# CHAPTER 0 Calculator Notes for the TI-83 and TI-83/84 Plus

## Note 0A • Order of Operations

To evaluate expressions, the calculator uses the standard order of operations, PEMDAS (parentheses, exponents, multiplication and division, addition and subtraction). For example, when you enter the expression 1+12/4*3

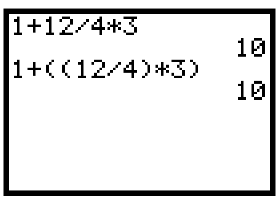
**a.** The calculator reads no parentheses or exponents.

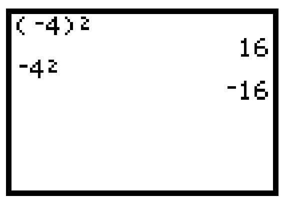
**b.** The calculator does multiplication and division from left to right: it evaluates 12/4 as 3 to get $1 + 3 * 3$, and it evaluates $3 * 3$ as 9 to get $1 + 9$.

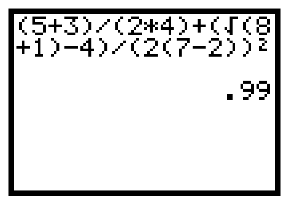
**c.** The calculator does addition and subtraction from left to right: it evaluates $1 + 9$ as 10.

Negation is on the same level as multiplication, so powers are calculated before negation. For example, −4^2 evaluates as −16. To square −4, you use parentheses: (−4)^2.

Although there are keys for the brackets and braces you use for grouping when working on paper, the calculator uses them for other things. To group on the calculator, you use only the parentheses keys. So, to evaluate the expression $\frac{5+3}{2\cdot 4}+\frac{\sqrt{8+1}-4}{(2(7-2))^2}$, you would enter (5+3)/(2*4)+(√(8+1)−4)/(2(7−2))². Study these examples and verify the results on your calculator.

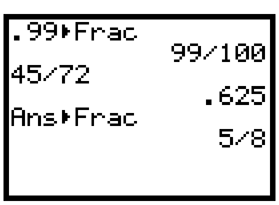


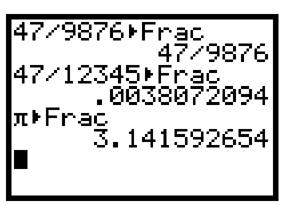




## Note 0B • Fractions

To convert fractions to decimals, use the division operation. (For example, to convert 3/5, press [3] [÷] [5].) You can also convert many decimals to fractions and reduce them to lowest terms. Type in the decimal you want, and press [MATH] [ENTER]. The window will show ▸Frac and pressing [ENTER] again will give you the fraction. Or, if you've already obtained a decimal result of a calculation, press [MATH] [ENTER] [ENTER] to see the result as a fraction in lowest terms. If the calculator does nothing to the number, the denominator (in reduced form) is more than 10,000.

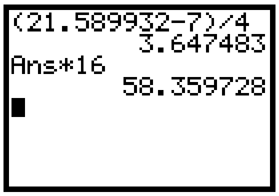


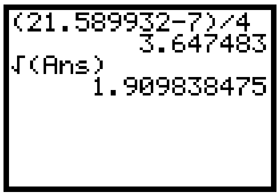



# Calculator Notes for the TI-83 and TI-83/84 Plus

## Note 1A • Reentry

If you want to do further calculation on a result you've just found, and that result is the first number in the expression you now want to evaluate, you can simply continue the expression. For example, if you've calculated a result of 3.647483, and you want to multiply by 16, press × 1 6 ENTER. If, on the other hand, you want to take the square root of that number, press 2nd [√‾] and then 2nd [ANS] ENTER to calculate $\sqrt{3.647483}$.



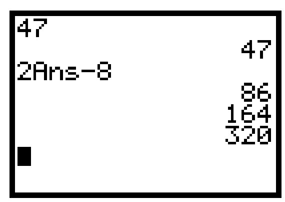

You can also recall and edit a previous expression. Press 2nd [ENTRY] and use the arrows to move across the expression and enter replacement characters. To delete characters press DEL, and to insert new characters press 2nd [INS]. When you are finished, press ENTER to recalculate the revised expression.

Repeatedly pressing 2nd [ENTRY] takes you back to previously evaluated expressions. The number of expressions you can recall depends on their length.

## Note 1B • Home Screen Recursion

The command 2nd [ANS] allows you to use the result of your last calculation in your next calculation. Also, if you press ENTER without pressing another key, the calculator will recompute the last expression. Using these two commands together gives you a recursion machine.

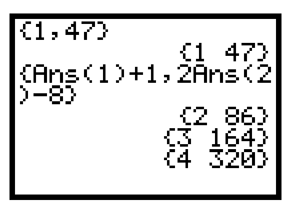
Start by entering the starting value of a sequence. Press ENTER. Now enter the rule, using 2nd [ANS] in place of $u_{n-1}$. Press ENTER repeatedly to generate the sequence. For example, this screen shows




$u_1 = 47$
$u_n = 2u_{n-1} - 8 \quad \text{where } n \geq 2$

If you go too far in the sequence, you cannot back up. You must start the process over by entering the starting value again, then the rule. You also have to start over if you lose count of the number of terms in your sequence.

One way to avoid losing count of your terms is to generate two recursive sequences at once, the first sequence counting the terms of the second. Use braces, { and }, to enclose the two sequences. This example shows the starting values of 1 and 47 in braces and separated by a comma. Use Ans(1) and Ans(2) in the rules to refer to the previous values. Here Ans(2) does not mean Ans times 2, but rather the second value of the previous list. You still have to start over if you go too far, but you can keep track of how many terms you've generated.




**(continued)**

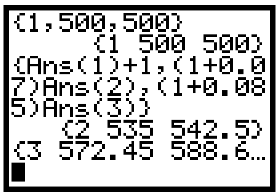
You can also use list recursion to keep track of more than two sequences at a time. In these screens the recursive formulas are

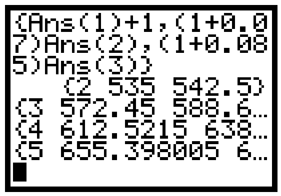
$u_1 = 500$
$u_n = (1 + 0.07)u_{n-1}$ where $n \geq 2$

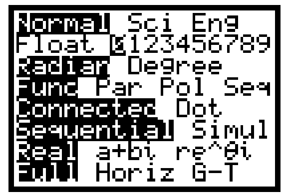
and

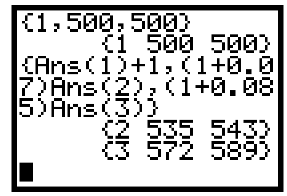
$u_1 = 500$
$u_n = (1 + 0.085)u_{n-1}$ where $n \geq 2$

If the answer list is too long, scroll to the right with the arrow key to see the last value(s). You can keep answers to a fixed length using a setting on the Mode screen that specifies the number of decimal places displayed. (See **Note 1C** for instructions on moving to and from the Mode screen.)







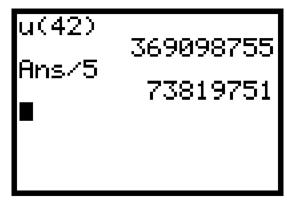



## Note 1C • Navigating Screens and Menus

You'll use a variety of screens while working with the calculator. These are the ones you'll use most often.

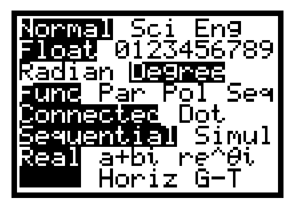
### Home Screen

Press [2nd] [QUIT]. This screen usually comes up when you turn on the calculator. You'll do almost all your calculations here.



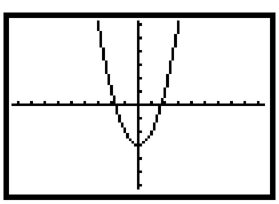

### Mode Screen

Press [MODE] to change the number of decimal places displayed, the style of graph displayed, and other settings as necessary. Most of the time, your Mode screen should look like this one.



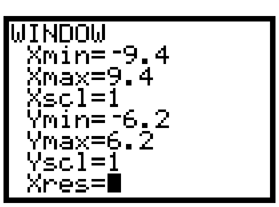

### Graph Screen

Press [GRAPH] to display graphs.



### Window Screen

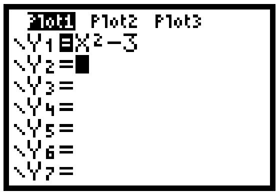
Press [WINDOW] to set the window of values that you want to graph.




**(continued)**

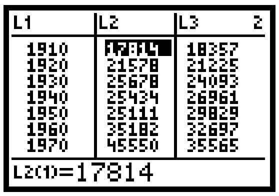
## Y= Screen

Press Y= to enter equations that you want to graph or evaluate.



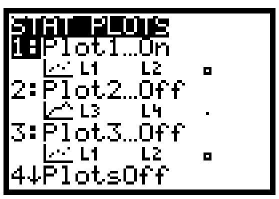

## Stat Edit Screen

Press STAT ENTER to enter and work with lists.



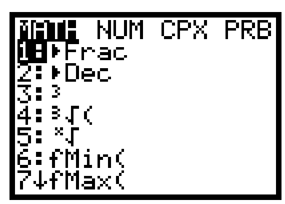

## Plot Setup Screen

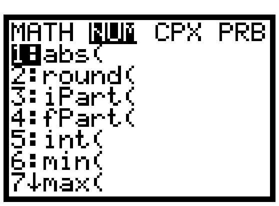
Press 2nd [STAT PLOT] to set up a box plot, histogram, or other statistics plot.

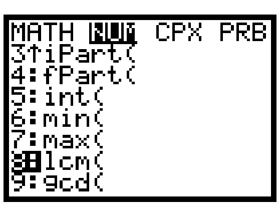


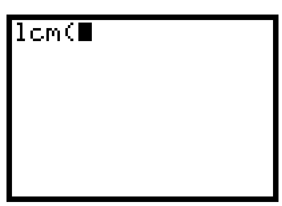

## Commands

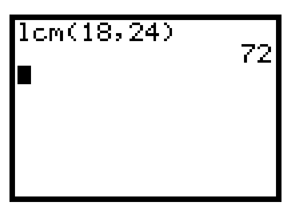
There are keys for the most common commands you'll use—numbers and operations, for example, and DEL (delete) and 2nd [INS] (insert). You'll choose other commands from menus and submenus. For example, press MATH and you will see four submenus: MATH, NUMber, ComPleX, and PRoBability. Use the right and left arrow keys to move among submenus. With each submenu, there is a list of commands. Use the up and down arrow keys followed by ENTER, or type a number, to select one of the commands. For example, to select the lcm( command in the NUM submenu, arrow right to NUM and then either arrow down repeatedly, or up twice, and press ENTER. You'll return to the Home screen. If you now type two integers, such as 18 and 24, separated by a comma, close the parentheses, and press ENTER, the calculator will display the least common multiple of 18 and 24, which is 72.



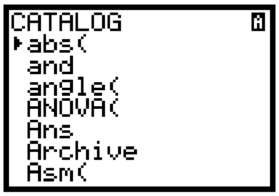




(continued)

### Finding a Command

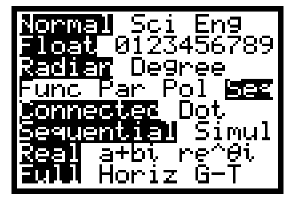
To find a command, you can press [2nd] [CATALOG] and then the first letter of the command (letters are printed in green on the calculator surface above the keys). Then use the arrow keys to scroll to and select the command. (On some calculators you can then press [+] to recall the parameters of the command.)







## Note 1D • Sequence Mode




Sequence mode is a powerful way of working with recursive formulas. Press [MODE], scroll down to the fourth line, and select **Seq**. Then go to the Y= screen.

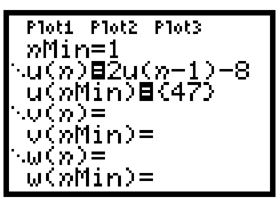
Follow these steps to enter the recursive formula

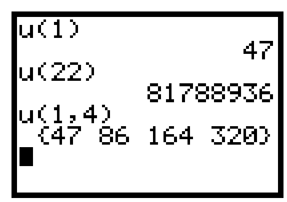
$u_1 = 47$
$u_n = 2u_{n-1} - 8 \quad \text{where } n \geq 2$

**a.** Set *n*Min to be the *n*-value of the starting term; in this example enter 1.

**b.** Enter the equation for u(*n*)=. To get $u(n-1)$ press [2nd] [u] [(] [X,T,θ,n] [−] [1] [)].

**c.** Set u(*n*Min) to be the value of the starting term; in this example enter 47. (The calculator will put the value in braces.)




You can find values of individual terms, as well as a range of terms, on the Home screen. To find $u_{22}$, press [2nd] [u] (22). To find a range of terms, use a comma between the first and last term.

## Note 1E • Graphing Sequence Mode

You can graph sequences to display numbers generated by recursive formulas. The *x*-axis will represent the values of *n*, and the *y*-axis will represent the values of $u(n)$.

Go to the Window screen. Set the window values to show the part of the graph you want to see.

*n*Min = the smallest value of *n* you want graphed on the *x*-axis. You've already set this on the Y= screen.

*n*Max = a value a little larger than the greatest value of *n* you want graphed.

(continued)

**PlotStart** = the first term of the sequence you want graphed. This is almost always 1.

**PlotStep** = the terms you want graphed. For example, if you want to plot every other term, **PlotStep=2. PlotStep** is almost always 1.

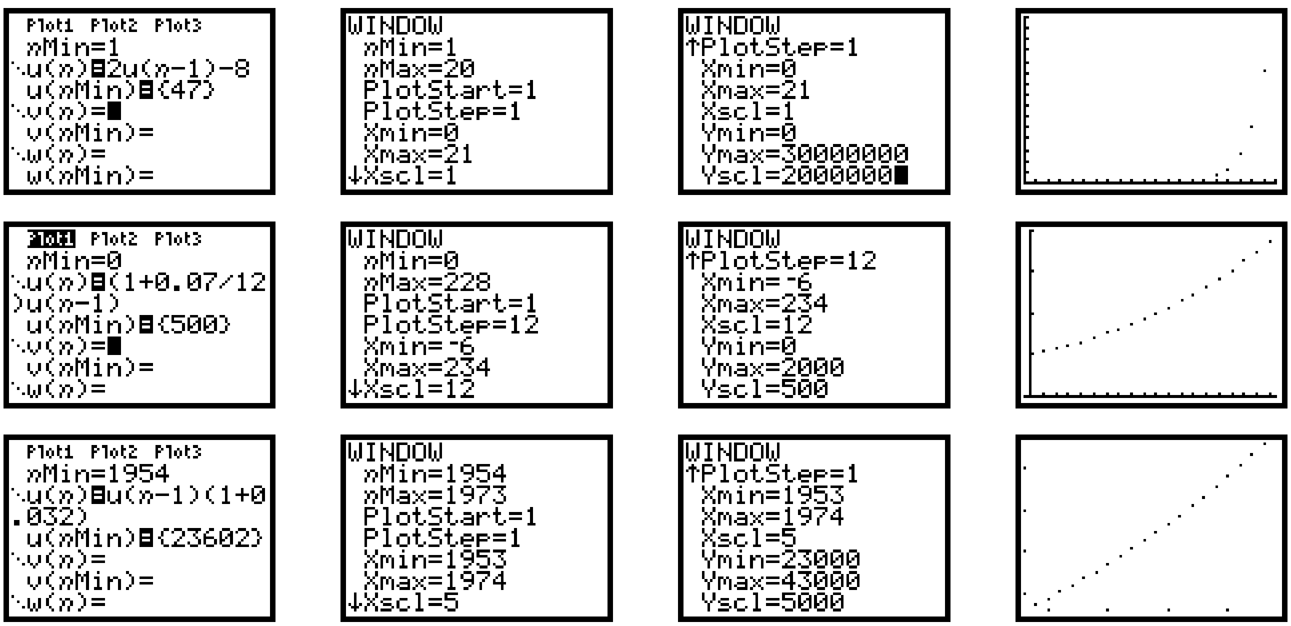
**Xmin** = and **Xmax** = the minimum and maximum values on the *x*-axis. These usually will be about the same as ***n*Min** and ***n*Max**, unless you want a close-up look at some part of the graph.

**Xscl** = and **Yscl** = the distance between tick marks on the two axes. The number of divisions should be less than 25. If there are too many tick marks, the axes will appear too thick.

**Ymin** = and **Ymax** = the range of function values you want graphed. Usually **Ymin** will be slightly less than the smallest function value and **Ymax** will be slightly greater than the largest function value.

Press GRAPH to see the graph.

These screens show graphing 20 terms of each sequence.




If you enter more than one sequence into the Y= screen, all will be graphed at the same time.

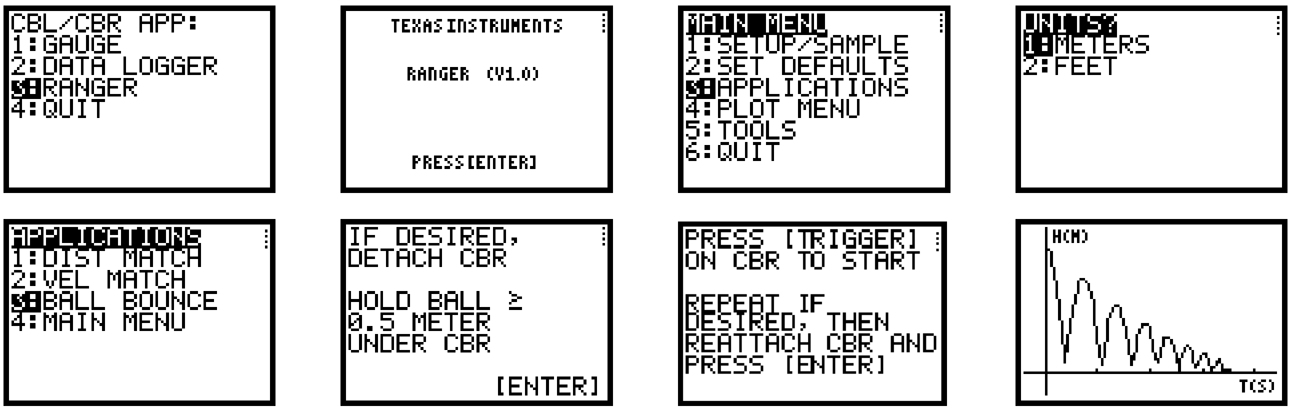
## Note 1F • Looking for the Rebound

With a link cable, connect the CBR (Calculator-Based Ranger) to the calculator. Be sure to push in each plug firmly. The application will be in either the applications menu or the programs menu. Press APPS; if **CBL/CBR** is there, choose it and select **3:RANGER**. If it isn't, press PRGM. In the submenu **EXEC**, arrow down to see if **RANGER** is one of the choices. If so, select it. Otherwise, you will need to load the program from the CBR. See **Loading the Program** in this note.

**(continued)**

Choose 3:APPLICATIONS from the MAIN MENU, and select your units. Choose the application 3:BALL BOUNCE. Press [ENTER] again for more instructions. You may now disconnect the CBR if you wish.

Hold the ball nearly a meter above the floor and the CBR half a meter above that. Release the ball as you press the trigger. When you think you have a good set of bounce data, reconnect the CBR to the calculator and press [ENTER]. You'll see a graph of your data. If you don't have good data showing at least five bounces, press [ENTER] and choose 5:REPEAT SAMPLE to repeat the experiment. When you are finished, press [ENTER] and choose 7:QUIT.




### Loading the Program

Press [2nd] [LINK], arrow to the RECEIVE submenu, and press [ENTER]. Open the pivot head of the CBR and press [83] or [82/83]. This loads the program into the calculator. If the program doesn't load, the calculator's memory may be full. The RANGER application requires about 17,500 bytes of memory. To delete items from the calculator's memory, press [2nd] [MEM]. Select **2:Mem Mgmt/Del** and arrow through the choices.

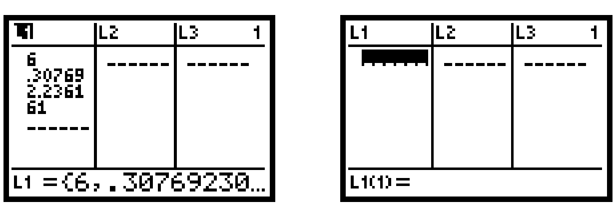
## Note 1G • Entering Data into Lists

The calculator keeps track of data through lists. It has six standard lists, lists L1 through L6. To refer to these lists, press [2nd] [L1] through [2nd] [L6].

There are several ways to enter data into a list. No matter how you enter the data, you can plot and trace the data using instructions from **Notes 1H** and **1I.**

### Clearing Data

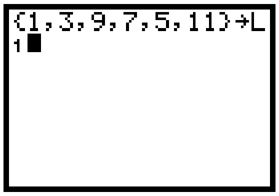
If a list already has data in it, arrow up to the list name and press [CLEAR] [ENTER].

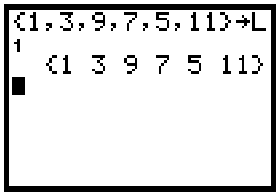


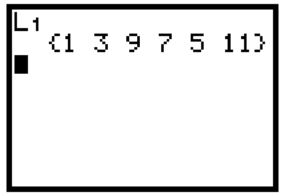

(continued)

### Entering Data into a List from the Home Screen

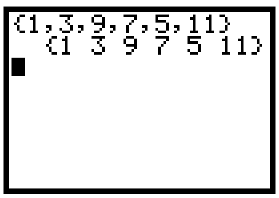
If you are working with a short list, you may want to enter it from the Home screen. If you enter 2nd [{] 1, 3, 9, 7, 5, 11 2nd [}] STO➔ 2nd [L1] ENTER, list L1 will contain those six numbers. To view the list on the Home screen, press 2nd [L1] ENTER.

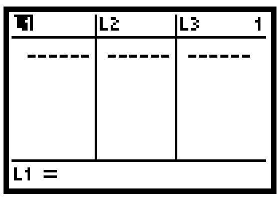






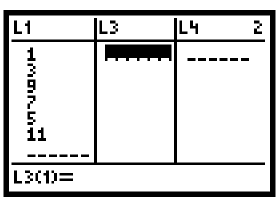

You can also enter a list into the Home screen without storing it in a stat list.

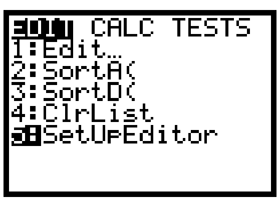


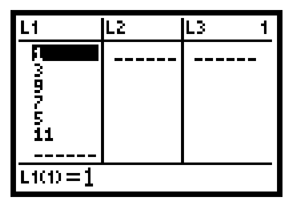



### Entering Data Directly into a List

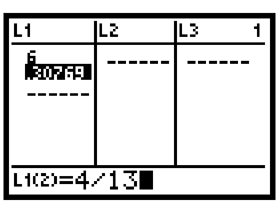
To enter a list into the Stat Edit screen, press STAT ENTER. You'll see three lists. You can arrow to the left or right to see the other three lists. (If the six standard lists don't appear, press STAT, select EDIT, arrow down to 5:SetUpEditor, then press ENTER.)

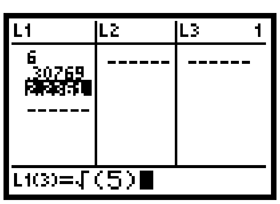


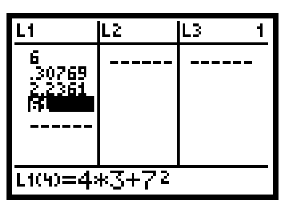





Enter or edit values in the list by typing numbers, expressions, fractions, or functions. Press ENTER after each value. All values are converted to decimals.







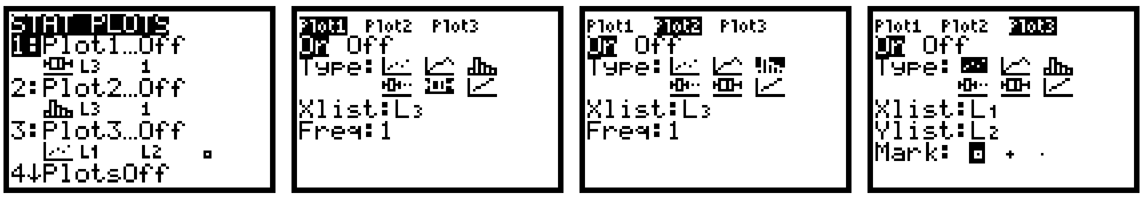
## Note 1H • Stat Plots

To set up a plot of the data stored in a list, press 2nd [STAT PLOT] and select one of the plots by scrolling down and pressing ENTER. Then follow these steps:

**a.** Select **On**.

**b.** Select one of the six plot forms: scatter plot, xyline plot, histogram, modified box plot, regular box plot, or normal probability plot (not used in this course).

**c.** Enter the lists to be used in the stat plot. For one-variable plots (box plots and histograms) enter one list, but for scatter plots and xyline plots enter a list into **Xlist** for the *x*-axis and a list into **Ylist** for the *y*-axis.




**d.** For one-variable plots, **Frequency** indicates the number of times each data point occurs in the data set. Usually **Freq** is set as **1**.

**e.** For scatter plots, xyline plots, and modified box plots, select the **Mark** to use in the plot. If you graph more than one plot at the same time, use a different **Mark** for each plot.

Before viewing the plot, you need to decide what part of the graph you want to view. Press WINDOW.

**Xmin** = a number slightly less than the smallest *x*-value you want displayed.

**Xmax** = a number slightly greater than the largest *x*-value you want displayed.

**Xscl** = and **Yscl** = the distance between tick marks on the two axes. The number of divisions should be less than 25. If there are too many tick marks, the axes will appear too thick.

**Ymin** = a number slightly less than the smallest *y*-value.

**Ymax** = a number slightly greater than the largest *y*-value.

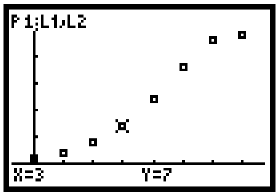
**Xres** = **1**.

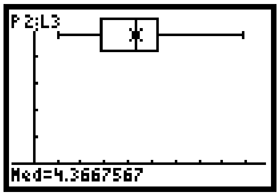
For more information about setting the window for box plots and histograms, see **Notes 2C** and **2D.**

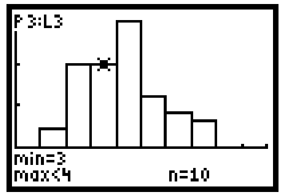
Press GRAPH to see the plot.

## Note 1I • Tracing

If you have a plot displayed and you press [TRACE], a "spider" will appear on the plot. Use the right and left arrow keys to move the spider along the plot. The spider's position is given at the bottom of the screen.



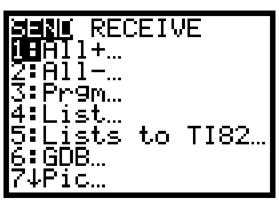

For scatter plots the data are traced in the order they appear in the list, so pressing the left arrow may not move the spider left. One-variable plots always trace the same way, histograms from the left and box plots from the center.

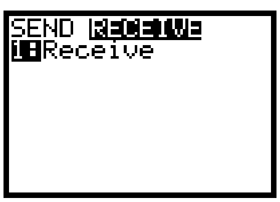
If you have displayed several plots at once, the spider will begin on the first stat plot that is turned on. Pressing the up and down arrow keys makes the spider jump to another stat plot. The top of the screen tells you the plot the spider is on and the lists being used.

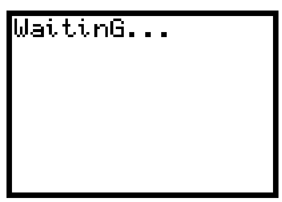
## Note 1J • Linking Lists

You can copy lists from one calculator into another. This can save time and ensure that you're working from the same data set as others. You will need a link cable and two compatible calculators. The TI-83, TI-83 Plus, TI-82, and TI-73 can all share list information, though the TI-82 can share only lists $L_1$ through $L_6$ and not any named lists.

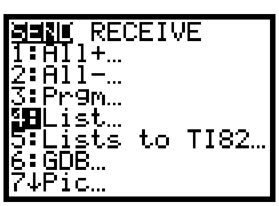
Push the plug firmly into the ports at the bases of both calculators. Press [2nd] [LINK] on each calculator. On the receiving calculator, choose RECEIVE and press [ENTER]. This calculator should read Waiting... at the top of the screen.

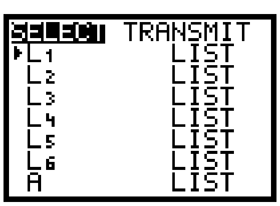


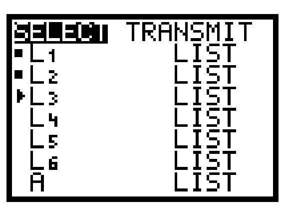



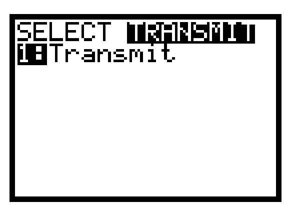




On the calculator with the data, select **4:List...** (or **5:Lists to TI82** if you are sending to a TI-82). Arrow down to a list you want to send and press [ENTER]. This marks the list but does not send it. Mark each list you wish to send.



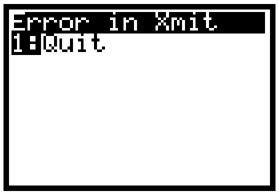



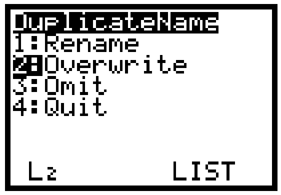



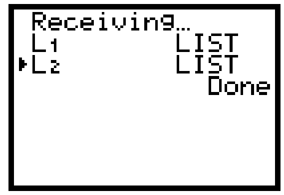




(continued)

When you have marked all the lists, press the right or left arrow to go to the TRANSMIT submenu. Press [ENTER]. If either calculator gives a LINK ERROR message, then push the link cable in again and start over. If the list you are sending already exists in the receiving calculator, choose 2:Overwrite to replace this list with the new list.

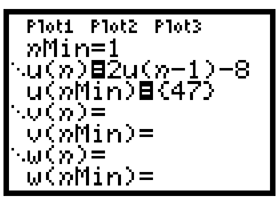


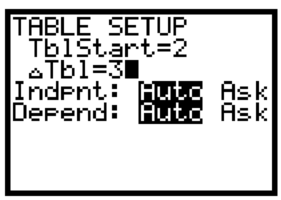



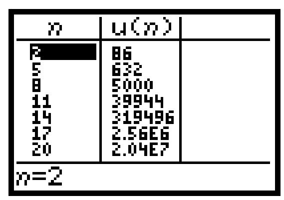




## Note 1K • Sequence Tables

You can view many elements of a sequence at once by using sequence tables. First enter the sequence into the Y= screen. (See **Note 1D** if you need help entering a sequence.) Then press [2nd] [TBLSET]. **TblStart** is the smallest *n*-value for which you wish to see a sequence value. The value of ΔTbl specifies which terms will actually be displayed. For example, if ΔTbl=3 the table will display every third term. Press [2nd] [TABLE] to display the table. Use the up and down arrow keys to see more *x*-values, or the right and left arrow keys to see values of other sequences that are entered.



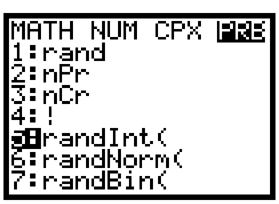



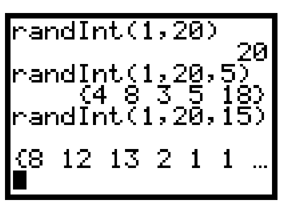

## Note 1L • Random Numbers

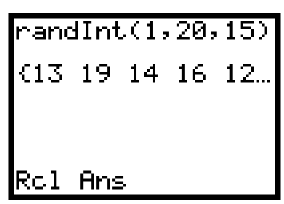
There are several ways to generate a list of random numbers within an interval.

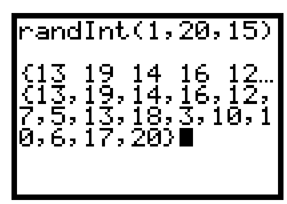
### Random Integers

To find a random integer between 1 and 20, on the Home screen press [MATH] and arrow to PRB. Select 5:randInt( and enter 1,20), then press [ENTER]. If you want five random numbers, either press [ENTER] five times, or enter randInt(1,20,5) and press [ENTER]. If you ask for more numbers than show on one line of the screen, you can scroll to see the rest of the list. Or you can press [2nd] [RCL] [2nd] [ANS] [ENTER] to see the entire list on the screen.



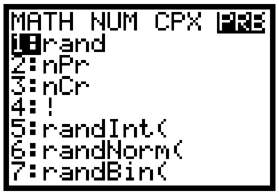



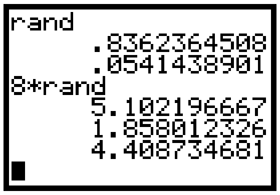




**(continued)**

### Random Decimal Numbers

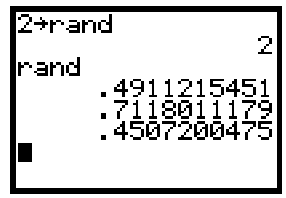
Press [MATH], arrow to PRB, and select 1:rand. Then press [ENTER] to display a random decimal number between 0 and 1. To generate a random decimal number between 0 and 8, enter 8*rand.




### Errors

If you are getting exactly the same random numbers as someone else, try changing the seed value. Enter a number other than 0 and press [STO→] [MATH], select PRB, and press [ENTER].




## Note 1M • Finance Mode

The Finance TVM (Time Value of Money) solver will solve problems about simple loans, mortgages, and investments. Press [APPS] and select 1:FINANCE. (On the TI-83 press [2nd] [FINANCE].) Choose 1:TVM Solver.... Enter values into all but one of the following positions. The solver will then calculate the missing entry. In general, negative amounts indicate money you give to the bank and positive amounts indicate money you receive.

N = the total number of payments.

I% = the annual interest rate as a percent.

PV = the principal or starting value (this is negative for investments).

PMT = the payment or regular deposit (this is negative for investments).

FV = the final value.

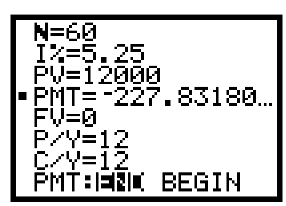
P/Y = payments per year.

C/Y = interest calculations per year.

PMT:END BEGIN indicates whether payments are made at the end or beginning of each month.

After entering the six known values, highlight the value you want to find and press [ALPHA] [SOLVE].

This screen shows calculating the monthly payment to completely repay a 5-year (60-month) $12,000 loan at 5.25% interest, with payments made at the end of each month. The answer, PMT, is negative because it is a payment made to the bank.



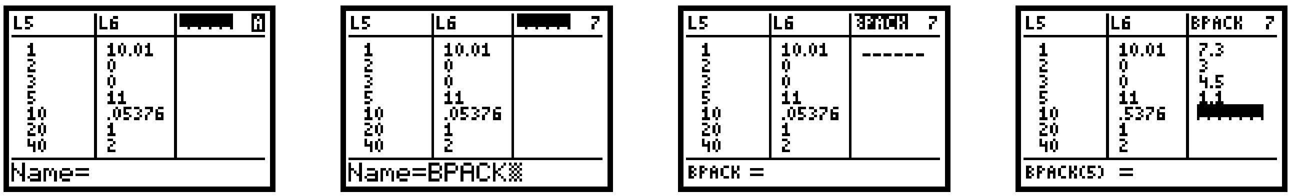
# Calculator Notes for the TI-83 and TI-83/84 Plus

## Note 2A • Naming Lists

In addition to the six standard lists L1 through L6, you can create more lists as needed. You can also give the standard lists meaningful names (of five or fewer characters) to help you remember what data are where. Here are three ways to name a list.

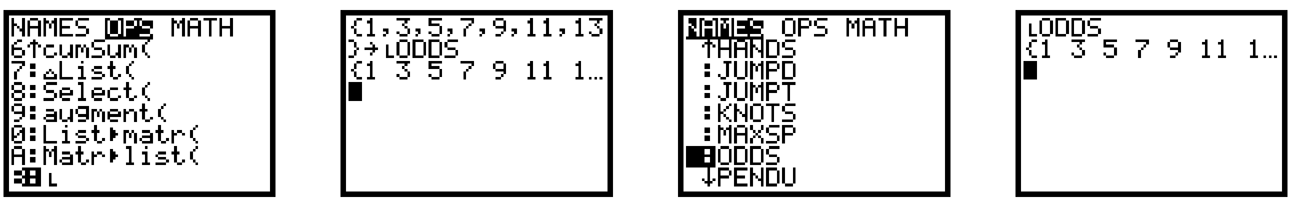
### Naming a List on the Stat Edit Screen

Press STAT ENTER and arrow up to a list name. Then arrow right to the list that immediately follows the last named list. Its name field will be blank. You are now in Alpha Lock mode, so type a name for your list and press ENTER. You can now enter list values.



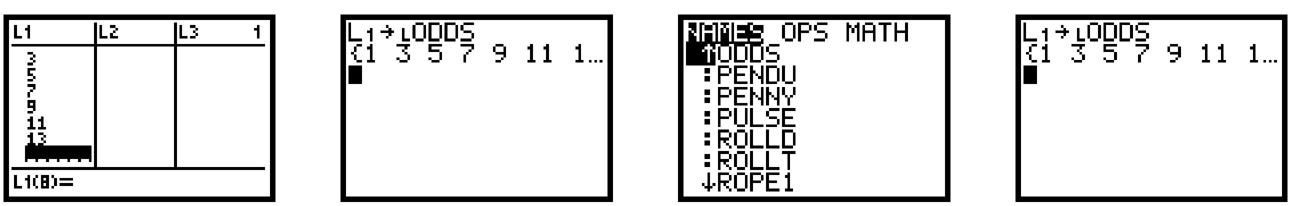

### Naming a List on the Home Screen

If you're entering this short list into the Home screen and you want to name it ODDS, type {1,3,5,7,9,11,13} and press STO➔ 2nd [LIST] OPS, then arrow down to B:L. Enter your list name by pressing ALPHA, the alphabet keys, and then ENTER. To refer to that list in the future, press 2nd [LIST] NAMES, choose the list name, and press ENTER.




### Copying and Naming Data from a Standard List

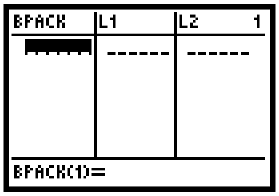
If you have data in a standard list, such as list L1, you can copy the data into another list and then name that list. On the Home screen, press 2nd [L1] STO➔ 2nd [LIST] OPS and arrow down to B:L. Use Alpha Lock mode to type a list name, and then press ENTER. To display the list, press 2nd [LIST] NAMES, arrow to your list, and press ENTER.

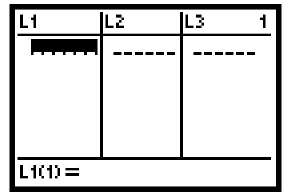



**(continued)**

### Resetting a List

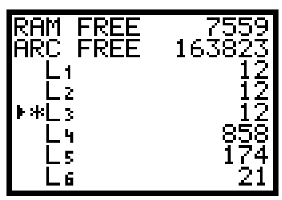
To reset the calculator so that only lists $L_1$ through $L_6$ are displayed, press STAT 5 (**SetUpEditor**) ENTER. This action will not delete a named list from the calculator's memory and you will still be able to recall a named list with its stored data.

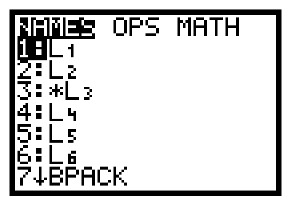





### Deleting and Archiving a List

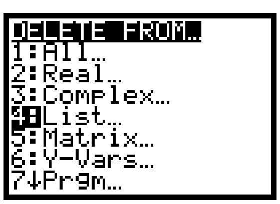
To delete a list, press 2nd [MEM], select **2:Mem Mgnt/Del…**, and then **4:List…**, arrow to the list you want to delete, and press DEL. You can delete a pre-set list or a named list. If you delete a list, you lose the data in the list. To avoid losing the data, instead of pressing DEL, press ENTER to mark the list with an asterisk. This is called archiving and will temporarily disable the list(s) you mark. An archived list will not appear on the screen when you press STAT 1 (**Edit…**). By pressing 2nd [LIST] you can see that each archived list is preceded by an asterisk. An archived list retains its data but cannot be used until it is enabled. To enable an archived list, press 2nd [MEM], select **2:Mem Mgnt…**, **4:List**, arrow to the list you want to enable, and press ENTER. The asterisk disappears.

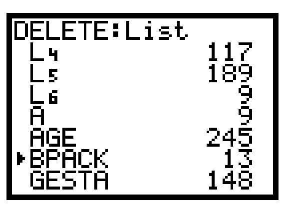


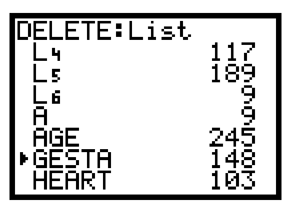



### Deleting a List on the TI-83

To delete a list, press 2nd [MEM], select **2:Delete…**, and then **4:List…**, arrow to the list you want to delete, and press ENTER. You can delete a pre-set list or a named list. If you delete a list, you lose the data in the list. You cannot archive data on the TI-83.





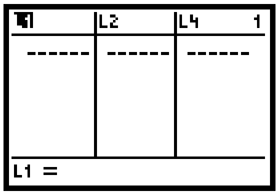


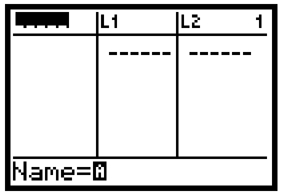

### Recalling a List

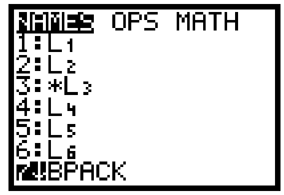
Press STAT 1 (**Edit…**) to display the current lists. Next, create a blank, nameless list by highlighting a list name and pressing 2nd [INS]. To recall one of the pre-set lists (lists $L_1$ through $L_6$) that you previously deleted, press 2nd [$L_1$] or 2nd [$L_2$] and so on, and ENTER. The name will reappear but not the data. (You can recall all the deleted pre-set list names by using the

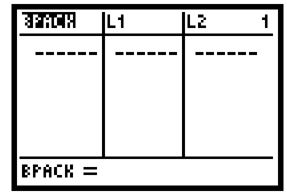
**(continued)**

**Resetting a List** procedure.) To recall a previously named list that was hidden from view by resetting a list, press [2nd] [LIST], arrow down to the list you want to recall, and press [ENTER] [ENTER]. The list name and data reappear. Note that you cannot recall a list that is archived unless you enable it first. Using the **Resetting a List** procedure will enable lists L1 through L6 whether they are archived or not.




## Note 2B • Analyzing Data

You can get several standard statistics for a data set stored in a list. Press [STAT] CALC 1:1-Var Stats, enter the name of the list, and press [ENTER]. If the frequencies of the data values are stored in another list, enter both list names separated by a comma. The following values will be displayed.

$\bar{x}$ = the mean.

$\Sigma x$ = the sum of the $x$-values.

$\Sigma x^2$ = the sum of the squares of the $x$-values.

Sx = the sample standard deviation.

$\sigma x$ = the population standard deviation.

n = the number of data values.

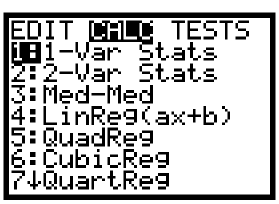
minX = the minimum data value.

$Q_1$ = the first quartile.

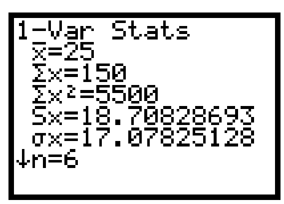
Med = the median.

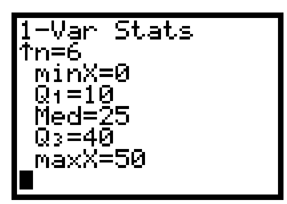
$Q_3$ = the third quartile.

maxX = the maximum data value.








You can display some of these statistics individually, such as the mean and median. Press [2nd] [LIST] MATH.

## Note 2C • Box Plots

The calculator can display up to three box plots at once. First, set up each plot, and then set up the window.

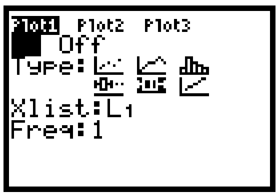
For help setting the Plot Setup screen see **Note 1H.** There are two types of box plots. The first type marks outliers as special. The calculator uses the

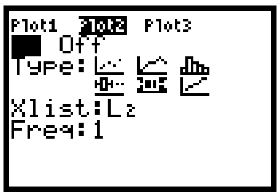
(continued)

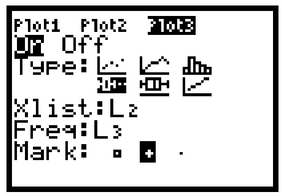
standard rule for defining an outlier: Values greater than $Q_3 + 1.5 \cdot IQR$ or less than $Q_1 - 1.5 \cdot IQR$ are outliers. If you select this type of box plot, you must choose what mark to use for an outlier. The second type of box plot does not show outliers as different from other data points.

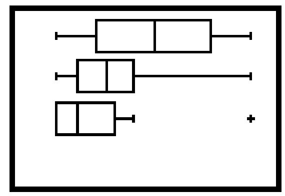
After setting up all your plots, go to the Window screen to set your graphing window. See **Note 1H** for help determining the window values to use. In a box plot **Ymin**, **Ymax**, and **Yscl** can be any value as long as **Ymin** is less than **Ymax**. When you are finished setting your window values, press GRAPH.

**Plot1** below is a box plot using the data set L1 = {0, 10, 20, 30, 40, 50}. **Plot2** and **Plot3** use the data set L2 = {0, 5, 10, 15, 20, 50}. Data in Plot3 have frequencies L3 = {7, 1, 1, 3, 2, 1}. This plot also shows outliers.



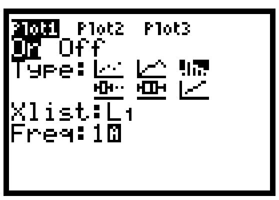



## Note 2D • Histograms

To graph a histogram, set the Plot Setup screen as directed in **Note 1H.**




Now set your Window screen. Setting a good window to view a histogram may take several tries. First decide on the bin width to use so that there are not too many or too few bins in your graph. A good rule is to set the bin width at about 15% of the range. Once you have found a good value for the bin width you can make your first try at a window:

**Xmin** = a multiple of bin width that is less than or equal to your smallest value.

**Xmax** = a multiple of bin width that is greater than your largest value.

**Xscl** = bin width.

**Ymin** = −1. A negative value keeps the tracing values from covering the bins.

**Ymax** = the number of items in your tallest bin. This will probably be a guess; start with half the number of items in your data set.

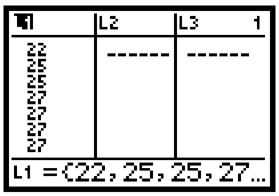
**Yscl** = the distance between tick marks on the $y$-axis. The number you choose will depend on the **Ymax** value. If the tick marks are too close together the $y$-axis will appear too thick.

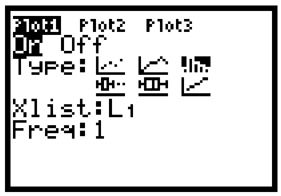
**Xres** = 1. This number does not affect a histogram.

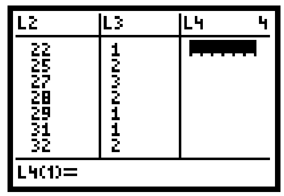
**(continued)**

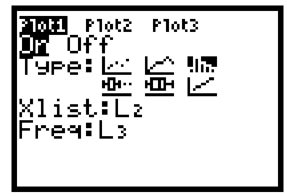
Press GRAPH. If the graph doesn't fit well in the window, press TRACE and use the left and right arrow keys to find the number of items in the tallest bin. (This is **n=** in the lower right of the screen.) Go back to the Window screen and reset **Ymax** (and **Ymin** if needed) and press GRAPH again.

In this example, the first two screens show setting up the stat plot for the data set {22, 25, 25, 27, 27, 27, 28, 28, 29, 31, 32, 32, 37}. The second two screens show how to set up the histogram if the same data are in list $L_2$ and their frequencies (number of occurrences) are in list $L_3$. The latter is usually done only for very large lists.

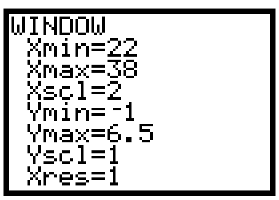


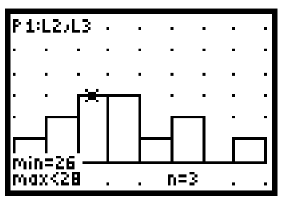



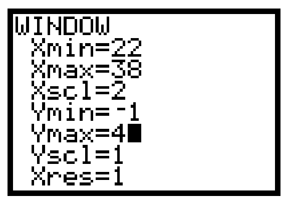



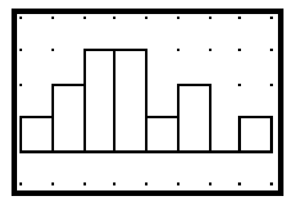




In either case, the range is $37 - 22 = 15$. Fifteen percent of that is $(15)(0.15) = 2.25$, so bin width $= 2$. There are 13 data points, so **Ymax** $= 6.5$. The histogram in the second screen is too short, so the window is adjusted.



# CHAPTER 3 Calculator Notes for the TI-83 and TI-83/84 Plus

## Note 3A • Entering, Graphing, and Tracing Equations

Equations are entered into the Y= screen for various purposes, including graphing. You can enter up to ten equations, Y1 to Y0.

### Entering Equations

Make sure you are in Function mode. Press MODE. In the fourth line select Func, then press Y=. Enter an equation. The variable must be X using the X,T,θ,n key. You can edit an equation by using the arrow keys and DEL or 2nd [INS]. To remove an equation from the Y= screen, highlight it and press CLEAR.

Before actually graphing, you'll need to determine which part of the Graph screen you want to view.

### Setting the Window

Press WINDOW and enter these values.

Xmin = the minimum *x*-value you want displayed.

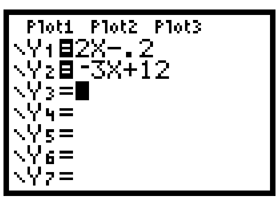
Xmax = the maximum *x*-value you want displayed.

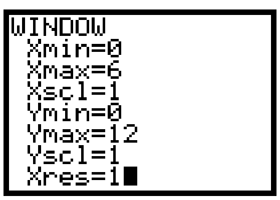
Ymin = the minimum *y*-value you want displayed.

Ymax = the maximum *y*-value you want displayed.

Xscl = and Yscl = the number of units between tick marks on each axis. If there are too many tick marks, individual marks won't be distinguishable and the axes will appear too thick.

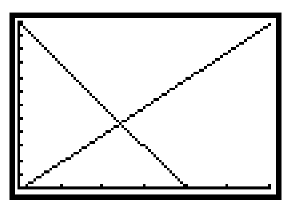
Xres = 1.



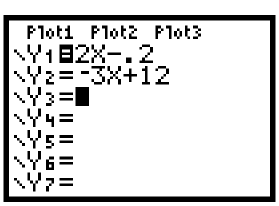

### Graphing

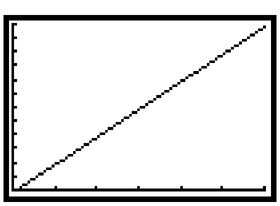
Press GRAPH to see the graph of the equation(s). They will appear one after another, in the order listed on the Y= screen.



If the graph is not situated on the screen to your satisfaction, go back to the Window screen and change the values. Experiment with various window settings until you're satisfied with the appearance of the graph.

You can turn off the graph of an equation without clearing it from the Y= screen by arrowing to its = symbol and pressing ENTER. When the = symbol is not highlighted, the equation is turned off and will not graph.

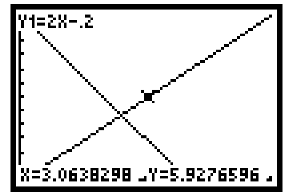


(continued)

### Tracing

You can find approximate coordinates of points on the graph by tracing. Press TRACE and a "spider" appears on the first graph. Use the left and right arrow keys to move it along the graph. The coordinates of the spider's position appear at the bottom of the screen. You can move to the graphs of other equations by arrowing up or down.



[0, 6, 1, 0, 12, 1]

Notation on the upper-left part of the screen tells you which equation's graph is being traced.

### Zooming

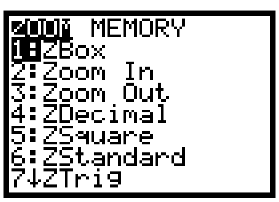
There are several ways to enlarge part of the graph. You can go back to the Window screen and change the window settings, or you can choose one of the commands that appear when you press ZOOM.

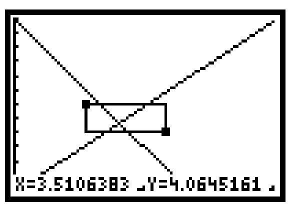
**1:Zbox** allows you to define your own enlargement. Select **1:Zbox** to display a spider. Use the arrow keys to move the spider to the area you'd like to enlarge. (This spider isn't restricted to the curve the way the trace spider is.) Press ENTER. Then draw a box by arrowing to the corner diagonally opposite from your current position. Press ENTER again. The interior of the box will enlarge and fill the screen.

**2:Zoom In** enlarges the screen by a factor of 4. Selecting **2:Zoom In** will display a spider that you can position to where you want the center of your new enlarged screen. Press ENTER to see the new screen.

**3:Zoom Out** does the opposite of **Zoom In**. Select **3:Zoom Out**, position the spider to the desired screen center, and press ENTER to see the new screen.

Zooming automatically changes the settings on the Window screen.

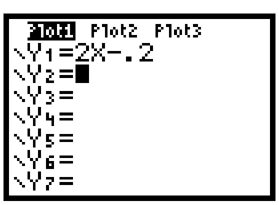


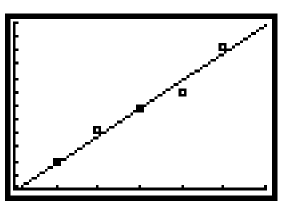



[0, 6, 1, 0, 12, 1]

### Graphing a Line and a Plot

You can graph a line over a plot by entering the equation into the Y= screen and the plot as directed in **Note 1H.** If you trace, arrowing up or down causes the spider to jump to each plot and to each function in order.





[0, 6, 1, 0, 12, 1]

**(continued)**

### Setting the Graph Style

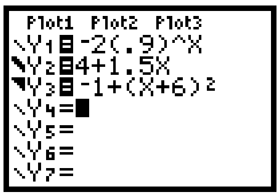
In order to distinguish between several displayed graphs or to achieve a special effect, it is sometimes helpful to use a graph style other than the usual thin, solid line.

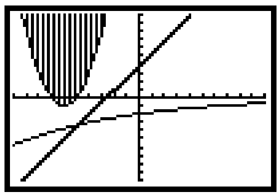
Use the left arrow key to highlight the style symbol to the left of Y1= and repeatedly press ENTER to cycle through the various styles. These examples show the possible styles.

Y1 graphs a curve using the usual thin, solid line. This is the default setting.

Y2 graphs a curve using a thick, solid line.

Y3 shades the area above the curve.



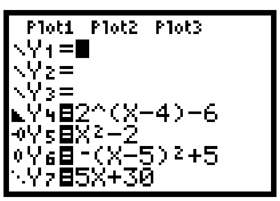
[−10, 10, 1, −10, 10, 1]

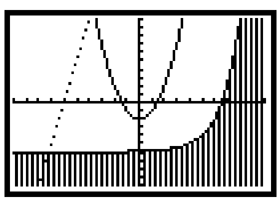
Y4 shades the area below the curve.

Y5 shows a moving circle that follows the curve and leaves a path.

Y6 shows a moving circle that follows the curve but leaves no path (not shown on the screen here).

Y7 graphs a curve using a dotted line.



[−10, 10, 1, −10, 10, 1]

## Note 3B • Function Tables

You can build a table of values for any function entered into the Y= screen. Press 2nd [TBLSET].

**TblStart** = the first $x$-value you wish to see in the table when first viewed.

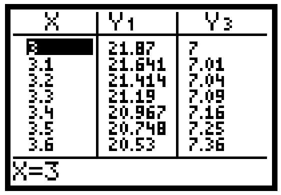
**ΔTbl** = the difference between the $x$-values in the table. In the first screen here ΔTbl=.1, so the difference between successive $x$-values is 0.1. ΔTbl can be negative.

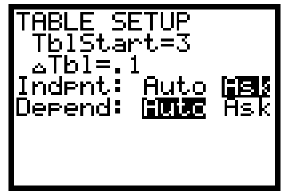
**Indpnt:** set to **Auto** means that the table will automatically start with the $x$-value equal to the **TblStart** value. If **Indpnt:** is set to **Ask**, the table will be blank until you provide the $x$-values.

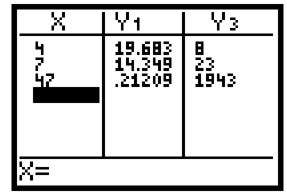
**Depend:** should always be set to **Auto**.

**(continued)**

Press [2nd] [TABLE] to display the table.

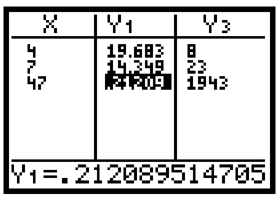



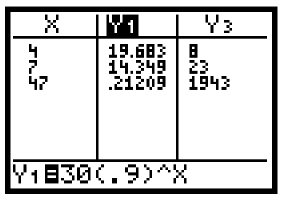



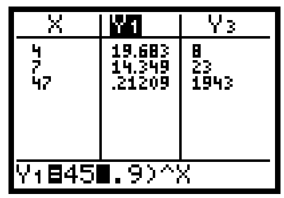



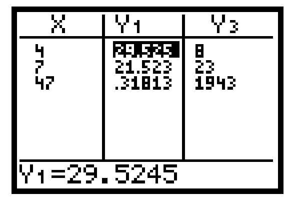

If **Indpnt:** is set to **Auto** on the TABLE SETUP screen, you can arrow up or down to see more *x*-values. You can also arrow right to see values of other functions that are turned on in the Y= screen. You can see only two columns of dependent variables at a time.

If you arrow up to the top of a function column, you can see the equation displayed at the bottom of the screen. Press [ENTER] to edit the equation. The changes will be reflected in the table when you press [ENTER] again.




## Note 3C • Balloon Blastoff

With a link cable, connect the CBR to the calculator. Be sure to push in each plug firmly. The application will be in either the applications menu or the programs menu. Press [APPS]; if CBL/CBR is there, choose it and select 3:RANGER. If it isn't, press [PRGM]. In the submenu EXEC, arrow down to see if RANGER is one of the choices. If so, select it. Otherwise, you will need to load the program from the CBR. See **Note 1F** for help loading RANGER.

Press [ENTER] to see the MAIN MENU. Select 1:SETUP/SAMPLE. Set REALTIME: to **No**. Arrow down to TIME(S). Enter the number of seconds you want to follow the rocket (2 should be good), and press [ENTER]. Finally, set BEGIN ON: to [TRIGGER].

Now arrow up to START NOW and press [ENTER]. Press [ENTER] again for more instructions. Disconnect the CBR if you wish.

Aim the CBR at the rocket. Right before the motion begins, start collecting data by pressing the trigger on the front of the CBR. If you think you didn't collect good data, get ready to restart the motion, again press the trigger, and repeat the movement.

Reconnect the CBR to the calculator and press [ENTER]. A graph of the data will be displayed. You can now unplug the CBR again.

You can transmit the data to another calculator by connecting it to the CBR, starting the RANGER program, choosing 5:TOOLS from the MAIN MENU, and then selecting 1:GET CBR DATA.

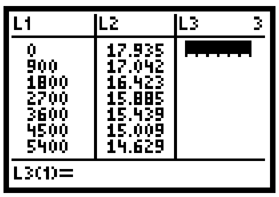
**(continued)**

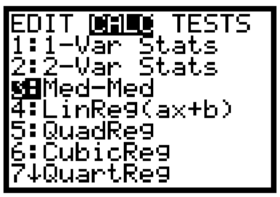
### Clean-Up

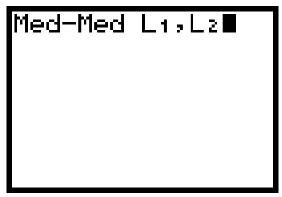
RANGER automatically sets your calculator to display three decimal places on the Mode screen. It also turns off expressions in the Format screen. Press MODE and reset the second line to **Float**, and then press 2nd [FORMAT] and select **ExprOn**.

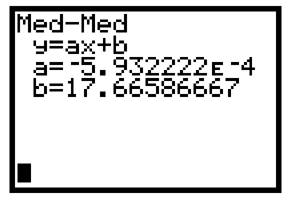
## Note 3D • Median-Median Line

The calculator can find the equation of the median-median line for a set of data. Press STAT **CALC 3:Med-Med**, then enter the two lists that contain the data, separating them with a comma. The independent variable list should be first. The command's default is to use lists L1 and L2, but it is a good habit to always specify the lists to be used.

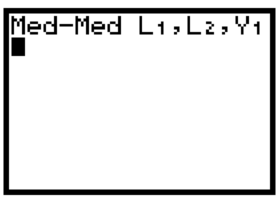


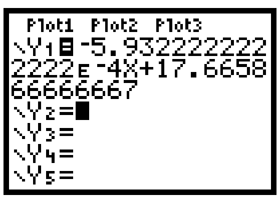



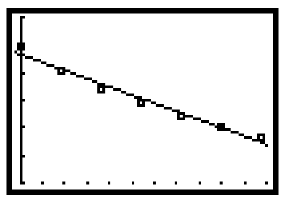




If you want the equation placed in Y1 on the Y= screen, after the second list press , VARS **Y-VARS 1:Function... 1:Y1** ENTER.



[0, 5500, 500, 13, 19, 1]

## Note 3E • Residuals and the Root Mean Square Error

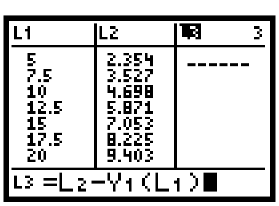
Once you have found a model for paired data, you can calculate the residuals and then the root mean square error.

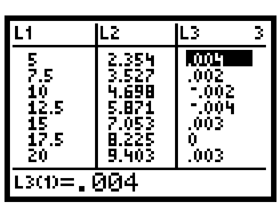
For this example, assume that your data are stored in lists L1 and L2 and your equation is stored in Y1.

### Residuals

**a.** Press STAT ENTER.

**b.** Move to the name cell at the top of list L3. Define list L3 as the residuals by entering the expression L2–Y1(L1). To get Y1, press VARS **Y-VARS 1:Function 1:Y1**. The resulting list will not change if you change the data in list L1 or list L2 or the equation in Y1. If you want this list to be dynamic (changing when list L1, list L2, or Y1 changes), enter the expression within quotation marks using ALPHA ["].




**(continued)**

### Root Mean Square Error

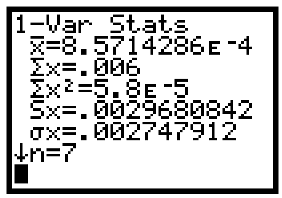
The root mean square error is defined as

$$s = \sqrt{\frac{\sum_{i=1}^{n}(y_i - \hat{y}_i)^2}{n-2}}$$

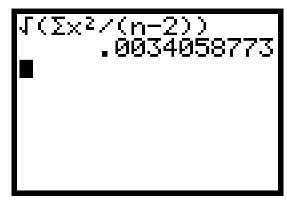
The numerator of the fraction is the sum of the squares of the residuals. The denominator is 2 less than the number of elements in list L3.

**a.** First calculate the residuals in list L3 as described above.

**b.** Calculate the numerator of the fraction and the value of $n$. Press STAT CALC 1:1-Var Stats 2nd [L3] ENTER. This puts the sum of the squares of the residuals into a variable called Σx² and the number of elements in the residual list into a variable called n.


**c.** Enter this formula into the Home screen: 2nd [√] VARS 5:Statistics:... Σ 2:Σx² ÷ ( VARS 5:Statistics 1:n − 2 ) ) ENTER. The result is the root mean square error.

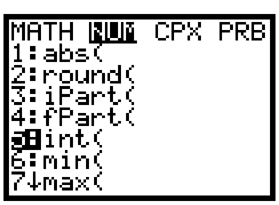


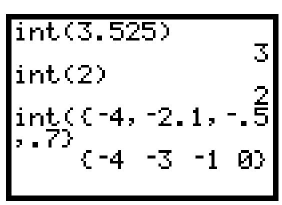

For large values of $n$, you can find a good approximation by dividing $n - 1$ instead of $n - 2$. This is the sample standard deviation of the residuals, or the value of Sx when you do 1-Var Stats.

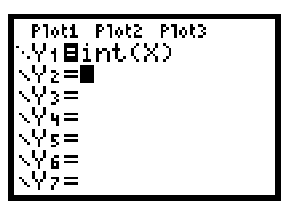
## Note 3F • Greatest Integer Function

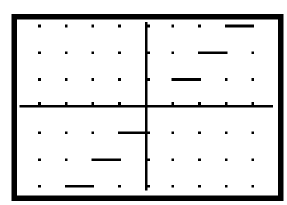
To find the greatest integer less than or equal to a value, press MATH NUM 5:int(, enter the value, and then close the parentheses. If the value is a positive decimal number, the function truncates everything after the decimal point; if the value is a negative decimal number, it does the same and then subtracts 1.

You can also use int( as a function of $x$. When graphing this function, the calculator may show almost-vertical segments that shouldn't be there. You can eliminate them by changing the graph style to a dotted line. (See **Note 3A** for help setting the graph style.)



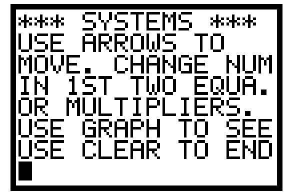



[−4.7, 4.7, 1, −3.1, 3.1, 1]

## Note 3G • SYSTEMS Program



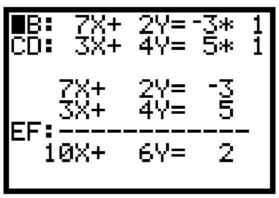

Run the program and press ENTER.

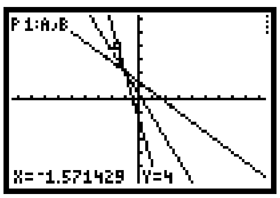
The top two lines of the screen show two equations of a system and a multiplier for each equation, initially set at 1. The third and fourth equations are the same as the first two, but each is multiplied by its multiplier. The fifth equation is the sum of the third and fourth.

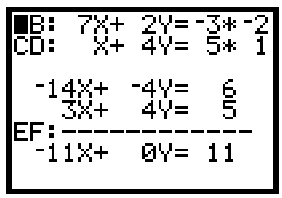
Use the arrow keys to move to the multiplier you wish to change. Enter a new integer value between −9 and 9. Once you've entered a new multiplier, the equations in the lower part of the screen will change accordingly.

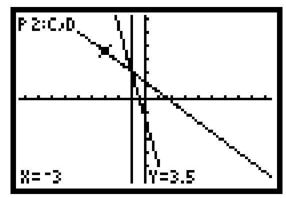
Press GRAPH at any time to see the graph of the system; you should do this frequently. The Graph screen shows the graphs of the two equations, and the graph of their sum, the fifth equation. Use the up and down arrow keys to identify each equation on the graph. To return to the equation screen, press ENTER.

From the equation screen, press CLEAR to exit the program and then CLEAR again to clear the Home screen.




### Graphing Your Own System

You can use this program to write any system of equations with integer parameters between −9 and 9. Instead of changing a multiplier, change the other parameters. When you change a coefficient or constant, only that corresponding number will change in the other affected equations. The new system is not equivalent to the original system and does not have the same solution. Press GRAPH to see how the graphs of the equations and their intersection change.

### Clean-Up

When you exit the program, all stat plots are left on. You might want to turn them off so they don't interfere with future work. Press 2nd [STAT PLOT] **4:PlotsOff** ENTER.

```
PROGRAM:SYSTEMS
{7,2,-3,1,3,4,5,1,7,2,-3,3,4,5,0,
  8,16}→LI
{1,1,1,1,2,2,2,2,4,4,4,5,5,5,7,7,7}
  →LG
{4,8,12,15,4,8,12,15,3,8,13,3,8,13,
  3,8,13}→LH
1→P:0→N
-9.4→Xmin:9.4→Xmax
-6.2→Ymin:6.2→Ymax
1→Xscl:1→Yscl
FnOff
Degree:ClrHome
Disp "*** SYSTEMS ***"
Disp "USE ARROWS TO    "
Disp "MOVE. CHANGE NUM"
Disp "IN 1ST TWO EQUA."
Disp "OR MULTIPLIERS."
Disp "USE GRAPH TO SEE"
Disp "USE CLEAR TO END"
```

*(continued)*

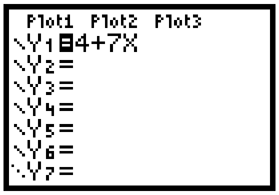
(*PROGRAM: SYSTEMS continued*)

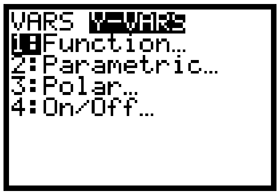
```
Pause
Repeat K=45
For(X,9,11)
ʟI(X-8)*ʟI(4)→ʟI(X)
ʟI(X-4)*ʟI(8)→ʟI(X+3)
ʟI(X)+ʟI(X+3)→ʟI(X+6)
End
(ʟI(6)*ʟI(3)-ʟI(2)*ʟI(7))/
  (ʟI(6)*ʟI(1)-ʟI(2)*ʟI(5))→A
(ʟI(5)*ʟI(3)-ʟI(1)*ʟI(7))/
  (ʟI(2)*ʟI(5)-ʟI(6)*ʟI(1))→B
-ʟI(2)→X:ʟI(1)→Y
2/max(abs({X,Y}))→Z
{XZ,-10X,0,10X}+A→ʟA
{YZ,-10Y,0,10Y}+B→ʟB
-ʟI(6)→X:ʟI(5)→Y
2/max(abs({X,Y}))→Z
{XZ,-10X,0,10X}+A→ʟC
{YZ,-10Y,0,10Y}+B→ʟD
-ʟI(16)→X: ʟI(15)→Y
2/max(abs({X,Y}))→Z
{XZ,-10X,0,10X}+A→ʟE
{YZ,-10Y,0,10Y}+B→ʟF
Plot1(xyLine,ʟA,ʟB,·)
Plot2(xyLine,ʟC,ʟD,·)
Plot3(xyLine,ʟE,ʟF,·)
ClrHome
Output(1,1,"AB:")
Output(1,6,"X+")
Output(1,10,"Y=")
Output(2,1,"CD:")
Output(2,6,"X+")
Output(2,10,"Y=")
Output(1,14,"*")
Output(4,5,"X+")
Output(4,10,"Y=")
Output(2,14,"*")
Output(5,5,"X+")
Output(5,10,"Y=")
Output(7,5,"X+")
Output(7,10,"Y=")
Output(6,1,"EF:-------------")
For(X,1,17)
Output(ʟG(X),ʟH(X)+(ʟI(X)≥0)-
  (abs(ʟI(X))≥10),ʟI(X))
End
0→V
Repeat V or K=45
ʟI(P)→X:0→T
Repeat K>13
T+21→T
If sin(T)<0:Output(ʟG(P),ʟH(P)+
  (X≥0)-(abs(X)≥10),X)
If sin(T)>0:Output(ʟG(P),ʟH(P)+
  (X≥0)-(abs(X)≥10),"  ")
getKey→K
End
Output(ʟG(P),ʟH(P)+(X≥0)-
  (abs(X)≥10),X)
If K=104:Then
1→N
Output(ʟG(P),ʟH(P)-
  (abs(ʟI(P))≥10),"-")
abs(ʟI(P))→ʟI(P)
End
If K>71 and K<95:Then
K-65-13(K>81)-13(K>91)→V
If N:-V→V:0→N
V→ʟI(P):26→K
Output(ʟG(P),ʟG(P)+(V≥0)-
  (abs(V)≥10),V)
End
If K=26:P+1→P
If K=24:P-1+8(P=1)→P
If K=25 or K=34:P+4→P
If P>8:P-8→P
If K=15:Trace

End:End
```

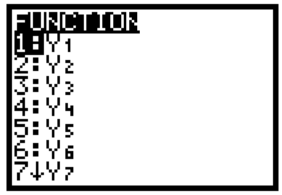
# Calculator Notes for the TI-83 and TI-83/84 Plus

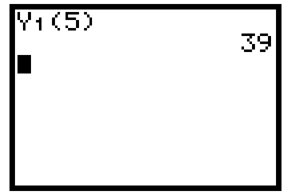
## Note 4A • Function Notation

The calculator treats an equation entered into the Y= screen as a function. A function can be evaluated for different *x*-values using standard function notation. For example, Y1(5) will give the value of the function when *x* is 5. On the Home screen press [VARS] **Y-VARS 1:Function...** followed by the number of the equation you want, and the *x*-value.




## Note 4B • Movin' Around

With bits of tape, label two CBRs A and B. Label two calculators A and B, and connect each to the respective CBR. Use the RANGER program to collect data for 10 seconds. See **Note 3C** for help with the RANGER program.

For both calculators, the time data will be in list L1 and the distance data will be in list L2. On the Home screen of calculator B, enter L1→L3, press [ENTER], enter L2→L4, and press [ENTER]. This moves calculator B's time and distance data to lists L3 and L4.

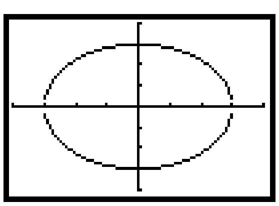
Finally, each group member should link to calculator A and copy lists L1 and L2, and link to calculator B and copy lists L3 and L4. See **Note 1J** for help with linking lists.

## Note 4C • Friendly Windows

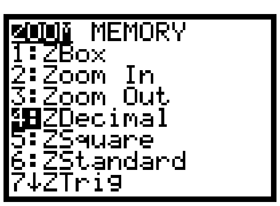
A friendly window scales the *x*-axis to correspond to the Graph screen's width in pixels (94). As a result, when you trace a curve on a friendly window, the spider always falls on points whose *x*-coordinates are "nice" decimal numbers. The *y*-coordinates are computed values and depend on the function being traced; they may or may not be nice decimal values.

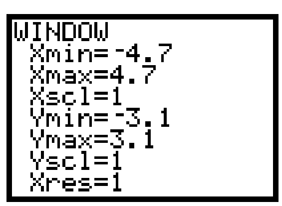
If the *y*-axis is scaled so its units are the same as the units on the *x*-axis, then the window will be a "square" window. On a square window there is no distortion of the graph.

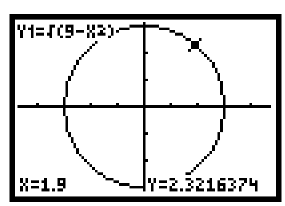
One friendly square window whose trace point has *x*-coordinates that are exact tenths can be found by pressing [ZOOM] **4:Decimal.**



[−4, 4, 1, −4, 4, 1]



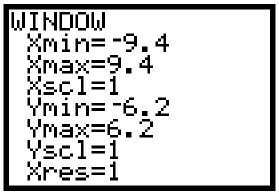



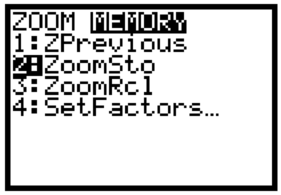



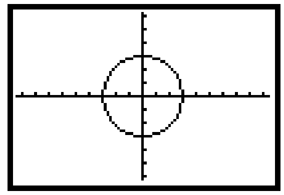

This window is a little small for much of the work in this course. However, if you double the minimum and maximum values in the window screen, you can get a larger friendly square window that is often useful.

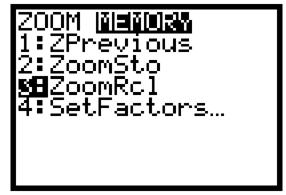
(continued)

You can save the settings for this larger window and recall it at any time. After setting the window values, press ZOOM **MEMORY 2:ZoomSto**. Now when you want to use it again, press ZOOM **MEMORY 3:ZoomRcl**. This particular window is often referred to as the friendly window with a factor of 2.

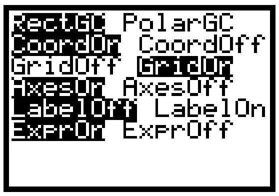


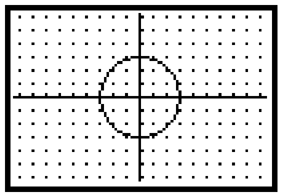






It is sometimes helpful to see a grid in the background of the screen display. To turn the grid on (or off), press 2nd [FORMAT] and select **GridOn** (or **GridOff**).



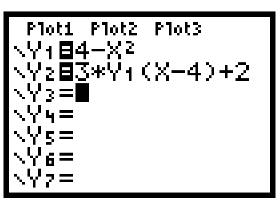
[−9.4, 9.4, 1, −6.2, 6.2, 1]

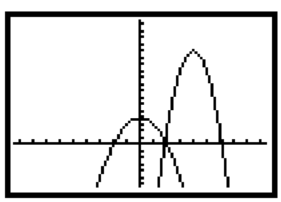
## Note 4D • Transformations and Compositions

You can use functions entered into the Y= screen in other functions to show transformations and to construct compositions.

### Transformations of Functions

You can enter an equation into the Y= screen and then define a second equation as a transformation of the first. For example, enter $4-X^2$ into $Y_1$ and define $Y_2$ as $Y_2=3*Y_1(X-4)+2$. (To get $Y_1$, press VARS **Y-Vars 1:Function 1:Y1**.) $Y_2$ is the image of $Y_1$ after being stretched vertically by a factor of 3, translated right 4 units and up 2 units.



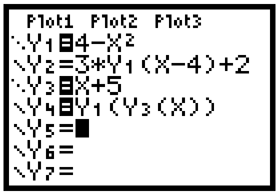
[−9.4, 9.4, 1, −6.2, 18.6, 1]

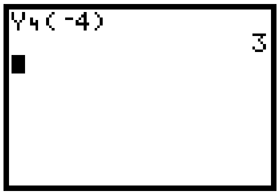
### Compositions of Functions

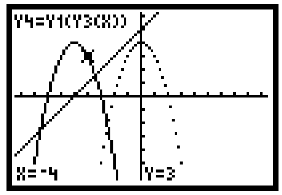
If you enter two (or more) equations into the Y= screen, you can define another equation as the composition of the equations you have entered. For

**(continued)**

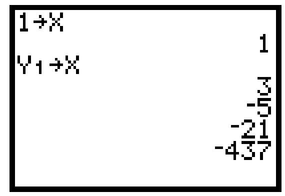
example, enter 4−X² into Y1 and X+5 into Y3. Define Y4 as the composition of Y1 and Y3 by entering Y4=Y1(Y3(X)).



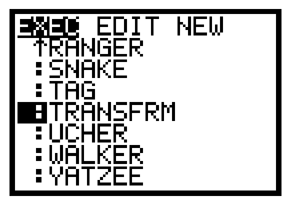

[−9.4, 9.4, 1, −6.2, 6.2, 1]



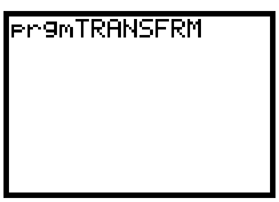

You can use the Home screen recursive loop Y1(X)→X (or simply Y1→X) to evaluate the repeated composition of a function with itself. Store a starting value in X and then press VARS Y-VARS **1:Function** **1:Y1** STO▸ X,T,θ,n ENTER ENTER ENTER. . . . (See **Note 1B** for more on Home screen recursion.)

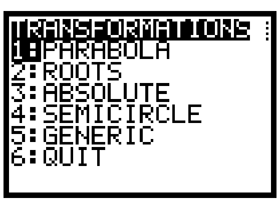
## Note 4E • TRANSFRM Program

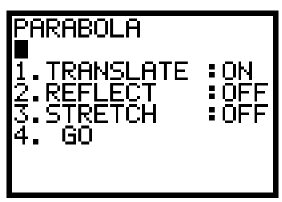
The program TRANSFRM gives you practice finding equations for given graphs. From the first menu, choose the type of function you want to practice. In the second menu, you can turn the different transformations on or off by pressing the number key. Press 4 when you're ready. The calculator will display a graph and stop. Study the graph and determine its equation. Press TRACE if you want to see the coordinates of points. When you have decided on an equation, press Y=, enter your equation into Y1, and press GRAPH. If your equation is correct, you'll have a match and nothing new will appear on the screen. You can press TRACE and toggle back and forth between the graph of your function in Y1 and the program's function to confirm that they really do match. If your equation is not correct, the graphs will not match. In that case, press Y= and try again.

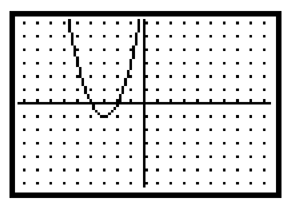



When you are finished with one graph, on the Graph screen press CLEAR ENTER to run the program again.



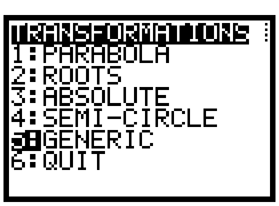



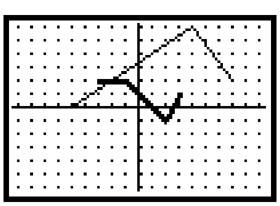



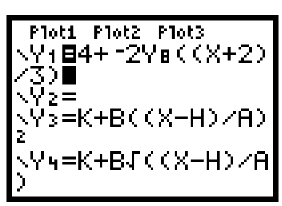
[−9.4, 9.4, 1, −6.2, 6.2, 1]

The option 5:GENERIC will draw the graph of a generic function using a thick line and the graph of its image after a transformation using the regular style. Enter the equation of the image into Y1. Use Y8(X) to represent the original function.



[−9.4, 9.4, 1, −6.2, 6.2, 1]




**(continued)**

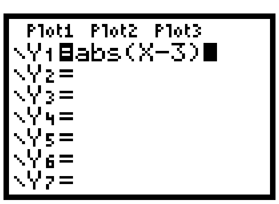
### Clean-Up

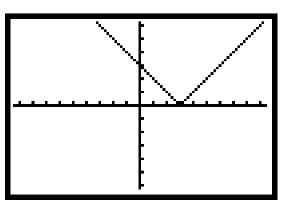
After you quit the program, you may want to go to the Y= screen and clear the functions so they don't interfere with future work.

```
PROGRAM:TRANSFRM
-9.4→Xmin:9.4→Xmax
-6.2→Ymin:6.2→Ymax
1→Yscl:1→Xscl
GridOn:AxesOn
PlotsOff
"K+B((X-H)/A)²"→Y3
"K+B√((X-H)/A)"→Y4
"K+Babs((X-H)/A"→Y5
"K+B√((1-((X-H)/A)²)"→Y6
"K+BY8((X-H)/A)"→Y7
"2(X<-1)/(X≥-3)+(1-X)(X≥-1)
  (X<2)+(-5+2X)(X≥2)/(X≤3)→Y8
GraphStyle(8,2)
Lbl 0:3→F:
If T≠0 and T≠1:1→T
If R≠0 and R≠1:0→R
If D≠0 and D≠1:0→D
Menu("TRANSFORMATIONS","PARABOLA",1,
  "ROOTS",2,"ABSOLUTE",3,"SEMI
  CIRCLE",4,"GENERIC",5,"QUIT",9)
Lbl 5:F+1→F
Lbl 4:F+1→F
Lbl 3:F+1→F
Lbl 2:F+1→F
Lbl 1:1→A:1→B
ClrHome:0→G:0→H:0→K
Disp sub("PARABOLA     SQUARE
  ROOTSABSOLUTE VALSEMICIRCLE
  GENERIC       ",12F-35,12)
Repeat G=82
Output(3,1,"1.TRANLATE   :"+sub
  ("OFFON  ",3T+1,3))
Output(4,1,"2.REFLECT    :"+sub
  ("OFFON  ",3R+1,3))
Output(5,1,"3.STRETCH
  :"+sub("OFFON  ",3D+1,3))
Output(6,1,"4. GO")
getKey→G:
If G=92:1-T→T
If G=93:1-R→R
If G=94:1-D→D
End
If T:Then
randInt(-7,7)→H
randInt(-4,4)→K
End
If R:Then
If rand <0.5:-1→A
If rand <0.5:-1→B
End
If D:Then
A*randInt(1,5)→A
B*randInt(1,4)→B
End
FnOff
FnOn F
If F=7:FnOn 8
DispGraph
Lbl 9
```

## Note 4F • Graphing Absolute-Value Functions

To use the absolute-value function, press MATH NUM **1:abs(**. For example, to graph $y = |x - 3|$, enter **Y1=abs(X−3)** into the Y= screen, set an appropriate window, and press GRAPH.



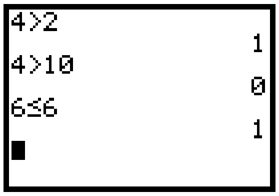



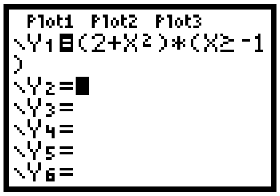
[−9.4, 9.4, 1, −6.2, 6.2, 1]

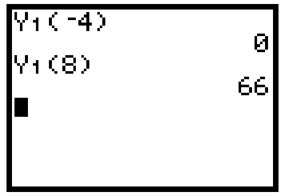
## Note 4G • Boolean Expressions

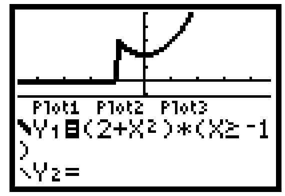
You can limit the domain of a function by using Boolean expressions. These are statements using <, ≤, >, ≥, =, or ≠ that have a value of 1 when true and 0 when false. To find these symbols, press [2nd] [TEST].

For example, the equation Y1=(2+X²)*(X≥−1) will equal zero for all values of $x$ less than −1 and equal $2 + x^2$ for values of $x$ greater than or equal to −1. You can evaluate the function on the Home screen or view it on the Graph screen.



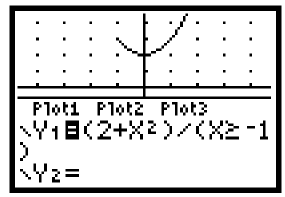



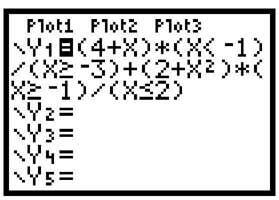

[−4.7, 4.7, 1, −1, 5, 1]

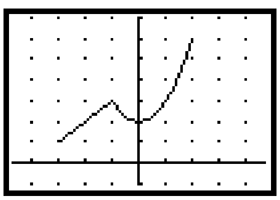
The calculator won't graph anything when it's dividing by 0, so the equation Y1=(2+X²)/(X≥−1) will result in no graph when $x$ is less than −1.




[−4.7, 4.7, 1, −1, 5, 1]

By adding functions that are each multiplied and divided by a Boolean expression, you can create a piecewise function that is defined over a limited domain. The equation Y1=(4+X)*(X<−1)/(X≥−3)+(2+X²)*(X≥−1)/(X≤2) will create a function by connecting the line $y = 4 + x$ to the parabola $y = 2 + x^2$ at (−1, 3) and limiting the domain to the interval from −3 to 2.



[−4.7, 4.7, 1, −1, 7, 1]

## Note 4H • Drawing Segments

On the Graph screen you can draw an overlay on top of the graph.

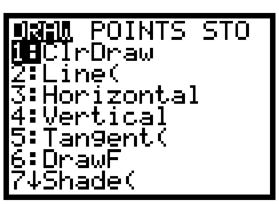
Follow these steps to draw a segment:

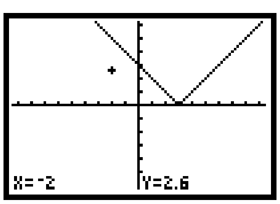
**a.** Press [2nd] [DRAW] 2:Line(.

**b.** Arrow to one endpoint of the segment you want and press [ENTER].

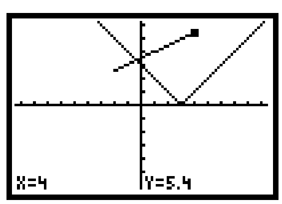
**c.** Arrow to the other endpoint and press [ENTER] again.

Pressing [ENTER] twice ends one segment and begins another at the same point, so you can make a closed figure.

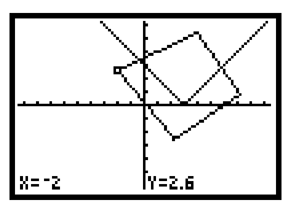



[−9.4, 9.4, 1, −6.2, 6.2, 1]



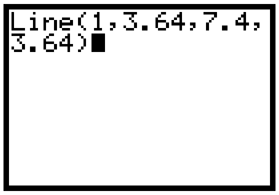

[−9.4, 9.4, 1, −6.2, 6.2, 1]

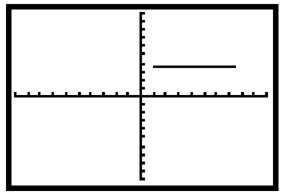



[−9.4, 9.4, 1, −6.2, 6.2, 1]

**(continued)**

You can also draw segments by entering instructions into the Home screen. To draw a segment between (1, 3.64) and (7.4, 3.64), enter **Line(1,3.64,7.4,3.64)**.



[−10, 10, 1, −10, 10, 1]

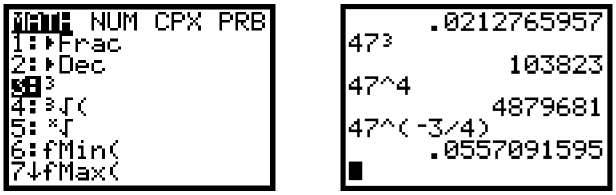
To erase any drawing, press [2nd] **[Draw] 1:ClrDraw.**

# CHAPTER 5 Calculator Notes for the TI-83 and TI-83/84 Plus

## Note 5A • Powers and Roots

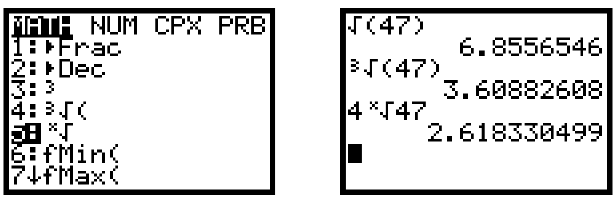
### Powers

The calculator has special keys for squaring, [$x^2$], and raising to a power of −1, [$x^{-1}$] (taking the reciprocal). The command for cubing is found under [MATH] **3:³**. You can find all powers, including these, by using the "caret" key, [^]. If you raise a number to a fractional power, use parentheses around the exponent.




### Roots

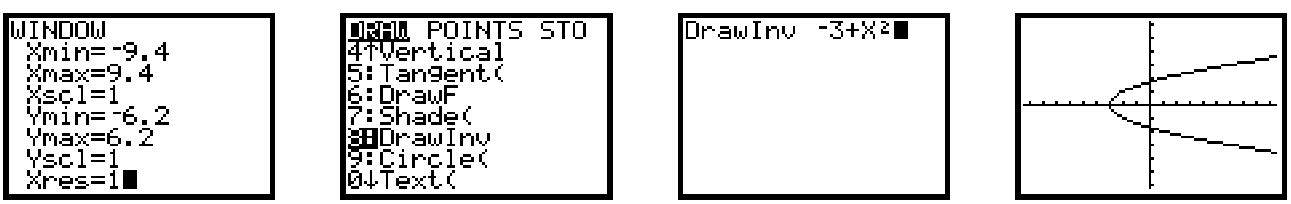
You can find the square root of a number by pressing [2nd] [√‾]. To find other roots, press [MATH]. The cube root is **4:∛‾(** and the *x*th root is **5:ˣ√‾**. For example, to find the fourth root of 47 press [4] [MATH] **5:ˣ√‾** [4] [7] [ENTER].

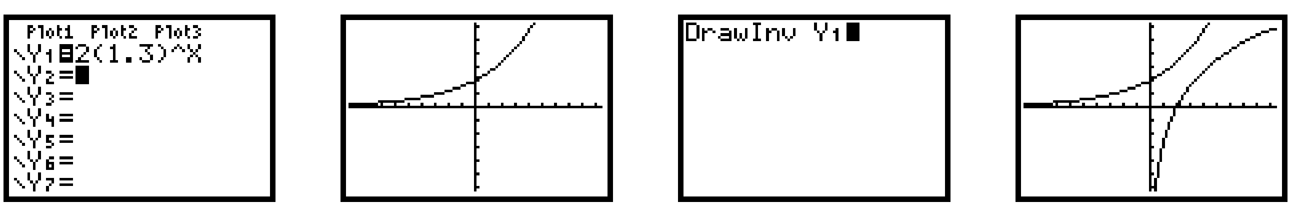



## Note 5B • Drawing the Inverse of a Function

Your calculator can draw the inverse of any function. From the Home screen press [2nd] [DRAW] **8:DrawInv**, followed by an expression containing X or one of the functions Y1 through Y0. Then press [ENTER] (not [GRAPH]).

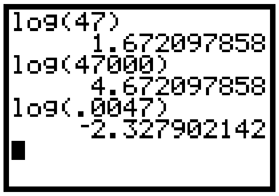
A drawing is overlaid on top of the Graph screen; it cannot be traced. If you change the window or alter anything on the Y= screen, the drawing will be cleared. You can restore it by returning to the Home screen and pressing [ENTER] again. To clear a drawing, press [2nd] [DRAW] **1:ClrDraw**.

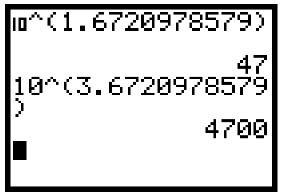


## Note 5C • Logarithms and Antilogs

Use LOG to find the common, or base 10, logarithm of any positive value. Use 2nd [$10^x$] for the common antilog of a number. Pressing 1 0 ^ ( gives the same result as pressing 2nd [$10^x$].




## Note 5D • Web Graphs

Follow these steps to display a web graph:

**a.** Set your calculator to Sequence mode.

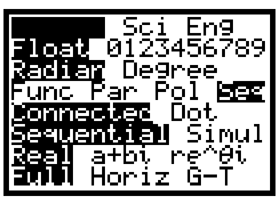
**b.** Press 2nd [FORMAT] and select **Web** in the first line.

**c.** Enter the function into the Y= screen. Replace $x$ with **u(*n*−1)** and set **u(*n*Min)** to the starting value of $x$.

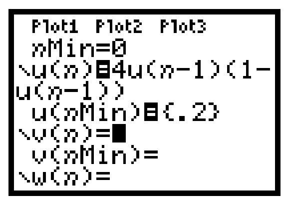
**d.** Set the Window screen and press GRAPH.

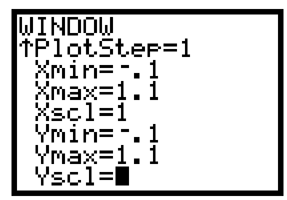
**e.** Press TRACE. Each time you press the right arrow key the graph will make one of the two steps in the next iteration of the function.

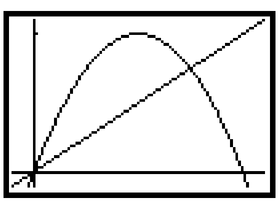
You can clear the web by pressing 2nd [DRAW] **1:ClrDraw.**

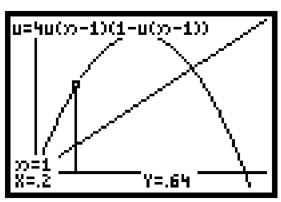


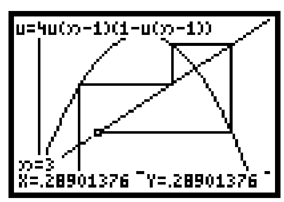


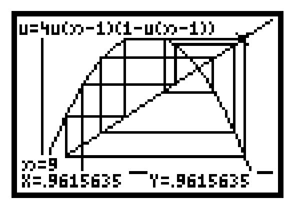





## Note 5E • Gathering Temperature Data

If you have an old CBL, you will use the CBL/CBR application. If you have a CBL2, transfer the application DataMate. To transfer either application to a calculator, connect the CBL and calculator, put the calculator in Receive mode (2nd [LINK] **RECEIVE 1:Receive**), and push TRANSFER on the CBL.

Connect the temperature probe and the calculator to the CBL and start the application.

**(continued)**

### DataMate

The application will sense which probe you are using. Choose 1:SETUP, arrow down to MODE:EVENTS WITH ENTRY, and press ENTER. Choose 2:TIME GRAPH, and then 2:CHANGE TIME SETTINGS. Enter 10 for the time between samples and 60 for the number of samples. Choose 1:OK, 1:OK again, and then 2:START. The calculator will collect data, graph them, and store time data in list L1 and temperature data in list L2.

### CBL/CBR

In the CBL/CBR application, choose 1:GAUGE, Temp, and then GO. . . . Follow the directions on the screen. The calculator will collect the data and graph them. Trace the graph and record about 20 data points by hand. After quitting the program, enter these points into lists for further analysis.

# Calculator Notes for the TI-83 and TI-83/84 Plus

## Note 6A • Entering and Editing Matrices

### Entering a Matrix

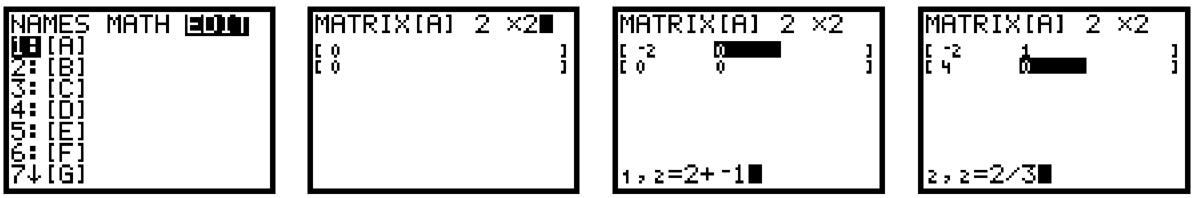
To enter a matrix, follow these steps:

**a.** Press 2nd [MATRX] and from the EDIT submenu select a matrix.

**b.** Enter the dimensions of the matrix (rows and then columns).

**c.** Enter a value into each cell. Press ENTER to register each entry and to move the cursor to the next position. You can use fractions and operations when you enter values.

**d.** When you finish entering values, press 2nd [QUIT] to return to the Home screen.




### Editing a Matrix

To edit a matrix, follow these steps:

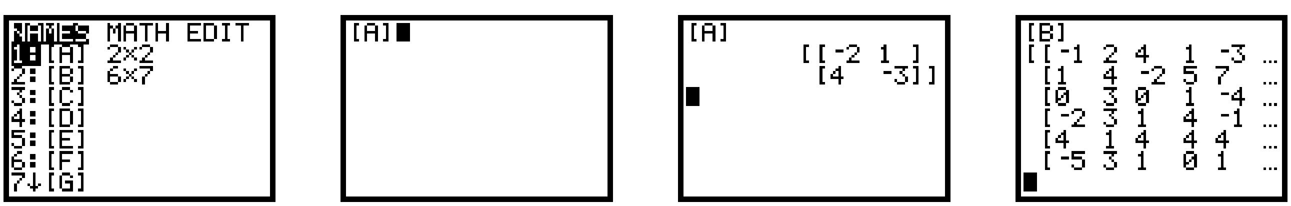
**a.** Press 2nd [MATRX] and from the EDIT submenu select the matrix you want to edit.

**b.** Arrow to the cell you want to change. Enter the new value and press ENTER. You can also change the dimensions of a matrix. Notice that when you create a new row or column the values in the cells begin as zeros.

**c.** When you finish editing values, press 2nd [QUIT] to return to the Home screen.

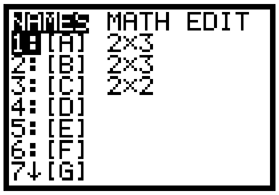

### Viewing a Matrix on the Home Screen

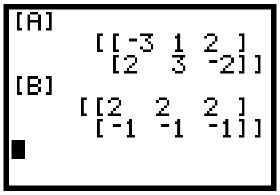
To view a matrix on the Home screen, press 2nd [MATRX] and from the NAMES submenu select the name of the matrix. Press ENTER to display the matrix. If the matrix is too large to fit on the screen, use the arrow keys to scroll across or down the matrix.

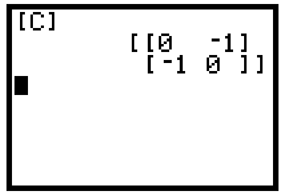


## Note 6B • Matrix Operations

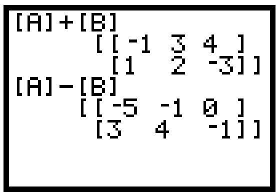
You can perform operations with matrices just as with numbers. The following examples use matrices [*A*], [*B*], and [*C*].



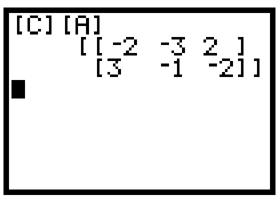



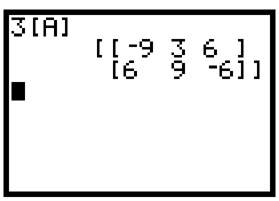

You can add or subtract matrices if they have the same dimensions.



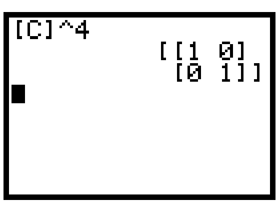

You can multiply two matrices if the number of columns in the first matrix matches the number of rows in the second matrix.



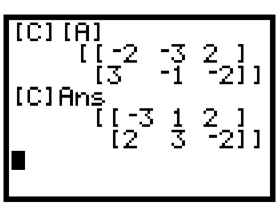

You can multiply any matrix by a constant.

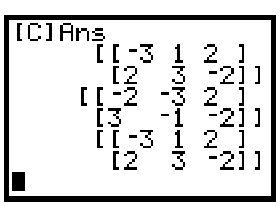



You can raise a square matrix to a power.




The result of a matrix operation can be stored into a matrix or used in the next calculation. This way you can work recursively with matrices.




**(continued)**

### Errors

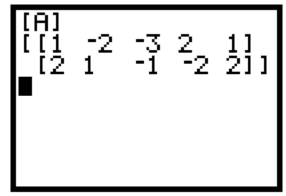
If you get an ERR:DIM MISMATCH message, then the dimensions of the matrices do not satisfy the operation's criteria.

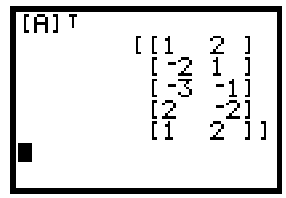
An ERR:UNDEFINED message probably indicates that you have named a matrix that is not defined.

## Note 6C • Plotting a Polygon

You cannot plot a polygon directly from a matrix, but you can convert a matrix into lists and plot a polygon from the lists.

For example, the matrix $\begin{bmatrix} 1 & -2 & -3 & 2 & 1 \\ 2 & 1 & -1 & -2 & 2 \end{bmatrix}$ represents the quadrilateral with vertices (1, 2), (−2, 1), (−3, −1), and (2, −2). (To graph a closed figure, the first point must be repeated as the last point.) You can convert the matrix columns into lists by selecting [2nd] [MATRX] MATH 8:Matr>list(. However, to plot a polygon, the matrix rows need to be converted into lists of *x*- and *y*-coordinates. To switch the rows for columns of your matrix, press [2nd] [MATRX] MATH 2:ᵀ. This matrix is the *transpose* of the original matrix.

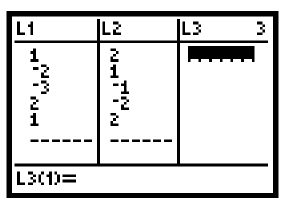




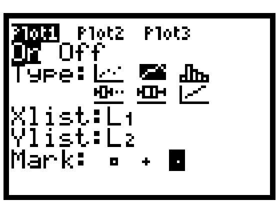
So, to plot the polygon represented by a matrix, follow these steps:

**a.** Enter the matrix and store it as matrix [A].

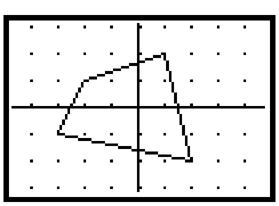
**b.** To store the coordinates as lists, enter [2nd] [MATRX] MATH 8:Matr>list( [2nd] [MATRX] NAMES 1:[A] [2nd] [MATRX] MATH 2:ᵀ [,] [2nd] [L1] [,] [2nd] [L2] [)] [ENTER].

**c.** Set up Plot1 as an xyline plot with list L1 as the Xlist and list L2 as the Ylist.



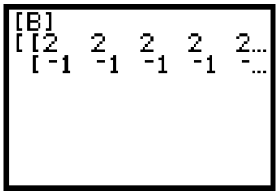
**d.** Set an appropriate window and display the graph.

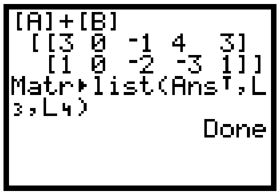


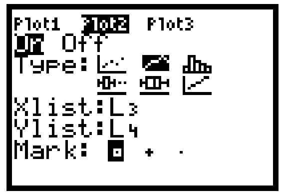
[−4.7, 4.7, 1, −3.1, 3.1, 1]

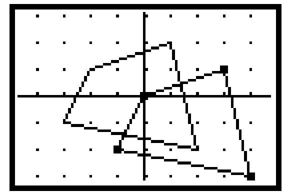
(continued)

You can also use matrices to transform polygons.



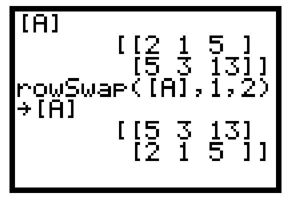



[−4.7, 4.7, 1, −3.1, 3.1, 1]

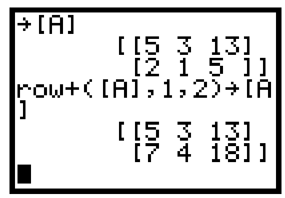
## Note 6D • Matrix Row Operations

The calculator can perform four operations on the rows of a matrix.

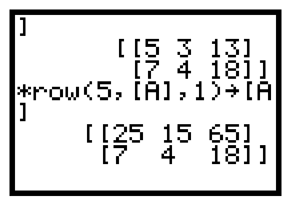
To exchange two rows in one matrix, use 2nd [MATRX] MATH C:rowSwap. For example, you exchange rows 1 and 2 of matrix [A] with the command rowSwap([A],1,2).



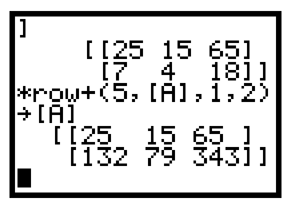

To add the entries of one row to those of another row, use 2nd [MATRX] MATHD:row+(. For example, you add the entries of row 1 to those of row 2 and store them into row 2 with the command row+([A],1,2).




To multiply the entries of one row by a value, use 2nd [MATRX] MATH E:*row(. For example, you multiply the entries of row 1 by 5 and store them into row 1 with the command *row(5,[A],1).



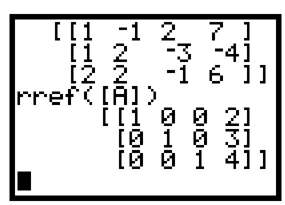

To multiply the entries of one row by a value and add the products to another row, use 2nd [MATRX] MATH F:*row+(. For example, you multiply the entries of row 1 by 5, add the products to row 2, and store them into row 2 with the command *row+(5,[A],1,2).




These commands don't change matrix [A]; they create a new matrix. You'll probably want to end each command by storing the new matrix with a new name or by replacing [*A*] with the new matrix, as was done in each of the examples.

## Note 6E • Reduced Row-Echelon Form

To convert an augmented matrix to reduced row-echelon form, enter 2nd [MATRX] MATH B:rref( and the name of the matrix.



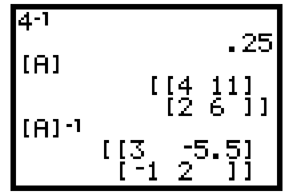

This example shows solving the system

$$\begin{cases} x - y + 2x = 7 \\ x + 2y - 3z = -4 \\ 2x + 2y - z = 6 \end{cases}$$

to get $x = 2$, $y = 3$, and $z = 4$.

## Note 6F • Inverse Matrices

To find the inverse of a matrix, enter the name of the matrix and press $\boxed{x^{-1}}$.




If you get an ERR:INVALID DIM message, the matrix is not square; if you get an ERR:SINGULAR MAT message, one row of the matrix is a multiple of another row. In either case, the matrix has no inverse.

## Note 6G • Graphing Inequalities

(See **Note 6G/App** if your calculator has the application Inequal.)

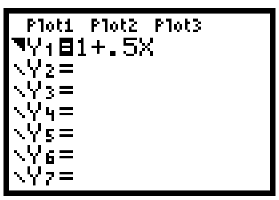
Graphing an inequality is like graphing an equation except you select a graph style to shade above or below the boundary line. The calculator always graphs a solid line for the boundary regardless of the type of inequality.

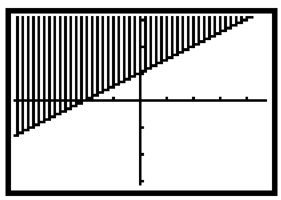
**a.** Enter the boundary line equation into the Y= screen.

**b.** Move the cursor to the left of the equation.

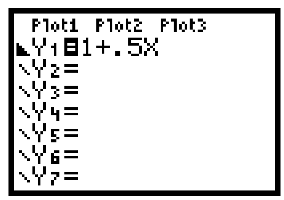
**c.** Press ENTER two times to shade above the boundary line, or press ENTER three times to shade below the boundary line.

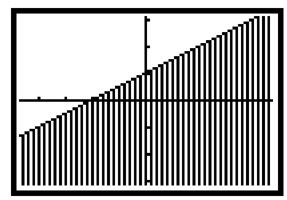
**d.** Set an appropriate window and then display the graph.



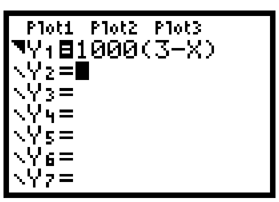
[−4.7, 4.7, 1, −3.1, 3.1, 1]

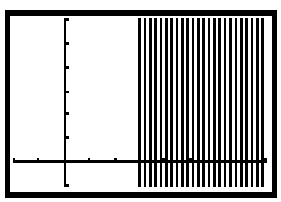


[−4.7, 4.7, 1, −3.1, 3.1, 1]

Vertical boundary lines can be approximated with a line of very steep negative slope. An equation in the form $y = 1000(b - x)$, where $b$ is the $x$-intercept, works well. These screens show an approximation for $x > 3$.



[−2, 8, 1, −1, 6, 1]

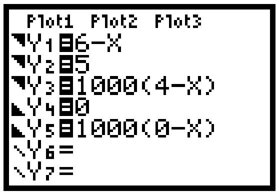
### Graphing Systems of Inequalities

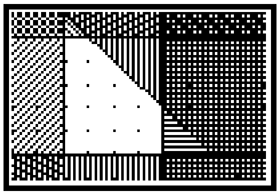
When graphing a system of inequalities, it is often easier to do reverse shading so that the feasible region is the area *not* shaded. To do this, shade above the boundary line for the inequalities $<$ and $\leq$, and shade below the boundary line for the inequalities $>$ and $\geq$. Vertical boundary lines can be approximated with a line of very steep negative slope.

**(continued)**

These screens show the region defined by the intersection of

$$\begin{cases} y \le 6 - x \\ y \le 5 \\ x \le 4 \\ y \ge 0 \\ x \ge 0 \end{cases}$$



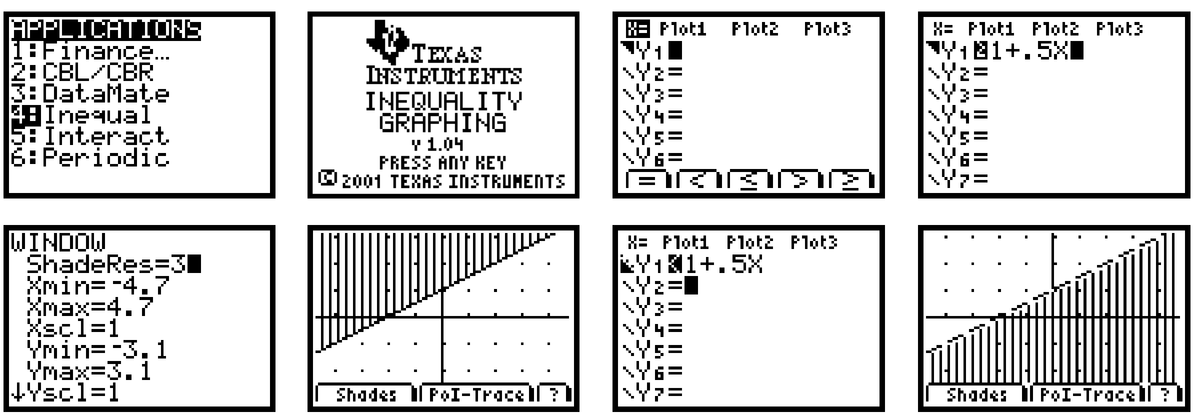
[−2, 8, 1, −1, 6, 1]

## Note 6G/App • Graphing Inequalities with the Inequal App

(See **Note 6G** if your calculator does not have the application **Inequal**.)

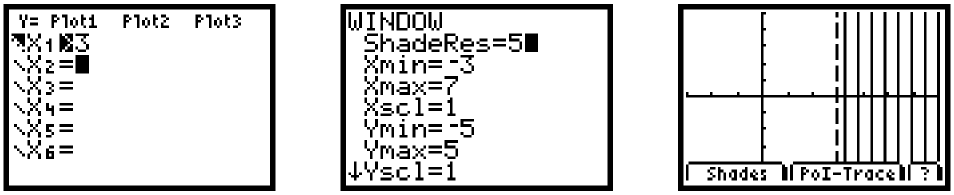
To start the application, press APPS and select **Inequal**. Go to the Y= screen.

- **a.** Move the cursor over the = symbol.
- **b.** Press ALPHA and one of the five top-row keys, [F1] to [F5], to select the type of inequality you want to graph.
- **c.** Arrow to the right of the inequality symbol and enter the rest of the inequality.
- **d.** Set an appropriate window. For **ShadeRes=** enter an integer from 3 to 8 to adjust the space between the shading lines. The larger the number, the larger the space.
- **e.** Press GRAPH to display the graph of the inequality. Notice that the boundary line of a strict inequality, < and >, is represented with a dashed line.




**(continued)**

To graph an inequality with a vertical boundary line, arrow to X= in the upper-left corner of the Y= screen, press [ENTER], and proceed as if on the Y= screen.




To turn off the application, press [APPS], select **Inequal**, and choose **2:Quit Inequal.**

### Graphing Systems of Inequalities

**a.** Enter the system of inequalities, set up the window, and press [GRAPH].

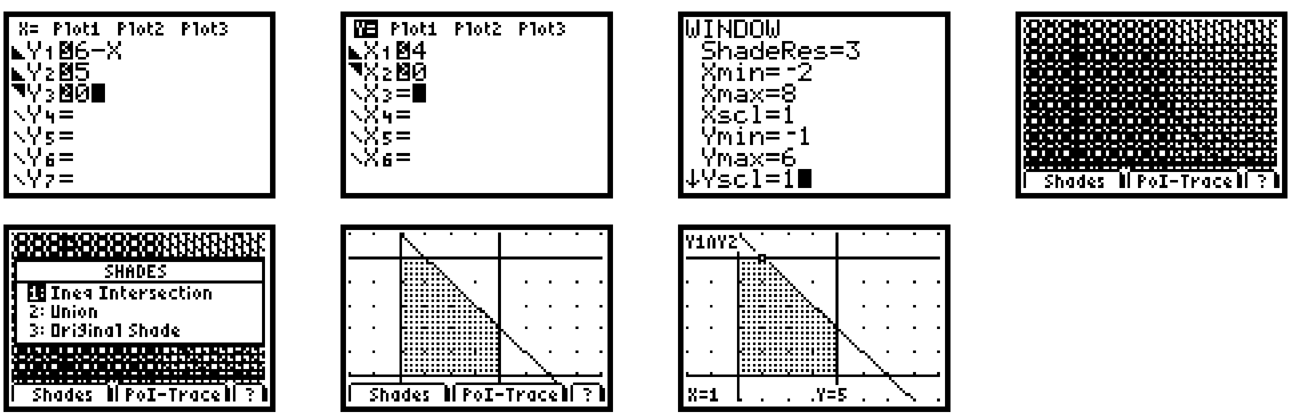
**b.** To find the intersection of the regions, press [ALPHA] and one of the keys under **Shades**, [F1] or [F2]. Then select **1:Ineq Intersection.**

**c.** To find the points of the intersection of the boundary lines, press [ALPHA] and one of the keys under **PoI-Trace**: [F3] or [F4]. Use the left and right arrow keys to move to a point on the same line and the up and down arrow keys to move to a point on a different line.

These screens show how to graph the region defined by the system

$$\begin{cases} y \le 6 - x \\ y \le 5 \\ x \le 4 \\ y \ge 0 \\ x \ge 0 \end{cases}$$

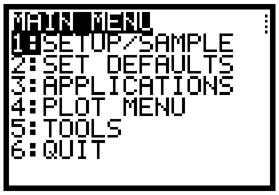
The last screen shows the intersection of the two boundary lines Y1 and Y2.



# CHAPTER 7 Calculator Notes for the TI-83 and TI-83/84 Plus

## Note 7A • Free Fall

Use the RANGER program to collect data for this investigation. See **Note 1F** if you need help with the RANGER program.




From the RANGER MAIN MENU, select 1:SETUP/SAMPLE. For the settings, choose

| | |
|---|---|
| REALTIME: | NO |
| TIME (S): | 5 |
| DISPLAY: | DIST |
| BEGIN ON: | [TRIGGER] |
| SMOOTHING: | LIGHT |
| UNITS: | METERS |

The RANGER program always collects 94 data points. For 5 seconds, a reading will be taken approximately every 0.05 second.

Position the CBR facing up on the floor as described in the investigation instructions. Arrow up to START NOW and press ENTER. Press ENTER again for more instructions. Press the trigger on the front of the CBR to collect data.

When data collection is complete, press ENTER and view the data to see if there is a short section of data showing the drop. If not, make the needed modifications to your procedure and repeat the data collection.

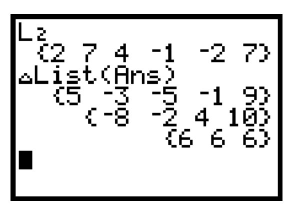
Use TRACE to identify the points of the drop, and copy these *x*- and *y*-values onto your paper. Continue with the investigation.

### Clean-Up

The RANGER program automatically sets your calculator to display three decimal places on the Mode screen. It also turns off expressions on the Format screen. Press MODE and reset the second line to **Float**, and then press 2nd [FORMAT] and select **ExprOn**.

## Note 7B • Finite Differences

To calculate finite differences for a list, enter 2nd [LIST] OPS 7:ΔList( and the name of the list. You can use this command recursively to look at the values of the first, second, and third differences of a sequence.



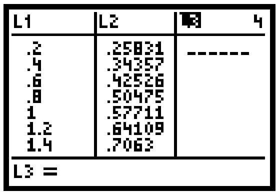

### Data Analysis Using Finite Differences

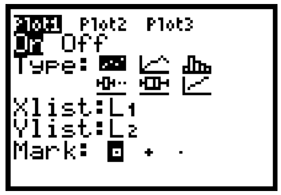
You can also use the command ΔList( on the Stat Edit screen to create lists of differences that can then be graphed.

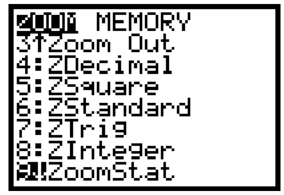
**(continued)**

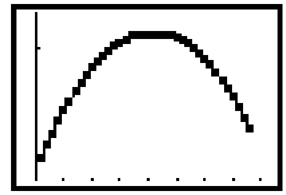
**a.** Enter *x*-values into list L1 and *y*-values into list L2. Remember that the *x*-values must be an arithmetic sequence.

**b.** Set a window (or use ZoomStat) and display a scatter plot of (L1, L2).







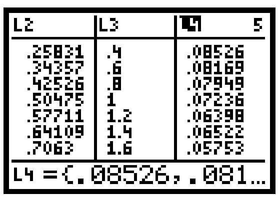


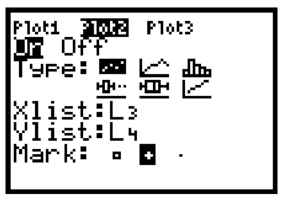
The plot does not show a horizontal linear pattern or even a linear pattern, so proceed to look at a graph of the first differences.

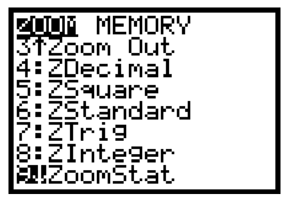
**c.** Define list L4 to be the first difference of list L2, ΔList(L2). Note that there is one less element in list L4 than there is in list L2.

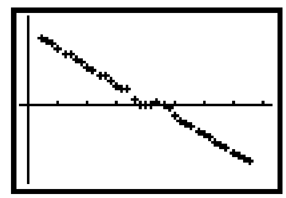
**d.** Let list L3 be the same as list L1 but omit the first entry. Lists L3 and L4 must have the same number of elements.

**e.** Set a window (or use ZoomStat) and display a scatter plot of (L3, L4).







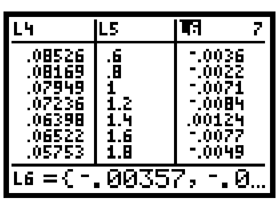


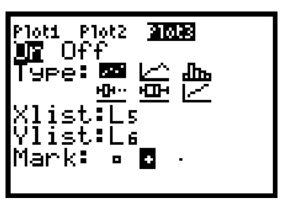
The plot shows a linear but nonhorizontal pattern using the first differences, so you must proceed to the next set of differences.

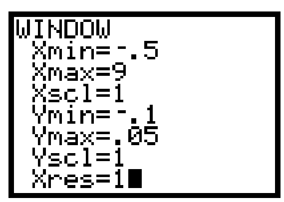
**f.** Define list L6 to be the differences of list L4, which are the second differences of the original *y*-values in list L2. There is again one less element in list L6 than there is in list L4.

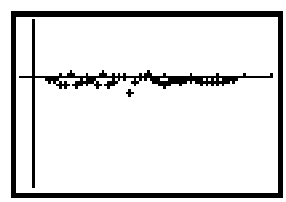
**g.** Let list L5 be the same as list L3 but, again, omit the first element.

**h.** Set a window (or use ZoomStat) and display a scatter plot of (L5, L6).









This graph of second differences has a horizontal linear trend, so the data in lists L1 and L2 can be modeled with a 2nd-degree polynomial.

## Note 7C • Rolling Along

Use the RANGER program to collect 6 seconds of data. See **Note 7A** for help with the SETUP/SAMPLE menu.

Position the CBR at the low end of the table as described in the investigation instructions.

**(continued)**

When data collection is complete, view the data to see if they look like a parabola. If not, make the needed modifications to your procedure and repeat the data collection.

Continue with the investigation. As mentioned in the instructions, make sure to subtract 0.5 meter from the distance measures in list L2.

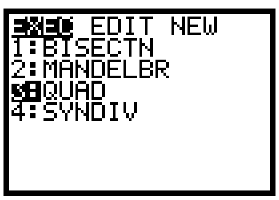
### Clean-Up

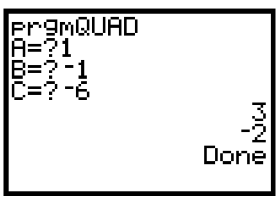
The RANGER program automatically sets your calculator to display three decimal places on the Mode screen. It also turns off expressions on the Format screen. Press MODE and reset the second line to **Float**, and then press 2nd [FORMAT] and select **ExprOn**.

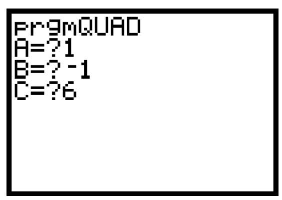
## Note 7D • QUAD Program

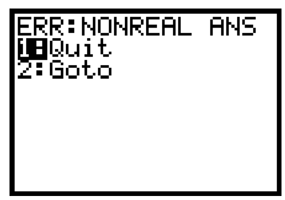
The program QUAD requests values A, B, and C. These values refer to the coefficients of the quadratic equation $ax^2 + bx + c = 0$. The solutions to the equation are displayed on the screen and stored in R and S.

If your calculator is in Real mode and your equation has no real roots, then the program will give an error message. See **Note 7E** for alternatives to Real mode.




```
PROGRAM:QUAD
Prompt A,B,C
(-B+√(B²-4AC))/(2A)→R
(-B-√(B²-4AC))/(2A)→S
Disp R,S
```

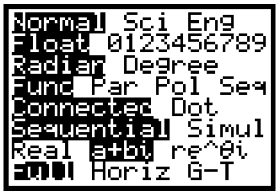
## Note 7E • Complex Numbers

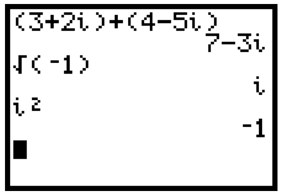
Your calculator has three number display modes. Press MODE and look at the seventh line.

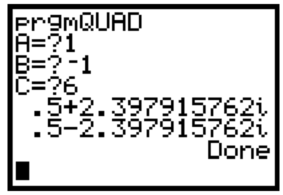
| | |
|---|---|
| **Real** | Displays only real values unless a complex number using *i* is entered. Otherwise, it gives an ERR:NONREAL ANS message. |
| **a+bi** | Displays both real and nonreal values in the form $a + bi$. You will use this mode when working with complex numbers. |
| **re^θi** | Displays both real and complex values in polar form. (Not used in this course.) |

**(continued)**

When entering a complex number, you get the symbol *i* by pressing [2nd] [*i*], or if you are in a+bi mode, by entering $\sqrt{}(-1)$.



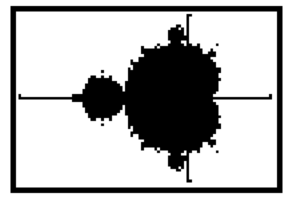




## Note 7F • MANDELBR Program

The program MANDELBR is based on the principle that, if a point moves more than 2 units from the origin, it will never return. If it remains within 2 units of the origin after 50 iterations, then it will likely stay in that range, so the program turns on the corresponding pixel.

First set the window you want to explore. To view the entire Mandelbrot set, set the window to [−2, 1, 1, −1, 1, 1]. Then run the program MANDELBR. Running this program can take several hours.



[−2, 1, 1, −1, 1, 1]

```
PROGRAM:MANDELBR
a+bi
PlotsOff
ClrDraw
FnOff
RectGC:CoordOn:GridOff:AxesOn
DispGraph
For(A,Xmin,Xmax,(Xmax-Xmin)/94)
For(B,Ymin,Ymax,(Ymax-Ymin)/62)
0→N:0→Z
While N≤50 and abs(Z)≤2
N+1→N
Z²+A+Bi→Z
End
If abs(Z)≤2
Pt-On(A,B)
End
End
```

## Note 7G • SYNDIV Program

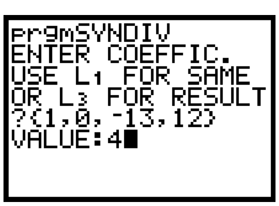
The program SYNDIV performs the synthetic division $\frac{P(x)}{x-a}$.

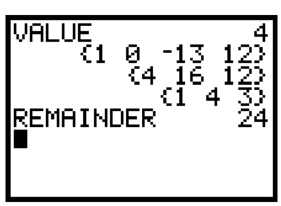
**a.** Run the program SYNDIV.

**b.** Enter the coefficients of the divisor, polynomial $P(x)$, as a list. These values must be entered in order of descending degree, including zeros for missing terms, and they must be separated by commas and enclosed in braces, { }. Press [ENTER].

**c.** For VALUE enter the value of $a$ in the divisor $x - a$ as an integer, decimal, or fraction. Press [ENTER].

**d.** The program displays the coefficients of $P(x)$ that you entered, the middle row of the division, and then the coefficients of the quotient polynomial in the third line. It displays the remainder of the division in the last line.




**(continued)**

After you have run the program, you can press ENTER to run it again. If you want to use the same polynomial, $P(x)$, again, enter list L1 for the coefficients. If you want to use the result of the last division as the new dividend, then enter list L3 for the coefficients of your new polynomial.

```
PROGRAM:SYNDIV
Disp "ENTER COEFFIC.","USE L1 FOR
  SAME","OR L3 FOR RESULT"
Input L1
Input "VALUE:",X
dim(L1)-1→D
0→R:{0}→L2: L2→L3
For(J,1,D)
L1(J)+XR→R
XR→L2(J)
R→L3(J)
End
L1(J)+XR→R
ClrHome
Disp X,L1,L2,L3,R
Output(1,1,"VALUE")
Output(5,1,"REMAINDER")
```

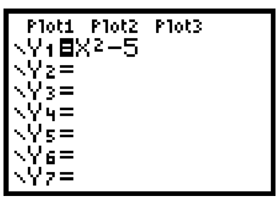
## Note 7H • Zero Finding

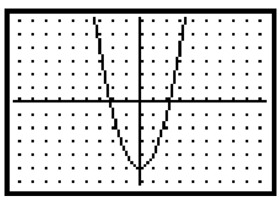
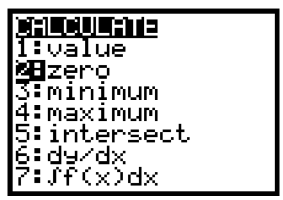
Your calculator can find the zero(s) of a function.

**a.** Enter the equation into the Y= screen.

**b.** Find a window that shows the zero you want to determine and display the graph.

**c.** Select 2nd [CALC] **2:zero.**




[−9.4, 9.4, 1, −6.2, 6.2, 1]

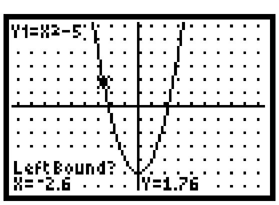
**d.** The calculator prompts you to enter left and right bounds around the zero and a guess. You can do this by arrowing left or right and pressing ENTER, or by typing a number.

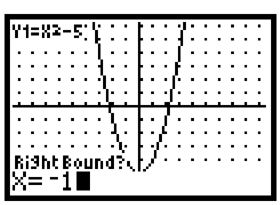
**Left Bound** = an $x$-value that is to the left of the zero.

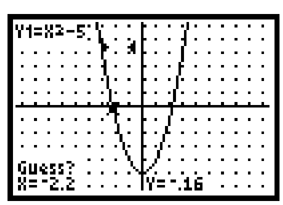
**Right Bound** = an $x$-value that is to the right of the zero.

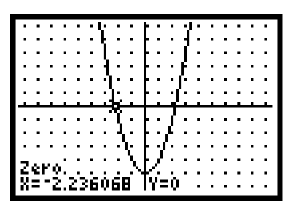
**Guess** = an $x$-value that is very near the zero.

**e.** The calculator locates a zero between the left and right bounds, if one exists.









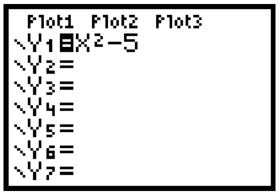

[−9.4, 9.4, 1, −6.2, 6.2, 1]

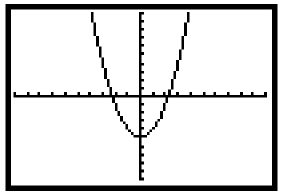
## Note 7I • BISECTN Program

The program BISECTN finds the zero(s) of a function using the bisection method.

**a.** Enter the function into Y1.

**b.** Look at its graph and approximate the value of a zero.



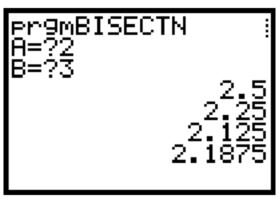


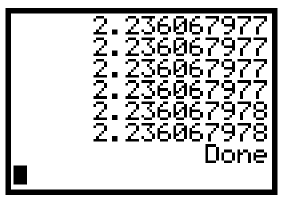
[−10, 10, 1, −10, 10, 1]

**c.** Run the program BISECTN.

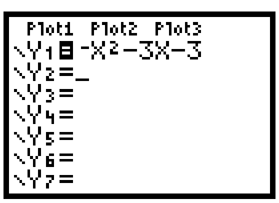
**d.** The program prompts you to enter two values, A and B. Enter values near your approximate zero value. One must be an *x*-value with a negative *y*-value and the other must be an *x*-value with a positive *y*-value. These should be values on either side of your approximate zero.

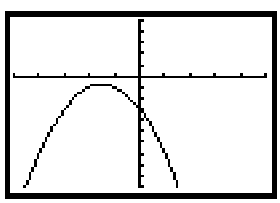
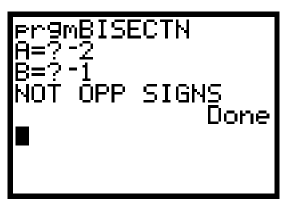
**e.** The program displays successive values of *x* as it narrows in on a zero between the two *x*-values you entered.






If both *x*-values have *y*-values on the same side of the *x*-axis, you will get a NOT OPP SIGNS message. Note that the program will not find a double root of a function because the function does not cross the *x*-axis.



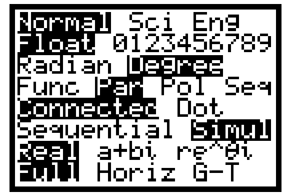

[−5, 5, 1, −10, 5, 1]

```
PROGRAM:BISECTN
Prompt A,B
If Y1(A)Y1(B)>0
Then
Disp "NOT OPP SIGNS"
End
If Y1(A)Y1(B)≤0
Then
1→C
Repeat (Y1=0 or C=50)
(A+B)/2→X
Disp X
If Y1(A)Y1(X)≥0
Then:X→A
Else:X→B
C+1→C
End
End
```

# Calculator Notes for the TI-83 and TI-83/84 Plus

## Note 8A • Changing Mode

For your work in this chapter, check and change, if necessary, three settings on the Mode screen.




**a.** Press MODE and set the third line to **Degree**. You will work with angles in the second half of the chapter and those angles are measured in degrees. If you get a "funny" answer when using a trigonometric function, check to see that you are still in Degree mode.

**b.** Set the fourth line to **Par**. In this chapter you graph and use parametric equations. When you switch to Parametric mode, the Y= screen and the Window screen change.

**c.** Set the sixth line to **Simul**. Often in this chapter you graph more than one set of parametric equations. In Simultaneous mode, all equations graph at the same time. In Sequential mode, equations graph one after the other.

## Note 8B • Graphing in Parametric Mode

In Parametric mode, you define equations in terms of the parameter *t*. To enter the variable *t*, press X,T,θ,n.

It takes a pair of equations to create a single parametric graph. Until you define both $X_{1T}$ and $Y_{1T}$ (or any other X-Y pair) on the Y= screen, nothing will graph.

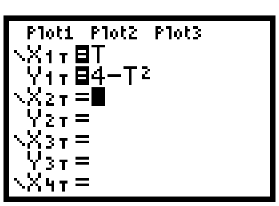
### Setting the Window

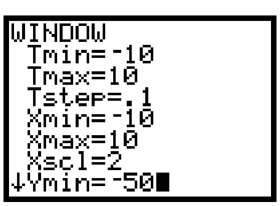
In Parametric mode the Window screen is different from the familiar Function mode Window screen. The Graph screen that you see is still set by the values of **Xmin**, **Xmax**, **Xscl**, **Ymin**, **Ymax**, and **Yscl**. But in addition, you must set the starting and stopping values of *t*. The *t*-values you choose do not affect the dimensions of the Graph screen, but they do affect what will be drawn.

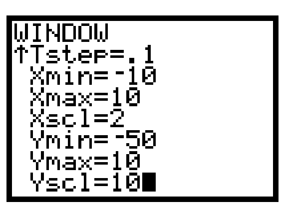
**Tmin** = the minimum *t*-value that the calculator uses to evaluate the *x*- and *y*-function values.

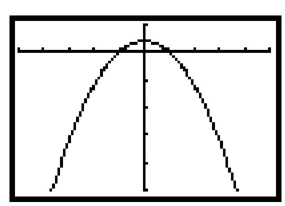
**Tmax** = the maximum *t*-value that the calculator uses to evaluate the *x*- and *y*-function values.

**Tstep** = the increment by which *t* increases between each evaluation. **Tstep** controls the speed at which the graph is drawn. Start with **Tstep** equal to about one hundredth of the range of *t*, $\frac{\text{Tmax}-\text{Tmin}}{100}$. If the graphing speed is not to your liking or your graph needs more detail, adjust **Tstep**.



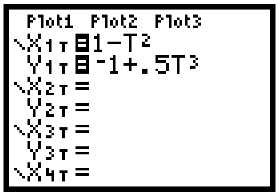
**(continued)**

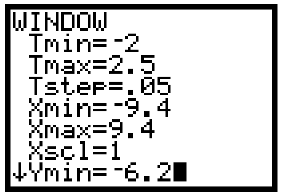
### Setting the Graph Style

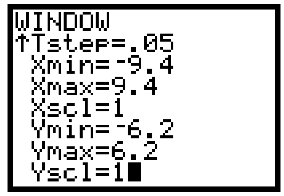
The graph styles are the same as those in Function mode except there is no shading in parametric equation graphs. See **Note 3A** for help with graph styles.

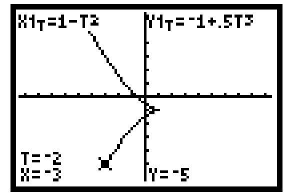
## Note 8C • Tracing Parametric Equations

In Parametric mode, when you press TRACE, the spider starts at the point ($x$, $y$) defined by **Tmin**. The $t$-, $x$-, and $y$-values are displayed.

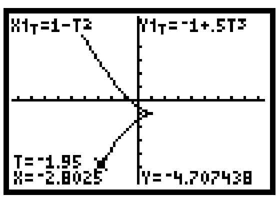


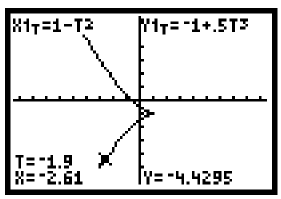






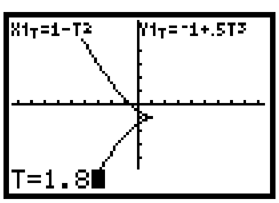

Each time you press the right arrow key, $t$ increases by **Tstep** and the spider moves to the new point defined by the new $t$-value. Note that the right arrow key may not necessarily move the spider to the right on the graph, but it will always increase the value of $t$. Pressing the left arrow key similarly decreases the value of $t$.

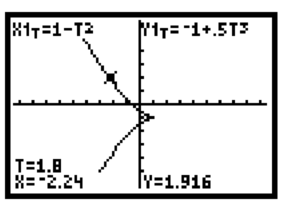





If more than one pair of equations is defined on the Y= screen, pressing the up and down arrow keys makes the spider jump to the previous or next pair of equations. When the spider jumps to another pair of equations, the new pair is evaluated at the current $t$-value. The spider may be anywhere on the screen depending on the $x$-value and $y$-value for the new pair of equations.

Instead of using the right or left arrow keys to increase or decrease the $t$-value, you can enter a number. The spider jumps to the point defined by that $t$-value as long as the number is between **Tmin** and **Tmax**.






In Parametric mode there are no commands for finding the intersection of two graphs or the $x$- or $y$-intercepts of one graph. You'll need to trace in order to approximate points of intersection.

## Note 8D • Parametric Walk

Use the RANGER program to collect data for both recorder X and recorder Y. See **Note 3C** for help with the RANGER program.

From the RANGER MAIN MENU select 1:SETUP/SAMPLE. Use these settings:

| | |
|---|---|
| REALTIME: | NO |
| TIME (S): | 5 |
| DISPLAY: | DIST |
| BEGIN ON: | [TRIGGER] |
| SMOOTHING: | NONE |
| UNITS: | METERS |

Arrow up to START NOW and press ENTER. Press ENTER again for more instructions. You may now disconnect the CBRs if you wish. Follow the instructions in the investigation; recorders X and Y should press their triggers on the front of their CBRs when the director says "go." When finished, reconnect the CBRs and press ENTER. RANGER stores time data in list L1 and distance data in list L2, and it will make an xyline plot of these data. In order to finish the investigation, see **Note 1H** for help with making scatter plots and see **Note 1J** for help with linking lists.

### Clean-Up

RANGER automatically switches the calculator to Function mode and sets it to display three decimal places. It also turns off expressions in the Format screen. Revisit **Note 8A** to change to Parametric mode, press MODE and reset the second line to Float, and then press 2nd [FORMAT] and select ExprOn.

## Note 8E • Drawing Functions

While in Parametric mode, the Draw menu allows you to graph a function that uses only $x$ and $y$. This gives you a way to check your work when eliminating the parameter. For example, follow these steps to graph $y = 3 + 2(x - 1)$ at the same time you are displaying parametric equations:

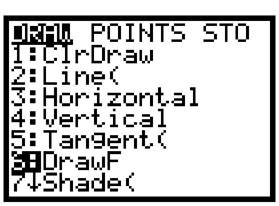
**a.** Press 2nd [DRAW] 6:DrawF.

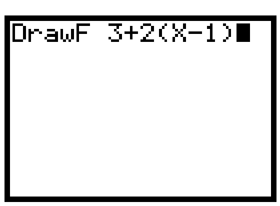
**b.** Enter the first part of the equation, 3+2(.

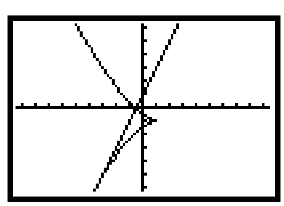
**c.** Press ALPHA [X]. You must use the alpha letter X, not X,T,θ,n, for the variable.

**d.** Enter the rest of the equation, −1).

**e.** Press ENTER. Do not press GRAPH to display the graph of the function.



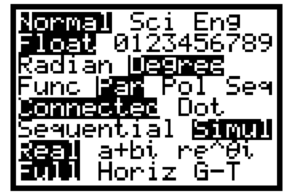



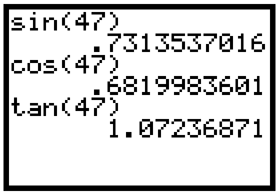
[−9.4, 9.4, 1, −6.2, 6.2, 1]

## Note 8F • Trigonometric and Inverse Trigonometric Functions

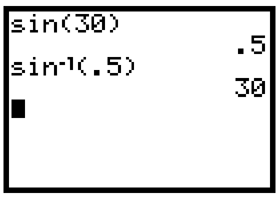
Before using the trigonometric functions on the calculator, press MODE to check that you are in Degree mode.

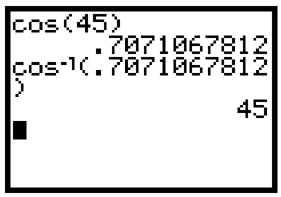


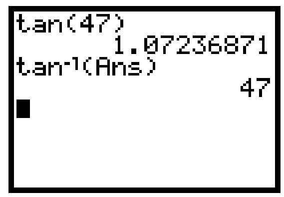

Use SIN, COS, or TAN to find the sine, cosine, or tangent ratio of any angle measure.




Use 2nd [SIN$^{-1}$], 2nd [COS$^{-1}$], or 2nd [TAN$^{-1}$] to find the angle measure that has the given ratio.




## Note 8G • Basketball Free Throw

You have two alternatives for doing a basketball simulation. You can manually set up your own simulation or you can use the BUCKETS program.

### Manual Set-Up

Follow these steps to manually set up your own simulation:

**a.** On the Window screen enter

Tmin = 0
Tmax = 2.1
Tstep = 0.01
Xmin = 0
Xmax = 18.8
Xscl = 5
Ymin = 0
Ymax = 15
Yscl = 5

**b.** Store {12,14.5} in list L1 and {10,10} in list L2. These values represent the *x*- and *y*-coordinates of the near and far edges of the basket; you may adjust them according to the data you collect.

**c.** Set up Plot1 to display a scatter plot of (L1,L2) using the square mark.

**d.** On the Y= screen enter $X_{1T}$=VTcos(A) and $Y_{1T}$=−16T$^2$+VTsin(A)+H.

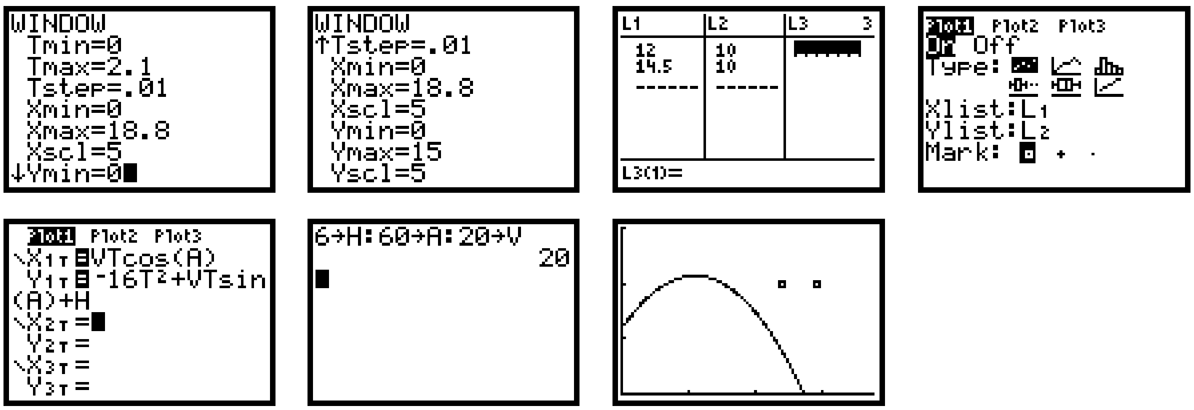
(continued)

**e.** On the Home screen enter and store values for H, the height (in feet) from which the shot is taken; A, the angle (in degrees) of the shot; and V, the initial velocity (in feet per second) of the shot. Enter all the variable values on the same line, separating each with a colon.

**f.** Press GRAPH to see your shot.

**g.** Press 2nd [ENTRY] to recall the stored variable entries. Make any changes you want to the values and press ENTER. Press GRAPH to see your next shot.

**h.** Repeat step g as often as you like.




## BUCKETS Program

Follow these steps to use the premade program:

**a.** Make sure all plots are turned off.

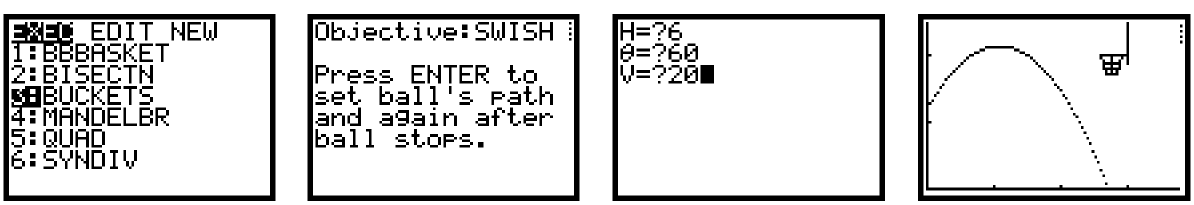
**b.** Run the program BUCKETS. Note: BUCKETS calls on the program BBBASKET in order to run. Make sure BBBASKET appears on your list of programs even though you won't run it directly.

**c.** Read the instructions and press ENTER.

**d.** At the prompts, enter values for H, the height (in feet) from which the shot is taken; *θ*, the angle (in degrees) of the shot; and V, the initial velocity (in feet per second) of the shot. Press ENTER after each entry.

**e.** Your shot displays on the screen. If you make it, you'll know it! (Be patient. It takes a while to complete the shot.)

**f.** Press ENTER to see the replay option. Press 1 and ENTER to reenter variable values and try again. Press any other number and ENTER to end the program.




## Clean-Up

After you quit the BUCKETS program, press 2nd [DRAW] **1:ClrDraw** ENTER to clear the drawing from the Graph screen so it won't interfere with future graphing. You may also want to clear all of the equations on the Y= screen.

**(continued)**

```
PROGRAM:BBBASKET
Line(13,10,15,10)
Line(13,10,13.4,8.6)
Line(14.6,10,14.2,8.6)
Line(13.4,8.6,14.2,8.6)
Line(13.2,9,14.2,9)
Line(13.2,9.4,14.4,9.4)
Line(13.8,10,13.8,8.6)
Line(15,9.4,15,13)
DispGraph
```

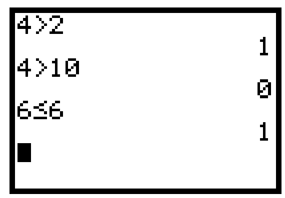
```
PROGRAM:BUCKETS
Param
Degree
"VTcos(θ)"→X1T
"-16T²+VTsin(θ)+H"→Y1T
"13(T-1.05)cos(70)+13"→X2T
"-16(T-1.05)²+13(T-1.05)sin(70)+10"→Y2T
"5(T-1.45)cos(230)+14.8"→X3T
"-16(T-1.45)²+5(T-1.45)sin(230)+12.4"→Y3T
"18(T-2.2)cos(100)+12.4"→X4T
"-16(T-2.2)²+18(T-2.2)sin(100)"→Y4T
"14(T-3.3)cos(100)+9"→X5T
"-16(T-3.3)²+14(T-3.3)sin(100)"→Y5T
"11(T-4.5)cos(100)+7"→X6T
"-16(T-4.5)²+11(T-4.5)sin(100)"→Y6T
FnOff 1,2,3,4,5,6
ClrHome
0→Tmin
1.5→Tmax
Tmax→M
.01→Tstep
0→Xmin
18.8→Xmax
5→Xscl
0→Ymin
12.4→Ymax
5→Yscl
Disp ("Objective:SWISH")
Disp ("")
Disp ("Press ENTER to")
Disp ("set ball's path")
Disp ("and again after")
Disp ("ball stops.")
Pause
prgmBBBASKET
Lbl 2
ClrHome
Prompt H,θ,V
0→T
Lbl 1
If (H≠5 or θ≠60 or V≠25)
Goto 3
5.5→M
If T≤1.05
Goto 3
If T≤1.45
Goto 4
If T≤2.2
Goto 5
If T≤3.3
```

*(continued)*

*(Program: BUCKETS continued)*

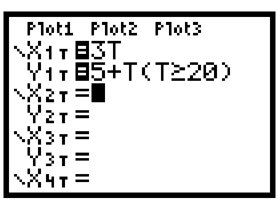
```
Goto 6
If T≤4.5
Goto 7
Pt-On(X6T,Y6T)
Goto 9
Lbl 7
Pt-On(X5T,Y5T)
Goto 9
Lbl 6
Pt-On(X4T,Y4T)
Goto 9
Lbl 5
Pt-On(X3T,Y3T)
If T=1.9
Text(40,30,"ITS GOOD!!!")
Goto 9
Lbl 4
Pt-On(X2T,Y2T)
Goto 9
Lbl 3
Pt-On(X1T,Y1T)
Lbl 9
.02+T→T
If (abs(13.75-X1T)≤.35 and
  abs(10-Y1T)≤.1)
Text(40,30,"SWISH")
If T≤M
Goto 1
Pause
Disp "AGAIN (1=YES)"
Input Y
If Y=1

Goto 2
```

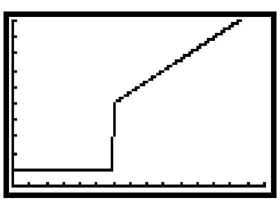
## Note 8H • Graphing with Boolean Expressions




A Boolean expression is a statement with an equality or inequality that is either true or false. The calculator gives a Boolean expression a value of 1 if it is true and a value of 0 if it is false. See **Note 4G** for more information about Boolean expressions.

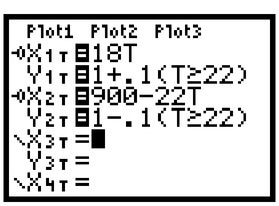
The calculator can use the 1 or 0 value of a Boolean expression to "turn on" or "turn off" part of an equation depending on the value of a variable. For example, the equations X1T=3T and Y1T=5+T(T≥20) graph the horizontal line $y = 5$ for $t$-values less than 20 because the calculator interprets T≥20 as false and the term T in the Y1T equation is multiplied by 0 and thus "turned off." For $t$-values greater than or equal to 20, the T in the Y1T equation is "turned on" because it is multiplied by the Boolean expression that now has value 1. So, at $t = 20$ the graph jumps to the diagonal line $y = \frac{1}{3}x + 5$. Here is what happens when **Tmin=0**, **Tmax=50**, and **Tstep=0.1**.

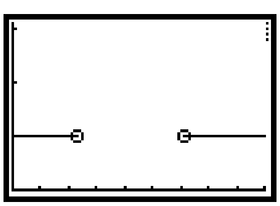


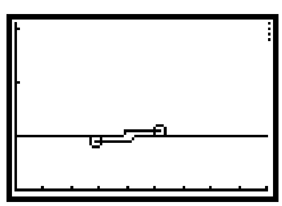
[0, 150, 10, 0, 50, 5]

In these screens the lines appear as if they will collide, but they bypass each other because part of the Y1T and Y2T equations are "turned on" at the right time.



[0, 900, 100, 0, 3, 1]



[0, 900, 100, 0, 3, 1]

# CHAPTER 9 Calculator Notes for the TI-83 and TI-83/84 Plus

## Note 9A • Intersections, Maximums, and Minimums

### Intersections

Follow these steps to find an intersection of two curves without tracing:

**a.** Display the graph of both curves.

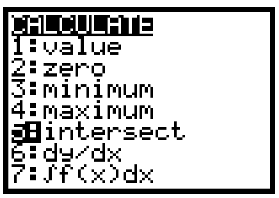
**b.** Press 2nd [CALC] **5:intersect.**

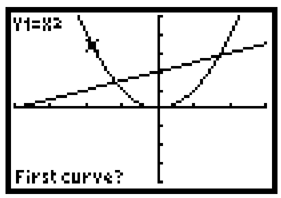
**c.** The screen shows the two curves with the spider on the curve defined by Y1. The prompt calls for a **First Curve?**. If you have graphed more than two curves and Y1 does not define one of the curves you want, use the up and down arrow keys to select a different curve. Press ENTER.

**d.** The prompt then calls for a **Second Curve?**. If necessary, use the up and down arrow keys to select a curve, and then press ENTER.

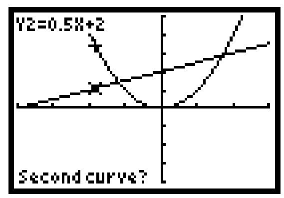
**e.** Finally, the prompt calls for a **Guess?** point. Use the left and right arrow keys to move the spider near the intersection you want to find, and then press ENTER. Note: If the two curves have more than one intersection, you must confine yourself to the vicinity of the intersection you want.

**f.** The screen shows the coordinates of the intersection nearest your guess.

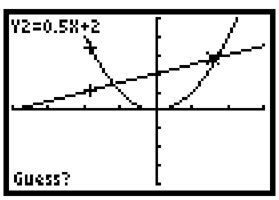


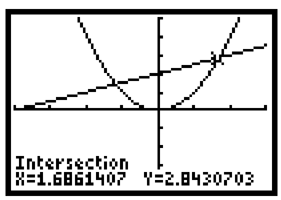

[−4, 3, 1, −4, 5, 1]




[−4, 3, 1, −4, 5, 1]




[−4, 3, 1, −4, 5, 1]




[−4, 3, 1, −4, 5, 1]

### Maximums and Minimums

A similar process allows you to find the coordinates of a maximum or minimum without tracing. For example, follow these steps to find the minimum of $y = (x - 3)^2 + 4$:

**a.** Display the graph of the function.

**b.** Press 2nd [CALC] **3:minimum.**

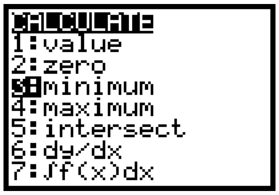
**c.** The prompt calls for a **Left Bound?**. Move the spider to the left of the minimum and press ENTER. Note: If the curve has several extreme values, you must confine yourself to the vicinity of the maximum or minimum you want.

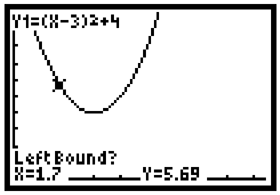
**d.** The prompt calls for a **Right Bound?**. Move the spider to the right of the minimum and press ENTER.

**e.** Finally, the prompt asks for a **Guess?**. Move the spider between the two bounds and press ENTER.

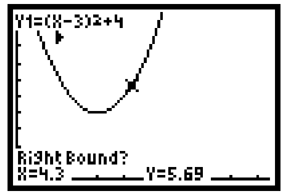
**(continued)**

**f.** The screen shows the coordinates of the minimum between the specified bounds.

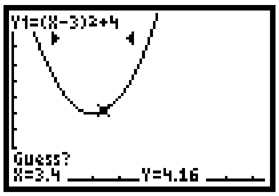


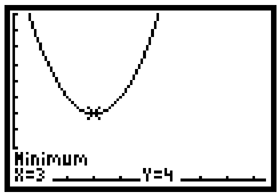
[0, 9.4, 1, 0, 10, 1]



[0, 9.4, 1, 0, 10, 1]



[0, 9.4, 1, 0, 10, 1]



[0, 9.4, 1, 0, 10, 1]

Selecting **4:maximum** results in the maximum between the specified bounds.

## Note 9B • Parametric Equations within Parametric Equations

Just as a function in Function mode can be used as part of other functions, parametric equations in Parametric mode can be used as part of other parametric equations. See **Note 4D** to review functions within functions.

For example, follow these steps to translate a hyperbola right 7 units and down 5 units:

**a.** Enter $X_{1T}$=3tan(T) and $Y_{1T}$=4/cos(T) into the Y= screen.

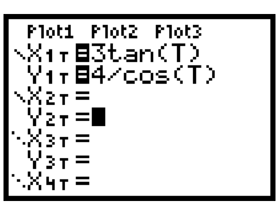
**b.** Set an appropriate window and display the graph of the hyperbola.

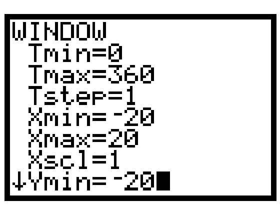
**c.** Define $X_{2T}$ as a translation of $X_{1T}$ by entering $X_{1T}$(T)+7. To find $X_{1T}$ as a variable, press VARS **Y-VARS 2:Parametric 1:$X_{1T}$.**

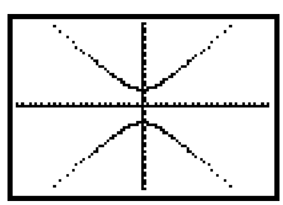
**d.** Define $Y_{2T}$ as a translation of $Y_{1T}$ by entering $Y_{1T}$(T)−5. To find $Y_{1T}$ as a variable, press VARS **Y-VARS 2:Parametric 2:$Y_{1T}$.**

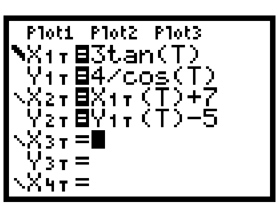
**e.** Use a different graph style for each pair of parametric equations so you can easily distinguish between their graphs.

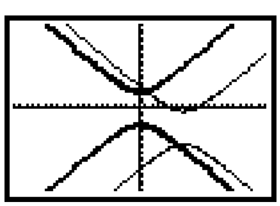
**f.** Check that the window is still appropriate and display both graphs.





[−20, 20, 1, −20, 20, 1]



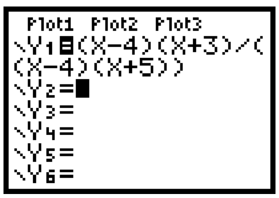


[−20, 20, 1, −20, 20, 1]

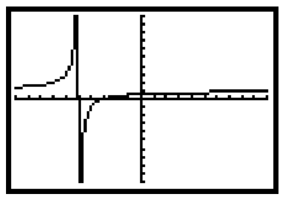
## Note 9C • Asymptotes, Holes, and Drag Lines

When the calculator graphs a function, it plots a sequence of points and connects each point to its adjacent points. The first point's $x$-coordinate equals **Xmin**. Each subsequent point's $x$-coordinate increases by $\frac{1}{94}$ of the screen width. If you graph a function that has a vertical asymptote or a hole that falls between two consecutive plot points, the calculator does not properly display the graph.

### Asymptotes

If the graph has a vertical asymptote that falls between two consecutive plot points, the calculator draws an erroneous, almost vertical, drag line. This occurs because the calculator connects the two points that span the asymptote, one with a positive $y$-coordinate and the other with a negative $y$-coordinate.

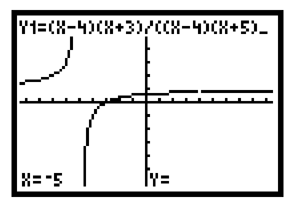


[−10, 10, 1, −10, 10, 1]

To eliminate the drag line, you must use a window in which the $x$-coordinate of one of the plot points equals the asymptote value. Most vertical asymptotes that you will encounter have simple, rational values. Therefore, an appropriate friendly window, which plots points with "nice," rational coordinates, will often attempt to plot a point on the asymptote. Such a point is undefined and the calculator cannot connect it to its adjacent points, so there is no drag line.

While a friendly window with a factor of 2 will work for many functions with vertical asymptotes, you may have to try other friendly windows from time to time. Remember that **Xmin** and **Xmax** are the important values when determining a friendly window; the plotting increment, $\frac{\text{Xmax}-\text{Xmin}}{94}$, must be equal to a "nice," rational number. See **Note 4C** for more information about friendly windows.




[−9.4, 9.4, 1, −6.2, 6.2, 1]

### Holes

The graph of a function with a hole is also often misrepresented on the calculator. If, as the calculator plots its sequence of points, one point is to the left of the hole and the next point is to the right of the hole, the segment connecting these points will cover the hole.

To see the hole, you must choose a window that attempts to plot a point in the hole. This usually requires an appropriate friendly window. In the last screen above, you can see the hole at $x = 4$.

# Calculator Notes for the TI-83 and TI-83/84 Plus

## Note 10A • Unit Circle

Follow these steps to graph a unit circle:

**a.** Press MODE and set the third line to **Degree** and the fourth line to **Par**.

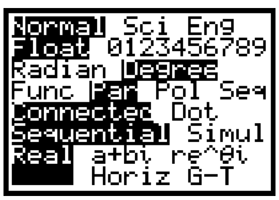
**b.** On the Y= screen, enter the equations $X_{1T}=\cos(T)$ and $Y_{1T}=\sin(T)$.

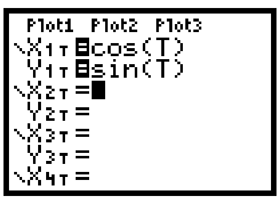
**c.** Set the Window screen to

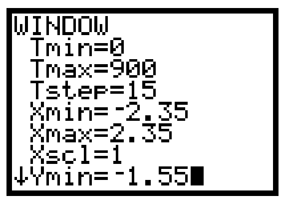
Tmin = 0
Tmax = 900
Tstep = 15
Xmin = −2.35
Xmax = 2.35
Xscl = 1
Ymin = −1.55
Ymax = 1.55
Yscl = 1

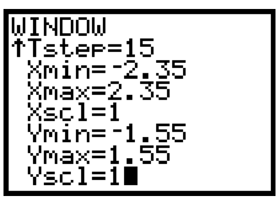
**d.** Display the graph.

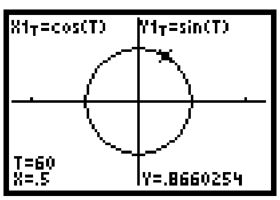
Now you can press TRACE to find the coordinates of points on the circle.



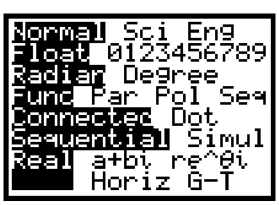



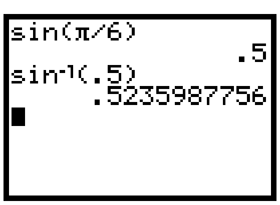




## Note 10B • Radian Mode

In Radian mode, the calculator treats the input of a sine, cosine, or tangent function as a radian measure instead of a degree measure. It also returns a radian measure when you use the inverse functions. To put the calculator in Radian mode, press MODE and set the third line to **Radian**.

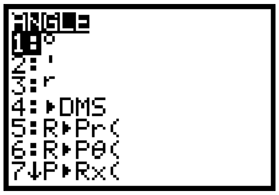


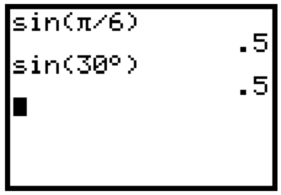




**(continued)**

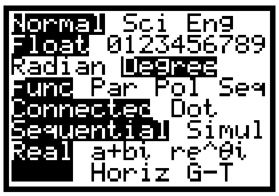
### Overriding Radian or Degree Mode

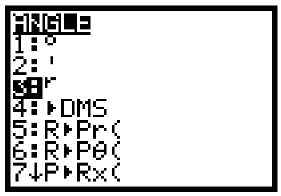
In Radian mode, enter a degree symbol, °, after the input if you want the calculator to override the Radian mode and treat the input as a degree measure. To find the degree symbol, press [2nd] [ANGLE] 1:°.

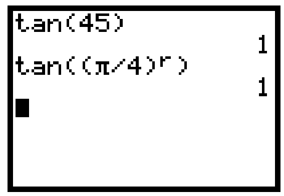



In Degree mode, enter a radian symbol, $^r$, after the input if you want the calculator to override the Degree mode and treat the input as a radian measure. To find the radian symbol, press [2nd] [ANGLE] 3:$^r$.




### Converting Between Radians and Degrees

You can use the override feature to convert an angle measure from radians to degrees or from degrees to radians.

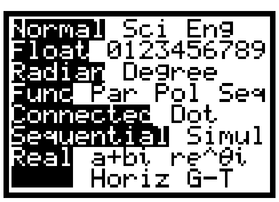
For example, follow these steps to convert 30° to radians:

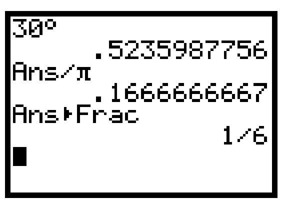
**a.** Set the calculator to Radian mode.

**b.** On the Home screen, enter 30 and press [2nd] [ANGLE] 1:°.

**c.** Press [ENTER]. This gives you the radian measure expressed as a decimal.

**d.** To find the radian measure expressed as a multiple of $\pi$, press [÷] [2nd] [$\pi$] [ENTER] [MATH] 1:▸Frac [ENTER]. Imagine that $\pi$ follows the fraction. So, 30° is equivalent to $\frac{1}{6}\pi$, or $\frac{\pi}{6}$, radians.



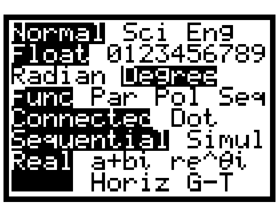



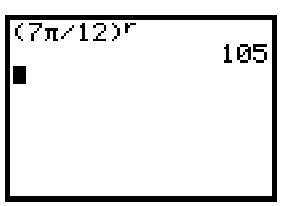

For another example, follow these steps to convert $\frac{7\pi}{12}$ radians to degrees:

**a.** Set the calculator to Degree mode.

**b.** On the Home screen, press [(] 7 [2nd] [$\pi$] [÷] 12 [)] [2nd] [ANGLE] 3:$^r$.

**c.** Press [ENTER]. So, $\frac{7\pi}{12}$ radians is equivalent to 105°.

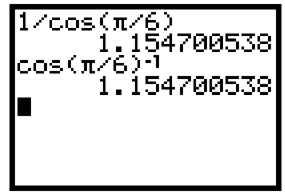


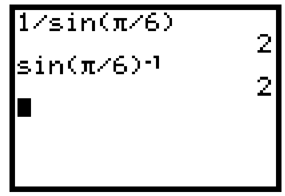
## Note 10C • Secant, Cosecant, and Cotangent

The calculator does not have built-in secant, cosecant, or cotangent functions. You must calculate these functions by using the appropriate reciprocal identities.

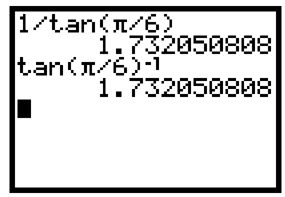
For example, in Radian mode, to evaluate $\sec\left(\frac{\pi}{6}\right)$, press 1 [÷] [COS] [2nd] [π] [÷] 6 [)] [ENTER], or press [COS] [2nd] [π] [÷] 6 [)] [$x^{-1}$] [ENTER].




To evaluate $\csc\left(\frac{\pi}{6}\right)$, press 1 [÷] [SIN] [2nd] [π] [÷] 6 [)] [ENTER], or press [SIN] [2nd] [π] [÷] 6 [)] [$x^{-1}$] [ENTER].




To evaluate $\cot\left(\frac{\pi}{6}\right)$, press 1 [÷] [TAN] [2nd] [π] [÷] 6 [)] [ENTER], or press [TAN] [2nd] [π] [÷] 6 [)] [$x^{-1}$] [ENTER].

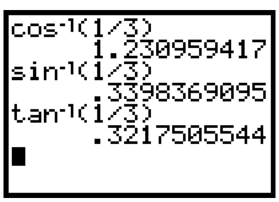



To find the inverse of a secant, cosecant, or cotangent function, use the reciprocal identity's inverse with the reciprocal of the input.

For example, in radian mode, to find $\sec^{-1}(3)$, press [2nd] [COS⁻¹] 1 [÷] 3 [)] [ENTER].

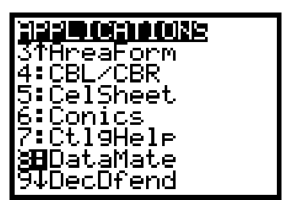
To find $\csc^{-1}(3)$, press [2nd] [SIN⁻¹] 1 [÷] 3 [)] [ENTER].

To find $\cot^{-1}(3)$, press [2nd] [TAN⁻¹] 1 [÷] 3 [)] [ENTER].




## Note 10D • Collecting Sound Frequency Data

You need a CBL2 and the DataMate application (or program) to collect sound frequency data. Press [APPS] and check that you have DataMate loaded. (On a TI-83, press [PRGM] to see if DataMate is loaded.) To load DataMate, connect the CBL2 and calculator, put the calculator in Receive mode ([2nd] [LINK] RECEIVE 1:Receive), and press [TRANSFER] on the CBL2.




Plug the microphone probe into channel CH 1 of the CBL2, and connect the calculator to the CBL2. Press [APPS] and select DataMate. (On a TI-83, press [PRGM] and select DataMate.) If the program does not recognize the microphone, follow these steps:

**a.** Select 1:SETUP.

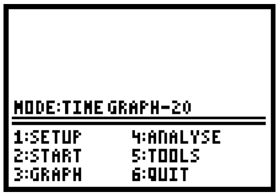
**b.** Press [ENTER] for CH 1.

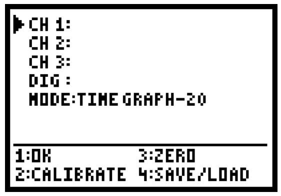
**(continued)**

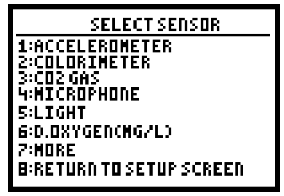
c. Choose 4:MICROPHONE from the second list of choices.

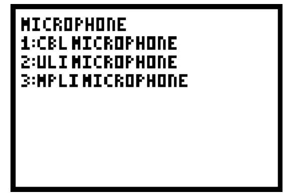
d. Enter the type (1, 2, or 3) as listed on the side of your microphone.

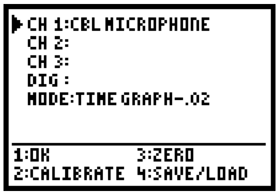
e. Select 1:OK to return to the data collection menu.

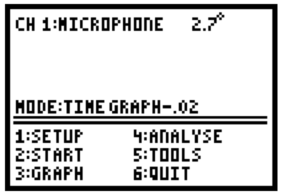


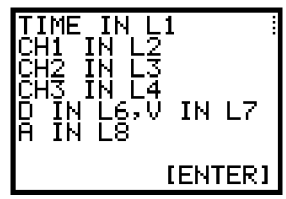




Ring a tuning fork and press 2:START to run the application. In a moment the CBL2 will beep as it begins to collect data. Since it collects data for only 0.02 second, it will beep again almost immediately to signal when it stops collecting. The calculator will display a graph. If the graph does not look like a sinusoidal curve, press ENTER and select 2:START to try again. If you continue to have trouble collecting good data, adjust the microphone's position.




When you have good data, choose 6:QUIT. The calculator will tell you that time data are stored in list L1 and sound frequency data are stored in list L2.

## Note 10E • Polar Coordinates

### Graphing Polar Equations

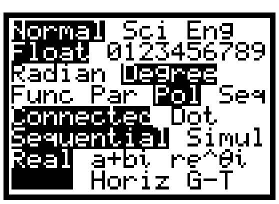
Follow these steps to graph a polar equation:

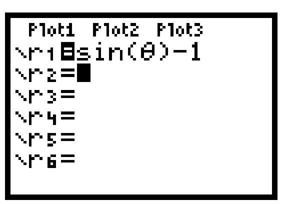
a. Press MODE and set the third line to **Degree** and the fourth line to **Pol**.

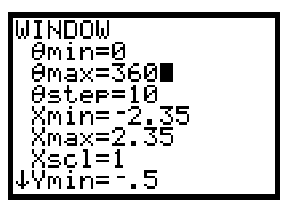
b. On the Y= screen enter a function in the form $r = f(\theta)$. Press X,T,θ,n to get $\theta$.

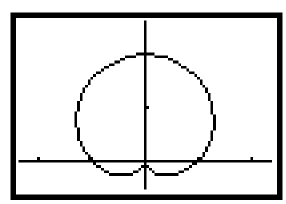
c. On the Window screen, set values of $\theta$ as well as $x$ and $y$.

d. Display the graph.



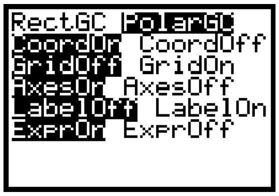



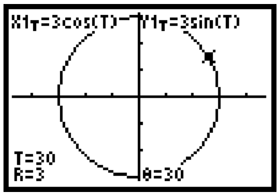
[−2.35, 2.35, 1, −0.5, 2.6, 1]

(continued)

### Tracing Polar Coordinates

No matter what mode you're in, you can find the polar coordinates of a point on a graph by pressing 2nd [FORMAT] and selecting **PolarGC**. Then when you trace or move the cursor about the screen, you will see coordinates in the form ($r$, $\theta$).




[−4.7, 4.7, 1, −3.1, 3.1, 1]

Remember to change the format back to **RectCG** in order to display coordinates in the form ($x$, $y$).

# CHAPTER 11 Calculator Notes for the TI-83 and TI-83/84 Plus

## Note 11A • Partial Sums of Series

Follow these steps to find partial sums of any recursively defined sequence:

**a.** Press MODE and set the fourth line to **Seq** and the fifth line to **Dot**.

**b.** Press 2nd [FORMAT] and set the first line to **Time**.

**c.** On the Y= screen, enter

$n$Min = 1.

u($n$) = the recursive rule for the sequence.

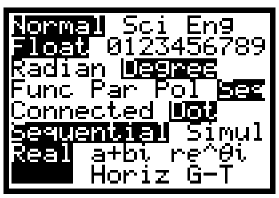
u($n$Min) = the starting value of the sequence.

v($n$) = the sum of $v(n-1)$ and the recursive rule for $u(n)$. Sequence $v$ is the sequence of partial sums of the terms of sequence $u$.

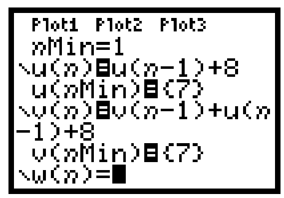
v($n$Min) = the same starting value as u($n$Min).

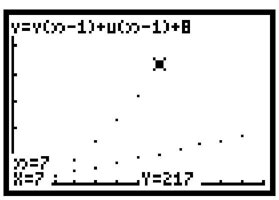
**d.** Set an appropriate Window screen or Table Set screen in order to view the terms of sequence $u$ and the partial sums, sequence $v$.

See **Notes 1D** and **1E** for more help with entering or graphing recursive sequences.

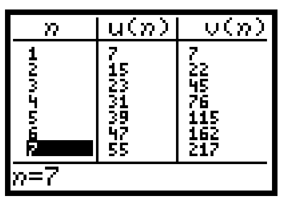






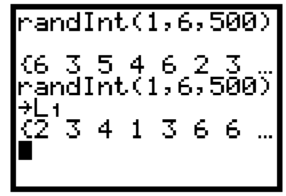

[0, 12, 1, 0, 300, 50]



# CHAPTER 12 Calculator Notes for the TI-83 and TI-83/84 Plus

## Note 12A • Dice Simulation

(If your calculator has the application **Prob Sim**, see **Note 12A/App** for an alternative way to simulate dice.)



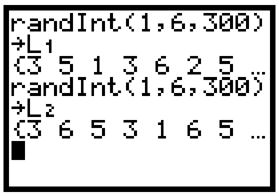

Recall that you can simulate the throw of a die using the random integer command, **randInt(1,6,*n*)**, where *n* is the number of throws. See **Note 1L** for help with the **randInt(** command. To store the outcomes into a list, say list $L_1$, press STO→ 2nd [$L_1$].

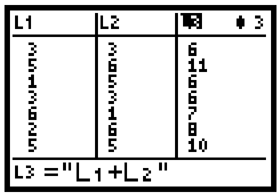
Follow these steps to simulate the sums for 300 throws of a pair of dice:

**a.** Store 300 throws of a die into list $L_1$, **randInt(1,6,300)**→$L_1$.

**b.** Store 300 throws of a die into list $L_2$, **randInt(1,6,300)**→$L_2$.

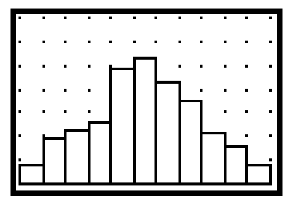
**c.** Define list $L_3$ as the sum of lists $L_1$ and $L_2$.




Notice in the second screen that the definition of list $L_3$ uses quotation marks, ALPHA ["], and the list name has a diamond, ♦, beside it. The quotation marks make the definition dynamic so that the values in list $L_3$ will automatically update if list $L_1$ or list $L_2$ changes. The diamond indicates that the list is dynamic.

**d.** You can display a histogram to show the distribution of the sums in list $L_3$. See **Note 2D** for help with histograms.



[2, 13, 1, 0, 70, 10]

## Note 12A/App • Dice Simulation with the Prob Sim App

(See **Note 12A** if your calculator does not have the application **Prob Sim**.)

To start the application, press APPS, select **Prob Sim**, and press any key. Follow these steps to simulate the sums for 300 throws of a pair of dice:

**a.** From the Simulation menu, select **2.Roll Dice**.

**b.** Press ZOOM to go to the Settings menu. Enter these settings and then press GRAPH to choose **OK**:

| | |
|---|---|
| **Trial Set:300** | The number of trials to perform at once. |
| **Dice:2** | The number of dice to use. |
| **Sides:6** | The number of sides on each die. |
| **Graph:Freq** | The graph can show frequency or probability. |
| **StoTbl:All** | The table can store all, the last 50, or none of the trials. |
| **ClearTbl:Yes** | The data clear when you do the experiment again. |
| **Update:50** | The number of trials after which the graph updates. |

**c.** Press WINDOW to roll the dice. The application will simulate 300 throws of a pair of dice and will show a bar graph of the sums. The bar graph will update every 50 rolls.

**d.** When the 300 throws are complete, you can arrow left or right to trace the bar graph and see the frequency of each sum.

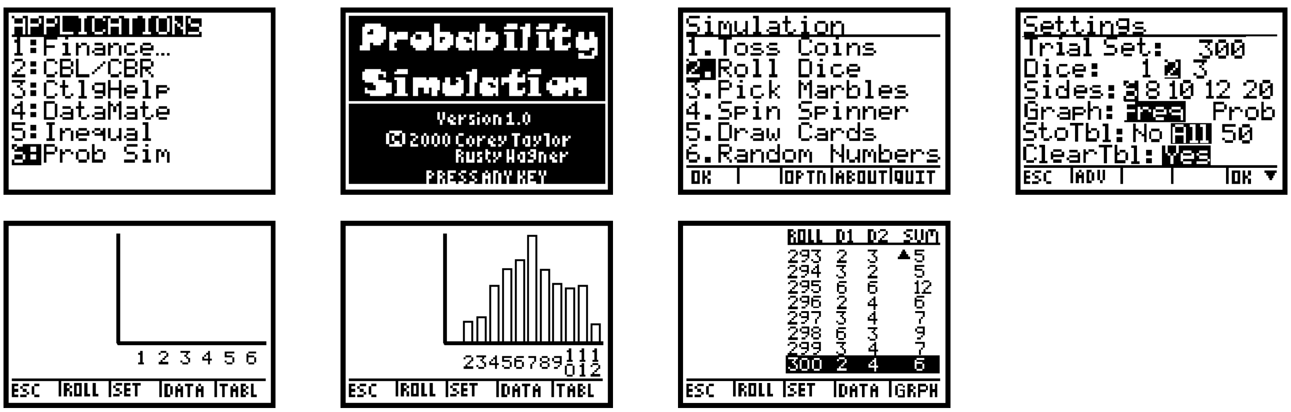
**(continued)**

**e.** If you press GRAPH, the bar graph will change to a table. You can arrow up or down to see the number on each die, D1 and D2, as well as the sum. Pressing GRAPH again changes the table back to a bar graph.

**f.** If you press TRACE, you have the option to save the data into four lists: ROLL for the roll number, D1 for the numbers on die 1, D2 for the numbers on die 2, and SUM for the sum of the dice. Press GRAPH to save the data, or press Y= to escape without saving.

**g.** Exit the program by pressing Y= to escape the dice simulation. Press Y= again to remove the trials from memory, and then press GRAPH to quit and Y= to confirm.

As is obvious from the Simulation menu, you can use the Prob Sim application to simulate many other probability situations. When you are in the Settings menu, press WINDOW to set advanced settings, such as the "weight" of a side, which can make the probability of one event greater than another.

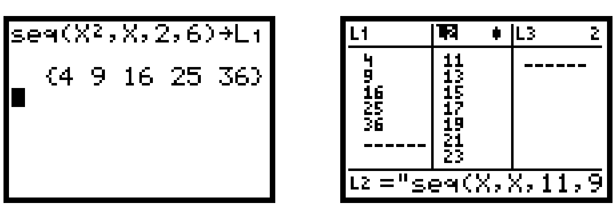



## Note 12B • Sequences into Lists

With the calculator in any mode, you can use the **seq(** command to generate a nonrecursive sequence. To find the **seq(** command, press 2nd [LIST] **OPS 5:seq(**.

The **seq(** command requires four arguments: an expression, a variable counter, the starting value of the counter, and the ending value of the counter. The counter increases in increments of 1 unless an optional fifth argument specifies a different increment.

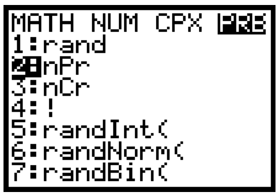
For example, **seq(**$X^2$**,X,2,6)** generates the sequence of perfect squares $2^2$ through $6^2$. As another example, **seq(X,X,11,99,2)** generates the odd integers from 11 to 99. To store the sequence into a list, you can use the store key, STO▸, from the Home screen, or enter a sequence definition into the Stat Edit screen. Entering the definition in quotation marks, ALPHA ["], keeps the definition dynamic and allows you to easily edit it.

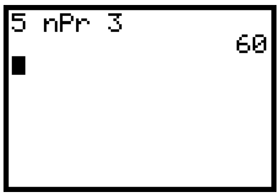


## Note 12C • Permutations

To find numbers of permutations, use the **nPr** command. To find the **nPr** command, press MATH **PRB 2:nPr**. First enter the value of *n*, the number of objects. Then enter the **nPr** command, and enter the value of *r*, the number of objects chosen. Then press ENTER.

For example, to find the number of arrangements of 5 objects chosen 3 at a time, enter **5 nPr 3**. The answer shows that there are 60 arrangements.

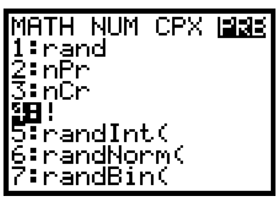


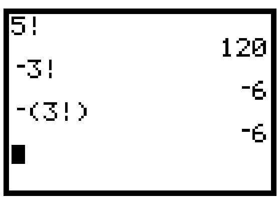




## Note 12D • Factorials

To find the factorial command, press MATH **PRB 4:!**. For example, to find 5!, press **5** MATH **PRB 4:!** ENTER.

In the order of operations, factorial has higher precedence than negation, so −3! is equivalent to −(3!).

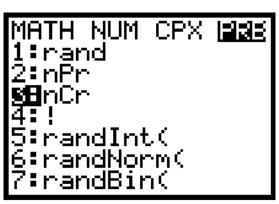


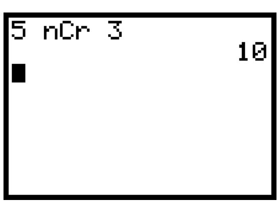




## Note 12E • Combinations

To find numbers of combinations, use the **nCr** command. To find the **nCr** command, press MATH **PRB 3:nCr**. First enter the value of *n*, the number of objects. Then enter the **nCr** command, and enter the value of *r*, the number of objects chosen. Then press ENTER.

For example, to find the number of groupings of 5 objects chosen 3 at a time, enter **5 nCr 3**. The answer shows that there are 10 different groupings.




## Note 12F • Binomial Probability

### Single Probability

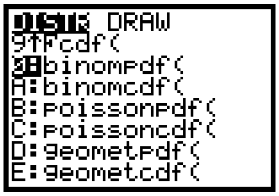
To calculate the probability of any number of successes in a probability experiment, use the binomial probability distribution function command, **binompdf(**. To find the **binompdf(** command, press 2nd **[DISTR] 0:binompdf(**.

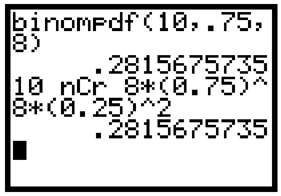
(continued)

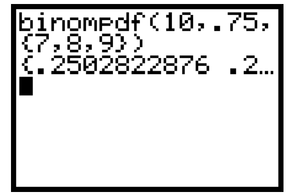
The **binompdf(** command requires three arguments: the number of trials, the probability of a success for each trial, and the number of successes.

For example, **binompdf(10,.75,8)** finds the probability of 8 successes out of 10 trials where the probability of each success is .75.

The **binompdf(** command is a shortcut for calculating the value of one term of a binomial expansion. That is, **binompdf(10,.75,8)** is the same as ${}_{10}C_8 \cdot (0.75)^8 \cdot (0.25)^2$.



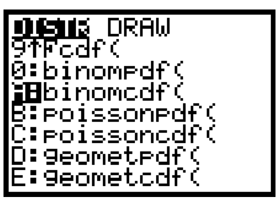



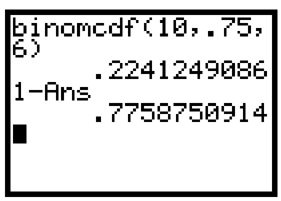

To find more than one probability at the same time, use the **binompdf(** command and enter the number of successes as a list.

## Cumulative Probability

The binomial cumulative distribution function command, **binomcdf(**, is similar to the **binompdf(** command, but it sums the binomial probabilities from 0 successes to the desired number. To find the **binomcdf(** command, press 2nd **[DISTR] A:binomcdf(**.

For example, **binomcdf(10,.75,6)** finds the probability of 6 or fewer successes out of 10 trials where the probability of each success is .75. To find the probability of more than 6 successes, subtract the previous answer from 1.

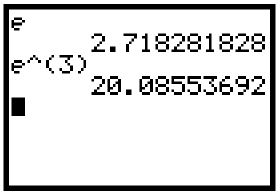


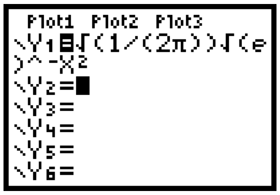



# CHAPTER 13 Calculator Notes for the TI-83 and TI-83/84 Plus

## Note 13A • Entering *e*

To display the value of *e*, press [2nd] [e] [ENTER]. To define an exponential expression or function with base *e*, press [2nd] [$e^x$].




## Note 13B • Normal Graphs

You can easily graph a normal curve with the normal probability distribution function, **normalpdf(**. To find the **normalpdf(** command, press [2nd] **[DISTR] 1:normalpdf(**.

Follow these steps to graph a normal curve in Function mode:

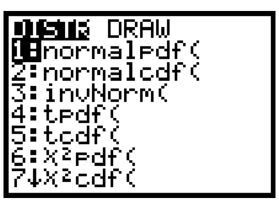
**a.** Make note of the mean, $\mu$, and the standard deviation, $\sigma$, of the distribution.

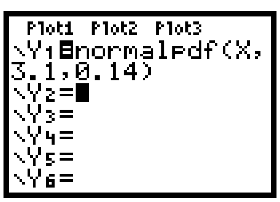
**b.** Press [Y=] and define **Y1=normalpdf(X,**$\mu$**,**$\sigma$**)**. Enter the numerical values of $\mu$ and $\sigma$. Or if you have stored your data into lists and used **1-Var Stats** to calculate the mean and standard deviation, you can use the exact values by pressing [VARS] **5:Statistics**, and selecting **2:**$\bar{x}$ for the mean and **4:**$\sigma$**x** for the standard deviation.

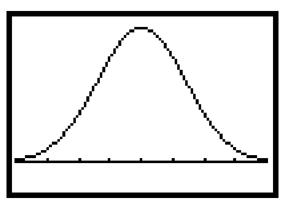
**c.** Set an appropriate window.

**d.** Press [GRAPH].

These screens show a normal curve with a mean 3.1 and standard deviation 0.14.



[2.7, 3.5, 0.1, −0.5, 3, 0]

To graph the standard normal distribution, that is, a normal curve with mean 0 and standard deviation 1, you need enter only **normalpdf(X)**.

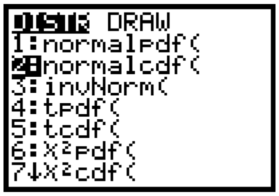
## Note 13C • Probabilities of Normal Distributions

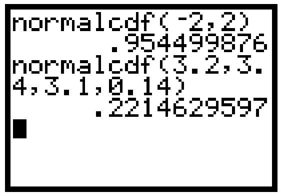
### Calculating Ranges

The normal cumulative distribution function, **normalcdf(**, calculates the area under a normal curve between two endpoints. To find the **normalcdf(** command, press [2nd] **[DISTR] DISTR 2: normalcdf(**. For a standard normal distribution with mean 0 and standard deviation 1, enter **normalcdf(***lower,upper***)**. For any normal distribution, with mean $\mu$

**(continued)**

and standard deviation $\sigma$, enter the command in the form **normalcdf(***lower,upper,* $\mu$, $\sigma$).

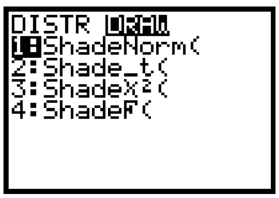


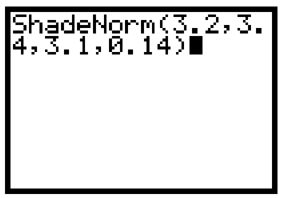



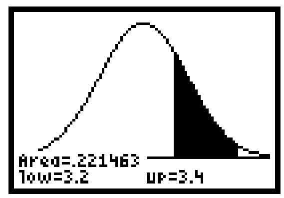

### Graphing Ranges

The **ShadeNorm(** command graphs the normal curve and shades the area between the specified endpoints. It also reports the probability associated with that area. To find the **ShadeNorm(** command, press [2nd] **[DISTR] DRAW 1:ShadeNorm(**.

To use the command, first set an appropriate window. Then, on the Home screen, enter the command in the form **ShadeNorm(***lower,upper,* $\mu$, $\sigma$).



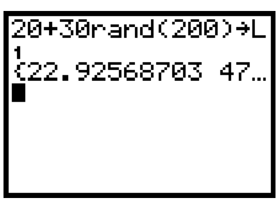



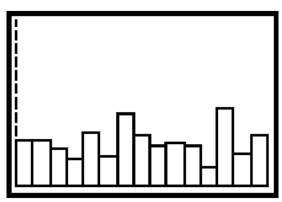

[2.7, 3.5, 0.1, −0.5, 3, 0]

## Note 13D • Creating Random Probability Distributions

You can create lists of various kinds of distributions.

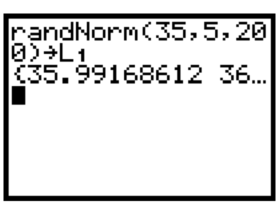
**a.** To create a uniform distribution, use [MATH] **PRB 1:rand**. This example creates a list of 200 values uniformly distributed between 20 and 50.

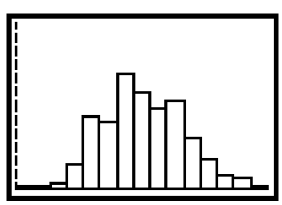


[20, 50, 2, 0, 50, 1]

**b.** To create a normal distribution, use [MATH] **PRB 6:randNorm(**. This example creates a list of 200 values with mean 35 and standard deviation 5. Almost all of the values will be between 20 and 50.

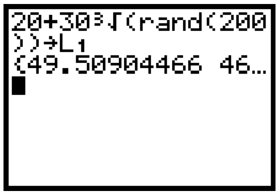


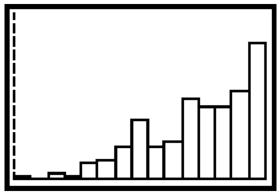



[20, 50, 2, 0, 50, 1]

**(continued)**

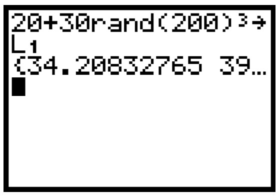
**c.** To create a left-skewed distribution, use the cube root of **rand(**. This example creates a left-skewed population of 200 values between 20 and 50.

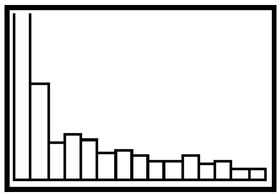


[20, 50, 2, 0, 50, 1]

**d.** To create a right-skewed distribution, use the cube of **rand(**. The example creates a right-skewed population of 200 values between 20 and 50.



[20, 50, 2, 0, 50, 1]

## Note 13E • Sampling from a Distribution

Before starting the sampling routine, make sure that you have stored your distribution data into list L1 (see **Note 13D**), calculated the population mean and standard deviation, and graphed $Y_1=\mu$, $Y_2=\mu-2\sigma/\sqrt{X}$, and $Y_3=\mu+2\sigma/\sqrt{X}$.

Now, the recursive routine below will randomly choose one value at a time from list L1 and add it to a sample, and then plot a point in the form (*number sampled, sample mean*). In the routine, the variable N is the number sampled and the variable T is the sum of the data values. Hence, the routine plots the point (N, T/N).

**a.** Initialize N to 0 by pressing **0** [STO→] [ALPHA] [N] [ENTER].

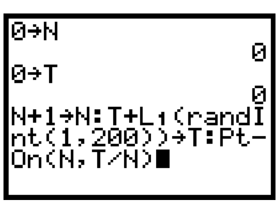
**b.** Initialize T to 0 by pressing [STO→] [ALPHA] [T] [ENTER].

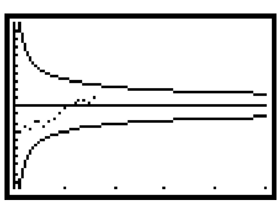
**c.** Enter this recursive routine on the Home screen:

**N+1→N:T+L1(randInt(1,200))→T:Pt=On(N,T/N)**

Find the **randInt(** command by pressing [MATH] **PRB 5:randInt(**. Find the point plotting command, **Pt-On(**, by pressing [2nd] [DRAW] **POINTS 1:Pt-On(**. Get the colon by pressing [ALPHA] [:].

**d.** Begin the sampling-and-plotting routine by pressing [ENTER] [CLEAR] [ENTER] [CLEAR], and so on. Each time you press [ENTER], you'll see a new point plotted on the graph.



[0, 50, 10, $\mu-20\sigma$, $\mu+20\sigma$, 1]

## Note 13F • Correlation Coefficient

There are two ways to find a correlation coefficient, *r*, using the calculator. You can manually enter the calculations yourself, or you can have the calculator do the work for you.

First store your bivariate data into two lists, say list L1 for the *x*-values and list L2 for the *y*-values.

Follow these steps to manually calculate *r:*

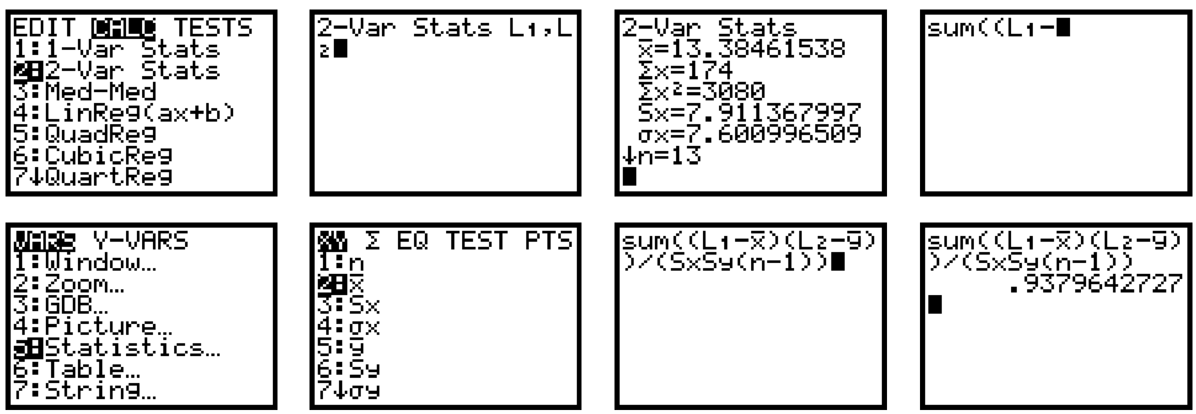
**a.** Calculate the two-variable statistics that you need for the formula by pressing [STAT] CALC **2:2-Var Stats** [2nd] [L1] [,] [2nd] [L2] [ENTER].

**b.** Start inputting the formula $\frac{\Sigma(x - \bar{x})(y - \bar{y})}{s_x s_y(n - 1)}$ by entering **sum((L1−**. Do not press [ENTER] yet. To find the **sum(** command, press [2nd] [LIST] MATH **5:sum(**.

**c.** Press [VARS] **5:Statistics 2:x̄** to enter $\bar{x}$ into the expression. Notice that by pressing [VARS] **5:Statistics** you can also get **1:n**, **3:Sx**, **5:ȳ**, and **6:Sy**.

**d.** Enter the rest of the formula, ((L2−ȳ))/(SxSy(n−2)).

**e.** Press [ENTER] to display the value of *r*.

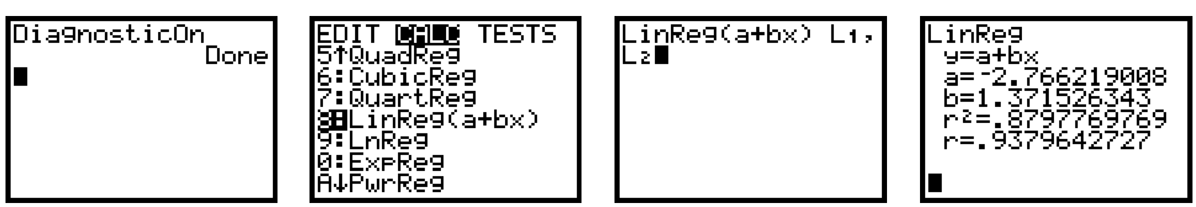



Follow these steps to have the calculator compute *r:*

**a.** Press [2nd] [CATALOG] [D]. Scroll down to **Diagnostic On**. Press [ENTER] [ENTER]. (Note: You need to do this step only once. After you turn the diagnostics on, the setting remains on.)


**b.** Press [STAT] CALC **8:LinReg(a+bx)** [2nd] [L1] [,] [2nd] [L2] [ENTER]. (Note: You can also use **4:LinReg(ax+b)** instead of **8:LinReg(a+bx)**.)

**c.** The calculator displays the value of *r*, as well as other information about the least squares line, which you'll learn about later.



## Note 13G • LSL Program

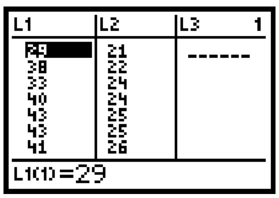
The program LSL allows you to adjust a line until the sum of the squares of the residuals is minimized. Follow these steps:

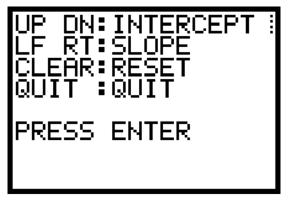
**a.** Store your data into lists L1 and L2.

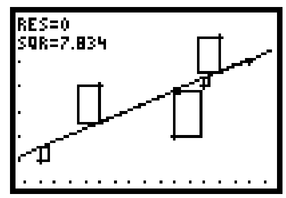
**b.** Run the program LSL.

**c.** A short set of instructions are displayed. Arrow up or down to change the intercept of the line. Arrow left or right to change the slope of the line. Press CLEAR to reset the line and start over. Press 2nd QUIT to quit the program. Press CLEAR to return to Home screen.

**d.** Press ENTER to see a scatter plot of your data, a line, and a physical representation of the squares of the residuals. (Note: The graphing window may not be square, so the squares may look like rectangles.) Keep adjusting the line until you have found the line with the smallest sum of the squared residuals, the value called SQR in the upper-left corner.








### Clean-Up

After you quit the program, all three Stat Plots remain on. To turn them off so they do not interfere with future graphing activities, press 2nd [STAT PLOT] 4 ENTER.

```
PROGRAM:LSL
Degree
ClrHome
Disp "UP DN:INTERCEPT"
Disp "LF RT:SLOPE"
Disp "CLEAR:RESET"
Disp "QUIT :QUIT"
Disp " "
LinReg(a+bx) L1,L2
PlotsOff :FnOff
Plot1(Scatter,L1,L2,+)
Pause "PRESS ENTER"
ZoomStat
b→A:b→B
2-Var Stats L1,L2
n→N:x̄→U:ȳ→T:T→W
{U}→L3:{T}→L4
seq(L1(int(X/5)+1),X,0,5N-1)→L5
seq(L2(int(X/5)+1),X,0,5N-1)→L6
Xmax→L5(5N+1)
Ymax→L6(5N+1)
augment({Xmin},L5)→L5
augment({Ymin},L6)→L6
Plot2(Scatter,L3,L4,□)
Plot3(xyLine,L5,L6,·)
Repeat K=22
For(J,1,N)
L1(J)→X:L2(J)→Y
W+A(X-U)→Z
Z→L6(5J-3):Z→L6(5J):Z→L6(5J+1)
X-(Y-Z)→Z
Z→L5(5J-1):Z→L5(5J)
End
W+A(Xmin-U)→L6(1)
W+A(Xmax-U)→L6(5N+2)
(Ymax-Ymin)/62→C
L2-(W+A(L1-U))→LR
sum(LR)→R
sum(LR²)→S
DispGraph
Text(0,0,"RES=")
Text(0,16,round(R,3))
Text(7,0,"SQR=")
Text(7,16,round(S,3))
```

*(continued)*

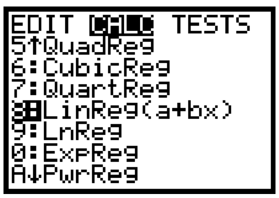
*(Program: LSL continued)*

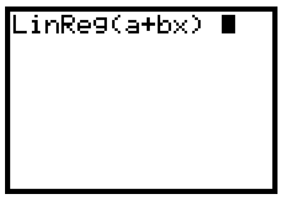
```
Repeat K≠0
getKey→K
End
W+C((K=25)-(K=34))→W
tan(tan⁻¹(A)+((K=24)-(K=26)))→A
If K=45:Then
B→A:T→W:End
End
```

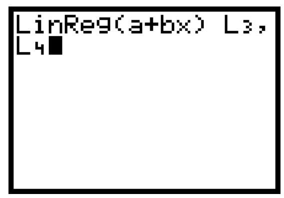
## Note 13H • Least Squares Line

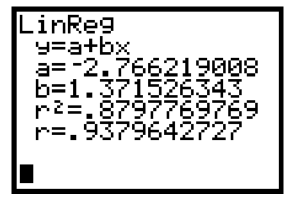
The calculator can find the equation of the least squares line in either the form $y = ax + b$ or the form $y = a + bx$. To find the least squares commands, press STAT CALC **4:LinReg(ax+b)** or **8:LinReg(a+bx)**. Either command defaults to using list $L_1$ for the $x$-values and list $L_2$ for the $y$-values, but you may specify another pair of lists by following the command with the list names separated by a comma.

When you press ENTER the calculator displays the slope and $y$-intercept of the least squares line, the correlation coefficient, $r$, and the coefficient of determination, $r^2$.

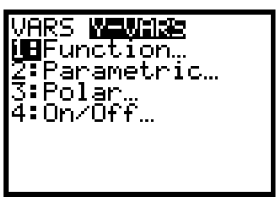


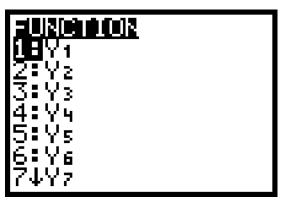



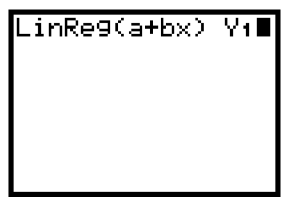



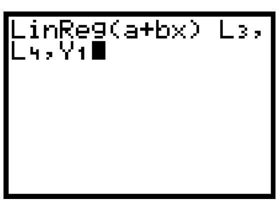



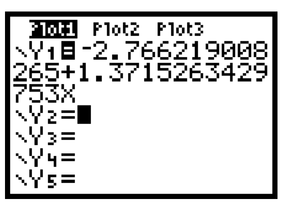

To enter the equation of the least squares line into the Y= screen, enter a function name after the command. Find the function names by pressing VARS **Y-VARS 1:Function.**



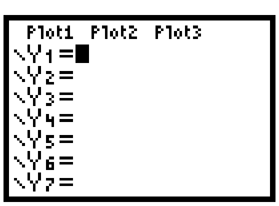



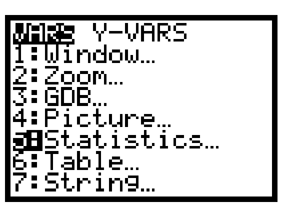



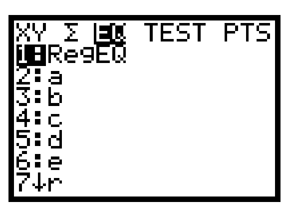



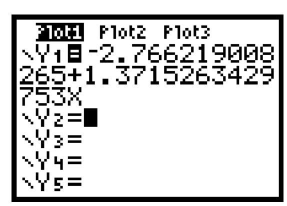




If you forget to specify a function name, you can later paste the least squares equation into the Y= screen. Press Y= and go to the desired function. Then press VARS **5:Statistics**, go to the **EQ** submenu, and select **1:RegEq.**



## Note 13I • Nonlinear Regression

The calculator uses a least squares approach to fit a curve to nonlinear data. It uses a combination of linearization and multivariable analysis.

You can find all of these nonlinear regression commands in the STAT **Calc** submenu:

| | |
|---|---|
| **5:QuadReg** | Quadratic: $y = ax^2 + bx + c$ |
| **6:CubicReg** | Cubic: $y = ax^3 + bx^2 + cx + d$ |
| **7:QuartReg** | Quartic: $y = ax^4 + bx^3 + cx^2 + dx + e$ |
| **9:LnReg** | Logarithmic: $y = a + b\ln(x)$ |
| **0:ExpReg** | Exponential: $y = a\left(b^x\right)$ |
| **A:PwrReg** | Power: $y = a\left(x^b\right)$ |
| **B:Logistic** | Logistic: $y = \dfrac{c}{1 + ae^{-bx}}$ |
| **C:SinReg** | Sinusoidal: $y = a\sin(bx + c) + d$ |

You enter each command followed by three optional arguments separated by commas—the names of the lists to use and the name of the function to store the equation into. If no lists are specified, the defaults are lists $L_1$ and $L_2$. If no function is specified, you can later paste it into the Y= screen. (See **Note 13H** for more information about entering a regression calculation.)

The regression commands return different coefficients:

Logarithmic, exponential, and power regressions give both a correlation coefficient, $r$, and a coefficient of determination, $r^2$.

Quadratic, cubic, and quartic regressions give only a coefficient of determination, $R^2$.

Logistic and sinusoidal regressions do not give $r$, $r^2$, or $R^2$.

Some of the nonlinear regression commands have special requirements:

Logarithmic regression must have all $x$-values greater than zero.

Exponential and logistic regressions must have all $y$-values greater than zero.

Power regression must have all $x$- and $y$-values greater than zero.

Quadratic and logistic regressions require at least 3 points; cubic and sinusoidal regressions require at least 4 points; and quadratic regression requires at least 5 points. In general, a regression command needs at least as many points as there are parameters in the equation.

Key Curriculum Press
Innovators in Mathematics Education

# Comment Form

Please take a moment to provide us with feedback about this book. We are eager to read any comments or suggestions you may have. Once you've filled out this form, simply fold it along the dotted lines and drop it in the mail. We'll pay the postage. Thank you!

Your Name ______________________________

School ______________________________

School Address ______________________________

City/State/Zip ______________________________

Phone ____________________

Book Title ______________________________

Please list any comments you have about this book.

Do you have any suggestions for improving the student or teacher material?

To request a catalog, or place an order, call us toll free at 800-995-MATH, or send a fax to 800-541-2242.
For more information, visit Key's website at www.keypress.com.

*Please detach page, fold on lines, and tape edge.*

NO POSTAGE
NECESSARY
IF MAILED
IN THE
UNITED STATES

BUSINESS REPLY MAIL
FIRST CLASS PERMIT NO. 338 OAKLAND, CA

POSTAGE WILL BE PAID BY ADDRESSEE

KEY CURRICULUM PRESS
1150 65TH STREET
EMERYVILLE CA 94608-9740

Key Curriculum Press
Innovators in Mathematics Education

# Comment Form

Please take a moment to provide us with feedback about this book. We are eager to read any comments or suggestions you may have. Once you've filled out this form, simply fold it along the dotted lines and drop it in the mail. We'll pay the postage. Thank you!

Your Name ______________________________

School ______________________________

School Address ______________________________

City/State/Zip ______________________________

Phone ______________________________

Book Title ______________________________

Please list any comments you have about this book.

______________________________

______________________________

______________________________

______________________________

______________________________

______________________________

______________________________

______________________________

______________________________

______________________________

Do you have any suggestions for improving the student or teacher material?

______________________________

______________________________

______________________________

______________________________

______________________________

______________________________

______________________________

To request a catalog, or place an order, call us toll free at 800-995-MATH, or send a fax to 800-541-2242.
For more information, visit Key's website at www.keypress.com.

*Please detach page, fold on lines, and tape edge.*

NO POSTAGE
NECESSARY
IF MAILED
IN THE
UNITED STATES

**BUSINESS REPLY MAIL**
FIRST CLASS PERMIT NO. 338 OAKLAND, CA

POSTAGE WILL BE PAID BY ADDRESSEE

KEY CURRICULUM PRESS
1150 65TH STREET
EMERYVILLE CA 94608-9740