EXPLORATIONS

CHAPTER 1

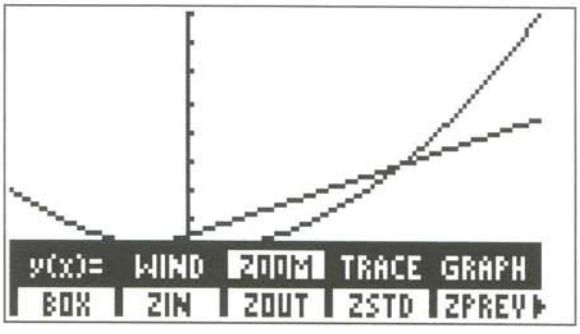
Getting Started and Graphing Fundamentals

In the early sections of the chapter we illustrate, by way of simple numerical examples, some of the important computational, algebraic, tabular, and editing features of the TI-86. The majority of the chapter, however, is devoted to the fundamentals of graphing on the TI-86. In Chapter 2, more advanced graphing capabilities of the calculator are explored.

Accessing Keys and Menus

Most keys on the TI-86 access more than one operation. For example, look at the squaring key [x^2]. Above and to the left of this key is a yellow square root symbol. Above and to the right of this key is a blue upper case **K** symbol. To access the squaring operation, you press the [x^2] key. To access the square root operation, you press the yellow [2nd] key and then the [x^2] key. In this book we say "press [2nd] [$\sqrt{}$]." To access the upper case **K** symbol, you press the blue [ALPHA] key (think alphabet) and then the [x^2] key. We say "press [ALPHA] **K**." To access the lower case **k** press, in sequence, the keys [2nd], [ALPHA], [x^2]. We say "press [2nd] [alpha] **k**."

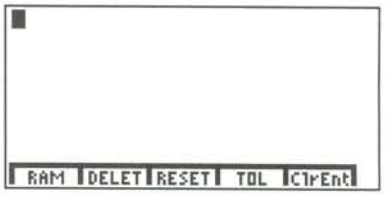
The menu keys are [F1], [F2], [F3], [F4], and [F5]. The 2nd function of the menu keys are [M1], [M2], [M3], [M4], and [M5]. Menu items are shown on the bottom line (or sometimes the bottom two lines) of the TI-86 display screen. Consider the display screen on the right. To select menu item ⟨**ZSTD**⟩, press [F4]. To select menu item ⟨**TRACE**⟩, press [2nd] [M4]. Note that we set off menu items with the ⟨ and ⟩ symbols.



§1 – Factory Settings

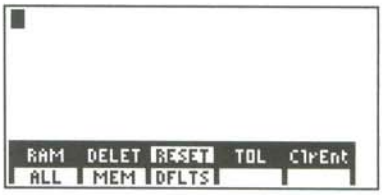
In this section we reset the calculator to its factory settings. Everything that you have stored in your calculator will be lost.

1. Press [ON] to turn the calculator on. Then press [2nd] [MEM] to obtain a display having the same bottom menu line as (1.1.1).



(1.1.1)

2. Select ⟨**RESET**⟩ by pressing [F3] to obtain a display having the two menu lines shown in (1.1.2).

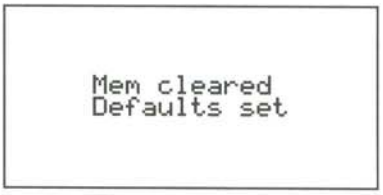


(1.1.2)

3. Select ⟨**ALL**⟩ by pressing [F1] to obtain the display (1.1.3).

(1.1.3)

4. Select ⟨**YES**⟩ by pressing [F4]. The resulting display should look like (1.1.4).



(1.1.4)

If you see no display, or the display is too faint, then you need to adjust the contrast. To make the display darker, press and release the [2nd] key. Then hold down the [▲] key until the contrast meets your approval. If you hold the [▲] key down too long, then the contrast will be too dark. To lighten the screen, press and release the [2nd] key and then hold down the [▼] key until the contrast is right for you. You may have to repeat these adjustments to the contrast a few times before you obtain an acceptable contrast setting. After adjusting the contrast to your satisfaction, press [CLEAR] to clear the screen.

Note: *If you release the cursor key too soon and wish to continue the process of lightening or darkening, you do not simply repress the cursor key. You must press and release the [2nd] key again before proceeding.*

The blinking ■ cursor in the upper left-hand corner of the display indicates the calculator is in the overtype mode, the default mode for the TI-86. Press [2nd] [INS] and note that the blinking ■ cursor has changed to a blinking _ underbar cursor. Press [2nd] [INS] again to return to overtype mode. Later in this chapter we will see how to use the overtype and insert modes to effectively edit command lines.

5. Next, press [2nd] [MODE] to see the factory mode settings for your calculator. See (1.1.5). Then press [2nd] [QUIT] to return to the home screen. The home screen is the primary screen of the TI-86. It is where you enter expressions to be evaluated and see the results. You can always return to the home screen from any other screen by pressing [2nd] [QUIT].

(1.1.5)

§2 – Basic Calculations

In the next few sections we use the compound interest formula $A = P(1 + R/12)^N$ to demonstrate some of the basic features of the TI-86. Recall that A is the amount present after N months if an amount P is invested at an annual rate of R compounded monthly. Thus, the amount present after 15 years for an investment of \$1000 at 8% compounded monthly would be given by

$$1000(1+.08/12)^{180}.$$

1. To set up this calculation on the calculator, clear the home screen and enter the keystrokes

   1000 [(] 1 [+] .08 [÷] 12 [)] [^] 180

   to obtain the display (1.2.1).

   Note: *Some liberty in the keystroke description above has been taken in the sense that the actual keystrokes needed to enter a number have been abbreviated; i.e., the keystrokes* [1] [0] [0] [0] *have been abbreviated to* **1000**.

```
1000(1+.08/12)^180
```

(1.2.1)

2. After the keystrokes have been entered, press [ENTER] to execute the expression as shown in (1.2.2).

   Note: *The TI-86 does implied multiplication, so it is not necessary to press the* [×] *key after entering 1000.*

```
1000(1+.08/12)^180
          3306.92147743
```

(1.2.2)

§3 – ENTRY and Editing Features

Suppose next we want to compute

$$1000(1+.07/12)^{240}.$$

We could enter this expression as in §2. However, the ENTRY and editing features of the TI-86 can be used to simplify the work. Before proceeding further, it's best to say a few things about the ENTRY feature. When [ENTER] is pressed on the home screen to execute an entry line then the entry line is placed in a storage area called ENTRY. In fact 128 bytes of memory are allocated to the ENTRY area and the TI-86 stores as many entry lines as possible without exceeding the 128 bytes limitation. Older entry lines are eliminated from the storage area as necessary to keep the most recent entry lines in storage. To display the most recent entry line, press [2nd] [ENTRY]. To continue scrolling previous entry lines continue pressing [2nd] [ENTRY] repeatedly. The scrolling is cyclical; *i.e.*, after the oldest entry line in storage is recalled, then the next press of [2nd] [ENTRY] recalls the newest entry line again.

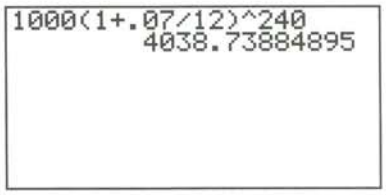
We are now ready to proceed with the computation posed at the beginning of the previous paragraph. With the display as in (1.2.2), press [CLEAR] to clear the home screen. (*Clearing the home screen at this time is optional and is done for the sake of appearance only.*)

1. Press [2nd] [ENTRY] to recall the most recent entry line on the TI-86. The resulting display is (1.2.1) with the blinking ■ cursor after the 0 in 180. Use the [◀] cursor pad key to move the blinking ■ until it covers the **8** preceding the /. Since we are in overtype mode, we only need to press [7] at this time to overtype the 8 with a 7 as shown in (1.3.1).

```
1000(1+.07/12)^180
```

(1.3.1)

2. Proceed in a similar fashion, with the aid of the ▶ key to change 180 to 240 in the expression. Finally, press [ENTER] to execute the entry line and obtain (1.3.2).



(1.3.2)

§4 – Insert Mode

To illustrate the use of the insert mode we will compute

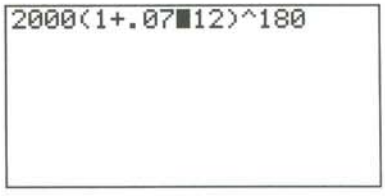
$$2000(1+.075/12)^{180}.$$

Clear the home screen display (1.3.2) and press [2nd] [ENTRY] enough times (probably twice) to obtain the display (1.2.1) with the blinking ■ at the end of the entry line.

1. We will first change the 1 in 1000 to 2 and the 8 in .08 to 7, using the overtype mode, and then insert 5 after the 7 in .07, using the insert mode. To begin the editing, press [2nd] ◀ to move the overtype cursor to the beginning of the entry line with the cursor covering the 1 in 1000.

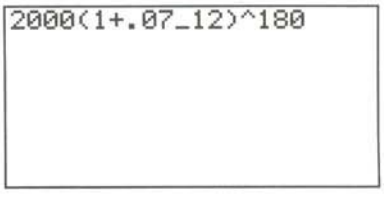
   Then press [2]. Next press ▶ enough times to move the overtype cursor over the 8 in .08, and then press [7]. At this point, the display should be (1.4.1) with the overtype cursor covering the / symbol.

Note: *It is worth remembering that* [2nd] ◀ *will always move the cursor to the beginning of the entry line and that* [2nd] ▶ *will always move the cursor to the end of the entry line.*



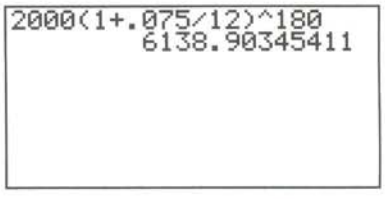
(1.4.1)

2. Press [2nd] [INS] to change from overtype mode to insert mode. The resulting display is similar to (1.4.2) except the underbar _ and the / are alternatively blinking. In insert mode, the next symbol entered will be to the immediate left of the / symbol. Thus, press [5] to insert the desired 5 after 7 in .07.



(1.4.2)

3. We are through editing the expression. However, note that if we move the underbar cursor at all by pressing ▶ or ◀, then we return to overtype mode by default. Finally, press [ENTER] to execute the edited entry line and obtain (1.4.3).

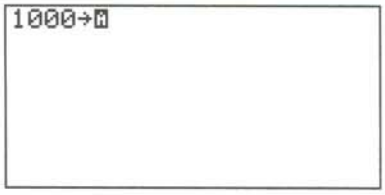


(1.4.3)

§5 – Using Stored Values

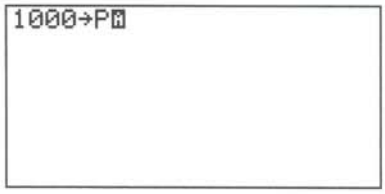
We will consider a more algebraic approach to the compound interest problem by storing values to P, R, and N and then entering and executing the entry line $P(1+R/12)^N$.

1. We begin by storing 1000, .08, and 180 as the values for the variables P, R, and N, respectively. After clearing the home screen press **1000** STO▸. Note that the blinking ■ cursor has changed to a blinking highlighted **A**, indicating that we are in ALPHA mode. See (1.5.1).



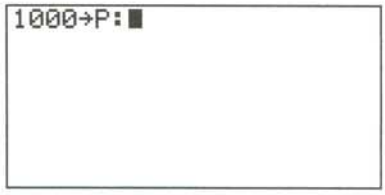
(1.5.1)

2. Press the key with the blue letter P above it (the , key) to obtain (1.5.2). *Note that we are still in ALPHA mode.*



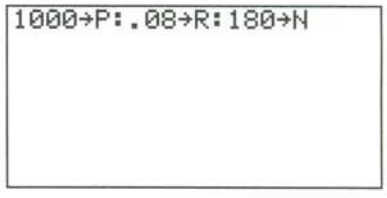
(1.5.2)

3. We are not yet through with the entry line because we plan to store the values for R and N on the same line. We can do this by using the colon **:** to separate the commands. To enter the **:**, we first escape from the ALPHA mode by pressing ALPHA. Note that the blinking highlighted **A** changes back to the familiar blinking rectangular cursor. Then press 2nd [:] to obtain (1.5.3).



(1.5.3)

4. Continue in this fashion to finish the entry line as shown in (1.5.4).

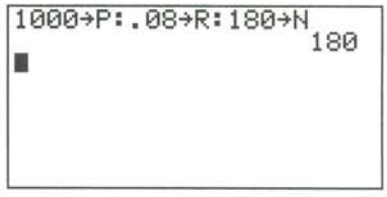


(1.5.4)

To summarize, the entire entry line is obtained by pressing

1000 STO▸ **P** ALPHA 2nd [:] **.08** STO▸ **R** ALPHA 2nd [:] **180** STO▸ **N**

5. If you mess up the entry line, either press CLEAR to start all over again, or use the editing features to correct any mistakes. Note that the DEL key can be used to delete individual characters on the entry line. After the entry line has been successfully keyed in, press ENTER to execute the entry line and obtain (1.5.5).

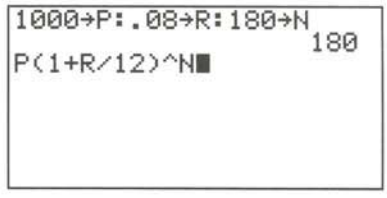


(1.5.5)

6. With the display as in (1.5.5), press

   ALPHA **P** (**1** + ALPHA **R** ÷ **12**) ^ ALPHA **N**

   to obtain (1.5.6).



(1.5.6)

7. Press [ENTER] to execute the entry line and obtain (1.5.7). Compare this result with that found in §2.

```
1000→P:.08→R:180→N
                  180
P(1+R/12)^N
        3306.92147743
```

(1.5.7)

8. We can use the set up in this section to give an alternate presentation of the result in §4. Clear the display in (1.5.7) and use ENTRY to recall the command line shown in (1.5.5). Edit this command line to obtain the line shown in (1.5.8).

```
2000→P:.075→R:180→N
```

(1.5.8)

9. Press [ENTER] to execute the entry line. Then use ENTRY again to recall the compound interest entry line shown in (1.5.6). Then press [ENTER] to obtain (1.5.9).

```
2000→P:.075→R:180→N
                  180
P(1+R/12)^N
        6138.90345411
```

(1.5.9)

§6 – Introducing the TABLE Feature

We can use the TABLE feature of the calculator to conveniently tabulate how \$1000 invested at 8% compounded monthly grows each year. To implement the TABLE feature, the function to be tabulated must be given, and the starting and increment values must be specified.

1. The function to be tabulated is entered in the ⟨**y(x)=**⟩ graphing editor. To access this editor from the home screen, press [GRAPH] to obtain a display with the same bottom menu line as (1.6.1).

```
2000→P:.075→R:180→N
                  180
P(1+R/12)^N
        6138.90345411

 y(x)= | WIND | ZOOM | TRACE | GRAPH▸
```

(1.6.1)

2. Press [F1] to select ⟨**y(x)=**⟩ and obtain (1.6.2).

```
 Plot1  Plot2  Plot3
\y1=

 y(x)= | WIND | ZOOM | TRACE | GRAPH
   x   |   y  | INSf | DELf | SELCT▸
```

(1.6.2)

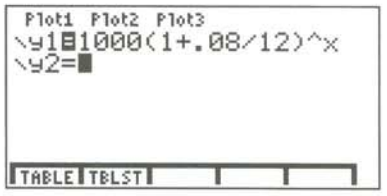
3. Type in **1000** [(] **1** [+] **.08** [÷] **12** [)] [^] [x-VAR] and press [ENTER] to obtain (1.6.3). The highlighted = after $y1$ indicates that the function $y1$ is activated for tabulation.

```
 Plot1  Plot2  Plot3
\y1■1000(1+.08/12)^x
\y2=

 y(x)= | WIND | ZOOM | TRACE | GRAPH
   x   |   y  | INSf | DELf | SELCT▸
```

(1.6.3)

4. To specify the starting and increment values for the table press [TABLE] to obtain (1.6.4).



(1.6.4)

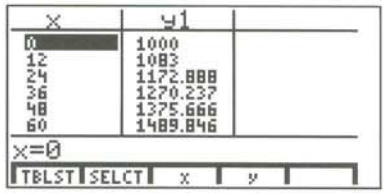
Then select menu item ⟨**TBLST**⟩ to obtain a display similar, if not identical, to (1.6.5).

(1.6.5)

5. With the aid of the cursor pad arrow keys and [ENTER], change (1.6.5) to (1.6.6).

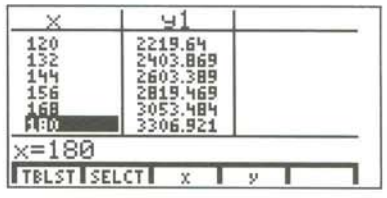
(1.6.6)

6. AUTO is selected so that the table will be generated automatically. Select ⟨**TABLE**⟩ to obtain (1.6.7).



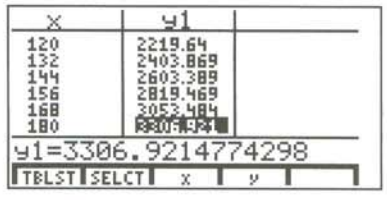
(1.6.7)

7. You can use ▼ to scroll down the table as was done in (1.6.8).



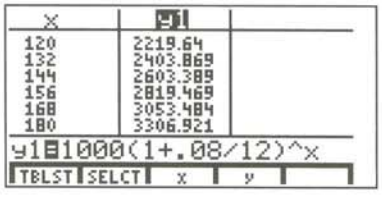
(1.6.8)

8. Use the cursor pad arrow keys to move the table cursor to the position shown in (1.6.9). *Note that the highlighted value of y1 is given in full form on the line just below the table.*



(1.6.9)

9. Next move the table cursor to the position shown in (1.6.10). *Note that the functional form of y1 is shown on the line below the table.*



(1.6.10)

§7 – Accessing Functions and Commands

Many of the commands and built-in functions on the TI-86 are not found on the keyboard and thus must be accessed by some other procedure. One such is the *sign* function defined by $sign(x) = |x| / x$. The expression

$$5 + sign(-5/2)$$

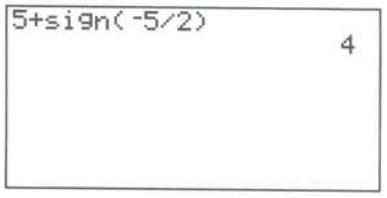
will be used to illustrate the three most common ways to access functions and commands not on the keyboard.

1. The most obvious way to enter the expression is directly via the keystrokes

   5 [+] [2nd] [alpha] [2nd] [alpha] **s i g n** [2nd] [alpha] [(] [(–)] **5** [÷] **2** [)].

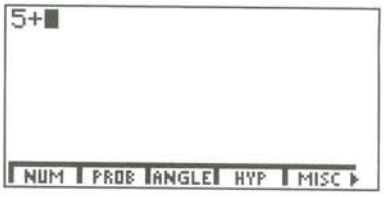
   The [2nd] [alpha] [2nd] [alpha] sequence of keystrokes puts the calculator in "alpha lock" mode so that the next keys we press in sequence will be lower case alphabet keys. The last [2nd] [alpha] cancels alpha lock mode and returns the calculator to ordinary keyboard mode. It is best to watch the cursor as the keystrokes are being entered. (*When in alpha mode the cursor will be a highlighted lowercase* **a**.) Also note that we must use the change sign key [(–)] rather than the [–] key when entering –5/2.

   After entering this entry line on the home screen, press [ENTER] to obtain (1.7.1).



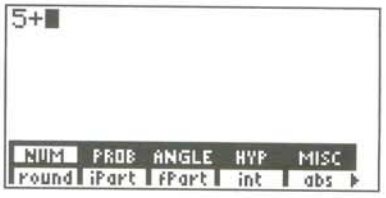
(1.7.1)

2a. The second way to enter the entry line in (1.7.1) is to type in the portion of the line shown in (1.7.2) and then access a menu on the TI-86 that contains the *sign* function.



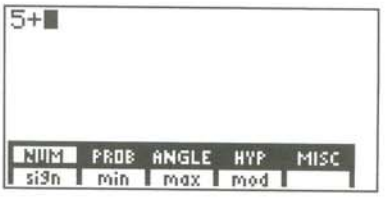
(1.7.2)

2b. A menu item that contains the *sign* function is ⟨**NUM**⟩ listed first on the menu line shown in (1.7.2). This menu line is obtained by pressing [2nd] [MATH]. With the display as in (1.7.2), select ⟨**NUM**⟩ to obtain (1.7.3).



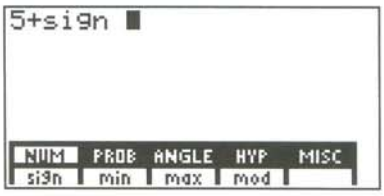
(1.7.3)

2c. Note the ▶ marker at the right end of the bottom menu line. This indicator means that there is more on the menu. Press [MORE] to obtain (1.7.4).



(1.7.4)

2d. Then select ⟨**sign**⟩ whereupon *sign* is pasted onto the line as shown in (1.7.5). The rest of the entry line can then be entered as before.



(1.7.5)

3a. The third way to enter the entry line in (1.7.1) is to type in the portion of the line as shown in (1.7.2) and then access *sign* from the CATALOG/VARIABLES menu. Thus, with the first line of the display as in (1.7.2), press [2nd] [CATLG-VARS] to obtain (1.7.6).

(1.7.6)

3b. Select ⟨**CATLG**⟩ to obtain (1.7.7).

(1.7.7)

3c. Press [ALPHA] **S** (*pressing the* [ALPHA] *key is optional here*) to make the catalog list scroll down to the items starting with an S as shown in (1.7.8).

(1.7.8)

3d. Use the ▼ key to scroll down until the ▶ marker is at the position shown in (1.7.9). Press [ENTER] to paste *sign* onto the entry line as shown in (1.7.5). Finish the rest of the entry line as before.

(1.7.9)

§8 – FUNC Graphing Mode

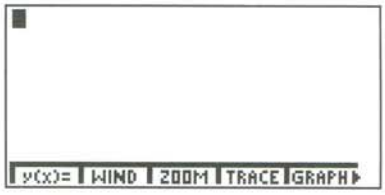
In FUNC graphing mode, we enter the function to be graphed in the ⟨**y(x)=**⟩ graphing editor and select the viewing window values using the ⟨**WIND**⟩ selection. In this book, the viewing window will be given in the format

[xMin, xMax, xScl] × [yMin, yMax, yScl].

Thus, [–1, 5, 2] × [–3, 15, 6] denotes the viewing window given by

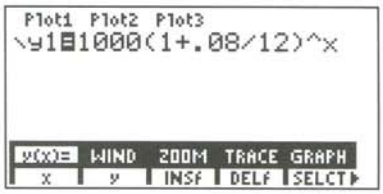
xMin = –1, **xMax** = 5, **xScl** = 2, **yMin** = –3, **yMax** = 15, and **yScl** = 6.

1. We start by graphing $y = x^2$ in the default viewing window [–10, 10, 1] × [–10, 10, 1]. Clear the home screen and press [GRAPH] to obtain (1.8.1).



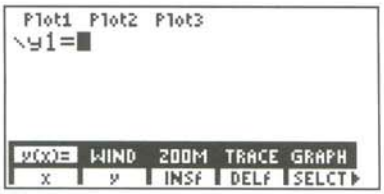
(1.8.1)

2. Press [F1] to select the graphing editor ⟨**y(x)=**⟩. See (1.8.2).



(1.8.2)

3. The current function $y1$ is the function we entered in §6. Delete this function by pressing [F4] to select ⟨**DELf**⟩. See (1.8.3).

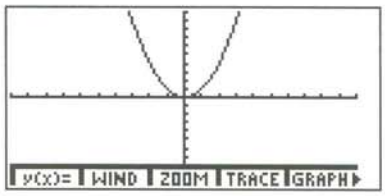


(1.8.3)

4. Type x^2 after the $y1=$ by pressing [X-VAR] [x^2] to obtain (1.8.4).

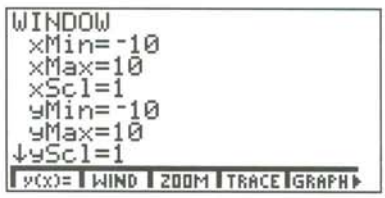
(1.8.4)

5. Next select ⟨**GRAPH**⟩ by pressing [2nd] [M5]. We obtain the graph of $y = x^2$ as shown in (1.8.5). To erase the bottom menu line(s), press [CLEAR]. To recover the menu line(s), press [EXIT].



(1.8.5)

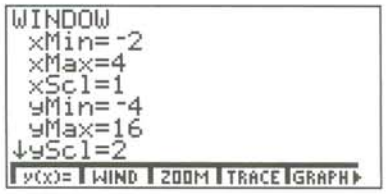
6. Select ⟨**WIND**⟩ by pressing [F2] to verify that the viewing window is as advertised in (1.8.6). (*The viewing window will be the default viewing window, provided you have not made any changes in the graphing window since the calculator was reset in §1.*)



(1.8.6)

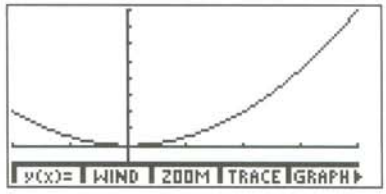
§9 – Changing the Viewing Window

1. With the aid of the arrow keys ▲, ▼, and [ENTER], change the viewing window to $[-2, 4, 1] \times [-4, 16, 2]$. (***Note:*** *Make sure to use the change sign key* [(−)] *when entering –2 and –4 and not the subtraction key* [−].)



(1.9.1)

2. Then graph $y = x^2$ in this new window by selecting ⟨**GRAPH**⟩. See (1.9.2).



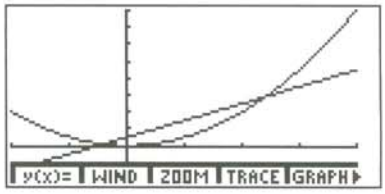
(1.9.2)

§10 – Graphing Several Functions

1. Select ⟨**y(x)=**⟩. Press [ENTER] and enter $2x+1$ after $y2=$ by pressing **2** [X-VAR] [+] **1**. See (1.10.1).

(1.10.1)

2. Then select ⟨**GRAPH**⟩ to obtain the graphs of both $y1$ and $y2$ as shown in (1.10.2).



(1.10.2)

§11 – Introducing the STYLE Menu

We can use the STYLE menu to change the way the graph of $y2$ appears.

1. Select ⟨**y(x)=**⟩ to once again obtain (1.10.1). Press [MORE], and move the cursor down to the $y2$ line to obtain (1.11.1).

(1.11.1)

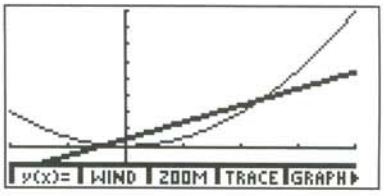
There are seven different graphing styles in FUNC mode graphing. Select ⟨**STYLE**⟩ repeatedly and observe how the left end of the $y2$ line changes with each selection of ⟨**STYLE**⟩. The Line style is denoted by \, and it is the style that uses a solid line to connect plotted points. The Thick style is denoted by a much thicker \. This style uses a thick solid line to connect plotted points. The third style is called the Above style. It results in the area above the graph being shaded. The fourth style is the Below style and results in the area below the graph being shaded. The third and fourth styles are useful in graphing inequalities. We will not have much use for them. The fifth style is the Path style in which a circular cursor traces the leading edge of the graph and draws a path. The sixth style is the

Animate style in which a circular cursor traces the leading edge of the graph without drawing a path. The fifth and sixth styles are useful in animation situations. We will not use them much. The seventh style is the Dot style in which a small dot represents each plotted point. As suggested above, the Line, Thick, and Dot styles will be used most heavily in this book. The Dot style will often be used to eliminate "false asymptotes" when graphing.

2. Use ⟨**STYLE**⟩ to select the Thick style for $y2$ as indicated in (1.11.2).

(1.11.2)

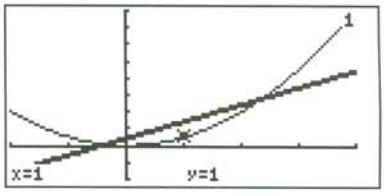
3. Then select ⟨**GRAPH**⟩ to see the graphs of both $y1$ and $y2$ in (1.11.3), in which $y1$ is graphed in Line style and $y2$ is graphed in Thick style. You may want to experiment a bit with the other styles before proceeding to the next section.



(1.11.3)

§12 – Introducing ⟨TRACE⟩

1. With the display as in (1.11.3) select ⟨**TRACE**⟩ to obtain (1.12.1).

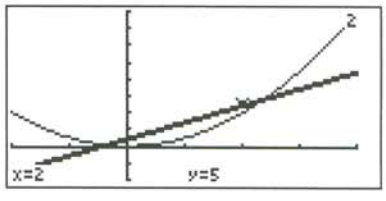


(1.12.1)

2. The 1 in the upper right-hand corner indicates you are tracing along the $y1$ curve. Press the ▼ key. You see that we are now tracing along the $y2$ curve, and that (1, 3) is a point on this curve.

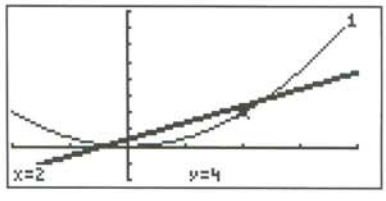
Note: *Be careful throughout the remainder of this section not to trace beyond* **xMin** = –2 or **xMax** = 4 *since doing so will make the TI-86 resize the viewing window. If by mistake you do this, then change the viewing window back to* [–2, 4, 1] × [–4, 16, 2] *before proceeding.*

3. Use the ◀ and ▶ arrow keys to show that the point (2, 5) is on $y2$. See (1.12.2).



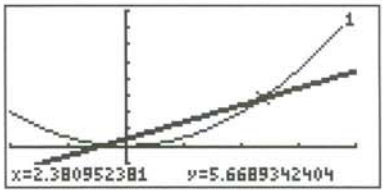
(1.12.2)

4. Then switch to $y1$ by pressing ▼ to see that the point (2, 4) is on $y1$. See (1.12.3).



(1.12.3)

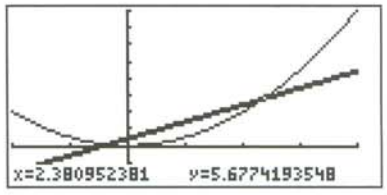
5. Continue to trace along $y1$ until you get as close as possible to the point of intersection of $y1$ and $y2$ in the first quadrant. See (1.12.4). In §19 we will see how the Trace mode can be used to conveniently evaluate functions at user-defined x-values.



(1.12.4)

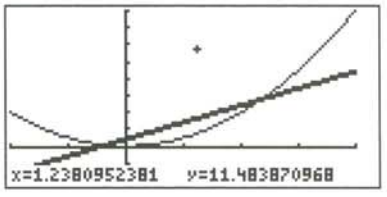
§13 – Using ⟨ZIN⟩

1. With the display as in (1.12.4) press [GRAPH] and select ⟨**ZOOM**⟩. Then select ⟨**ZIN**⟩, the zoom-in feature of the TI-86. The resulting display in (1.13.1) is almost exactly like (1.12.4) except for a slight change in the y-coordinate.



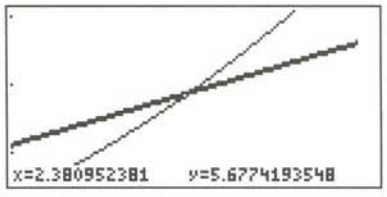
(1.13.1)

2. However, there is one other important difference. The cursor located at the point indicated in (1.13.1) is now a free-moving cursor. To see this, use the four arrow keys to move the free-moving cursor to the point shown in (1.13.2).



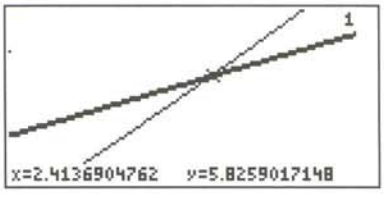
(1.13.2)

3. However, we really want the free-moving cursor to be at the location shown in (1.13.1), so move it back there before proceeding. Then press [ENTER] to have the TI-86 zoom-in on the graph at the free-moving cursor point. See (1.13.3).



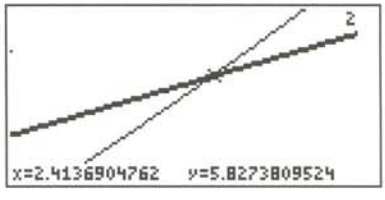
(1.13.3)

4. Press [ENTER] to zoom-in again. Then press [GRAPH] and select ⟨**TRACE**⟩. Trace along $y1$ until you come as close as possible to the point of intersection. See (1.13.4).



(1.13.4)

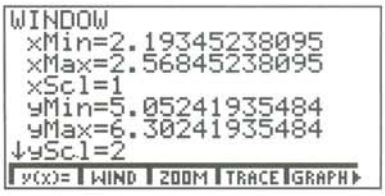
5. Then switch to $y2$ by pressing the [▼] key. See (1.13.5). The results indicate that the point of intersection is (2.41, 5.83) correct to a two decimal place accuracy in both the x and y coordinates. Of course, we could continue to zoom-in to get even better estimates of the intersection point. In Chapter 2 we will see how to use the GRAPH MATH menu to find the intersection point in an easier and much more accurate manner.



(1.13.5)

§14 – Understanding the ZOOM Factors

1. Press [GRAPH] and select ⟨**WIND**⟩ to see how the zoom-in procedure changed the window values. The viewing window obtained should be similar to but not necessarily the same as that shown in (1.14.1).



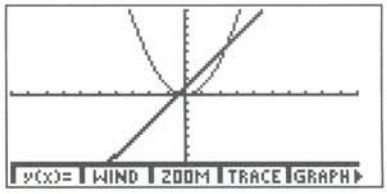
(1.14.1)

2. A simple calculation yields **xMax** – **xMin** = 0.375. Before we started the zoom-in procedure, **xMax** was 4 and **xMin** was –2, a difference of 6. Now 6/0.375 = 16, and since we zoomed in twice, it appears that each zoom-in resulted in a 4-fold magnification in the x-direction. A similar calculation shows the same to be true in the y-direction. To verify this is the case, select ⟨**ZOOM**⟩, press [MORE] [MORE], and select ⟨**ZFACT**⟩. See (1.14.2). These are the default zoom factors. You can, of course, change them, but for most applications the default zoom factors are best.

(1.14.2)

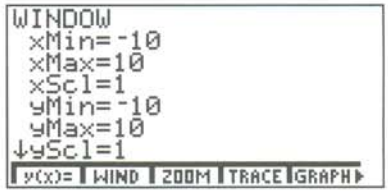
§15 – Using ⟨ZSTD⟩

1. Now select ⟨**ZOOM**⟩ and then ⟨**ZSTD**⟩ to obtain (1.15.1), the graphs of $y1$ and $y2$ in the standard $[-10, 10, 1] \times [-10, 10, 1]$ viewing window.



(1.15.1)

2. Verify the viewing window by selecting ⟨**WIND**⟩ to obtain (1.15.2).



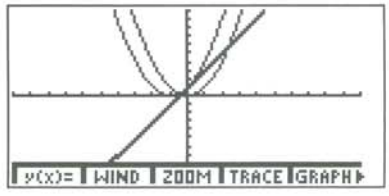
(1.15.2)

§16 – Combining Functions

1. Select ⟨**y(x)=**⟩ and press the down arrow until $y3=$ appears. Now type in $y1 + y2$ by pressing ⟨**y**⟩ **1** [+] ⟨**y**⟩ **2**; that is, select ⟨**y**⟩, press [1], press [+], select ⟨**y**⟩, press [2]. See (1.16.1).

(1.16.1)

2. Then select ⟨**GRAPH**⟩. Note that $y1$, $y2$, and $y3$ are graphed in sequence. See (1.16.2).



(1.16.2)

§17 – Using ⟨SELCT⟩

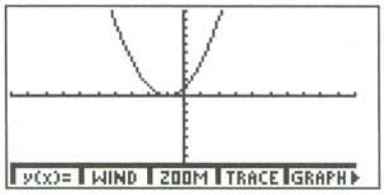
1. Select ⟨**y(x)=**⟩ to obtain (1.16.1). If necessary, use the up and down arrow keys to move the blinking cursor to the $y1$ line. Choose ⟨**SELCT**⟩ to obtain (1.17.1).

(1.17.1)

2. Note that the = after $y1$ is no longer highlighted. This means that $y1$ has been deselected for graphing. Select ⟨**SELCT**⟩ again, and note that the = after $y1$ is again highlighted. Now use ⟨**SELCT**⟩ and the up and down arrow keys to select only $y3$ to be graphed. See (1.17.2).

(1.17.2)

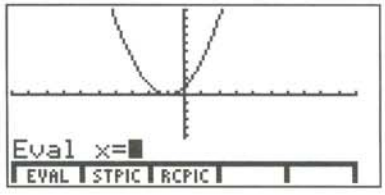
3. Then select ⟨**GRAPH**⟩ to obtain (1.17.3), the graph of $y3$ in the standard $[-10, 10, 1] \times [-10, 10, 1]$ viewing window.



(1.17.3)

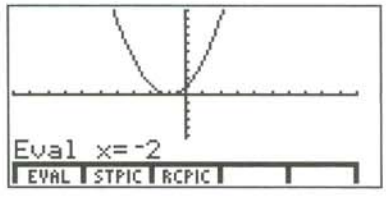
§18 – Using ⟨EVAL⟩

1. From the graph screen we can use EVAL to conveniently evaluate graphed functions for values of x between **xMin** and **xMax**. We illustrate by evaluating $y3$ at $x = -2$ and $x = 3.5$. With the display as in (1.17.3), press [MORE] [MORE] and select ⟨**EVAL**⟩ to obtain display (1.18.1).



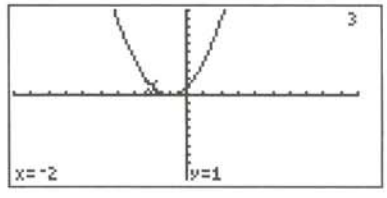
(1.18.1)

2. Then press [(-)] [2] to obtain (1.18.2).



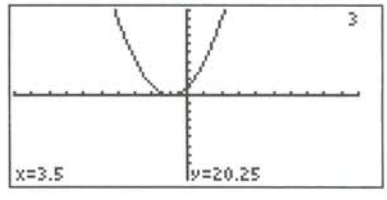
(1.18.2)

3. Then press [ENTER] to obtain (1.18.3). We see that $y3 = 1$ when $x = -2$.



(1.18.3)

4. With the display as in (1.18.3) press [3] [.] [5] [ENTER] to obtain (1.18.4). We see that $y3 = 20.25$ when $x = 3.5$. We can continue using EVAL in this fashion to evaluate $y3$ for any x-value between **xMin** and **xMax**.

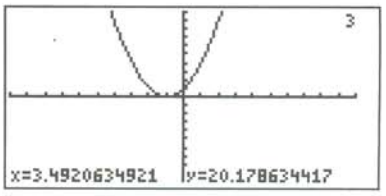


(1.18.4)

§19 – Evaluating Functions Using the TRACE Mode

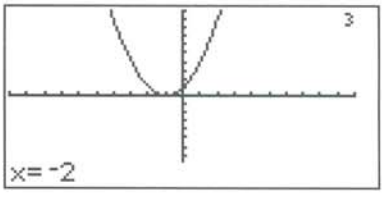
A second convenient way to evaluate graphed functions at x-values between **xMin** and **xMax** from the graph screen is to use an important feature of the TRACE mode. We illustrate by again evaluating $y3$ at $x = -2$ and $x = 3.5$.

1. With the display as in (1.18.4), press [GRAPH] to obtain (1.17.3), and then select ⟨**TRACE**⟩ to obtain a display similar to (1.19.1).



(1.19.1)

2. Then press [(-)] [2] to obtain (1.19.2). Finally, press [ENTER] to obtain (1.18.3) again. Similarly, with the display as in (1.18.3), press [3] [.] [5] [ENTER] to obtain (1.18.4) again.



(1.19.2)

§20 – Evaluating Functions from the Home Screen

We can also evaluate functions from the home screen. Unlike evaluation from the graph screen, from the home screen we can use an x-value which is not between **xMin** and **xMax**. We illustrate by evaluating $y1$ and $y3$ at $x = 11.5$.

1. Return to the home screen by pressing [2nd] [QUIT] and clear the display by pressing [CLEAR]. Then press **11.5** [STO▸] [X-VAR] [ENTER] and then [2nd] [alpha] **y 1** [ENTER] to obtain display (1.20.1). We see that $y1 = 132.25$ when $x = 11.5$.

```
11.5→x
                    11.5
y1
                    132.25
```

(1.20.1)

2. Next press [2nd] [alpha] **y 3** [ENTER] to obtain (1.20.2). Thus, $y3 = 156.25$ when $x = 11.5$.

```
11.5→x
                    11.5
y1
                    132.25
y3
                    156.25
```

(1.20.2)

3. An alternative technique is to enter and execute the entry lines $y1(11.5)$ and $y3(11.5)$, respectively as shown in (1.20.3).

```
y1(11.5)
                    132.25
y3(11.5)
                    156.25
```

(1.20.3)

§21 – Using the FORMAT Graph Menu

In §11 we used the STYLE menu to change the appearance of a graph. We can further change the presentation of a graph by using the FORMAT graph menu.

1. From the home screen, press [GRAPH] to again obtain (1.17.3). Then press [MORE] and select ⟨**FORMT**⟩ to obtain (1.21.1), the default graph format settings.

(1.21.1)

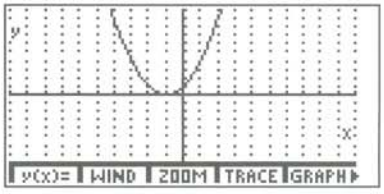
2. Use the arrow keys to move the blinking block to GridOn, and press [ENTER] to obtain (1.21.2).

(1.21.2)

3. Next move the blinking block to LabelOn, and press [ENTER] to obtain (1.21.3).

(1.21.3)

4. Then select ⟨**GRAPH**⟩ to obtain (1.21.4), the graph with the new format settings shown in (1.21.3). You might want to experiment with other graph format settings at this time. However, in the course of our work in this book we will have little occasion to deviate from the default graph format settings. Before proceeding to the next section, change the graph format settings back to the default settings shown in (1.21.1).



(1.21.4)

§22 – Deleting Functions from the Graph Editor

In this section we see how to delete functions from the ⟨**y(x)=**⟩ graph editor.

1. With the display as in (1.17.3), select ⟨**y(x)=**⟩ to obtain (1.17.2). If necessary, move the blinking cursor to the $y1$ line. Select ⟨**DELf**⟩ to obtain (1.22.1) which indicates that $y1$ has been eliminated from the graphing editor (in fact, from the machine memory).

(1.22.1)

2. Continue to select ⟨**DELf**⟩ to delete the remaining two functions $y2$ and $y3$. See (1.22.2).

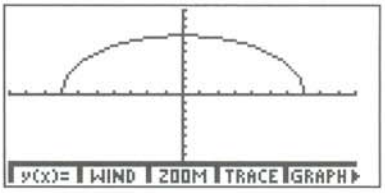
(1.22.2)

§23 – Equalizing Length of Units on x and y Axes

1. An equation for the upper half of the circle with center (0, 0) and radius 7 is given by $y = \sqrt{49 - x^2}$. Enter this function as $y1$ in the graphing editor as shown in (1.23.1)

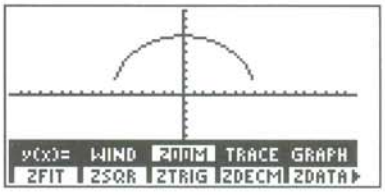
(1.23.1)

2. Graph in the standard $[-10, 10, 1] \times [-10, 10, 1]$ viewing window as shown in (1.23.2). The graph in this viewing window does not look like the graph of a semicircle because the length representing one unit on the x-axis is not the same as the length representing one unit on the y-axis. In fact the ratio of the length to the width of the graph display is about 1.7 to 1.



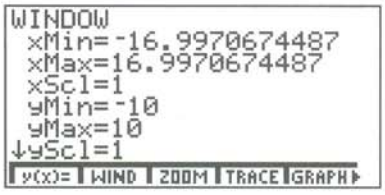
(1.23.2)

3. The ⟨**ZSQR**⟩ option allows us to adjust the viewing window so that a unit on the x-axis and a unit on the y-axis have the same length. To access ⟨**ZSQR**⟩, select ⟨**ZOOM**⟩, press [MORE], and select ⟨**ZSQR**⟩. You obtain (1.23.3). ***Note:*** *In* (1.23.3), *the graph of the semicircle is incomplete. This is due to the fact that* (–7, 0) *and* (7, 0) *are not pixel points in this viewing window, and thus* (–7, 0) *and* (7, 0) *are not among the points plotted in obtaining the graph.*



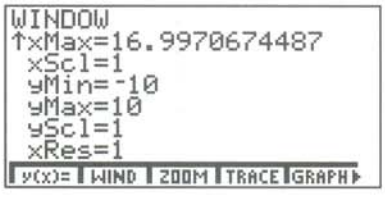
(1.23.3)

4. Select ⟨**WIND**⟩ to see how the window settings have been changed. See (1.23.4). A quick calculation shows that the ratio of (**xMax** – **xMin**) to (**yMax** – **yMin**) is about 1.7 to 1 as expected.



(1.23.4)

5. With the display as in (1.23.4), use the ▼ key to scroll down the window until you obtain (1.23.5). Note the **xRes** setting at the bottom of the window screen. The **xRes** setting affects the graphing resolution and is the subject of the next section.

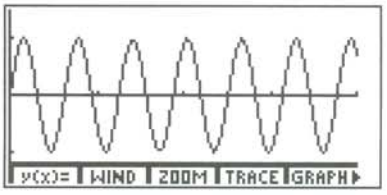


(1.23.5)

§24 – Understanding the xRes Variable

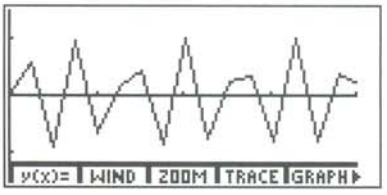
The **xRes** variable in the WINDOW editor can be any integer from 1 through 8. The default value which we have used until now is 1. When **xRes** = 1, functions are evaluated and graphed at each pixel along the x-axis. When **xRes** = 8, functions are evaluated and graphed at every 8th pixel along the x-axis. Large values of **xRes** speed up the graphing process, but the graph's resolution may suffer. An example is illustrated by (1.24.1) and (1.24.2), which both give the graph of $y = \sin(x)$ in the viewing window $[0, 40, 10] \times [-1.5, 1.5, 1]$. The default value of 1 is usually the best choice, and we will have only a few occasions in Chapters 5 and 6 where an **xRes** setting other than 1 will be used to speed up graphing.

1. In (1.24.1), **xRes** = 1;



(1.24.1)

2. and in (1.24.2), **xRes** = 8. Note the obvious loss of graphing resolution in (1.24.2).



(1.24.2)

§25 – Memory Management

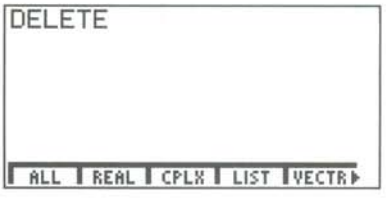
In §1 we briefly visited the MEMORY menu when the calculator was reset to its factory default settings. We close this chapter with a little excursion in memory management on the TI-86.

1. From the home screen, press [2nd] [MEM] to access the MEMORY menu as shown on the bottom line of (1.1.1). Then select ⟨**RAM**⟩ to obtain (1.25.1).

(1.25.1)

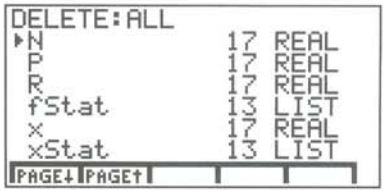
From this screen we see that there are 98113 bytes of memory available, and we also see how many bytes of memory are being used for the 11 different types of variables. Of course it is highly unlikely that your RAM screen will have exactly the same memory numbers shown in (1.25.1), since in the course of the 25 sections of this chapter you have undoubtedly done a little experimentation along the way.

2. Over a period of time, the variables you use tend to accumulate and use up valuable memory space. Thus, it is a good idea to occasionally visit the MEMORY menu of the calculator and eliminate variables you no longer need. This deletion of variables is accomplished as follows. With the display as in (1.1.1) or (1.25.1), select ⟨**DELET**⟩ to obtain (1.25.2).



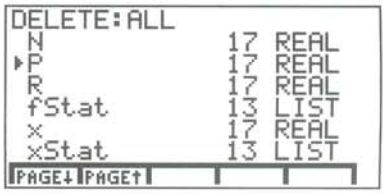
(1.25.2)

3. The bottom menu line allows you to visit any of the 11 types of variables individually or to view all of them at once by selecting ⟨**ALL**⟩. Since we have not introduced many variables in the course of this chapter, select ⟨**ALL**⟩. This results in a display similar to (1.25.3).



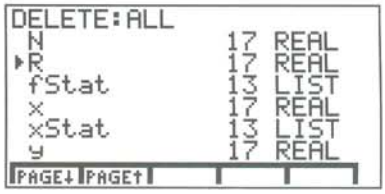
(1.25.3)

4. In (1.25.3) we see that the triangular indicator ▶ is beside the variable N, which is using up 17 bytes of memory. (Recall that the variables N, P, and R were introduced in the work we did on the compound interest formula.) Use the ▼ cursor pad key to move the ▶ indicator to P as shown in (1.25.4)



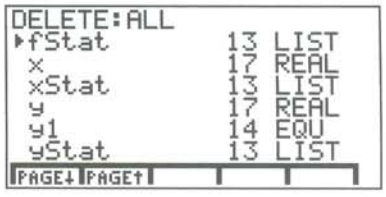
(1.25.4)

5. Then press [ENTER] to obtain (1.25.5). We see that pressing [ENTER] immediately deleted the variable P from memory. Other variables are eliminated in the same fashion; namely, move the ▶ indicator to the variable you want to delete, and press [ENTER] to delete that variable. Clearly, you must be careful when deleting variables since an inadvertent press of [ENTER] can zap a variable you do not want to delete.



(1.25.5)

6. As shown in (1.25.6), we have also eliminated the variables N, and R. Unlike the other variables, the variables xStat, yStat, and fStat cannot be deleted from memory because they are system variables. Verify this by pressing [ENTER] when the triangular indicator is beside xStat, yStat, or fStat.



(1.25.6)

Although we seldom find it beneficial to clear the ENTRY storage area, it can be cleared by typing or pasting the command **ClrEnt** on the home screen and pressing [ENTER]. See the menu line in (1.1.1) or (1.25.1).

As you have probably experienced during the course of this chapter, when there is no activity on the TI-86 for about 5 minutes, the machine turns itself off. When the calculator is turned back on after such an automatic shutdown, it is in exactly the same state it was before shutting down. Thus, if a graph was being displayed when automatic shutdown occurred, then that same graph display will reappear when the calculator is restarted. Similarly, if the calculator is turned off by pressing [2nd] [OFF], then all settings and memory are retained. However, when restarted after a manual shutdown the initial display will always be the home screen as it was when last used before the shutdown.

Exercises

1. Recall that the horizontal distance Δx between two adjoining pixels on the TI-86 is given by Δx = (**xMax** − **xMin**)/126 and that the vertical distance Δy is given by Δy = (**yMax** − **yMin**)/62.

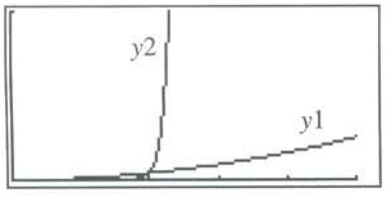
   (a) Find a viewing window in which each horizontal pixel movement is 1 unit and each vertical pixel movement is 1 unit.

   (b) Find a viewing window in which each horizontal pixel movement is 3 units and each vertical pixel movement is 5 units.

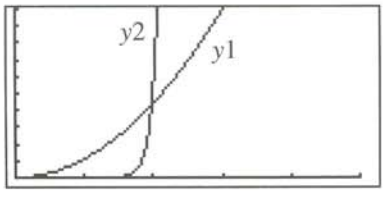
2. Graph $y1 = (x - \{1,2,4\})^2$ in the viewing window [−10, 10, 1] × [−10, 10, 1], then experiment with ⟨**TRACE**⟩. Do the same with $y2 = x^2 - \{1,2,4\}$. *Note that the set brackets can be found in the* LIST *menu.*

3. Graph $y1 = \sin(126\pi x)$ in the viewing window [−1, 1, 0.5] × [−2, 2, 1]. Then graph $y2 = \sin(125\pi x)$ in the same viewing window. Explain the results.

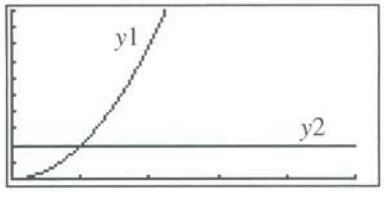
4. In each of the displays below find a viewing window which makes the graphs of $y1 = x^2$ and $y2 = 0.01e^{0.01x}$ look like the display.



(a)



(b)



(c)

5. As was done in §6, use the TABLE feature to tabulate how $800 invested at 5.5% annual interest compounded monthly grows each year. In what year does the original investment become doubled?

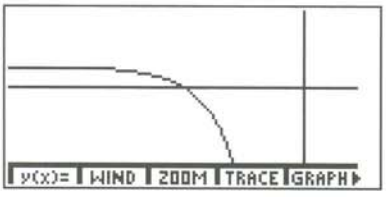
6. In each of (a) and (b) below, graph the indicated function in both the Line style and the Dot style. In each case specify which style gives the best representation of the graph.

   (a) $y1 = \sin(10x)$ in the viewing window [−3, 3, 1] × [−1, 1, 0.5].

   (b) $y2 = \text{int}(x)$ in the viewing window [−5, 5, 1] × [−5, 5, 1]. The function **int** is the greatest integer function and is accessed by pressing [2nd] [MATH] ⟨**NUM**⟩ ⟨**int**⟩.

7. It is not difficult to see that the function $y1 = \dfrac{3x^2 - x + 5}{x^2 + 4}$ has a horizontal asymptote at $y = 3$. Graph $y1$ and $y2 = 3$ in the standard viewing window, and use the trace feature to evaluate each function at $x = -7$ to see that, in fact, $y1$ intersects the horizontal asymptote at the point (−7, 3). Proceed to give graphical evidence of this intersection as follows. Access the zoom factors as

explained in §14, and change **xFact** to have value 1, leaving the value of **yFact** at 4. Return to the graph and, with the cursor very near (–7, 3), select ⟨**ZOOM**⟩ ⟨**ZIN**⟩ and press [ENTER]. Wait for the zoom-in to finish and press [ENTER] again. This causes another zoom-in. Wait for it to finish and press [ENTER] one more time. The outcome should be a screen similar to the image below.



NOTE: *Before proceeding to Chapter 2, be certain to reset* **xFact** *to 4.*