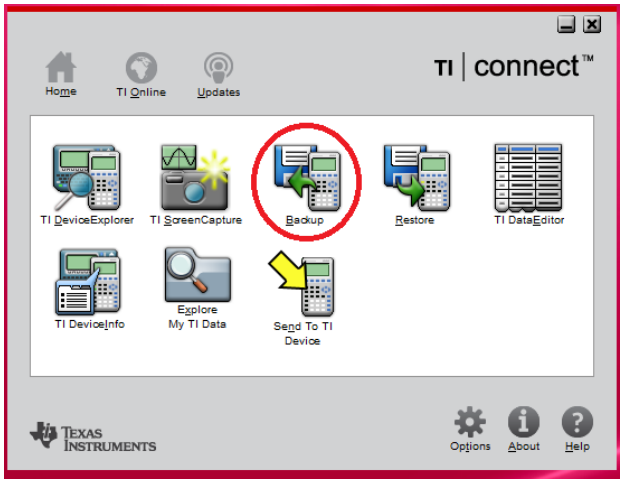
With the Restore tool you can:

- Restore the calculator's RAM
- Restore the calculator's Archive
- Restore the calculator's Apps.

Step 1:

To Use the Backup feature:

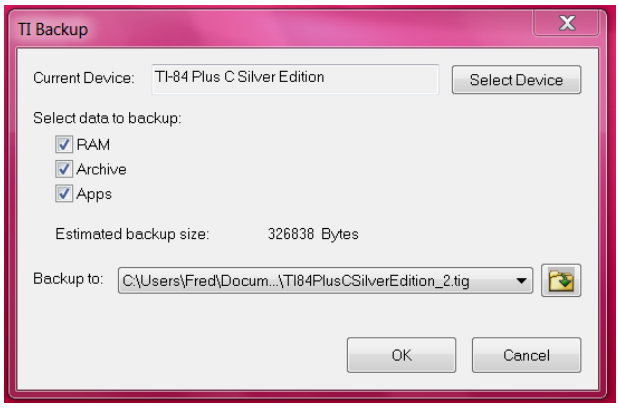
- Connect your graphing calculator to the computer using either the Silver Link or black USB cable.
- Click the Backup icon.
- If the Current Device does not display, press the Select Device button.



Step 2:

Select data to back up by using the checkboxes.

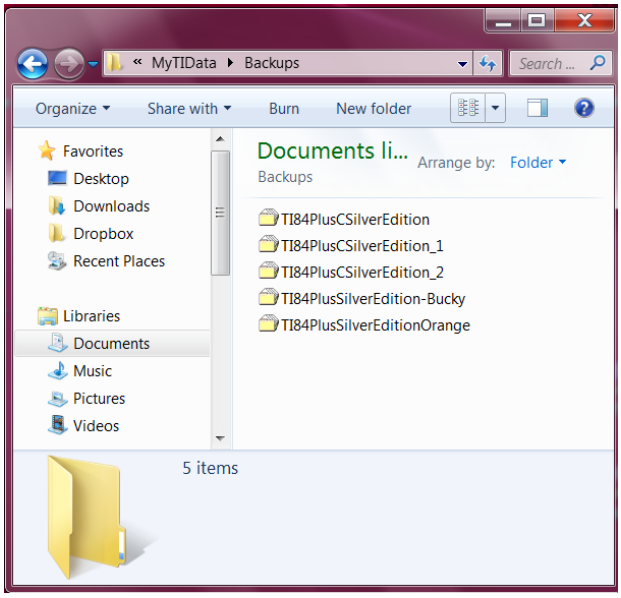
- Accept the default name, or type a new name for the backup file.
- Accept the default "Backup to" location, or navigate to a new location.
- Press **OK**.



Step 3:

A Transferring window appears.

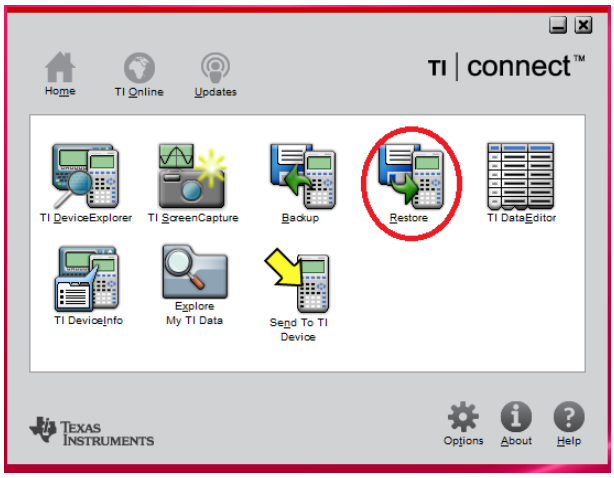
- When the transferring is complete, the window closes.
- You can find the backup file in the location where it was saved with a .tig file extension.



Step 4:

To use the Restore feature;

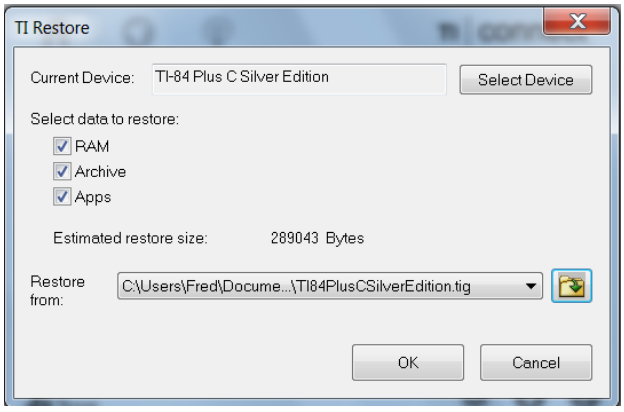
- Connect your graphing calculator to the computer using either the Silver Link or black USB cable.
- Click the Restore icon.



Step 5:

Two dialog boxes open.

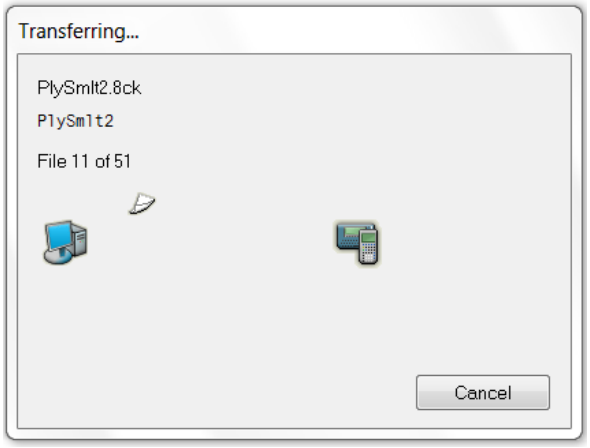
- In the Open dialog box, select the backup file (navigating to the location of the backup file if needed) and press **Open**.
- If the Current Device does not display in the TI Restore dialog box, press the Select Device button.
- Select data you want to restore by using the checkboxes. Press **OK**.



Step 6:

A Transferring window appears.

- A TI Device Data Transfer Warning window might appear. Press the appropriate button to continue.
- When the transferring is complete, the window closes.
- Your graphing calculator now contains the restored information.



Keep In Mind:

- Backups should be done periodically.
- Remember the location where you saved the backup.
- Backup can only backup RAM, Archived, and Apps. You cannot back up an operating system.
- Before restoring, it is a good idea to check that you have the latest operating system installed.
- Restore copies the device files in the backup file to the connected calculator.
- Do not unplug TI connectivity cables while using Backup or Restore.

Part Six – TI Data Editor

The TI DataEditor feature in TI Connect™ provides an easy way for students and teachers to work with data variables on their TI-84 Plus C Silver Edition.

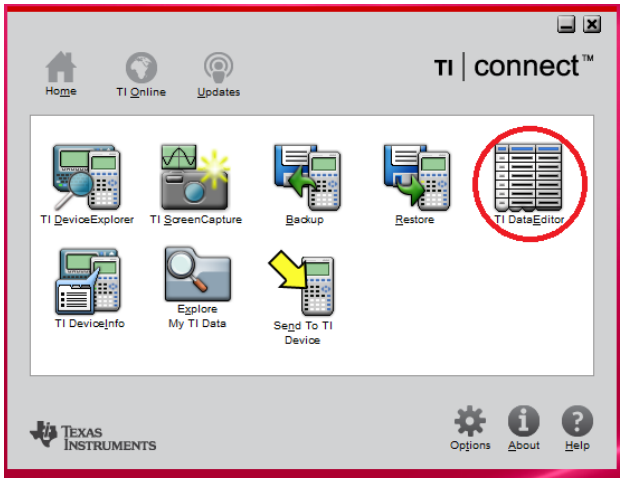
With the TI DataEditor tool you can:

- Create number, list and matrix variables.
- Edit the variables.
- Share the variables with the graphing calculator and computer.

Step 1:

To use the TI DataEditor feature:

- Connect your graphing calculator to the computer using either the Silver Link or black USB cable.
- Click on the TI DataEditor icon.

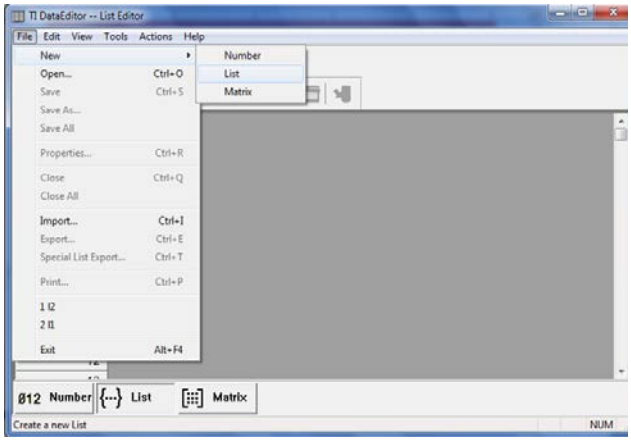


Step 2:

The DataEditor will open. The Data Editor Window has three modes:

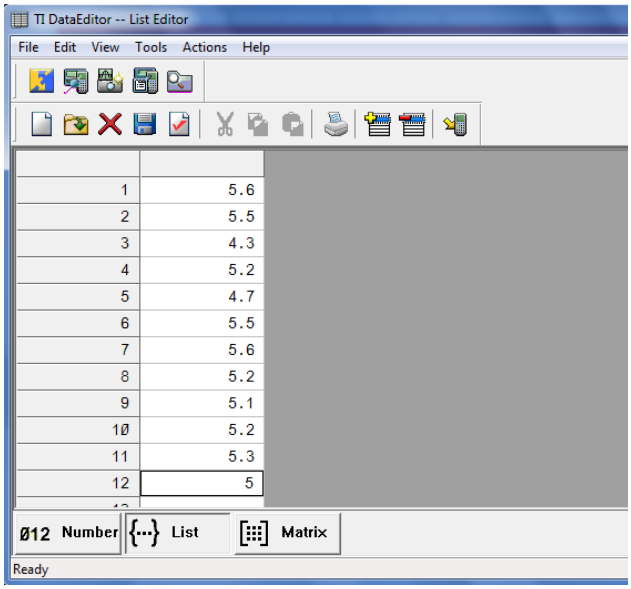
- Number Editor
- List Editor
- Matrix Editor

To open the List Editor, click **View**, and choose **List** or click on the List button at the bottom of the window. To create a list, click **File** > **New** > **List**.



Step 3:

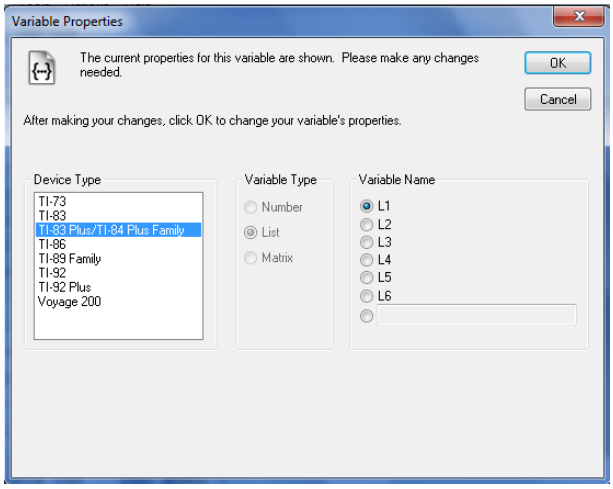
Data can now be entered into the list.



Step 4:

When the data has been entered, click **File** > **Save As**. A Variable Properties window opens.

- Select the Device Type and Variable Name. Then press **OK**.
- The File Save As window opens. Verify the file name and location, and press **Save**.
- The Number Editor and Matrix Editor work in a similar fashion.



Keep In Mind

- Once a List, Number, or Matrix is saved, it can be opened in the Editor for editing.
- Once a List, Number, or Matrix is saved, it can be sent to the calculator using the Send to Device icon or dragging and dropping into TI Device Explorer.
- The TI DataEditor supports importing and exporting of data in .txt and .csv file formats.
- The TI DataEditor supports copying and pasting.
- The TI DataEditor can also be opened from TI ScreenCapture and TI DeviceExplorer.

Part Seven – TI DeviceInfo

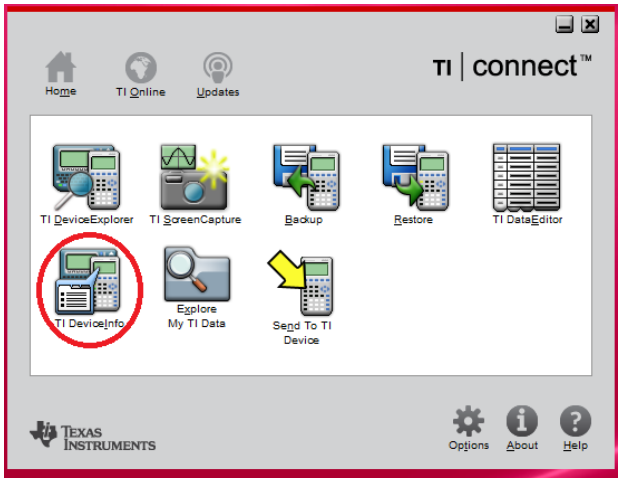
The TI DeviceInfo feature in TI Connect provides an easy way for students and teachers to find out information about their TI-84 Plus C Silver Edition. The TI DeviceInfo tool can:

- Find general information about your calculator.
- Find applications on your calculator.
- Find the ID list on your calculator.
- Create information files.
- Open information files.
- Change communication settings.

Step 1:

To use the TI DeviceInfo feature:

- Connect your TI-84 Plus C Silver Edition to the computer using either the Silver Link or black USB cable.
- Click on the TI DeviceInfo icon.



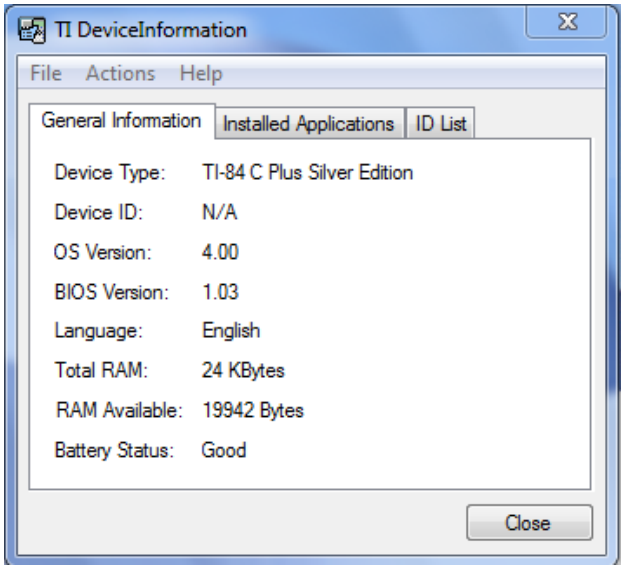
Step 2:

The TI DeviceInfo window will open and communicate with the calculator. If necessary, Select Device.

The TI DeviceInformation Window has three tabs:

- General Information
- Installed Applications
- ID List

Information files can be saved and opened using the **File** menu.



Keep in Mind

You can find calculator type, calculator ID, OS version, BIOS version, language, RAM information, battery status, installed applications, and ID list.

Part Eight – Explore My TI Data

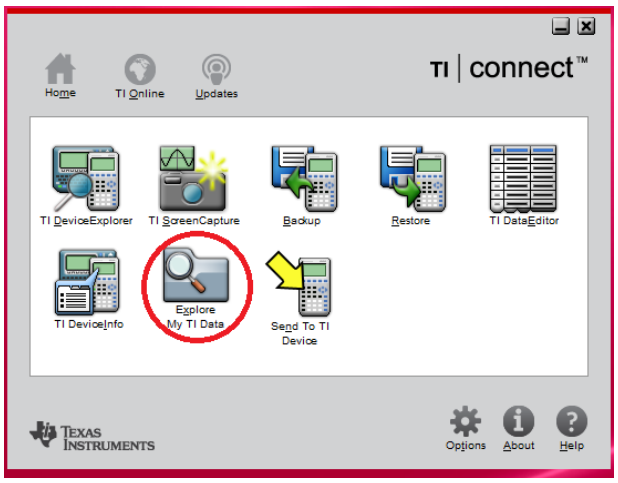
The Explore My TI Data feature lets students and teachers create and work with Group files.

With the Explore My TI Data tool you can:

- Create Group files
- Edit Group files
- Send group or device files to a connected TI-84 Plus C Silver Edition.

Step 1:

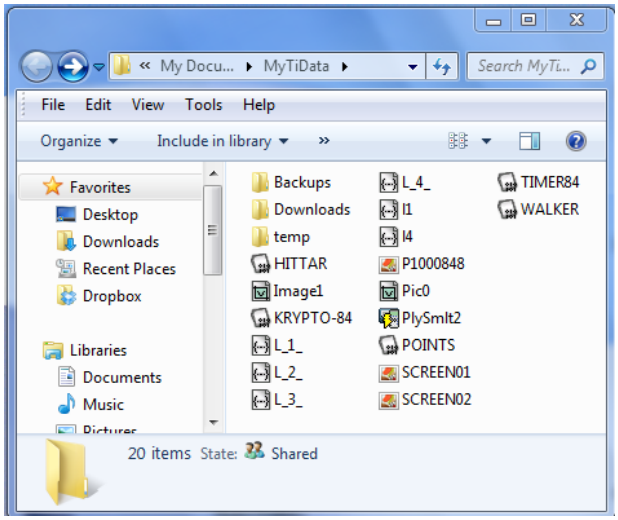
To use the Explore My TI Data feature, click on the Explore My TI Data icon.



Step 2:

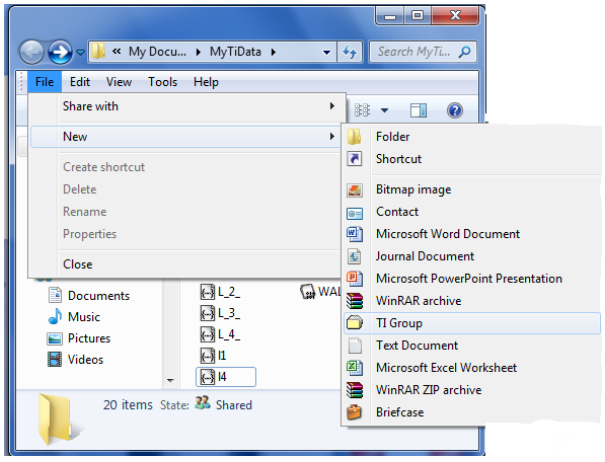
The Windows Explorer window opens.

You can also create a Group file containing one or more related calculator files.



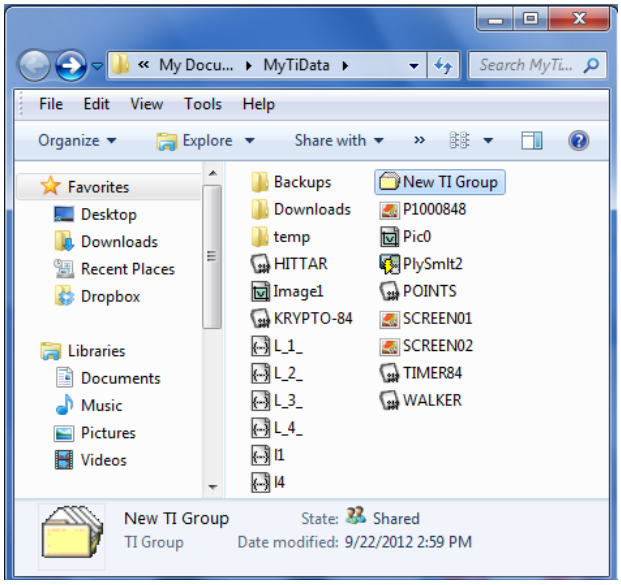
Step 3:

To create a Group file with the Windows Explorer window open, click **File** > **New** > **TI Group**.



A Group file named “New TI Group” appears in the window.

- Drag or copy the calculator files you want in the group to the Group file.
- Rename the Group file if you want.
- The Group file can act as a backup and be restored to the calculator.



Keep in Mind

- Explore My TI Data provides quick access to the computer folder containing your TI Data and to the files in that folder.
- The Backup feature creates a Group file of a connected calculator. With Explore My TI Data, you can select which individual calculator supported files you want to put into a Group file. For instance, you might want to put all your programs in a Group file. The Group file would serve as a backup of your programs and the Restore feature could restore them to a connected TI-84 Plus C Silver Edition. You can also send the one Group file with all the programs in it to the calculator, simplifying the send process.

Other icons on the TI Connect Home Page include:

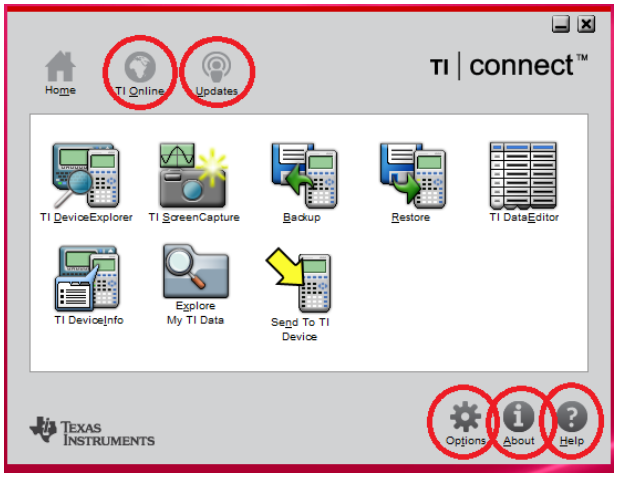
TI Online – If you are connected to the internet you will taken to the TI education portal

Updates – You can check to see if you have the latest operating system and Apps.

Options – You can set the options for the TI Connect software. The options you can set include the default application, the default directories, and automatic software update checking.

About – Displays the version of the TI Connect software that is installed on your computer.

Help – Opens a PDF help file with additional information about the TI Connect software.



Getting Started with the TI-SmartView™ Emulator Software

TI PROFESSIONAL DEVELOPMENT

Activity Overview

You will explore basic features of the TI-SmartView™ emulator software. The TI-SmartView software gives you the complete functionality of both the TI-84 Plus and TI-84 Plus C Silver Edition graphing calculators on your computer. The software contains additional functionality that can be used to enhance presentations and classroom demonstrations.

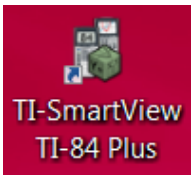
Materials

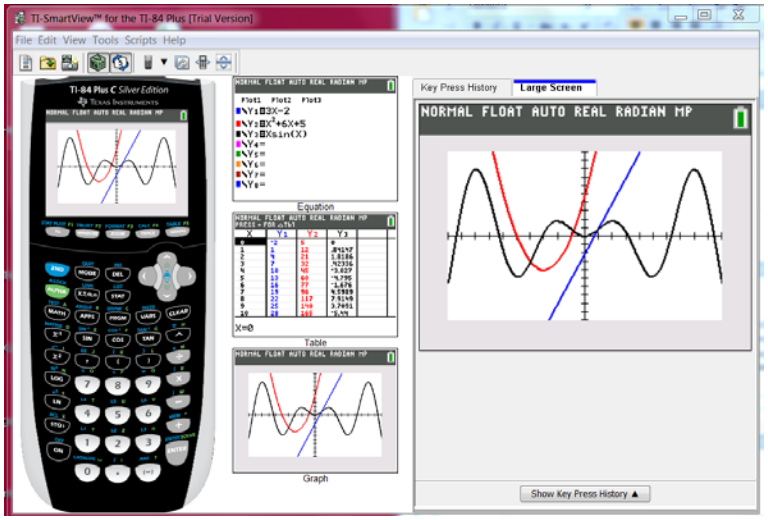
- TI-SmartView emulator software (version 4.0)
- A Silver Link USB cable

Note: Although screen captures of the TI-84 Plus C Silver Edition are used throughout this activity, the TI-SmartView software contains two emulators: TI-84 Plus and TI-84 Plus C. If you are running version 3.0 or earlier, upgrade to version 4.0 and get all the features of both calculators.

TI-SmartView Software

To open the TI-SmartView software, click on the TI-SmartView TI-84 Plus icon on your computer. The software will open and is ready to be used.





Notes:

Two new features for TI-SmartView:

- TI-SmartView contains dual emulators, one for the TI-84 Plus C and one for the TI-84 Plus.
  - The functionality of the emulators is the same as their respective graphing calculator.
  - If a teacher is changing between graphing calculator models, data is not shared between the emulators. Work done on one would need to be re-entered on the other.
- A Keypad and Large Screen view have been added. Additional updates include changes to the layout options, the emulator views, View^3 and large screen, and screen capture.

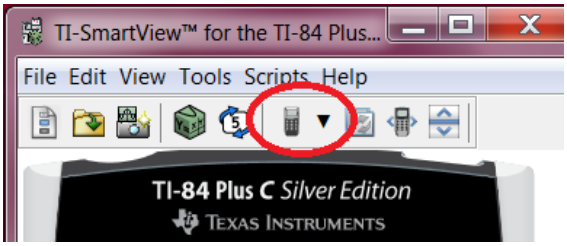
Dual Emulators

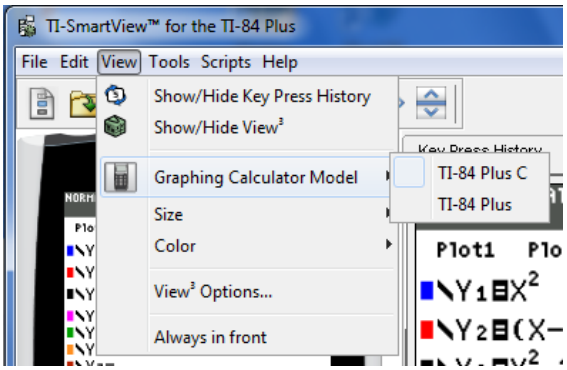
When TI-SmartView opens, it opens to its last emulator state. To change emulators:

- Click on the graphing calculator model icon on the tool bar.

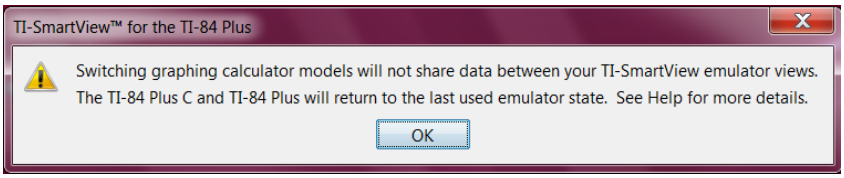
-or-

- Click on **View** > **Graphing Calculator Model** > **TI-84 Plus C** or **TI-84 Plus**.





Note: When switching between emulators, a warning message appears stating that data is not shared between the emulators. The two emulators are independent of each other.



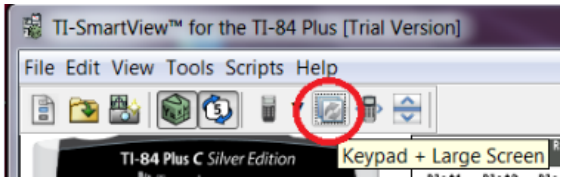
TI-SmartView Keypad View

The TI-SmartView Keypad View will display the keypad of the TI-84 Plus or TI-84 Plus C graphing calculator without the calculator screen. It can be used in conjunction with the Show/Hide Key Press History and Show/Hide View^3.

To use the TI-SmartView Keypad View:

- Click the **Keypad + Large Screen** icon on the tools bar.
- To change back to full calculator view, click the **Keypad + Large Screen** icon again.

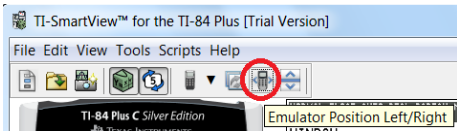
Note: There is no menu option to access the **Keypad + Large Screen** feature. You can only access this feature by clicking the **Keypad + Large Screen** icon on the tool bar.



TI-SmartView Layout Options

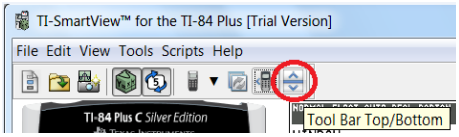
The TI-SmartView Layout Options allows teachers to choose the location of both the emulator and the toolbar.

To change the position of the emulator from left to right:

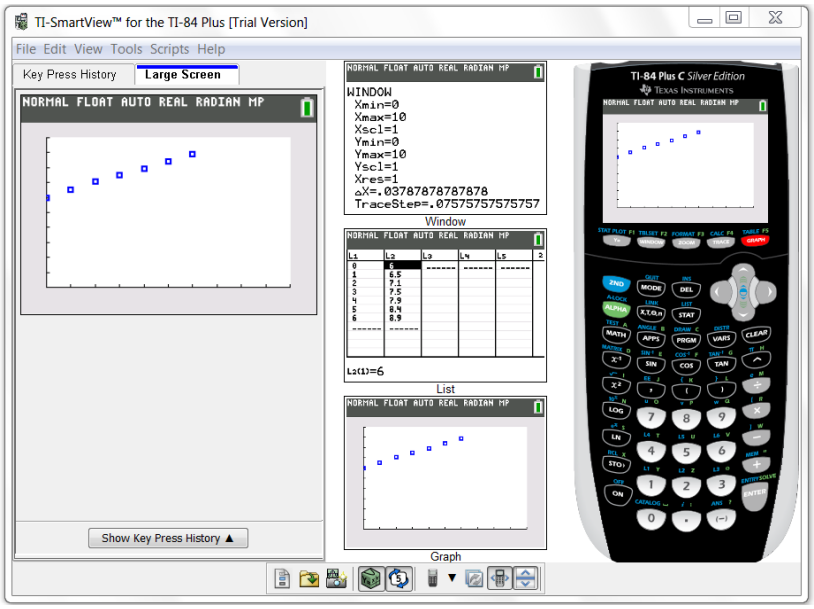


- From the TI-SmartView™ toolbar, click on the **Emulator Position Left/Right** icon to change the layout.
- **The Emulator Position Left/Right** icon toggles the position of the emulator on the screen.

To change the position of the tool bar from top to bottom:



- From the TI-SmartView™ toolbar, click on the **Tool Bar Top/Bottom** icon to change the layout.
- **The Tool Bar Top/Bottom** icon toggles the position of the toolbar on the screen.



Notes:

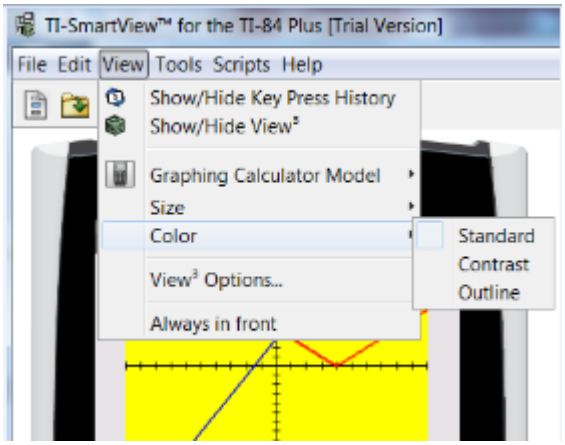
- The **Emulator Position Left/Right** icon on the tool bar toggles the emulator position between the left and right sides.
- The **Tool Bar Top/Bottom** icon on the tool bar toggles the position of the tool bar from the top of the software to the bottom. The emulator will open in the same position as its last-used state.
- There are no menu items for these features. The only way to change the layout is by using the icons on the toolbar.

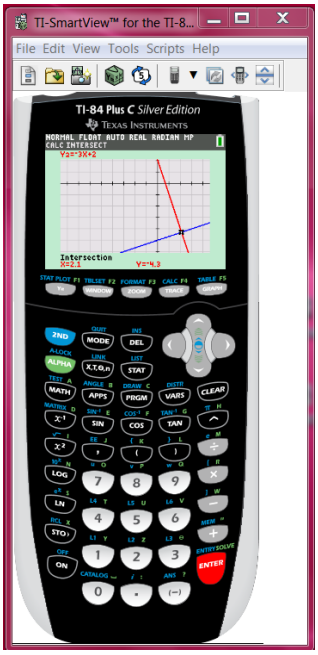
TI-SmartView Emulator Views

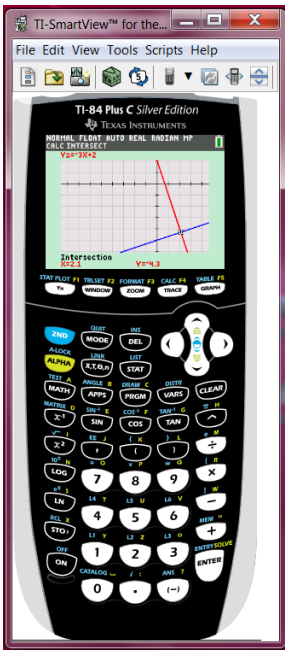
The TI-SmartView Emulator allows you to display the TI-84 Plus C Silver Edition in three different views:

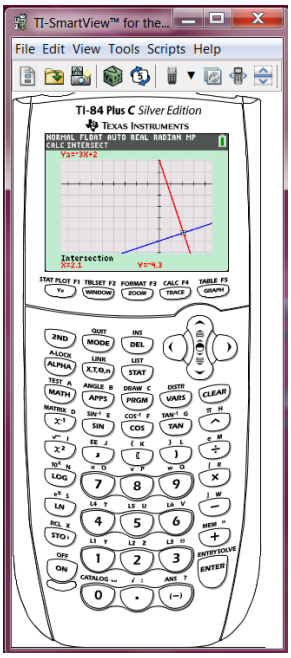
- Standard
- Contrast
- Outline

To change to a different emulator view, click **View** > **Color** > **Standard** or **Contrast** or **Outline**.









Notes:

- **Standard View** – Standard black faceplate matching the calculator keys in the appropriate colors.
- **Contrast View** – Brighter standard black faceplate with ALPHA keys in yellow and grey keys in white to help improve visibility.
- **Outline View** – White calculator with each key outlined in black. No color keys are displayed. The black and white nature of this view helps to reduce the amount of ink needed to print documents.

View[3] and Large Screen

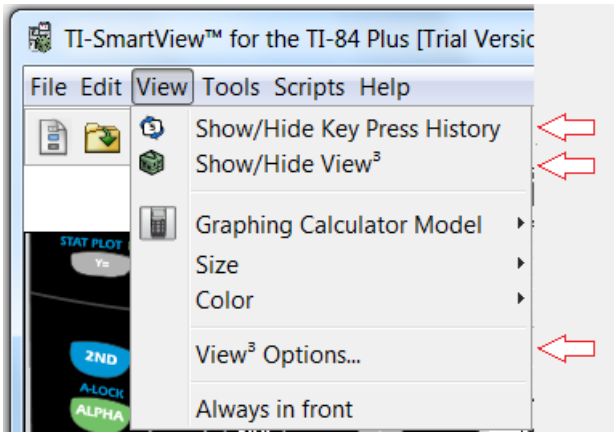
The View[3] pane lets you display three additional TI-84 Plus C graphing calculator screens simultaneously. The teacher can choose from the Y= editor, table, graph, stat plot, list, or window. These screens update as you make changes on the emulator. The Large Screen tab lets the teacher display a larger view of the calculator screen. There is color support in View[3] and Large Screen displays in the TI-84 Plus C calculator model.

To show or hide the Key Press History/Large Screen tabs:

- Click **View** > **Show/Hide Key Press History**.

-or-

- Click on the **Show/Hide Key Press History** icon on the tool bar.

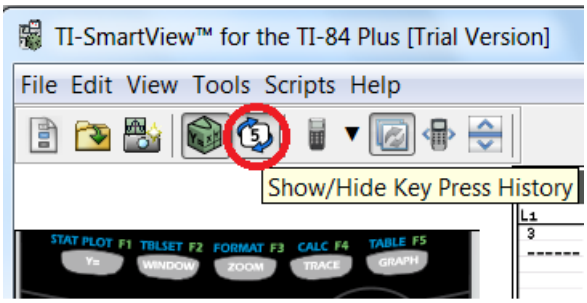


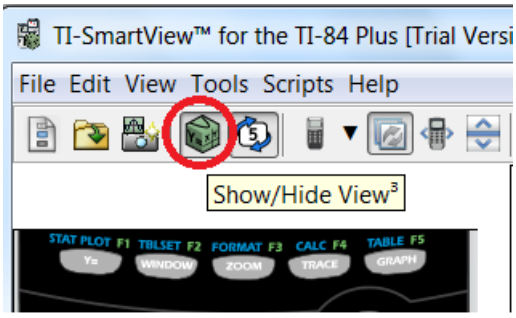
To show or hide the View[3] pane:

- Click **View** > **Show/Hide View[3]**.

-or-

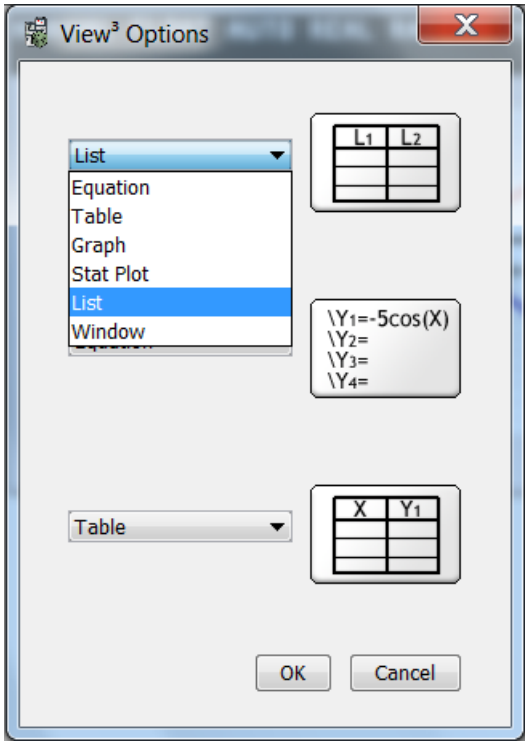
- Click on the **Show/Hide View[3]** icon on the tool bar.





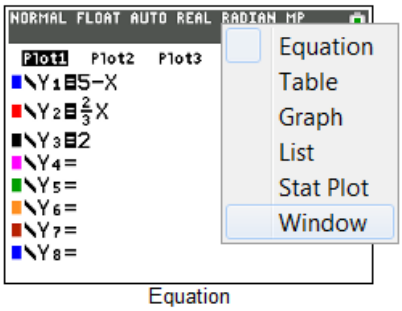
To select a calculator screen for each frame in the View^3 pane

- Click **View** > **View^3 Options**.
    - An options window will open. Use the pull down lists to make your selections. Click **OK**.



-or-

- Right Click on each frame in the View^3 pane to bring up the selection choices.



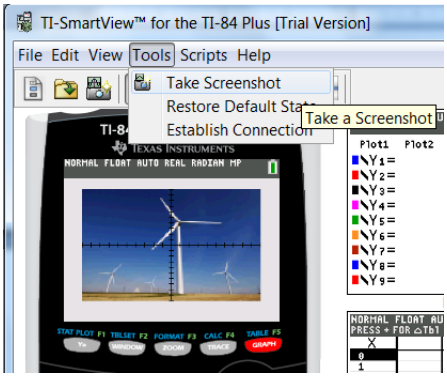
Notes:

- The View^3 pane and Large Screen tab update as you make changes on the emulator's calculator screen.
- The View^3 pane and Large Screen tab are in color to reflect the TI-84 Plus C color features.
- There is flexibility in how and when these views are displayed.

Screen Capture

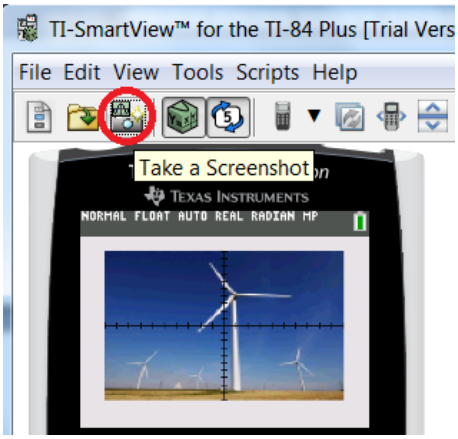
TI-SmartView™ Screen Capture allows the teacher to capture the current image displayed on the TI-SmartView emulator. When you capture a screen, the Screen Capture window is displayed. In this window, you can view, manipulate, and save screen images.

To access the Screen Capture feature:

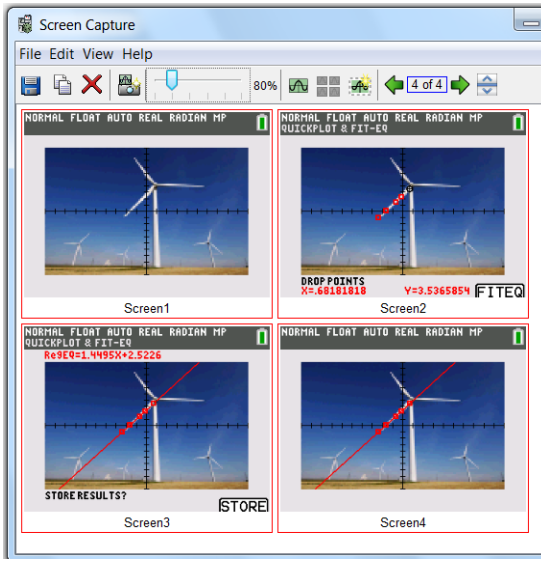


- Select **Tools > Take a Screenshot**.

-or-



- Click the **Take a Screenshot** icon on the tool bar.



- The Screen Capture Window opens.

- There is also a **Take a Screenshot** icon on Screen Capture Window toolbar for repeat captures.

Notes:

- Screenshots can be saved in .jpg, .gif, .tif and .png file formats.
- Screenshots can be copied and pasted into a variety of other applications.
- Screenshots can be dragged and dropped into a variety of other applications.
- Screenshots can be resized using the slider in the screen capture window.
- Borders are automatically inserted for screenshots in the Screen Capture Window. Clicking the **Remove Border** icon on the toolbar will toggle between removing and inserting borders on the screenshot.
- The screen capture window can be used as a record of the steps you went through in a lesson.

Drag Screen

TI-SmartView™ DragScreen allows the teacher to drag a screen image from the TI-SmartView software to a 3rd party application such as Microsoft® Word and PowerPoint™.

Drag and drop any TI-SmartView™ screen image to paste it into another application. These images include the following:

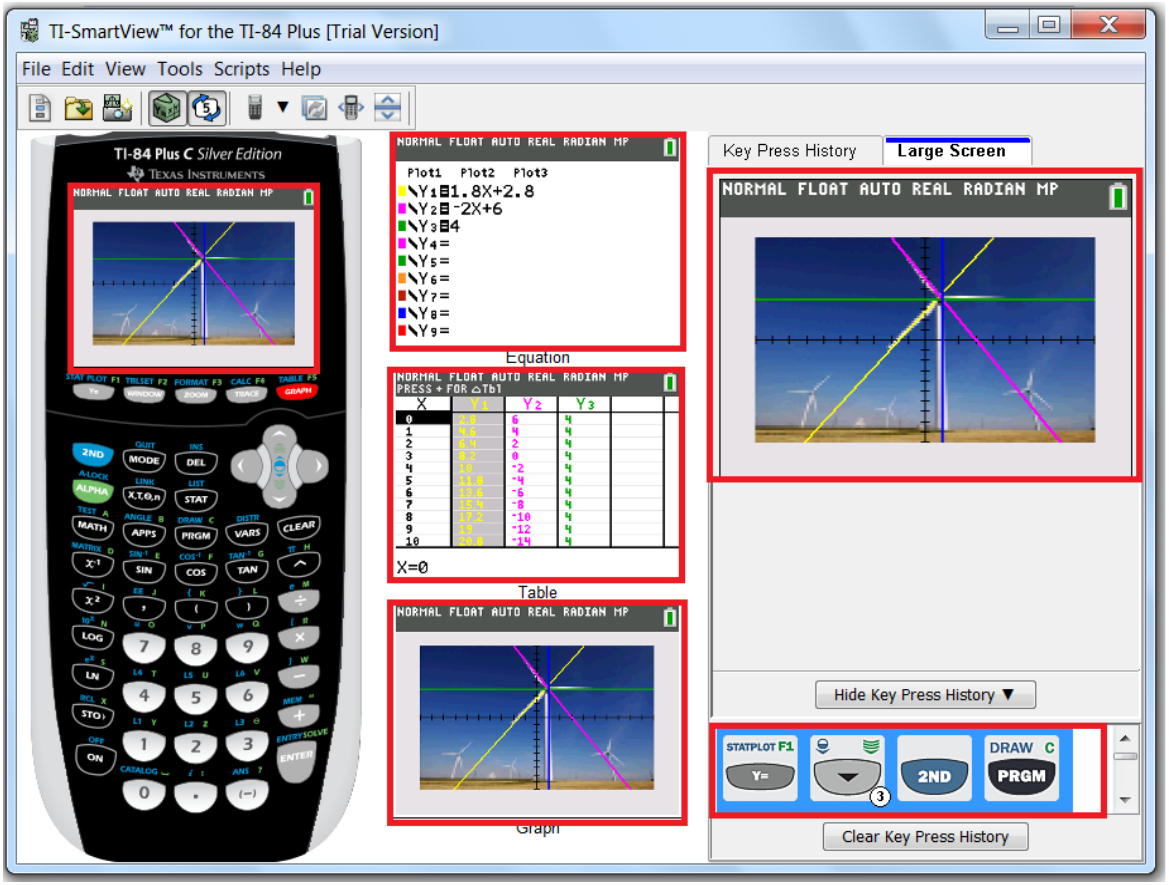
- Saved or unsaved screen capture images from the screen capture window
- Emulator screen
- View3™ pane screens
- Large Screen image
- Key Press History

To drag and drop an image into another application:

- Adjust the sizes of the windows of the two applications so that both of them fit on the computer screen.
- Click the screen image to select it.
- Drag the screen image from the TI-SmartView™ software and drop it into the other application.

To drag-and-drop the Key Press History:

- Use your mouse to select the keys you want to capture.
- Drag the selection from the TI-SmartView™ software and drop it into the other application.



Notes:

When dragging a screen:

- From the View[3], a border is automatically created around the image by the receiving application.
- From the Calculator or Large Screen, panes will not contain a border in the receiving application.
- From Screen Capture, the border will be maintained by the receiving application.
- Images can be resized in either the Screen Capture window or by using the tools in the 3rd party application.

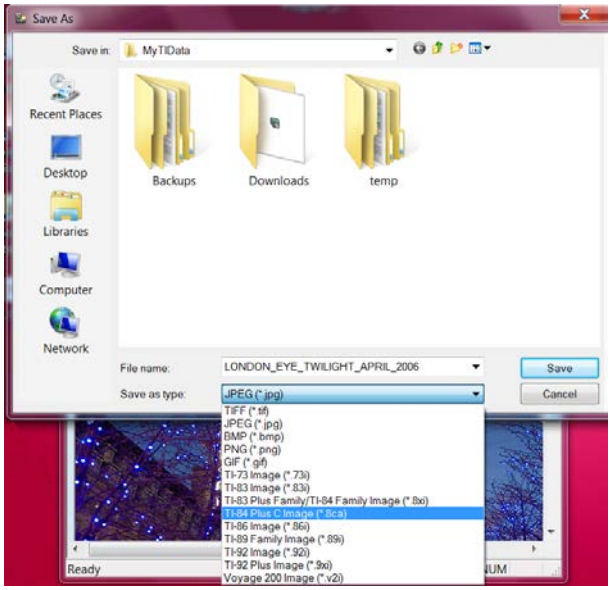
Loading an Image into the TI-SmartView Software

We have just seen one way to get an image onto the TI-SmartView emulator. Here is another way. In Step 8 of the Screen Capture section of Getting Started with TI Connect, you saw how to save a picture as an image. Here is a recap:

From Getting Started with TI Connect - Step 8

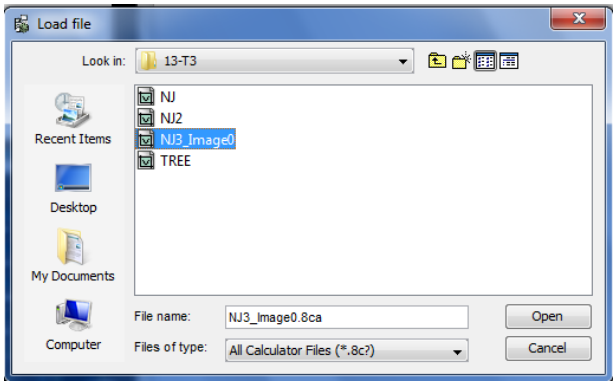
After an picture has been opened in TI Connect Screen Capture, save the picture as an image for use with TI SmartView or as a backup:

- Click **File** > **Save As** > **Save as type**
- Select **TI-84 Plus C Image (*.8ca)**
- Click **Save.**
- The background image is now ready to **Load** into the TI SmartView emulator.

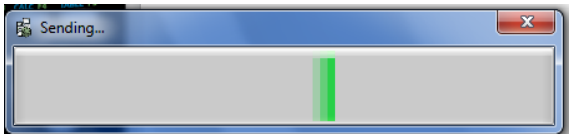


In the TI-SmartView software. Click **File** > **Load File**. In the dialog box:

- Navigate to the folder that contains the file you want to load.
- Click the file name to highlight it.
- Click **Open**.
- If the TI-SmartView™ program already contains a data item with that name, you are prompted whether to overwrite the existing file.



A Sending screen will be displayed. When the sending is complete, you can access the loaded file on your emulator.



Memory Management in the TI-84 Plus Family

TI PROFESSIONAL DEVELOPMENT

Activity Overview

This activity features how memory can be managed in the TI-84 Plus family of graphing calculators. This includes working with memory in RAM, archiving memory, and grouping files, lists, and variables for later retrieval.

Note: The TI-84 Plus C Silver Edition is referenced throughout this activity, but the information applies to the entire TI-84 Plus graphing calculator family.

Introduction

The TI-84 Plus C Silver Edition is equipped with FLASH memory: special hardware that allows you to upgrade the operating system, install special software called APPS, and utilize additional memory features. This extends the use life of the device and expands its functionality.

This document explains two ways in which you can use the memory of the calculator for backing up your work.

Archiving and Grouping

Memory in the TI-84 Plus family is divided into two sections:

1. RAM (an acronym for **R**andom **A**ccess **M**emory) is the "working memory" for most of the things that you do on the calculator: programs, lists, matrices, functions, and other data are kept in RAM. Each of these "things" that you work with in RAM is called a variable. Each variable has three properties: a name, a type, and a value.

2. ARCHIVE memory is a separate, but connected, portion of memory used for APPS, GROUPS, and "safe" storage (archiving) of your RAM variables. Memory management is important because you might need to "free up" RAM to make room for other data or programs.

Notes: **Archiving** protects your files from intentional or inadvertent resets.

Grouping allows you to make copies of files, such as one student's Lists, so that another student can use the calculator for the same activity.

Accessing Memory Features

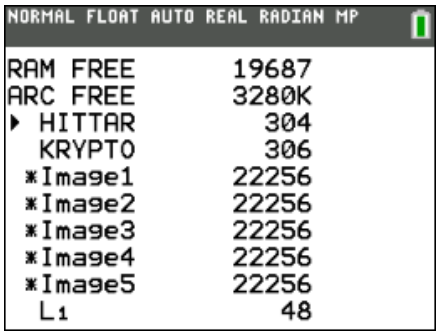
1. Press [2nd] [MEM] (on the [+] key) to access the MEMORY menu.

2. Select 2:Mem Mgmt/Del. With this option, you can delete variables or move variables between the RAM and Archive areas of memory.

   - When a variable is in RAM, it is "usable". The variable is available for general use as a "normal" variable.

Archiving

1. When the variable is in Archive memory, it is not available for use generally.
   - Apps, Pic, and Image variables are stored in Archive memory and can be used.
   - Why put a variable in archive? The main reason is to free up RAM for something else without deleting any variables.
   - You will usually put programs and lists into archive because these variables take up the most memory.
2. To archive, press [2nd] [MEM]. Then select 2:Mem Mgmt/Del. Next, select 1:All to see all of the variables in the TI-84 Plus C.



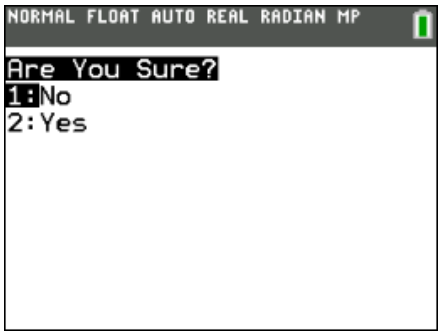
The variable list screen contains a lot of information.

- The two numbers at the top, RAM FREE and ARC FREE, are the numbers of bytes available in each portion of memory, RAM and Archive.
- On the left side of the screen is the "selection pointer" pointing to a particular variable. Move the selection pointer down or up with the arrow keys, [▲] and [▼].
- The second column (just to the left of the variable names) is the indicator that tells you whether a variable is in RAM or Archive**. A blank space indicates that it is in RAM, and an asterisk (*) indicates that it is in Archive**.
- The number on the right of the screen is the size of the variable in bytes.

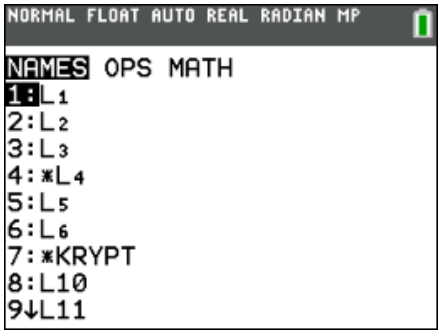
3. Press [ENTER] when the selection pointer is pointing to the variable.
   - [ENTER] switches the location of the variable.
   - "Archiving" is the act of moving a variable from RAM to Archive. "Unarchiving" is the opposite process.
   - As you move between RAM and ARCHIVE, notice the numbers at the top of the screen change to indicate new memory-free values. When you move a variable from RAM to Archive, the RAM FREE value increases and the ARC FREE value decreases by the size of the variable.
   - APPS and Pic & Image variables remain in archive and cannot be unarchived.

The Memory Management variable list screen is also used for deleting variables, although it is seldom necessary to delete variables on the TI-84 Plus. It is more convenient to move it into Archive memory.

4. To delete a variable, make sure the "selection pointer" is pointing to it, then press [DEL].
5. Some variables, programs, and anything in Archive memory provide you with one last chance to change your mind: "Are You Sure?"
   - To finally delete the variable, select 2:Yes.
   - If you decide not to delete the variable, press [ENTER] or select 1:No.



When a variable is in Archive, an asterisk appears to the left of its name in the List menu ([2nd] [STAT]) too.



- The List menu shown has two archived lists: L4 and KRYPT.
- Since L4 is in Archive memory, it is not available for regular use. If you try to make a Stat Plot using L4 while it is in Archive, you get an error message. This error message will appear whenever you try to use an archived variable.
- If a program is archived, it is not available for regular use. If you try to run the program while it is in Archive, you get an error message. This error message will appear whenever you try to use an archived program.
- If you need to use an archived variable, you must move it from Archive to RAM using the Memory Management tool.

Grouping

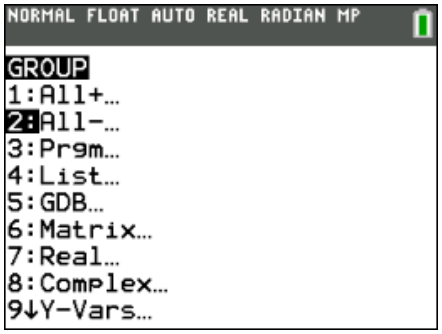
The second useful memory management tool on the TI-84 Plus C is the ability to “group” variables into a Group file. This is identical to the computer linking technique of grouping variables into a single file using TI Connect™ software (*.8xg files), but a computer is not needed here.

Grouping makes a file in the calculator containing copies of the variables that you want. Grouping does not “free up” memory. The Group file resides in Archive, so it does not use any RAM. This is a very handy tool for backing up your TI-84 Plus C variables, especially programs and lists.

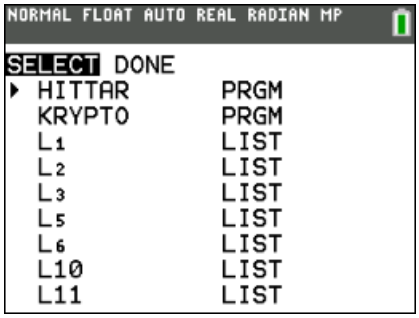
1. Select [2nd] [MEM] 8:Group.

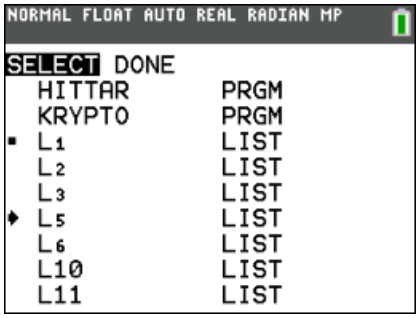
2. Select “Create New,” enter any name up to eight characters long for the GROUP file, and press [ENTER].
   - The next screen works like the LINK-selection screen.

3. Selecting 2:All gives a list of all variables in the TI-84 Plus C (that can be put into a Group file), unselected.



Just as in linking, use ▲ and ▼ to point to variables and press ENTER to select (or deselect) them for copying into the Group file.





- The two lists, L1 and L5, have been “selected” for this Group file (note the square mark).
- You might choose mixed data types as well. For instance, choose some lists, some programs, and some matrices.
- Pic & Image variables cannot be grouped.
- When you have selected all your variables, press ▶ to go to the “DONE” menu, and press ENTER to finish making the Group file.
- The Home Screen displays the message: “Copying Variables to Group: yourname”, and then displays “Done” on the right side of the screen.
- The key word here is “copying”— your variables are undisturbed in RAM. The Group file contains copies of the selected variables, just as linking transmits copies of your variables to another TI-84 Plus C.

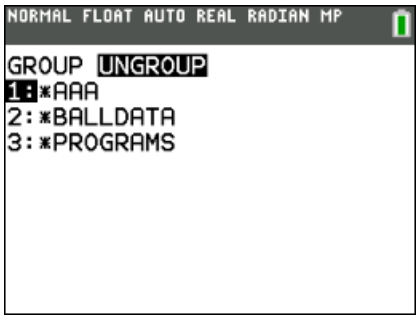
Note: You cannot have a group with just one object. Each group must contain at least two objects.

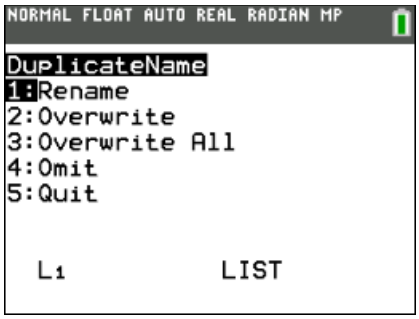
The Group files reside in Archive, so a “normal” Reset, “2nd [MEM], 7:Reset, 1:AllRam, 2:Reset”, will not disturb any Group files. These Group files can be linked (sent) to other TI-84 Plus units, and can be stored on a computer using TI Connect™ software.

Ungrouping

"Ungrouping" is the act of putting copies of the variables in a Group file back into RAM. The Group file remains intact while the variables are copied back into RAM.

1. Select 2nd [MEM] 8:Group.
2. Press ▶ to UNGROUP, and select your Group file from the listing using ▼ and ▲ (notice the asterisks – all Group files reside in Archive).
   - Press ENTER. If any of the variables in the Group file are already in RAM, then you get a "DuplicateName" menu of choices.
   - Just as in Linking, choose 2:Overwrite to overwrite the variable with the one from the Group file.





Notes:

- You cannot put an Archived variable into a Group file. Unarchive it first, then make the Group file.
- Once a Group file is established, it cannot be modified, only UNGROUPED or DELETED. Thus you cannot add variables to a group file afterward.
- When linking to a computer, you cannot make a group file on the computer containing a Group file from the TI-84 Plus.

Tip: Make a Group file of all your programs to prevent loss from inadvertent resets. When you add programs to the TI-84 Plus C that you want to keep, delete the programs Group and then make it again.

- It is convenient to Group everything on your handheld before resetting RAM. You can quickly restore everything after resetting the RAM by ungrouping the file. You can then delete that group.

Deleting A Group

1. Selecting 2nd [MEM], 2:Mem Mgmt/Del, and C:Groups gives the list of Group files.
2. Press ▼ next to one of them to delete it, and press the appropriate choice at the "Are You Sure?" menu.

Reminder: Use 2nd [MEM], 8:Group for Grouping and Ungrouping.

Use 2nd [MEM], 2:Mem Mgmt/Del, and C:Groups for viewing the size of and deleting Group files.

Tip: When the archive gets full, consider putting large Group files on a computer, and then deleting them from the TI-84 Plus.

Summary of Memory Management

- Two sections of memory: RAM and Archive.
- Archiving/Unarchiving moves variables.
- Grouping/Ungrouping copies variables.
- Archived variables are unavailable for use, except for Pic & Image.
- Grouped variables are still available for use.
- You cannot put an archived variable into a group file.
- Archived variables and group files can be transferred to other compatible calculators or a computer.
- Ungrouping leaves the group file intact.
- Rather than deleting to free up RAM, consider moving to Archive first.
- Normal Reset—2nd [MEM], 7:Reset, 1:AllRam, 2:Reset—leaves archived variables and group files intact.

Memory Management Keystroke Summary

Archive/Unarchive:

- 2nd [MEM], 2:Mem Mgmt/Del.
- 1:All (or choose your variable sub-type).
- ▼▲ to point to a variable.
- ENTER to move a variable (note the * toggle).

Group:

- 2nd [MEM], 8:Group, 1:CreateNew.
- Enter a group name.
- ▼▲ ENTER to select multiple variables (note the squares).
- ▶ to DONE.
- ENTER to execute the grouping.

Ungroup

- 2nd [MEM], 8:Group, ▶ to UNGROUP.
- ▼▲ to point to the desired group file.
- ENTER to execute the ungrouping.

Deleting Variables

- 2nd [MEM], 2:Mem Mgmt/Del.
- 1:All (or choose your variable sub-type).
- ▼▲ to point to a variable.
- DEL, possibly “Are You Sure?” will appear.

One Final Note …

On the 2nd [MEM] menu, there are two menu items, 5:Archive and 6:UnArchive. These are used in programs so that the program can manipulate specific variables’ locations.

For example, a program might contain the statement ‘Archive L1, L2, L3, L4, L5, L6’ which will move these six lists from RAM to Archive. You do not need to use these two commands unless you are programming.

TI graphing calculators are permitted on important college entrance exams.

education.ti.com/go/testprep

TEXAS INSTRUMENTS

TI-Nspire™ CX	TI-Nspire™ CX CAS	TI-Nspire™	TI-Nspire™ CAS	TI-84 Plus C Silver Edition	TI-84 Plus Silver Edition	TI-84 Plus	TI-83 Plus	TI-89 Titanium
SAT*	SAT	SAT	SAT	SAT	SAT	SAT	SAT	SAT
AP*	AP	AP	AP	AP	AP	AP	AP	AP
ACT®*		ACT		ACT	ACT	ACT	ACT	
IB®* Exam		IB Exam		IB Exam	IB Exam	IB Exam	IB Exam	
Praxis™*		Praxis		Praxis	Praxis	Praxis	Praxis	

SAT*

MAY 2013	JUN 2013	OCT 2013	NOV 2013
4	1	5**	2**

DEC 2013	JAN 2014	MAR 2014	MAY 2014
7**	25**	8**	3**

For deadlines and registration, visit **collegeboard.com/testing**.

** These anticipated test dates are provided for planning purposes and are subject to final confirmation. The finalized, confirmed test dates, when announced, may differ from the dates shown.

ACT®*

JUN 2013	SEP 2013	OCT 2013	DEC 2013
8	21	26	14

FEB 2014	APR 2014	JUN 2014	SEP 2014
8***	12	14	13

For deadlines and registration, visit **act.org**.

***No test centers are scheduled in New York for the February test dates.

AP*

MAY 2013	MAY 2013	MAY 2013	MAY 2013
6 Chemistry	8 Calculus AB|BC	10 Statistics	13 Physics B|C

MAY 2014	MAY 2014	MAY 2014	MAY 2014
5 Chemistry	7 Calculus AB|BC	9 Statistics	12 Physics B|C

For deadlines and registration, visit **apcentral.collegeboard.com**.

International Baccalaureate®* (IB) Exam/Praxis™*

For information on the IB test and test dates, visit ibo.org.

For information on the Praxis test and test dates, please visit ets.org/praxis.

Testing agencies are responsible for respective testing dates; Texas Instruments is not responsible for any testing date changes.

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