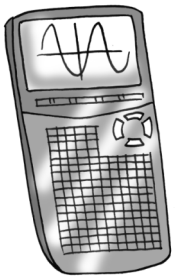
TI83+/TI-84+ Calculator Instructions



Several units in the *CPM Statistics and Probability Resource* assume that students have daily access to a TI-83+ or TI-84+ graphing calculator and that the teacher has access to a whole-class calculator display. It is expected that students will have their graphing calculators available at all times, including for any additional problems you may assign for homework.

Teachers should note that the procedures for other TI graphing calculators (TI-89, TI-73, and others), and calculators from other manufacturers, are very different.

Before teaching any lesson that uses technology, be sure to set up and test your equipment in advance to make sure that batteries, software, and the projection system are working properly. It makes sense to have extra batteries and a replacement projector bulb readily available. It also is a good idea to walk through the activity using the actual technology in the classroom yourself before the day of the lesson to review the key strokes and anticipate any issues that may arise during the lesson.

Much more detailed operating instructions for your calculator than are provided in this appendix can be downloaded from education.ti.com by clicking on "downloads" and then "guidebooks."

TI83+/TI-84+ Calculator Instructions
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X. WHOLE-CLASS PROJECTION

An option for the teacher to demonstrate calculator use to the whole class is a document camera: you can project both the calculator's screen and demonstrate which keypad buttons you are pressing.

Another option is a projector connected to a computer with a graphing calculator emulator. For the TI-SmartView calculator emulator software go to http://epsstore.ti.com and click on Computer Software / SmartView Emulator / T1-84. For a demonstration of the TI SmartView emulator in use, go to http://hotmath.com/graphing_calculators/ti84_movie_index.html. A free option for emulator software is vti.exe at http://www.ticalc.org/archives/files/fileinfo/84/8442.html ; you are required to own a TI-83+/TI-84+ calculator to activate the software.

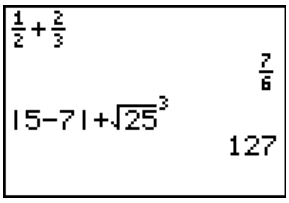
There are two other options for demonstrating calculator use to a whole class, but neither of these options are capable of displaying the keypad. Only the calculator screen in projected; the teacher cannot project which keystrokes are being entered. However, Texas Instruments can provide a wall poster of the keypad to aid a teacher in demonstrating keys pressed. A TI-Presenter connects a presentation-model TI-84 to the video input of a TV or video projector. The TI-ViewScreen is a large transparent display screen that lies on top of a traditional overhead projector. Both the TI-Presenter and the TI-ViewScreen are available from http://education.ti.com.

1. GETTING STARTED – ADJUSTING SETTINGS

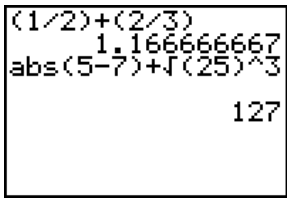
1a. "Classic" View

Recent TI-84 calculators (those with version 2.53 and later of the operating system) are set to MathPrint mode to display formulas and fractions more naturally. To determine which version of the operating system you have, press 2nd [MEM] "1:ABOUT".

These newer TI-84 calculators can be set to the older Classic mode so that they match the displays of older calculators and TI-83 calculators. Compare the newer MathPrint mode (Display 1.1) to the older Classic mode (Display 1.2) below. *All displays in this manual assume you are using an older calculator, or a newer calculator in Classic mode.*

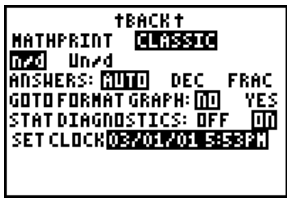


MathPrint
Display 1.1



Classic
Display 1.2

To change a newer calculator to Classic mode, press MODE, then scroll down and select "CLASSIC" (as shown in the first line of Display 1.3).



Display 1.3

You may choose to update your older TI-84 calculators to the new operating system so that all calculators can take advantage of MathPrint. (TI-83 calculators cannot be upgraded to MathPrint.) To update an older TI-84 calculator to the latest version of the operating system, you have two choices: either download the operating system from the Texas Instruments website, or, upload the operating system from another calculator that already has the latest operating system.

> DOWNLOADING THE OPERATING SYSTEM FROM THE TEXAS INSTRUMENTS WEBSITE. Load the *TI-Connect* software on to your computer. This software allows you to download programs, and it also allows you to print your calculator screen on your computer. Get *TI-Connect* from http://education.ti.com/educationportal and click on Downloads/Computer Software/Connectivity Software. Install *TI-Connect* on your computer. Then download the latest operating system to your computer from the same website. After you download the operating system file to your computer, connect your calculator to the computer with the cable. (For a TI-84, you need a USB-A to

USB-MiniB cable like many digital cameras use. For the TI-83 you need a special cable available from education.ti.com.) Drag the downloaded file over the *TI-Connect* icon to install the file on your calculator. (Be patient!)

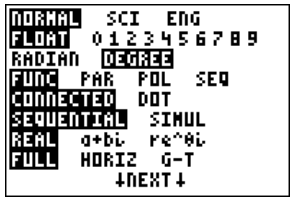
OR, GETTING THE OPERATING SYSTEM FROM ANOTHER CALCULATOR
See Section 8b on how to link two calculators.

1b. Resetting the Calculator

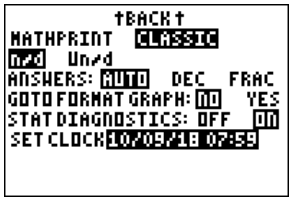
When the calculator does not behave as you expect, first turn the calculator off and then on again. (Often there is several seconds of delay before the calculator turns off.) If that still does not fix the problem, reset the calculator by pressing [2nd] [MEM] "7:Reset" "1:All RAM" "2:Reset." *Caution: This action will delete all lists, user-downloaded programs and applications, and reset all factory settings.* Nonetheless, resetting the calculator is often the quickest, easiest, and most common way to solve calculator problems in the classroom.

1c. MODE settings

Anytime you reset the calculator as in Section 1b, or if the display does not appear as you desire, check the settings for the calculator by pressing [MODE]. If you are not sure how the calculator should be set, set all of the values to match those shown in Display 1.4.



Display 1.4



Display M.100

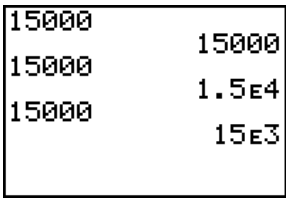
Note that TI-84 calculators with recent operating systems have a second screen of mode settings, accessed by scrolling down with the ▼ key as shown in Display M.100. Older calculators do not have this second screen of options.

Normal Sci Eng: This sets the numerical notation. Display 1.5 below shows the various ways that 15000 can be displayed. Normal uses standard notation for numbers (15000). Sci uses scientific notation (1.5E4 which stands for 1.5×10^4). Eng uses engineering notation—similar to scientific notation but all of the exponents are always in multiples of 3 (15E3 which stands for 15×10^3).

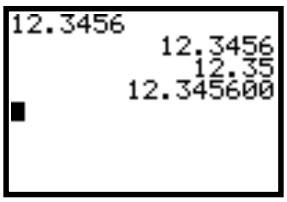
Float 0123456789: This determines how many decimal places are displayed. Display 1.6 below shows the various ways 12.3456 can be displayed based on the different mode settings. Float will automatically show up to 10 decimal places if the number contains decimals. However, if the number is an integer, then only the integer is shown. The other settings force the decimals to the number specified. 12.35 is displayed when 2 decimal places are specified (note that the last digit is rounded). 12.345600 is displayed when 6 decimal places are specified.

Radian Degree: This option sets the units for trigonometric functions. CPM *Geometry Connections* and *Algebra 2 Connections* measure angles in degrees, so you will want to *change this option to highlight "Degree."*

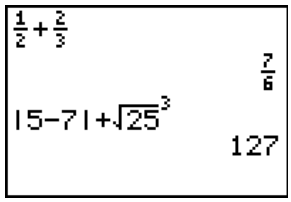
MathPrint Classic: In MathPrint mode (only on TI-84 calculators with newer operating systems), the TI-84 calculator displays formulas and fractions more naturally (Display M.101). In Classic mode, TI-84 calculator displays match the displays of older calculators and TI-83 calculators (Display M.102). *All displays in this manual assume you are using an older calculator, or a newer calculator in Classic mode.* For more information, refer to Section 1a.



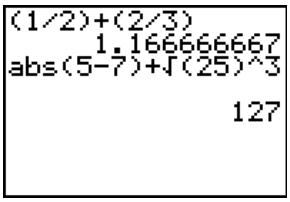
Display 1.5



Display 1.6



Display M.101



Display M.102

2. ENTERING DATA

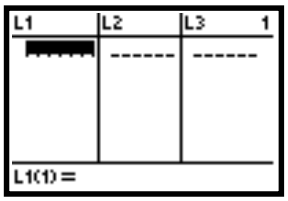
2a. Lists of Data

Press [STAT] "1:Edit" as shown in Display 2.1. This will bring up a screen similar to Display 2.2 shown below.

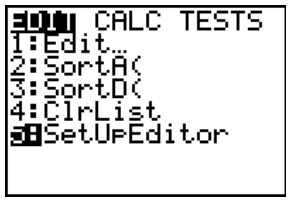
If there are values in the list already, see Section 2b on how to clear a list.

If you do not see the columns labeled L1, L2, and L3 (which stand for List 1, List 2, and List 3), scroll left or right using the [◄] or [►] keys. If you still do not see L1, L2, and L3, run the SetUpEditor by pressing [STAT] "5:SetUpEditor" as shown in Display 2.3 and Display 2.4.

Display 2.1



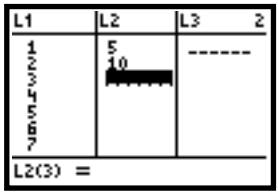
Display 2.2



Display 2.3

Display 2.4

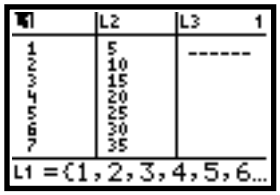
Position the cursor to the first item in List 1 as shown in Display 2.2. Key in your data then press [ENTER]. The curser will move down to the next position on the list. Make sure to press [ENTER] after keying the last data value into the list. When finishing entering data into L1, press [▸] to move to L2. Display 2.5 shows the first values entered in List 2 after List 1 is complete.



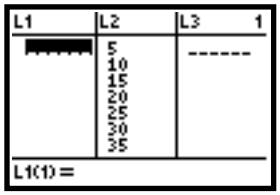
Display 2.5

2b. Clearing Lists Of Data

If you want to remove the data from List 1, move the curser onto the list name (as shown in Display 3.1). Press [CLEAR], then [ENTER], and you will clear the list as shown in Display 3.2. *Do not* select the [DEL] key; [DEL] removes the list from the screen.



Display 3.1



Display 3.2

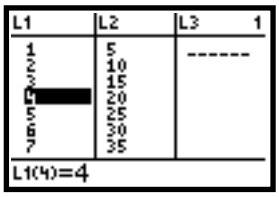
If you unintentionally press [DEL] while the cursor is on the list name, the entire list will be removed from the display. To restore the list to the screen, press [STAT] "5:SetUpEditor" as shown in Displays 2.3 and 2.4 above.

2c. Editing Lists Of Data

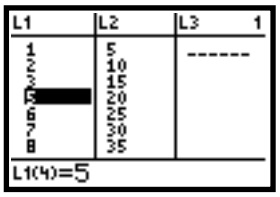
To remove an individual value from a list, move the cursor over the item to remove and press [DEL]. Note how the 4 was highlighted then deleted from List 1 in Displays 4.1 and 4.2.

To change an existing value in a list, move the curse over the number you wish to change, type the new value, and press [ENTER].

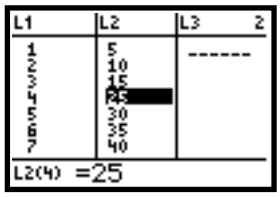
To add a number in the middle of the list, move the cursor to the value *after* the one you want to insert and press [2nd] [INS] (which will insert a zero) as shown in Displays 4.3 and 4.4. Move the cursor over the zero, type in desired value, and press [ENTER].



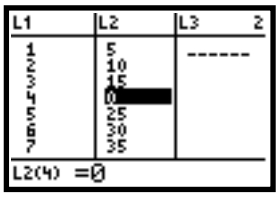
Display 4.1



Display 4.2



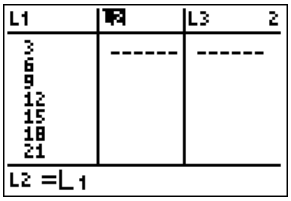
Display 4.3



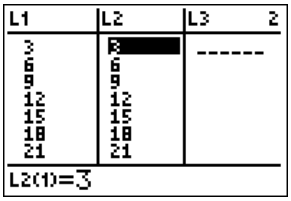
Display 4.4

2d. Copying Lists of Data

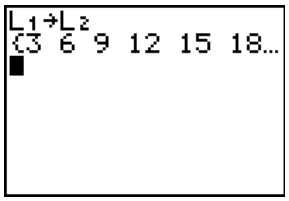
To copy List 1 to List 2, move the cursor to the label L2 and press [ENTER]. The cursor will move to the bottom of the screen. Enter [2nd] [L1], which is the name of the list you want to copy to L2, as shown in Display M.1. Press [ENTER] to copy the list, as shown in Display M.2.



Display M.1



Display M.2



Display M.3

Alternatively, you could enter [2nd] [L1] [STO▶] [2nd] [L2] at the main screen, as shown in Display M.3.

2e. Sorting Lists of Data

To sort List 1 in ascending order from low to high values, from any screen press [2nd] [LIST], submenu OPS, "2:SortA(" [2nd] L1. This will *overwrite* the original List 1 with the sorted List 1. If you want to also keep the original List 1, make a copy of List 1 into List 2 *before* sorting the list.

3. UNIVARIATE DATA

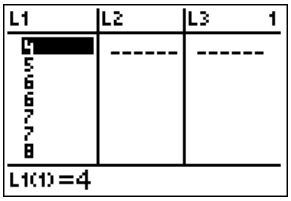
3a. Displaying a Boxplot

Enter data into List 1 as described in Section 2. For example, let List 1 contain {4 5 6 6 7 7 8 10 14 17} as shown in Display M.4.

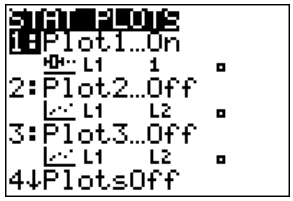
Turn off undesired graphs as follows. Press [2nd] [STAT PLOT] and verify that Plot2 and Plot3 are off, as shown in Display M.4A. If not, select "4:PlotsOff" [ENTER] to turn off all the plots. Verify that there are no functions entered in the Y= screen by pressing [Y=] then pressing [CLEAR] on each line, as shown in Display M.4B. Remember to scroll down to see all the Y= functions.

To return to the main screen, from any of the graphing screens, press [2nd] [QUIT].

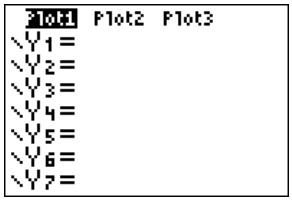
To set up a box plot, press [2nd] [STAT PLOT] "1:Plot 1..." Enter settings as shown in Display M.5. Specify the list in which the univariate data is stored at "Xlist:"; specify L1 by pressing [2nd] [L1]. (The icon of the box plot highlighted in Display M.5 will create a box plot graph displaying outliers; the other boxplot icon will not show outliers. "Freq" specifies how many times each of the pieces of data in L1 will be used.)



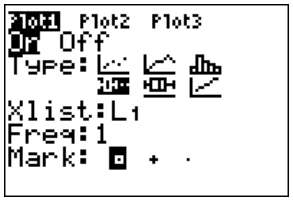
Display M.4



Display M.4A



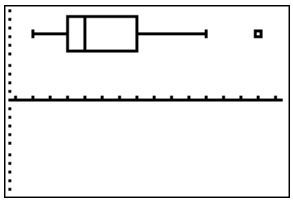
Display M.4B

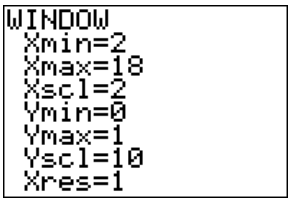


Display M.5

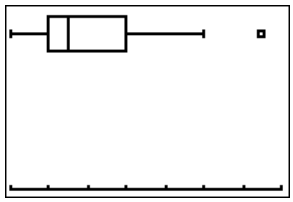
Press [ZOOM] [9]: ZoomStat to create a box plot similar to the one shown in Display M.6. The square to the right of the boxplot indicates an outlier.

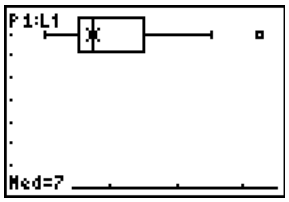
ZoomStat attempts to fit the graph in the display window, but does not make the best choices for intervals on the axes. To make better choices, press [WINDOW] and enter options as shown in Display M.7. (The minimum and the maximum of the data can be found with "1-Var Stats" as described in Section 3d, or with "SortA" as described in Section 2e. Choose Xmin less than or equal to the minimum data value, Xmax larger than or equal to the maximum data value, and Xscl as the interval between tick marks on the *x*-axis. Box plots do not have a *y*-axis; choose a Yscl that is larger than the range between Ymin and Ymax to eliminate the *y*-axis. Xres should always be set to 1.) Press [GRAPH] to display the graph as shown in Display M.8A.


Display M.6



Display M.7


Display M.8A



Display M.8B

Press [TRACE] and then [◄] or [►] to display the minimum (minX), first quartile (Q1), median (Med), third quartile (Q3), or maximum (maxX) data values, as shown in Display M.8B.

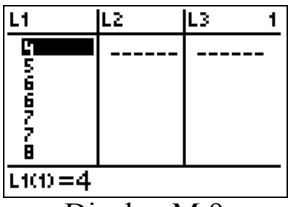
3b. Displaying a Histogram

Enter data into List 1. For example, let List 1 contain {4 5 6 6 7 7 8 10 14 17} as shown in Display M.9.

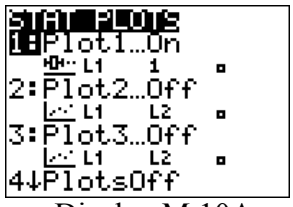
Turn off undesired graphs as follows. Press [2nd] [STAT PLOT] and verify that Plot2 and Plot3 are off, as shown in Display M.10A. If not, select "4:PlotsOff" [ENTER] to turn off all the plots. Verify that there are no functions entered in the Y= screen by pressing [Y=] then pressing [CLEAR] on each line, as shown in Display M.10B. Remember to scroll down to see all the Y= functions.

To return to the main screen, from any of the graphing screens, press [2nd] [QUIT].

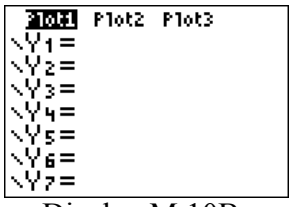
To set up a histogram, press [2nd] [STAT PLOT] "1:Plot 1..." Enter settings as shown in Display M.11. Specify the list in which the univariate data is stored at "Xlist:"; specify L1 by pressing [2nd] [L1]. "Freq" specifies how many times each of the pieces of data in L1 will be used.



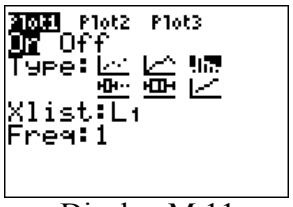
Display M.9



Display M.10A



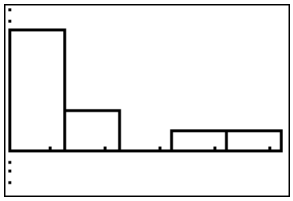
Display M.10B

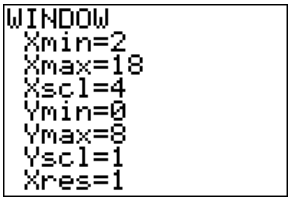


Display M.11

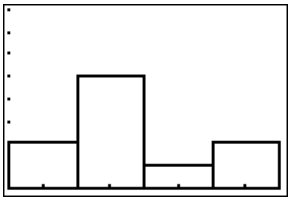
Press [ZOOM] [9]: ZoomStat to create a histogram as shown in Display M.12.

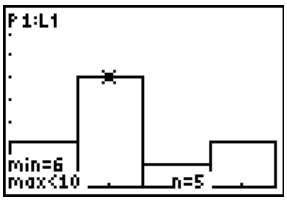
ZoomStat attempts to fit the graph in the display window, but does not make the best choices for intervals on the axes. To make better choices, press [WINDOW] and enter options as shown in Display M.13. The minimum and the maximum of the data can be found with "1-Var Stats" as described in Section 3d, or with "SortA" as described in Section 2e. Choose Xmin less than or equal to the minimum data value, Xmax *larger than* the maximum data value. Xscl is the bin width; typically the number of bins should be approximately the square root of the number of data values. Make choices for the *y*-axis using guess-and-check. Xres should always be set to 1. Press [GRAPH] to display the graph as shown in Display M.14A.


Display M.12.



Display M.13

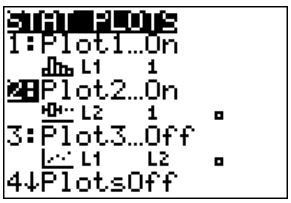

Display M.14A



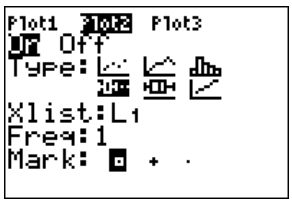
Display M.14B

Press [TRACE] and then [◄] or [►] to display the range and height of each bin, as shown in Display M.14B.

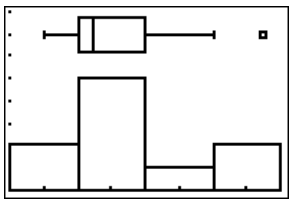
Typically, a box plot is also displayed whenever a histogram is displayed. To create both a histogram and a box plot together, set up the histogram as above. Set the windows for the histogram. Then set up a box plot in [2nd] [STAT PLOT] "2:Plot 2...," as shown in Displays M.15A and M.15B. Press [GRAPH] to display both plots together as shown in Display M.16.



Display M.15A



Display M.15B

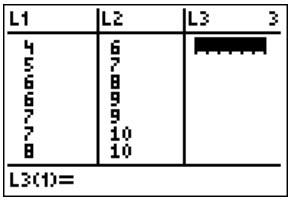

Display M.16

3c. Comparing Distributions

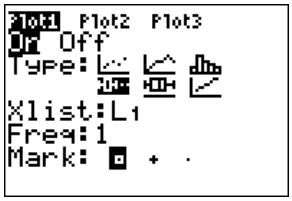
To compare two distributions, two box plots are drawn on the same axes. Enter data into List 1 and List 2. For example, let List 1 contain {4 5 6 6 7 7 8 10 14 17} and List 2 contain {6 7 8 9 9 10 10 12 12 13} as shown in Display M.17.

To set up the first box plot, press [2nd] [STAT PLOT] "1:Plot 1..." Enter settings as shown in Display M.18. Specify the first list in which the univariate data is stored at "Xlist:"; specify L1 by pressing [2nd] [L1].

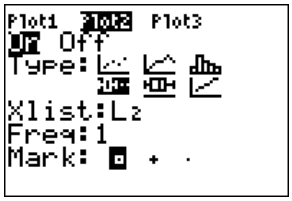
To set up the second boxplot, press [2nd] [STAT PLOT] "2:Plot 2..." Enter settings as shown in Display M.19. Specify the second list in which the univariate data to be compared is stored at "Xlist:"; specify L2 by pressing [2nd] [L2].



Display M.17

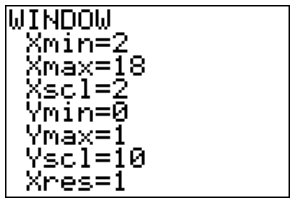


Display M.18

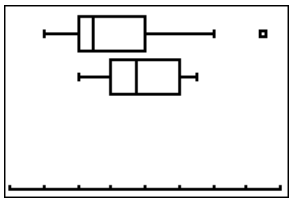


Display M.19

Press [ZOOM] [9]: ZoomStat to create a quick general comparison, or press [WINDOW] to make more appropriate choices for the axes, as shown in Display M.20. Remember that box plots do not have a *y*-axis. Press [GRAPH] to display the graph as shown in Display M.21.



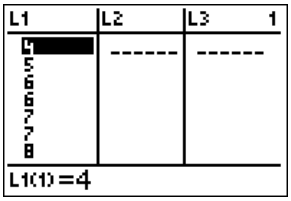
Display M.20


Display M.21

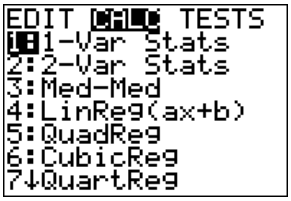
3d. Getting Statistics: Summarizing Data Numerically

Enter data into List 1. For example, let List 1 contain {4 5 6 6 7 7 8 10 14 17} as shown in Display M.22.

To get a numerical summary of the data in List 1, press [STAT], submenu CALC, "1:1-Var Stats" [2nd] [L1] as shown in Displays M.23 and M.24.



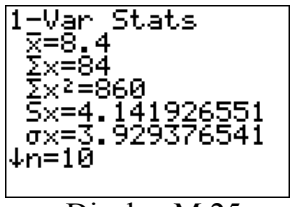
Display M.22



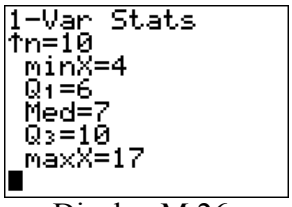
Display M.23

Display M.24

Press [ENTER] for the numerical summary. You can scroll up and down through the data by pressing [▲] and [▼] as shown in Displays M.25 and M.26.



Display M.25



Display M.26

1-Var Stats	
$\bar{x}$	mean of the list
Σx	sum of the list
Σx^2	sum of the squares of the values in the list
Sx	standard deviation if the data is a sample from the population
σx	standard deviation if the data is the whole population
n	number of items of data (sample size)
minX	minimum in the list
Q1	first quartile (median of the lower half of the data)
Med	median
Q3	third quartile (median of the upper half of the data)
maxX	maximum in the list

4. BIVARIATE DATA

4a. Setting Up A Scatter Plot

Once you have bivariate data in List 1 and List 2, a scatter plot can be used to display the data. For example, suppose you have the following bivariate data:

(4,6) (5,7) (6,8) (6,9) (7,9) (7,10) (8,10) (10,12) (14,12) (17,13)

Note that bivariate data is often displayed in a table as follows:

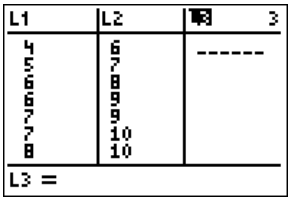
x	4	5	6	6	7	7	8	10	14	17
y	6	7	8	9	9	10	10	12	12	13

Enter the explanatory (independent x-axis) data in List 1, and the response (dependent y-axis) data in List 2 as shown in Display M.40A.

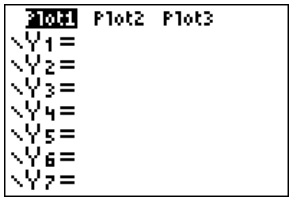
Turn off undesired graphs as follows. Press [2nd] [STAT PLOT] and verify that Plot2 and Plot3 are off, as shown in Display 6.1. If not, select "4:PlotsOff" [ENTER] to turn off all the plots. Verify that there are no functions entered in the Y= screen by pressing [Y=] then pressing [CLEAR] on each line, as shown in Display M.40B. Remember to scroll down to see all the Y= functions.

To return to the main screen, from any of the graphing screens, press [2nd] [QUIT].

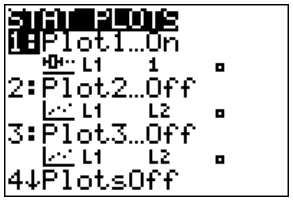
To set up a scatterplot, press [2nd] [STAT PLOT] "1:Plot 1..." Enter settings as shown in Display 6.2. Specify the list in which the explanatory (independent x-axis) data is stored at "Xlist:" by pressing [2nd] [L1]; specify the response (dependent y-axis) data at "Ylist:" by pressing [2nd] [L2].



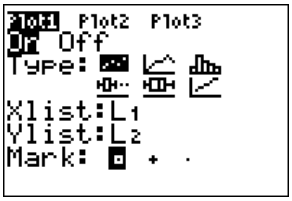
Display M.40A



Display M.40B



Display 6.1

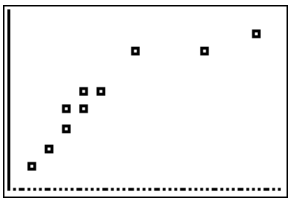


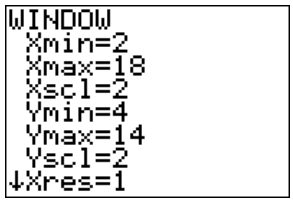
Display 6.2

Press [ZOOM] [9]: ZoomStat to create a scatterplot similar to the one shown in Display M.12.

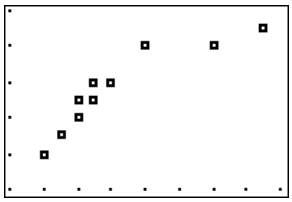
ZoomStat attempts to fit the graph on to the display, but does not make the best choices for intervals on the axes. To make better choices, press [WINDOW] and enter options as shown in Display M.13. These choices were made by looking over the data that you wish to plot and determining the smallest and largest values of *x* and *y*. The 1-VarStats function, as described in Section 3d, will find the maximum and minimum values for the data. Xmin needs to be below your lowest value of *x* and Xmax needs to be above the highest value of *x* that you have. Xscl (*x*-scale) sets where the tick marks are on the *x*-axis. Ymin, Ymax, and Yscl perform a similar function for the *y*-values. Xres should always be set to 1.

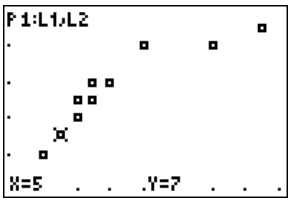
Press [GRAPH] to display the graph as shown in Display M.14A.


Display M.12



Display M.13


Display M.14A

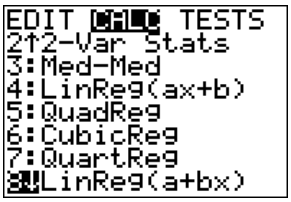


Display M.14B

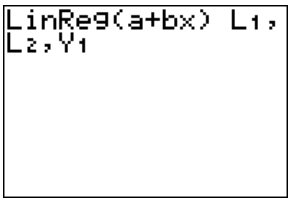
Press [TRACE] and then [◄] or [►] to display the coordinates of the individual points, as shown in Display M.14B. If the trace text overwrites a portion of your graph, press [WINDOW] and select a lower value for Ymin.

4d. Least Squares Regression Line (LSRL)

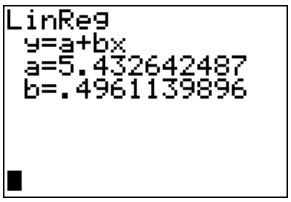
Once you have entered bivariate data in List 1 and List 2, you can find the Least Squares Regression Line of best fit. Enter [STAT], submenu CALC, "8:LinReg(a+bx)" "L1, L2, Y1" as shown in Displays M.27 and M.28. Press [ENTER] to obtain the values of a and b for the LSRL as shown in Display M.29. See the next paragraph for entering Y1 into the command.



Display M.27

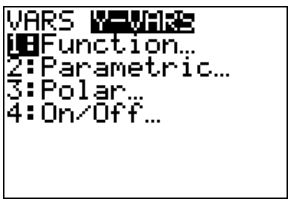


Display M.28

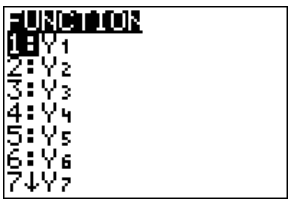


Display M.29

"Y1" is entered in the command above by pressing [VARS], submenu Y-VARS, "1:Function," "1:Y1" as shown in Displays M.30 and M.31.



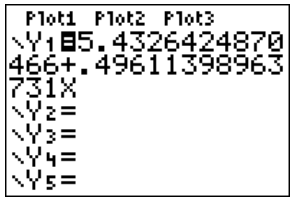
Display M.30



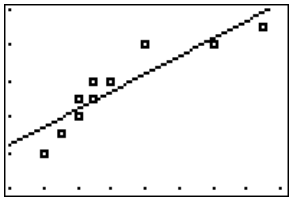
Display M.31

The calculator can also display the LSRL as y=ax+b, however y=a+bx is the standard notation in statistics and prepares students for multiple regression in future courses.

By specifying "Y1" in the command, the calculator puts the LSRL into the function Y1= as shown in Display M.32 so that it can be graphed. Once you have set up a scatter plot as described in Section 4a, press GRAPH to plot the LSRL with the scatterplot as shown in Display M.33.



Display M.32

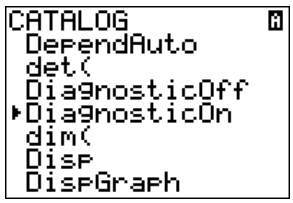

Display M.33

When specifying the lists using the LinReg command, the explanatory (independent *x*-axis) variable comes first, followed by the response (dependent *y*-axis) variable, followed by the Y= function in which you want the LSRL stored. (A different LSRL is calculated if you inadvertently switch the explanatory and responses variables.) In the example shown in Display M.28, the explanatory variable is in List 1, the response variable is in List 2, and the LSRL will be stored in Y1=.

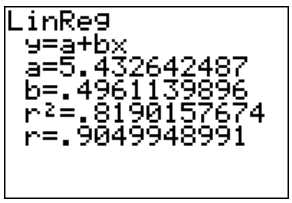
4e. Correlation Coefficient

To display the correlation coefficient, the calculator must be set up by pressing 2nd [CATALOG] "DiagnosticOn" as shown in Display M.34. The calculator will remember Diagnostics have been turned on in future calculator sessions. If you reset the calculator memory, you will need to turn DiagnosticOn again.

To display the correlation coefficient, enter the LSRL command: STAT, submenu CALC, "8:LinReg(a+bx)" "L1, L2, Y1" as shown in Display M.28. Press ENTER to display the values of a and b for the LSRL and the correlation coefficient as shown in Display M.35.



Display M.34

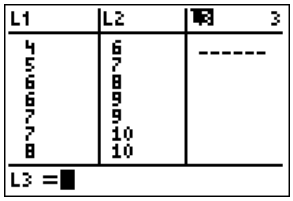


Display M.35

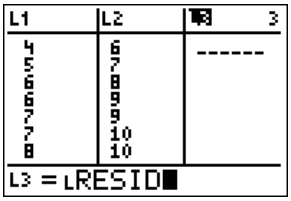
4f. Residuals

When you perform a LSRL regression, the calculator will automatically store the residuals in a list named RESID. Residuals are calculated by subtracting the *y*-value predicted by the LSRL for any bivariate point from the observed *y*-value. For example, if you entered the data from Section 4a, the residual for the point (4, 6) is –1.417 because *observed – predicted* = [6] – [5.4326 + 0.4961(4)] = –1.417.

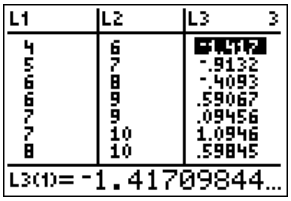
After you perform a LSRL regression for the data in List 1 and List 2, you can display the residuals in List 3 as follows. Highlight the label for List 3 as shown in Display M.36 and press [ENTER]. Press [2nd] [LIST] "RESID" as shown in Display M.37. Press [ENTER] to copy the list as shown in Display M.38A.



Display M.36



Display M.37



Display M.38A

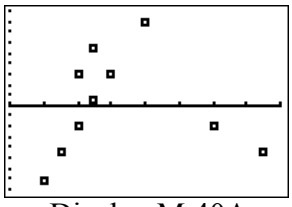
Display M.38B

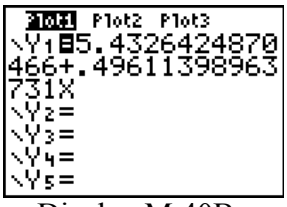
Alternatively, from the main screen you can enter [2nd] [LIST] "RESID" [ENTER] [STO▶] [L3] as shown in Display M.38B. The residuals will be copied into List 3.

4g. Residual Plots

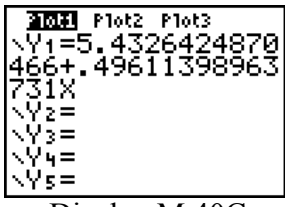
Once the residuals have been copied into a List as described above, a residual plot is created by making a scatterplot with the explanatory (independent) variable on the *x*-axis and the residuals on the *y*-axis. (Note: The Ylist is now L3.) For example, Displays M.39 and M.40A show how a scatterplot can be created from the data in Display M.38.

Display M.39


Display M.40A



Display M.40B

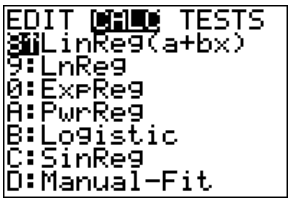


Display M.40C

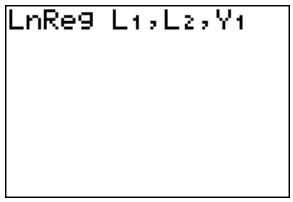
When creating a residual plot, the windows will need to set appropriately. Before making the residual plot, turn off the LSRL line in the function Y1=; the LSRL is not appropriate on a residual plot. To turn the equation "off" but keep it for later, move the cursor over the = and press [ENTER] as shown in Display M.40B. The = should no longer be highlighted as shown in Display M.40C. (Pressing [ENTER] over the = again later will highlight the = and turn the equation back on for graphing.)

4h. Non-Linear Regressions

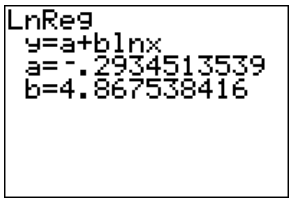
The calculator can perform non-linear regressions in a similar manner to how it creates a LSRL. For example, to perform a log regression with the data from Section 4a, press [STAT], submenu CALC, "9:LnReg" "L1, L2, Y1", then press [ENTER] as shown in Displays M.41 through M.43. Recall that "Y1" is entered by pressing [VARS], submenu Y-VARS, "1:Function" "1:Y1" as shown in Displays M.30 and M.31.



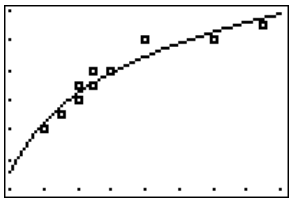
Display M.41



Display M.42



Display M.43

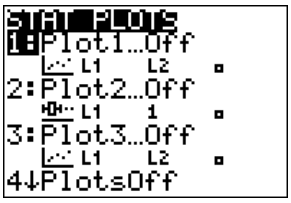

Display M.44

After setting the appropriate window, press [GRAPH] to display the non-linear regression curve as shown in Display M.44.

5. THREE REPRESENTATIONS OF FUNCTIONS

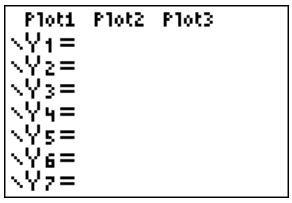
5a. Entering Equations

Turn off undesired graphs and functions as follows. Press [2nd] [STAT PLOT] and verify that all three plots are off, as shown in Display M.130. If not, select "4:PlotsOff" and press [ENTER] to turn off all the plots as shown in Display M.131. Verify that there are no functions entered in the Y= screen by pressing [Y=] then pressing [CLEAR] on each line, as shown in Display M.132. Remember to scroll down to see all the Y= functions.



Display M.130

Display M.131

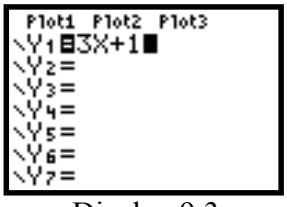


Display M.132

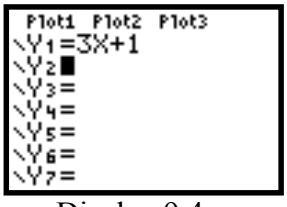
To return to the main screen, from any of the equation, graphing, or table screens, press [2nd] [QUIT].

To input an equation for graphing or creating a table, press [Y=] to bring up the Y= function window as shown in Display M.132. Move the cursor to Y1=. For example, if you wish to enter the equation $y = 3x + 1$, press [3] [X,T,Θ,n] [+] [1] as shown in Display 9.3. The [X,T,Θ,n] key places the variable x into the equation.

Note that the = sign is highlighted in Display 9.3. This shows that equation Y1 is "on" and will be graphed and tabled. To turn the equation "off" but keep it for later, move the cursor over the = and press [ENTER] as shown in Display 9.4. Pressing [ENTER] over the = sign again will turn the equation back on for graphing and tabling.



Display 9.3



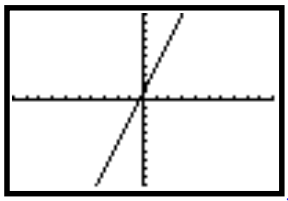
Display 9.4

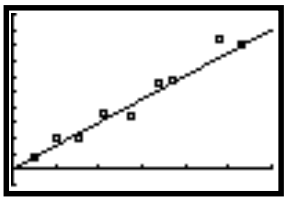
5b. Displaying A Graph

Once the equation or data has been entered, a graph can be displayed by pressing [GRAPH]. The settings that are currently in the window screen will be used to scale the axes. If you would like a standard graphing window which goes from –10 to 10 for both the *x*- and the *y*-axes, press [ZOOM] "6:ZStandard" as shown in Display 10.1. The graph of $y = 3x + 1$ after pressing [ZOOM] [6] is shown in Display 10.2.

To display both a scatterplot and the graph of an equation, set up the scatterplot and window as described in Section 4a, and set up the equation as described above. Press [GRAPH] to display both, similar to Display 10.4.

Display 10.1


Display 10.2

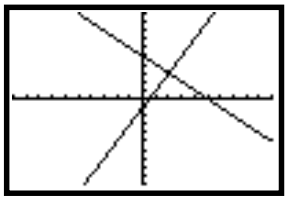
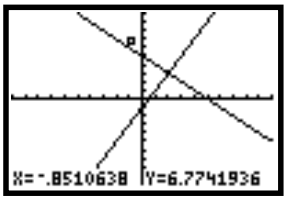
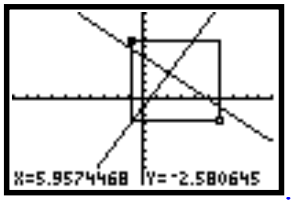
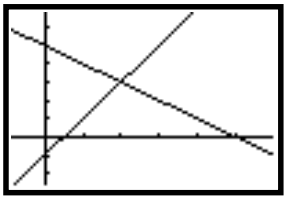

Display 10.4

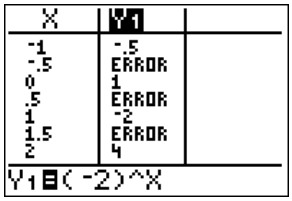
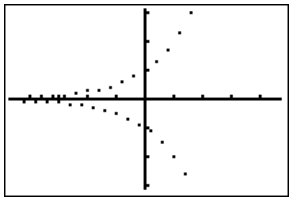
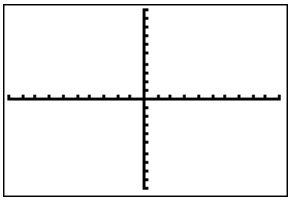
SETTING THE WINDOW

Zoom is used to quickly set the window. Pressing [ZOOM] will bring up the zoom window as shown in Display 12.1. Below is a brief description of the uses of the various zoom settings.

Display 12.1

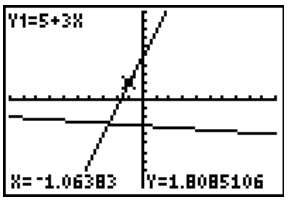
Options for zooming are as follows:

1: ZBox	Allows you to specify the region for the window by drawing a box around the region. For example, to view where two lines (like those shown in Display 13.1) intersect, press [ZOOM]"1:ZBox". Use the arrows to move the blinking cursor to the top left corner of the box you are going to create. Press [ENTER] and the cursor will change to a blinking box (Display 13.2). Use the right and down keys to form a box about the point of intersection (Display 13.3). Press [ENTER] when the box contains the desired region. The result is shown in Display 13.4.  Display 13.1  Display 13.2  Display 13.3  Display 13.4
2: Zoom In	Zooms in *at the location of the cursor* after [ENTER] is pressed. Imagine moving in closer to the graph. This will allow you to explore a smaller region in more detail.
3: Zoom Out	Zooms out *from the location of the cursor* after [ENTER] is pressed. This will allow you to see more of the graph.

4: ZDecimal	Makes tracing easier. When tracing the points on graph, the *x*-coordinates will increase by "nice" values of 0.1. However, the window is fixed from –4.7 to 4.7 on the *x*-axis and –3.1 to 3.1 on the *y*-axis. ZDecimal is also useful for graphing certain very unusual functions. Consider the function $y = (-2)^x$. The table for this function is shown in Display M.140. Pressing ZDecimal displays a correct graph as shown in Display M.141, while pressing ZStandard as in Display M.142 does not.  Display M.140  Display M.141  Display M.142
5: ZSquare	Sets the window so that the *x*- and *y*-values have the same scale and the display is not stretched in the *x*-direction. This allows the graph of a circle to look like a circle, rather than a stretched ellipse. Note that the calculator screen is not square. Since the screen is wider than it is tall, ZSquare sets the *x*-axis to a larger range of values to compensate. The midpoint of the current display becomes the midpoint of the display after ZSquare is pressed; Xscl and Yscl remain unchanged.
6: ZStandard	This will be the most common zoom setting for graphing functions in CPM *Connections* texts. It sets the window to –10 to 10 for both *x* and *y*.
7: ZTrig	Sets the window for graphing trig functions.
8: ZInteger	Resets the window to Xscl=10 and Yscl=10, centered around wherever you move the cursor to.
9: ZoomStat	Sets the window to accommodate any statistics plots that are currently turned on. ZoomStat sets the window so that all of the data will be displayed on the screen. However, it makes poor choices for the intervals on the axes.
0: ZoomFit	Adjusts Ymin and Ymax of the window so that all of the *y*-values between the current Xmin and Xmax can be displayed. Xmin and Xmax are not changed.
submenu MEMORY, 1:ZPrevious	Uses the window that was displayed before you used the most recent ZOOM key.
submenu MEMORY, **2:ZoomSto**	Stores the current viewing window. This is particularly useful for CPM *Algebra 2 Connections* where graphs are frequently made from –5 to 5 on both the *x*-axis and the *y*-axis. The –5 to 5 window can be stored with this function and recalled with ZoomRcl.
submenu MEMORY, 3:ZoomRcl	Recalls the viewing window you stored using ZoomSto above.

5c. Finding Coordinates On Graphs (Tracing)

Tracing a cursor along a line is very useful to estimate interesting points like intersections and intercepts. Press [TRACE] and then press [◄] or [►] to move along the line. The coordinates of the cursor are given at the bottom of the screen, as shown in Display M.150.



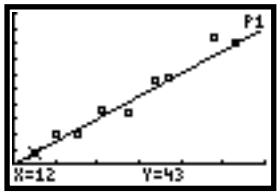
Display M.150

To "jump" the cursor to the other line, press [▲] or [▼], and then press [◄] or [►] to move along the new line.

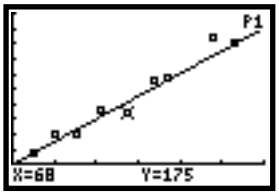
If a scatterplot is being displayed on the screen, the trace cursor will go to the first of the data points (as shown in Display 11.1) and the *x*- and *y*-coordinates of the point appear at the bottom of the window. Using [◄] and [►], you can move forward through the set of points. Display 11.2 shows a trace that has been advanced by the right arrow several times. To shift the trace to the line or other graph element, press [▲] or [▼], and then press [◄] or [►] to move along the line. Display 11.3 shows the tracing of the line.

While tracing a line or curve, you can type in a number and the trace will jump directly to that value of *x* on the graph. For example, if you wanted to know the coordinate when $x = 80$, press [TRACE] "80" [ENTER]. Display 11.4 shows how the screen will look just before pressing [ENTER]. You can enter *x*-values only for the range of the *x*-axis shown on the screen; if you get an "ERR: INVALID" message, you entered an *x*-value that was not displayed on the graph.

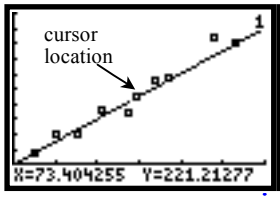
This technique of entering an *x*-value will not work when tracing points on a scatterplot.



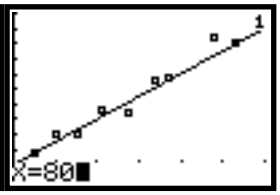
Display 11.1



Display 11.2



Display 11.3

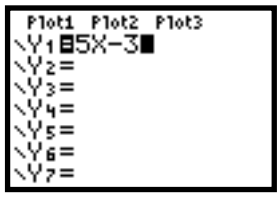


Display 11.4

To return to the main screen from any of the equation, graphing, or table screens, press [2nd] [QUIT].

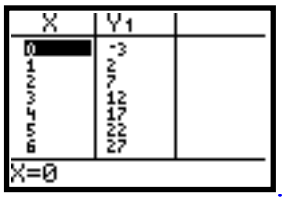
5f. Using Tables

In addition to graphing, the calculator can also show tables of values for functions. First, enter an equation into Y1= (see Section 5a) as in the example shown in Display 14.1. Press 2nd [TBLSET] to view the table setup window (Display 14.2). TblStart determines the first value for x in the table. ΔTbl sets the increment for the x-values. Leave the Independent (Indpnt) and Dependent (Depend) variables set to Auto as shown. (When set to "Ask", the values have to be entered manually.) Pressing 2nd [TABLE] will display the table as shown in Display 14.3. You can use the up and down arrows to move to values above and below the ones that are displayed. Display 14.4 shows the table if you pressed the up arrow 3 times.

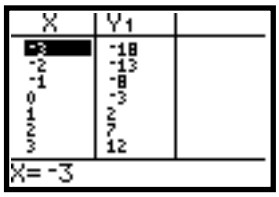


Display 14.1

Display 14.2

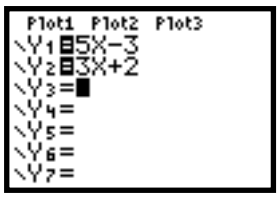


Display 14.3

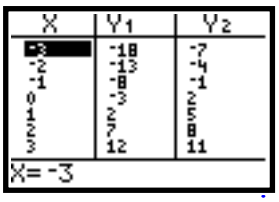


Display 14.4

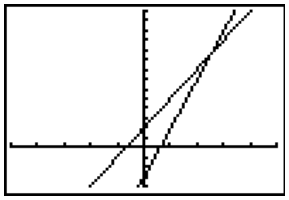
The table can show values for multiple equations at the same time. If there are two active equations (as shown in Display 14.5), the resulting table would look like Display 14.6A. As a point of interest, the graph is shown in Display 14.6B, emphasizing that all three representations of a function can be displayed with the calculator.



Display 14.5



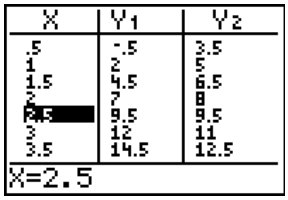
Display 14.6A



Display 14.6B

If you want to change the x-values to display in increments of 0.5 on the table, press 2nd [TBLSET] and change the ΔTbl to 0.5, as shown in Display 14.7. The resulting table with ΔTbl = 0.5 is shown in Display 14.8 below. Note that the point of intersection is found in the table by scrolling through the table until an x-value is found that has the same Y1 and Y2 values. Display 14.8B shows the point of intersection as (2.5, 9.5).

Display 14.7

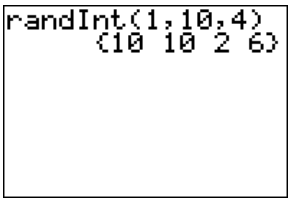


Display 14.8

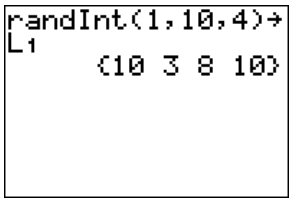
6. RANDOM NUMBERS

Before generating any random numbers, students must "seed" their calculator with a haphazard starting place for the pseudo random number generator in their calculator. If students do not take this step, all their calculators may generate the same "random" number! This step needs to be taken only once (or when the calculators are reset as in Section 1b). Have each student enter their ID number, phone number, or some other unique number, into their calculator as follows: *number* [STO▶] [MATH], submenu PRB, "1:rand". This step is crucial when generating random numbers as a class!

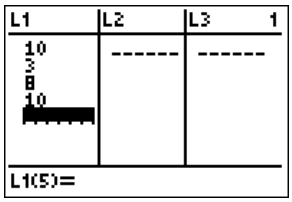
To generate random integers, you need to specify the minimum and maximum integers possible, and how many random integers to generate. For example, to generate four random integers between 1 and 10, press [MATH], submenu PRB, "5:randInt(1, 10, 4)" [ENTER] as shown in Display M.110. Of course your calculator will most likely generate different random numbers.



Display M.110



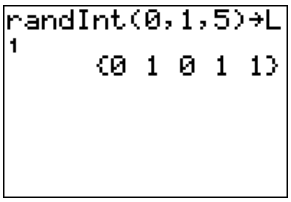
Display M.111



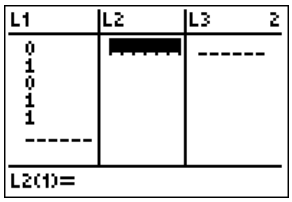
Display M.112

To put the random numbers into List 1, press [MATH], submenu PRB, "5:randInt(1, 10, 4)" [STO▶] [2nd] [L1] [ENTER] as shown in Displays M.111 and M.112. Of course your calculator will most likely generate different random numbers.

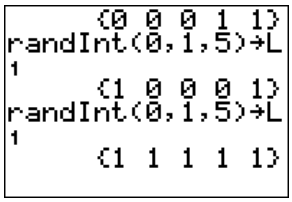
If, for example, you wish to simulate tossing five coins, you could let "1" represent heads, and "0" represent tails. Enter [MATH], submenu PRB, "5:randInt(0, 1, 5)" [STO▶] [2nd] [L1] as shown in display M.113. In List 1 as shown in Display M.114, you can count 3 heads. To "toss" the coin five more times, return to the main screen by pressing [2nd] [QUIT] and press only [ENTER] as shown in Display M.115.



Display M.113

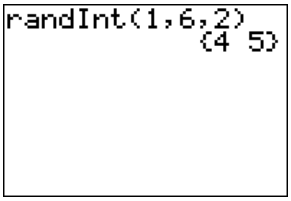


Display M.114

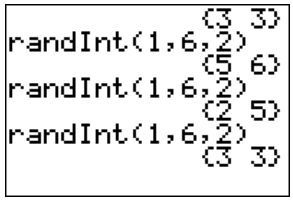


Display M.115

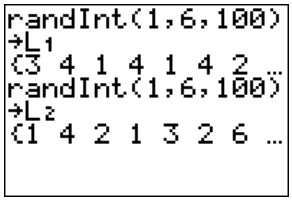
To determine how many "doubles" you get when tossing two dice, roll two dice by entering [MATH], submenu PRB, "5:randInt(1, 6, 2)" [STO▶] [2nd] [L1] as shown in display M.117. "Roll" the dice as many times as desired by pressing [ENTER] repeatedly as shown in Display M.118 while tallying how many "doubles" appear. In Display M.118, "doubles" appeared twice.



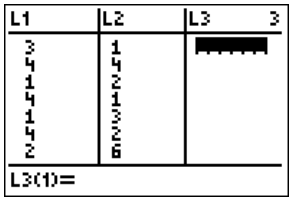
Display M.117



Display M.118



Display M.119



Display M.120

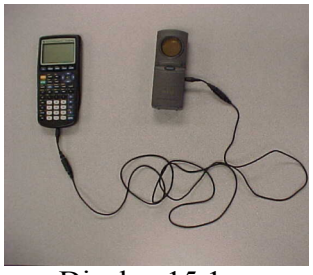
To simulate rolling two dice many times and storing the results in lists, you can place the results of the first die in List 1, and the results of the second die in List 2 as follows. Press [MATH], submenu PRB, "5:randInt(1, 6, 100)" [STO▶] [2nd] [L1] and then [MATH], submenu PRB, "5:randInt(1, 6, 100)" [STO▶] [2nd] [L2] as shown in Display M.119. Display M.120 simulates the 100 rolls of the dice.

7. USING A CBR (CALCULATOR BASED RANGER)

7a. Introduction to CBR

A CBR can be used to measure distance between the motion sensor and an object.

- Connect the calculator and CBR with a link cable as shown in Display 15.1. Flip the face of the CBR up to form a *right angle* as illustrated in Display 15.2.


Display 15.1


Display 15.2

- The CBR can be placed on the floor, on a table, or held, depending on the placement of the object that you wish to measure. Be sure that the path between the CBR and the target is clear of any objects that may interfere with the readings.

- Press [APPS], scroll to CBL/CBR and press [ENTER]. The display will be similar to Display 15.3. Display 15.4 shows the choices available. The GAUGE will allow you to check settings and just measure continual distances. The DATA LOGGER will be used to record data over time.

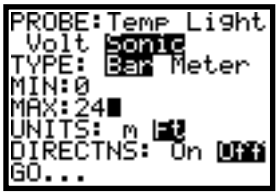
  If the CBL/CBR application is missing, it can be downloaded from education.ti.com. Follow the directions in Section 1a for downloading a file.

7c. Using Gauge

Press "1:Guage" from the screen shown in Display 15.4. Select Sonic as shown in Display 15.5. When you move the cursor over GO and press [ENTER], you will hear a clicking sound and see a display that shows a gauge and the current distance from the object. Press the (TRIGGER) button on the CBR to stop the readings. This application is useful to check the preconditions for other applications. If the readings do not make sense, check the units (feet versus meters) to see if they are set correctly. If the units are correct, try changing the angle of the CBR slightly. Pressing [2nd] [QUIT] will return to the CBL/CBR APP Screen.

Display 15.3

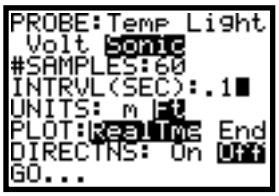
Display 15.4



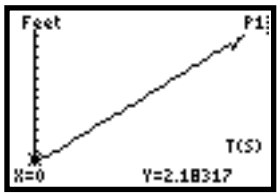
Display 15.5

7d. Using Data Logger

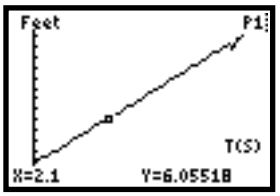
From the CBL/CBR APP screen, select "2:DATA LOGGER". Have the PROBE set to Sonic as shown in Display 15.6. #SAMPLES will determine the number of data points recorded. INTRVL(SEC) determines how often a reading is taken. Setting PLOT to RealTme will allow the graph to be viewed as the data is collected. The screen will automatically resize after all of the samples are complete. Display 15.7 shows the results of the CBR measuring an object under constant velocity. The data can be traced by pressing the left and right arrow keys. The data is automatically stored under the list names TDIST (for the *x*-values) and DIST (for the *y*-values). The graph is displayed by utilizing Plot1 as described in Section 4a. To exit the CBR/CBL Application press [2nd] [QUIT] [4].



Display 15.6

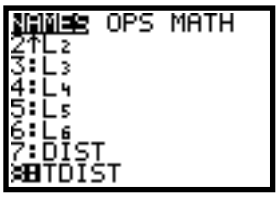


Display 15.7

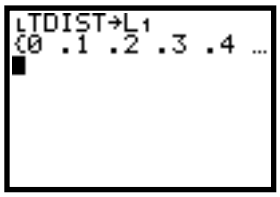


Display 15.8

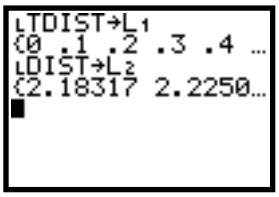
If the data needs to be retrieved, press [2nd] [LIST] and scroll to TDIST (Display 15.9) and press [ENTER]. Press [STO▶] [2nd] [L1] to store the list into L1. Recall DIST in a similar manner and store in it List 2. Both lists can be viewed at the same time by pressing [STAT] "1:Edit". The result should look similar to Display 15.12



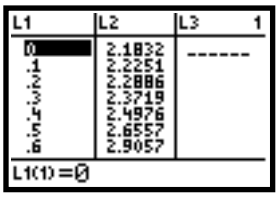
Display 15.9



Display 15.10



Display 15.11



Display 15.12

7e. Comparing the Linear Functions with Student "Walks"

Set up the scatterplot as described in Section 4a. Press [Y=] to enter the linear functions the students attempt to walk. Use the [X,T,Θ,*n*] to enter the variable *x*. Press [GRAPH] to display both the function and the student data points for their walk for comparison.

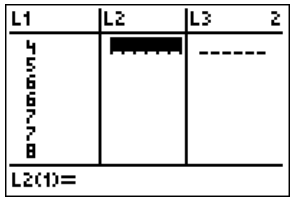
8. LARGE DATA SETS

8a. Checksums

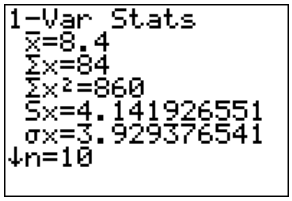
Some of the problems have large data sets that need to be entered into calculator. To assure that large data sets are entered into calculators without error, a "checksum" is provided. After students enter the data, they can use the 1-Var Stats function of their calculator to verify that the sum of the data they input matches the "checksum" value provided with the larger data sets.

For example, suppose we wish to enter the data below into the calculator:
4 5 6 6 7 7 8 10 14 17 *checksum 84*.

Enter the data into List 1 as shown in Display M.50. As a check that the data has been entered correctly, press [STAT], submenu CALC, "1:1-Var Stats" as shown in Display M.51. Since the calculator display Σx=84 matches the printed *checksum* of 84, we can be fairly confident that the data was entered correctly.



Display M.50



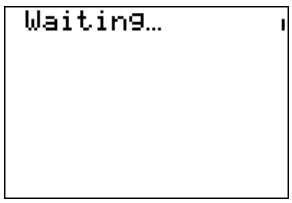
Display M.51

8b. Linking Calculators

Calculators can be linked to transfer data from the "sending" calculator to a "receiving" calculator. Connect the two calculators with the unit-to-unit (I/O) cable provided with the calculator. The cable can be ordered from http://education.ti.com or 1-800-TI-CARES.

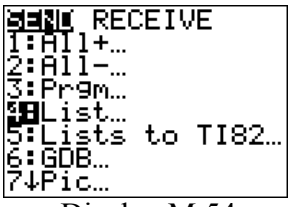
On the receiving calculator, press [2nd] [LINK], submenu RECEIVE, "1:RECEIVE" as shown in Displays M.52 and M.53.

Display M.52



Display M.53

On the sending calculator, press [2nd] [LINK] and then choose the category of items you want to send, typically "4:List..." as shown in Display M.54. Press [ENTER] to get the screen shown in Display M.55. From the screen in Display M.55, select the specific items you want to send by pressing [ENTER]. Items you have selected for sending will be preceded by a solid square ■. In Display M.55, List 1, List 2, and List 3 have been selected for sending.



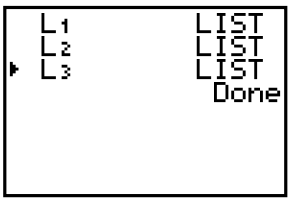
Display M.54

Display M.55

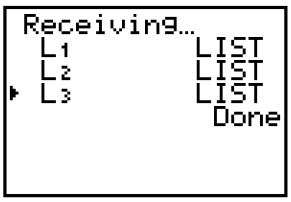
Display M.56

To send the selected items to the receiving calculator (which is displaying "Waiting..."), on the sending calculator select the submenu TRANSMIT, "1"TRANSMIT" as shown in Display M.56.

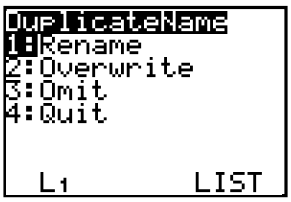
During the process of transmitting data, the sending calculator is shown in Display M.57 and the receiving calculator is shown in Display M.58. The data has been fully transmitted when both screens display "Done."



Display M.57



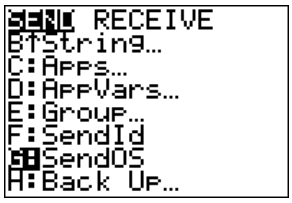
Display M.58



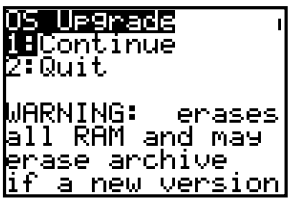
Display M.59

If the receiving calculator already contains data of the sort that the sending calculator is attempting to send, the calculator will show Display M.59. Make a selection, usually "2:Overwrite".

Linked calculators can also be used to update operating systems. Use the newer calculator to send the operating system to the older receiving calculator. To send an operating system, on the sending calculator select [2nd] [LINK] "G:SendOS" as shown in Display M.60.



Display M.60



Display M.61

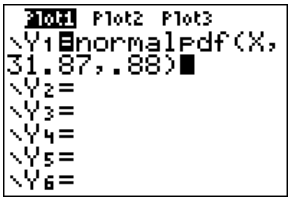
The receiving calculator will display a warning that you are about to erase all data on the receiving calculator, as shown in Display M.61. Press "1:Continue" if you want to continue with erasing all data on the receiving calculator.

A transfer of operating system is not possible unless both calculators have fresh batteries.

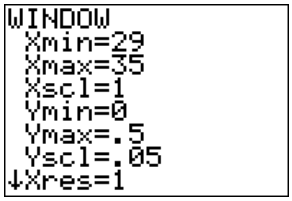
9. NORMAL CURVES

9a. Graphing a Normal Curve

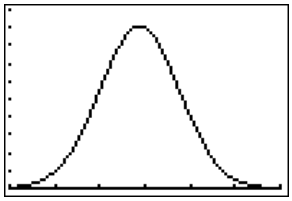
A normal curve can be graphed by entering the normal probability density function into the calculator. For example, graph a normal curve with mean 31.87 and standard deviation 0.88. Enter [Y=] [2nd] [DISTR] "1:normalpdf([X,T,Θ,n], 31.87, .88)" as shown in Display M.65.



Display M.65



Display M.66


Display M.67

Before graphing, the window will need to be set. Although normal curves extend from negative infinity to infinity on the *x*-axis, the observable part lies between negative three standard deviations and positive three standard deviations from the mean. In this example, that would be from 31.87 – 3(0.88) = 29.23 to 31.87 + 3(0.88) = 34.51. The *y*-axis will start at zero, but the maximum will need to be set by guess-and-check; a good place to start for the maximum is 0.5. Appropriate window settings are shown in Display M.66.

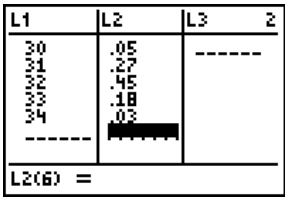
Press [GRAPH] to create the graph as shown in Display M.67.

Normal curves can be graphed on top of the relative frequency histogram which they model. Since the height of the bars in a relative frequency histogram represent the *percentages* of the total population, the sum of the frequencies in a relative frequency histogram always adds to 100%. For example, consider the data below.

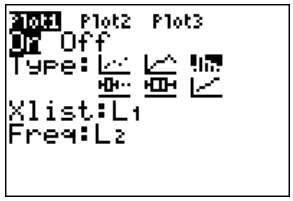
x	30	31	32	33	34
relative frequency	0.05	0.27	0.45	0.18	0.03

sum = 1

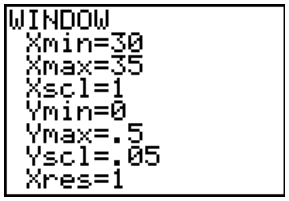
Enter the data in List 1 and List 2 as shown in Display M.68A. Create the relative frequency histogram by pressing [2nd] [STATPLOT] and entering the settings shown in Display M.68B. Note that Freq is set to L2 by pressing [2nd] [L2]. Set appropriate windows as suggested in Display M.68C. The histogram is shown in Display M.69.



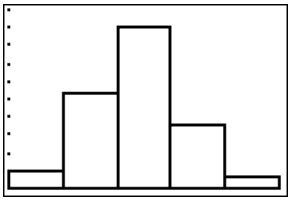
Display M.68A



Display M.68B

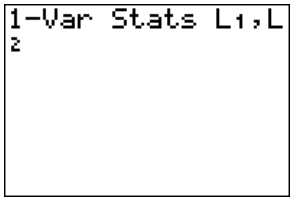


Display M.68C

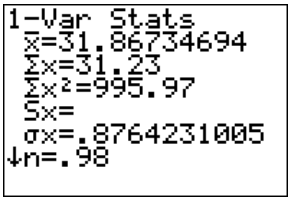

Display M.69

Determine the mean and standard deviation by pressing [STAT], submenu CALC, "1:1-Var Stats" [2nd] [L1] "," [2nd] [L2] as shown in Displays M.70 and M.71. The [2nd] [L2] in the command tells the calculator that relative frequency data is in List 2.

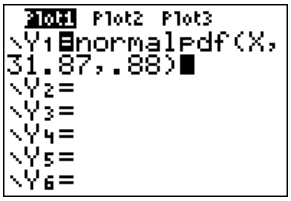
Using the mean and standard deviation from the display, define the normal function in Y1= as shown in Display M.72.



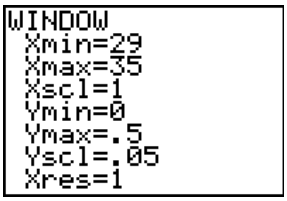
Display M.70



Display M.71

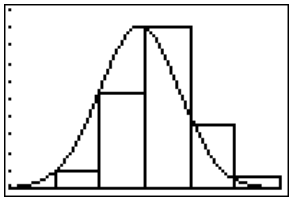


Display M.72



Display M.73

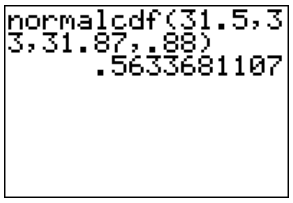
Set appropriate window values from negative three standard deviations to positive three standard deviations as shown in Display M.73. If you are going to draw a normal curve over the relative frequency histogram, the bin width (Xscl) must be 1. Press [GRAPH] to create the graph as shown in Display M.74.


Display M.74

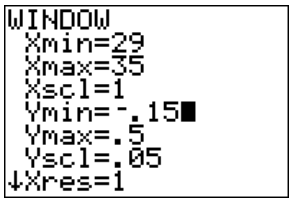
9b. Finding the Area Under a Normal Curve

Recall that the normal curve models a relative frequency histogram for which the height of the bars sum to 100%. Therefore the total area under the normal curve is always 1. The calculator can find the area under a portion of the normal curve.

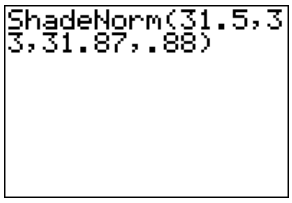
For example suppose that we are measuring the length of widgets. Some widgets are longer, and some shorter. Their lengths can be modeled with a normal curve with mean of 31.87cm and standard deviation of 0.88cm. What percentage of widgets are between 31.5cm and 33cm? To find the area under the normal curve between 31.5cm and 33cm, enter [2nd] [DISTR] "2:normalcdf(31.5, 33, 31.87, .88)" as shown in Display M.80. "normalcdf" stands for normal cumulative density function. The display indicates the area under the curve is about 0.563. Thus, according to our normal model of the lengths of widgets, 56.3% of the widgets have lengths between 31.5cm and 33cm.



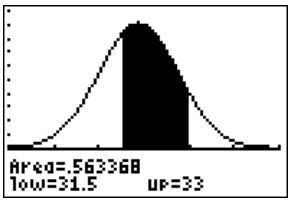
Display M.80



Display M.81



Display M.82



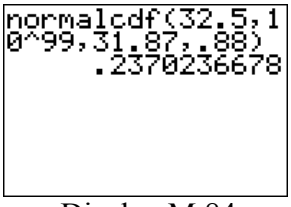
Display M.83

The calculator can graph the area under the curve. Enter an appropriate window from negative three standard deviations to positive three standard deviations as usual. However, to allow for text at the bottom of the graph, set the Ymin value to a small negative number found by guess-and-check. Appropriate windows for this example are shown in Display M.81.

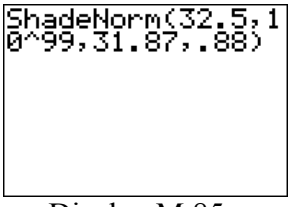
To graph, press [2nd] [DISTR], submenu DRAW, "1:ShadeNorm(31.5, 33, 31.87, .88)" as shown in Display M.82. The graph is shown in Display M.83.

To erase a ShadeNorm graph in preparation for drawing another one, press [2nd] [DRAW] "1:ClrDrw" [ENTER].

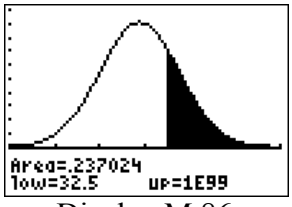
To find the proportion of widgets with length greater than 32.5cm, find the area under the curve between 32.5cm and infinity. Infinity can be represented on the calculator with 10^{99}. Enter [2nd] [DISTR] "2:normalcdf(32.5, 10^99, 31.87, .88)" as shown in Display M.84. About 23.7% of the widgets are longer than 32.5cm.



Display M.84



Display M.85



Display M.86

Or, you could have gone directly to the graph to find the area. Clear previous graphs by pressing 2nd [DRAW] "1:ClrDrw" ENTER. Enter 2nd [DISTR], submenu DRAW, "1:ShadeNorm(32.5, 10^99, 31.87, .88)" as shown in Displays M.85 and M.86.

Negative infinity can be represented on the calculator by -10^{99}. To find the proportion of widgets with length less than 31cm. Enter ENTER [DISTR] "2:normalcdf(–10^99, 31, 31.87, .88)". About 16.1% of the widgets are shorter than 31cm.