

1 TI-83 Basics

This initial chapter is a brief introduction to many of the capabilities and uses of the **TI-83** that will be important throughout the remainder of this manual. This is not intended to be a substitute for the **TI-83 Guidebook**. Always keep your **TI-83 Guidebook** handy for reference. In particular, you should work carefully through Chapters 1 and 2 and make at least a cursory pass through Chapter 3 of your **TI-83 Guidebook** before proceeding any further in this manual.

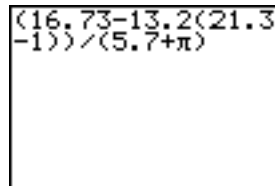
1.1 The Home screen

The home screen is the starting point for numerical computation on the **TI-83**. Let's clear the home screen (press **[CLEAR]**) and work a few simple examples.

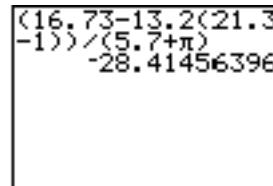
Basic arithmetic can be easily performed on the **TI-83**. For example, try calculating

$$\frac{16.73 - 13.2(21.3 - 1)}{5.7 + \pi}$$

The screen on the left below shows the expression before pressing **[ENTER]**; the screen on the right shows the expression after pressing **[ENTER]**. (Note that π is typed by pressing **[2nd][^]**.)

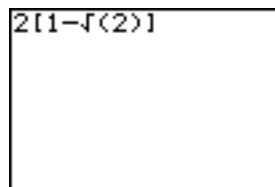


(16.73-13.2(21.3-1))/(5.7+π)

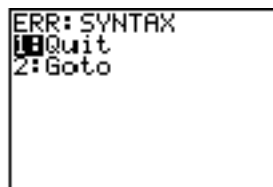


(16.73-13.2(21.3-1))/(5.7+π)
-28.41456396

It is very important to be careful with parentheses when using the **TI-83**. The calculator *will not read your mind*. You must be precise. Also, it is important to use the proper type of grouping symbols. Always use (*round*) parentheses when doing calculations. Notice what happens when we try to use (*square*) brackets to compute $2(1 - \sqrt{2})$.



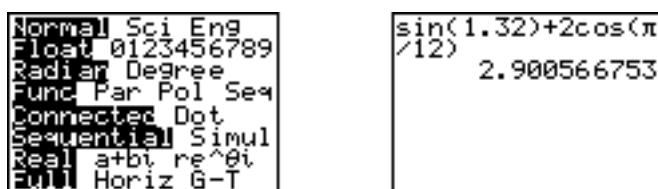
2[1-√(2)]



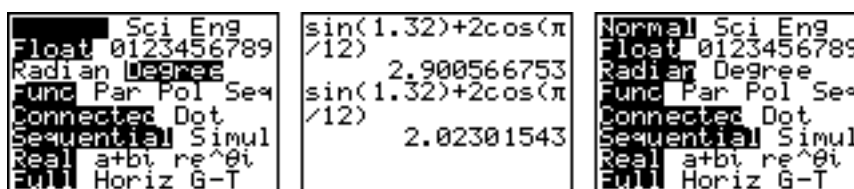
ERR: SYNTAX
1:Quit
2:Goto

Computations involving the basic functions can also be done on the **TI-83**. However, before any calculations involving *trigonometric* functions are performed, you should check whether the calculator will treat arguments as *radians* or *degrees*. Most trigonometric computations in Calculus should be done in radians. To specify this on the **TI-83**, press **[MODE]** and select **Radian** as shown below. Use the cursor keys to highlight **Radian**, press **[ENTER]**, and finally press **[QUIT]** (i.e., **[2nd][MODE]**) to return to the home screen.

Now, for example, let's compute $\sin(1.32) + 2\cos(\pi/12)$.



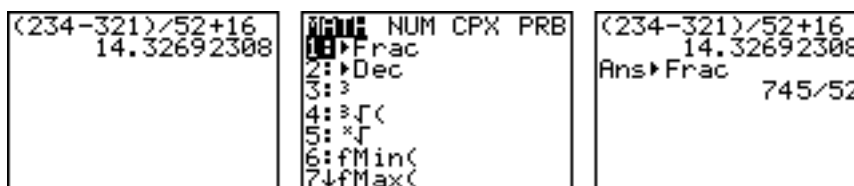
Notice that the result is much different if the calculator is in **Degree** mode.



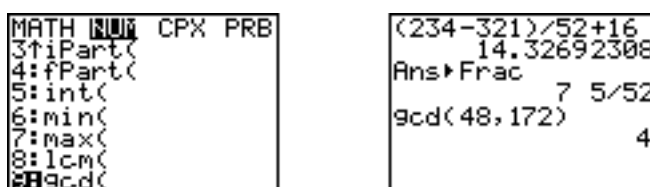
There are a number of special types of calculations that the **TI-83** can perform. For example, suppose you want to calculate

$$\frac{234 - 321}{52} + 16$$

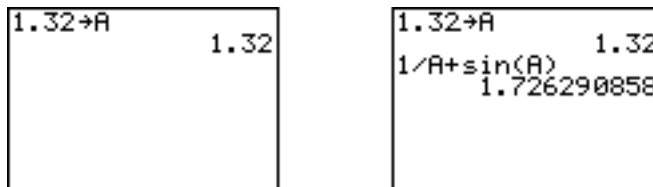
and have the result in the form of a fraction. Simply perform the calculation and then press **[MATH]**. The **▷Frac** command should appear as item 1. Press **[ENTER]**, and then press **[ENTER]** again after you return to the home screen.



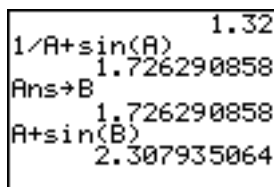
Notice that there are three other headings on the **MATH** screen. These are **NUM**, **CPX** and **PRB**, for *number*, *complex* and *probability*, respectively. Use the cursor keys to highlight each of these headings and notice the functions that appear. Many of the functions on these screens can be very useful. For example, select **NUM** and use the down-arrow key to select **gcd()**. The **gcd()** function computes the greatest common divisor of two numbers. The result of applying this function to the numbers 48 and 172 is shown below.



It is often very convenient to store values in variable names so that they can be used in later calculations. For example to store the value 1.32 in the variable **A**, type **1.32** and press **[STO▷] A** and then **[ENTER]**. Once this is done, this variable can be used in subsequent calculations.



It is also possible to store the result of a previous calculation as a new variable. For example, if we want to store the result of the output above as **B** then we can press **[STO>]** **B** and then **[ENTER]**. Then the variables **A** and **B** can be used together in calculations.



Memory management. Finally, we should note that variables can be cleared (to free-up memory) by using the TI-83's memory manager. Press **[MEM]** (i.e., **[2nd][+]**); then select **Delete** followed by **Real**. Now press **[▽]** to point to the variable name that you want to clear and press **ENTER**. When you are done, press **QUIT**.



Warning: Be extremely careful when you use the memory manager! It is very easy to delete variables and programs accidentally. *Never* select **Reset** from the **MEMORY** menu unless you want to delete everything.

Exercises

Make sure that **Radian** mode is selected for trigonometric calculations.

1. Compute $\frac{\sin(1.32) - \ln(21)}{2 + e^{-5}}$.
2. Compute $\frac{21.25 - 3.2}{16.3} + 11.3$ and give the result in both decimal and fraction form.
3. Suppose there are 7 people who stand in line at the same bus stop every day. There are exactly 7 factorial (i.e., $7!$) ways that these people can be ordered in line. If they agree to stand in line a different way every day, then how many years will it take for them to exhaust all possibilities? (Note: The factorial command is found by pressing **[MATH]** and selecting **PRB**. However, it might be easier in this case to simply perform the calculation from the home screen by using the definition of factorial.)
4. Store the values 1.2, 1.35 and 2π in the variables **L**, **P** and **Q**. Now compute $\sin(L) - \cos(P) + e^Q$ and store the result in the variable **D**. What is the value of $D^3 - 4P^2 + 3Q$?
5. Find both the least common multiple and greatest common divisor of the integers 644 and 1376.

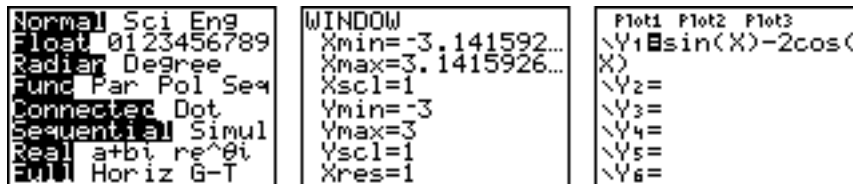
6. There was once a country with a terrible problem that was threatening its existence. Out of desperation, the ruler of this country offered to give a wonderful reward to any person who could solve this problem and help the country survive. Many people came forward with ideas, and finally there was a woman who solved the country's problem. When the ruler asked her to name her reward, she insisted that her request was a trivial one. She brought a checker board and told the ruler that she would return the next day and collect one grain of rice from the first square on the board. She would then return the next day to collect 2 grains of rice from the second square on the board. On each subsequent day (for 64 days) she would return to collect twice the number of grains of rice from the board as she collected on the previous day. Do you think she ever received her entire reward?

1.2 Graphs of functions

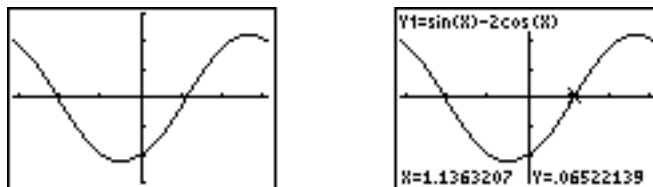
The graphing capabilities of the **TI-83** make it a truly impressive tool. Let's begin by plotting the graphs of a few functions. Make sure that the **Func** mode has been selected (press **[MODE]** and select **Func**). To graph the function

$$f(x) = \sin(x) - 2 \cos(x)$$

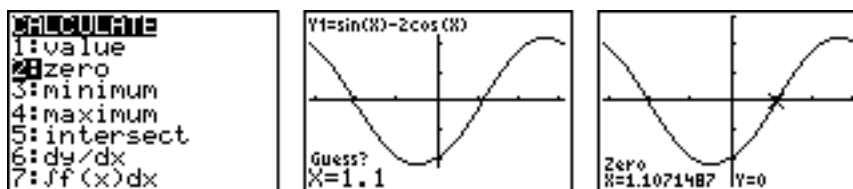
on the interval $-\pi \leq x \leq \pi$, we'll first press **[WINDOW]** and set the values shown below. Then we press **[Y=]** and enter $f(x)$ as **Y1**. Use the **[X,T,θ,n]** key to type "X" while in **Func** mode.



Once this is done, we can press **[GRAPH]** to obtain the graph. We can also learn quite a bit more about the function $f(x)$ from the graph screen. For example, if we press **[TRACE]**, then we can use the arrow keys to move along the graph and display the values at the points. From the second graph below, we can see that $f(x)$ has a root near $x = 1.1$.

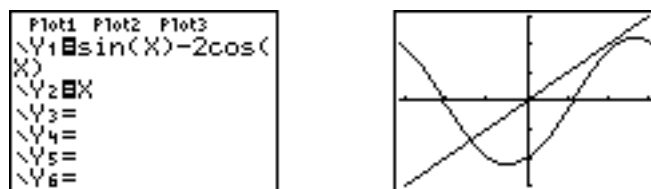


To find a good approximation of this root, we can press **[CALC]** (i.e., **[2nd] [TRACE]**) and select **zero** by highlighting the second item and pressing **[ENTER]**. The **TI-83** will then prompt us for both a left bound and a right bound for the zero. Of course, we can see from the graph that 1 is a left bound and 1.2 is a right bound. Simply enter each of these values (following each with **ENTER**) and then supply a guess of 1.1 followed by **ENTER**.

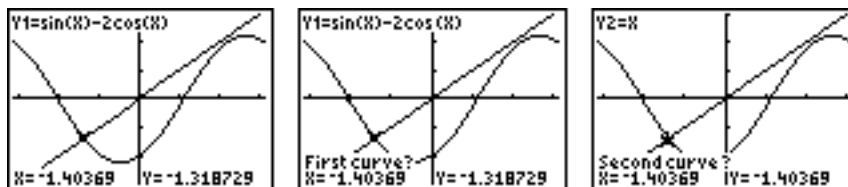


It takes the **TI-83** a few seconds to respond with the result $x = 1.1071487$, which is very accurate!

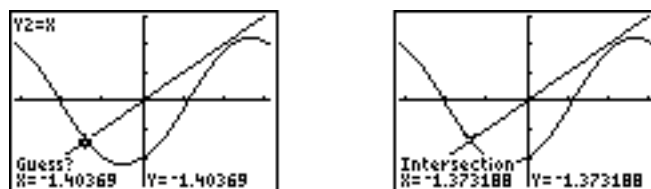
If we want to plot another function along with the function $f(x)$ given above, then we can press **[Y=]** and enter it as **Y2**. For example, if we want to plot $g(x) = x$ along with $f(x)$, then we enter it in the **Y=** editor as **Y2** and press **[GRAPH]**.



The graph indicates that these curves intersect at only one point. By using **TRACE**, we can approximate this point. According to the first screen below, the intersection point is approximately $(-1.4, -1.32)$. We can find a very accurate approximation of this point by pressing **[CALC]** and selecting **intersect**. The **TI-83** will then prompt you for the first curve. Notice that it already has a curve listed at the top of the screen. Simply press **[ENTER]**. The **TI-83** will then prompt for a second curve. (This is necessary since you might have many functions graphed in the same window.) Once again, notice that the **TI-83** has already made the proper selection, so press **[ENTER]**. (Note: The **[△]** and **[▽]** keys can be used to change the curve selections.)



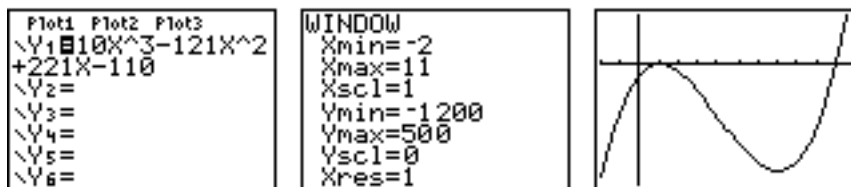
Now we simply need to provide a guess. Since **TRACE** was used to obtain an estimate, the values that are filled in for x and y are already very good guesses. Consequently, just press **[ENTER]**.



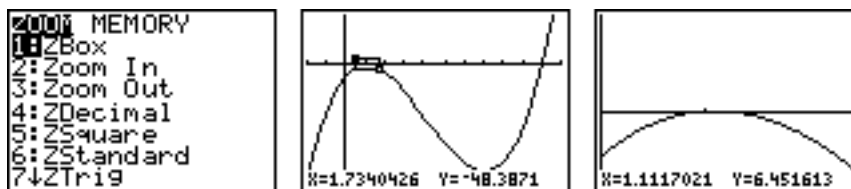
You should experiment with some of the other commands that are available when **[CALC]** is pressed. However, you probably won't encounter the ideas behind items 6 and 7 from this menu until a little later in your calculus course.

Now let's experiment a little with the **ZOOM** capabilities of the **TI-83**. Consider the function $f(x) = 10x^3 - 121x^2 + 221x - 110$. Let's start by returning to the **Y=** editor and clearing

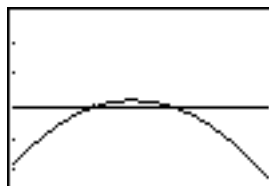
both **Y1** and **Y2** (use the \uparrow and \downarrow keys to select **Y1** and press **[CLEAR]** ... repeat for **Y2**). Then let's enter $f(x)$ as **Y1**. Set the window variables as shown below and press **[GRAPH]**.



It is apparent from the graph that $f(x)$ has a root near $x = 10$. However, we cannot tell whether there is also a root near $x = 1$. Let's try zooming in on this part of the graph. Press **[ZOOM]** and select **ZBox**. Use the cursor keys to move the cursor to the upper left corner of the new viewing rectangle and press **[ENTER]**. Then move the cursor to the lower left corner of the rectangle and press **[ENTER]**.



It is still not clear whether $f(x)$ has a root on this interval. By repeating the process above twice more, you should be able to obtain something like the plot shown below.



Apparently there are 2 roots near $x = 1$. It is now possible to use **zero** from the **CALC** menu to find these roots.

Note: You should experiment with the other tools that are available in the **ZOOM** menu. In particular, try using **Zoom In**.

Exercises

- Plot $y = x^n$ for $n = 1, 2, 3, 4, 5, 8, 11$ in a $[-1, 1] \times [-1, 1]$ window.
- Plot $y = \sin(k\pi x)$, for $k = 1, 2, 3, 4$ in a $[0, 2] \times [-1, 1]$ window.
- In a $[-1, 1] \times [-1, 1]$ window, plot the graph of $y = x \sin(x/(x^2 + 0.001))$. Use **ZOOM** tools and **zero** to find all of the positive roots in this window.
- Use **zero** to find all of the solutions of the equation $7 \cos(3x) = x^2$.
- Find all zeros of the polynomial $f(x) = 5x^3 + 4x^2 - 34x - 45$. Is there a rational zero? If so, use it to help factor the polynomial.
- Use graphs to verify the trigonometric identity

$$\sin(3x) = 4 \sin(x) \cos^2(x) - \sin(x).$$

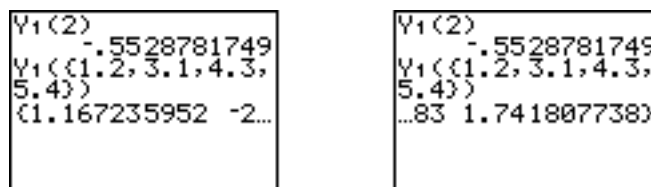
1.3 Lists, tables, and matrices

Suppose we are interested in values of the function $f(x) = 2\cos(x) - \sin(3x)$ for a variety of values of x . One way to obtain these values is to enter $f(x)$ in the **Y=** editor as **Y1**. Then we can request values from the Home screen. Simply press **[VARS]** and then press the right arrow key to highlight **Y-VARS**, and press **[ENTER]**. Now highlight **Y1** and press **[ENTER]** to place **Y1** on the home screen. If we want to compute $f(2)$ then we can type **(2)** and then press **[ENTER]**.



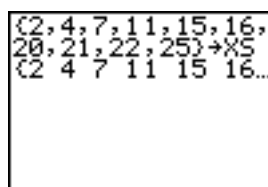
Other values can also be computed in this manner. However, this process can become very tiring if we need to compute $f(x)$ for many values of x . Luckily the **TI-83** has a couple of built-in mechanisms for making this process easier; namely *lists* and *tables*. Both of these mechanisms also have a variety of other uses.

Lists. Lists are created by using set braces $\{ \}$ (press **[2nd][(]** and **[2nd][)]**). Suppose we want to evaluate the function $f(x)$ given above at $x = 1.2, 3.1, 4.3,$ and 5.4 . One simple way to do this is to put the numbers in a list and then put the list into $f(x)$.



Use the **[<]** and **[>]** keys to scroll through these numbers. If the list is very long, then it might be difficult to keep track of which $f(x)$ values correspond to which x values.

One way to help this situation is to give variable names to lists. Unlike real variables, list variable names can have more than one character (**TI-83** only). Suppose we want to evaluate the function $f(x)$ at $x = 2, 4, 7, 11, 15, 16, 20, 21, 22, 25$. Let's create a list containing these values and name it **XS** as shown below.



To access the entries in the list, press **[LIST]** (i.e., **[2nd][STAT]**), highlight the entry for **XS**, and press **[ENTER]**. This places the symbol **XS** on the home screen. Then the third entry, for example, can be accessed by entering **XS(3)**.

```

NAME: OPS MATH
L1XS

```

```

(2,4,7,11,15,16,
20,21,22,25)→XS
(2,4,7,11,15,16...
LXS(3)
7

```

Furthermore, if we want to evaluate $f(x)$ at each of these values, then we can simply evaluate Y_1 at the list XS . If we store the output from this calculation as YS , then we can look at individual entries by either using the same process that was applied to XS above, or by using the **STAT** editor. In the latter case, press **[STAT]** and select **Edit**. Enter XS and press **[ENTER]** (note that you are already in the **ALPHA** entry mode). Now use the **[Δ]** key followed by the **[\triangleright]** key to move to the top of the second column. Enter YS followed by **[ENTER]**. Now you have a table of values where it is easy to see both the x and $f(x)$ values.

```

(2,4,7,11,15,16...
LXS(3)
7
Y1(LXS)
(-.5528781749 -...
Ans→YS
(-.5528781749 -...

```

XS	YS	-----	Z
2	-.5528		
4	-.7707		
7	.67115		
11	-.9911		
15	-2.37		
16	-1.147		
20	1.121		
YS = (-.552878174...			

There are a number of other uses of lists. One of the most important uses of lists is in plotting the graphs of several members of a family of functions. For example, consider the family of functions given by $f(x) = \sin(k\pi x)$ and suppose we want to plot members of this family for $k = 1, 2, 3,$ and 4 on the interval $-1 \leq x \leq 1$. To create the plot we simply store the list $\{1, 2, 3, 4\}$ in the variable K either on the home screen or the **STAT Edit** screen. Then we go to the **Y=** editor and enter the expression shown below for Y_1 . (Recall that LK is accessed by pressing **[LIST]**.) Now press **[GRAPH]**.

```

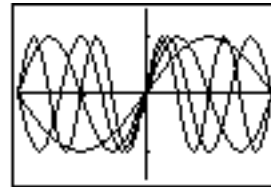
(1,2,3,4)→K
(1 2 3 4)

```

```

Plot1 Plot2 Plot3
Y1=sin(LK*πX)
Y2=
Y3=
Y4=
Y5=
Y6=
Y7=

```



Tables. Another way to obtain the same type of information is to use the **TI-83 TABLE** mechanism. Start by pressing **[TBLSET]** (i.e., **[2nd][WINDOW]**) and setting the values shown below. Then press **[TABLE]** (i.e., **[2nd][GRAPH]**). Enter a value for X and press **[ENTER]**. The corresponding value of Y_1 will appear in the second column. This can be repeated to obtain any number of values. An “Ask table” such as this provides a very flexible and fast way to perform numerous function evaluations, allowing a measure of spontaneity in the choice of variable values. (**Note:** Lists can also be named and created from the **STAT Edit** screen.)

```

TABLE SETUP
TblStart=0
ΔTbl=.1
Indent: Auto [ASK]
Depend: [Auto] Ask

```

X	Y1	
X=		

X	Y1	
2	-.5528	
4	-.7707	
7	.67115	
11	-.9911	
15	-2.37	
16	-1.147	
X=		

If we are interested in evaluating a function at variable values that are a specified distance apart, then we can automate this process by making the appropriate choices using **TBLSET**.

For example, if we want to evaluate $f(x)$ at values of x starting at $x = 0$ and incrementing by 0.1, then we can make the changes shown below in **TBLSET**, and access the **TABLE** again. This time, the values of **Y1** will already be computed. We can simply scroll through the table to see additional values.

TABLE SETUP		
TblStart=	0	
ΔTbl=	.1	
Indpnt:	Auto	Ask
Depend:	Auto	Ask

X	Y1	
0	2	
.1	1.6945	
.2	1.3955	
.3	1.1273	
.4	.91008	
.5	.75767	
.6	.67682	

Note: Sometimes it is necessary to start scrolling in order to force the **TABLE** values to be updated.

Matrices. The **TI-83** allows us to conveniently store a two-dimensional array of numbers as a matrix. As you may already know, matrices provide a means of representing systems of linear equations. We will briefly discuss solving such systems in the next chapter. A matrix can also be used as a data structure for storing collections of points in the plane, for example. We will do precisely that in the next section, where we will create a program that draws line segments between consecutive members of an ordered collection of points. So let's get acquainted now with the **TI-83** matrix editor.

Suppose we want to store the points (1, 3), (2, 2), (3, 1), and (4, 3) as rows in a matrix. To do this, first press **[MATRIX][>][>]** to select **EDIT**. Then press **[▽]** to select the desired matrix name and press **[ENTER]**. This takes us to the matrix editor, where we'll specify 4×2 as the dimension of the matrix—four rows and two columns.

NAMES MATH	MATRIX[A] 1 × 1	MATRIX[A] 4 × 2
1: [A]	[0]	[0 0]
2: [B]		[0 0]
3: [C]		[0 0]
4: [D]		[0 0]
5: [E]		
6: [F]		
7: [G]		

Next we simply enter the numbers into the matrix. Once that's done we'll press **[QUIT]** to leave the matrix editor. To access the matrix we've just defined from the home screen, press **[MATRIX]** once again and either scroll down to the desired matrix with the **[▽]** key and press **[ENTER]**, or just press the number next to it. Pressing **[ENTER]** after the matrix name is placed on the home screen displays the entries of the matrix.

MATRIX[A] 4 × 2	NAMES MATH EDIT	[A]
[1 3]	1: [A] 4×2	[[1 3]
[2 2]	2: [B]	[[2 2]
[3 1]	3: [C]	[[3 1]
[4 3]	4: [D]	[[4 3]
	5: [E]	
	6: [F]	
	7: [G]	

A number of matrix functions are accessible by pressing **[MATRIX][>]** to select **MATH**. One of the most useful of these is **dim()**, which produces a list containing the number of rows and the number of columns in a matrix. Also, individual entries in a matrix can be addressed by specifying column number and row number in parentheses.

```

NAMES NAME EDIT
1:det(
2:T
3:dim(
4:Fill(
5:identity(
6:randM(
7:augment(

```

```

dim([A])      {4 2}
[A] (4,1)     4
[A] (3,2)     1

```

Exercises

- Use a list to plot $y = x^n$ for $n = 1, 2, 3, 4, 5, 8, 11$ in a $[-1, 1] \times [-1, 1]$ window.
- Use a list to plot $y = \sin(k\pi x)$, for $k = 1, 2, 3, 4$ in a $[0, 2] \times [-1, 1]$ window.
- Use a list to evaluate the function $f(x) = x^2 - \sin(x)$ at the values $x = -2, -1, 0, 1, 2, 3$. Repeat using a table instead.
- Store the list $\{1, 2, 3, 4, 5, 6, 7, 8, 9, 10\}$ in the variable **L1**. (Notice that **L1** can be “typed” by pressing **[2nd][1]**.) Then use **L1** to do the following.
 - Compute a list containing k^2 for $k = 1, 2, \dots, 10$. Then use the **prod()** function from the **LIST-MATH** menu to compute $2^2 3^2 4^2 \dots 10^2$.
 - Compute a list containing 2^k for $k = 1, 2, \dots, 10$. Then use the **sum()** function from the **LIST-MATH** menu to compute $\sum_{k=1}^{10} 2^k$.
- The **seq()** function in the **LIST-OPS** menu can be used to create lists in which the k^{th} entry is given by some function of k . For example, entering **seq(2J-5,J,1,6)** produces the list $\{-3, -1, 1, 3, 5, 7\}$. Use **seq()** to rework problem 5.
- Use a table with the **Indpnt** mode set to **Ask** in **TBLSET** to approximate the maximum value of the function $g(x) = 1 + 3x - x^4$. Give an explanation (using complete sentences) of the strategy that you employ.

1.4 The Program Editor

This section is an introduction to creating and running a program on the **TI-83**. However, if you’ve never had any programming experience, you should read Chapter 13 of your **TI-83 Guidebook** or Chapter 16 of your **TI-83 Guidebook** before going any further here.

It is very simple to create programs on the **TI-83**. We’ll first create a simple program that finds the zeros (or *roots*) of a quadratic polynomial. This program is very simple, but it illustrates a number of useful programming features.

To create a new program press **[PRGM]** and use the cursor keys to select **NEW**. Then press **[ENTER]** and you will be prompted for the **Name** of your program. Notice that the calculator is already in the **ALPHA** entry mode. Enter the name **ZEROS** and press **[ENTER]**.

```

EXEC EDIT NEW
1:DFIELD
2:FC
3:FS
4:IMPEULER
5:LBOX
6:MBOX
7:RBOX

```

```

EXEC EDIT NEW
1:Create New

```

```

PROGRAM
Name=ZEROS

```

Note: If you have not entered any programs in your calculator, then no program names will appear under **EXEC** when you press **[PRGM]**.