A Quick Introduction to the TI-86
Version 2.0

Scott MacDonald

Based on work of Pat Averbeck and H. L. Wilson

This booklet is typeset using $\mathcal{AMS}$-LaTeX with the help of the `dvips` DVI to PS driver, Alladin Ghostscript, and GSView. These are all free programs.

All graphs (other than screenshots of the TI-83) are drawn using Graphmatica, and all graphics are converted to encapsulated postscript using WMF2EPS. These are shareware programs.

Printing History:

Version α Spring 1999: Examples section incomplete.
Version β September 2000: Examples completed, some screenshots not ready.
Version 1.0 October 2000: Ready to go!
Version 2.0 April 2001: Minor typos fixed. Final comments added. Other general improvements made.

This printing: April 27, 2001.

0 Notation

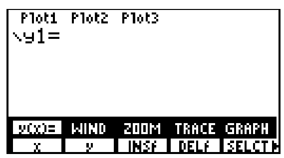
To illustrate keystrokes, I have a special notation which will be used throughout this introduction to the TI-86.

TEXT Indicates the primary function of the key. "TEXT" is printed in white on the key. ON indicates the "ON" button, for example.

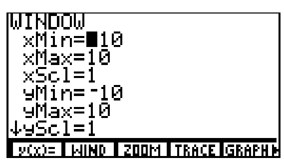
TEXT Indicates the secondary function of the key. "TEXT" is printed in yellow above the key. This function is accessed by first pressing the yellow key at the top left of the main keypad (represented by 2nd).

TEXT Indicates the alpha function of the key. "TEXT" is printed in blue above the key. This function is accessed by first pressing the blue key just below 2nd (represented by ALPHA). Most alpha functions are just a single letter.

F#: TEXT Indicates an option selected by pressing the indicated function key (located under the viewscreen, marked F1–F5). For example, the keystrokes GRAPH F1: $y(x) =$ will bring you to the screen used to enter functions for graphing, as shown below.



M#: TEXT Indicates an option selected by pressing 2nd and then the indicated function key (located under the viewscreen, marked M1–M5). For example, after entering a function to graph on the screen shown above, you might want to edit the window settings. To do so, press 2nd M2: WIND to get the screen shown below.



1 Contrast

Sometimes, especially if your batteries are low, the display on your screen may be so light that it is difficult or impossible to read. This is actually quite easy to fix.

Keystrokes:
To make the display darker, press 2nd, then press AND HOLD ▲ until the display is the desired darkness.
To make the display lighter, press 2nd, then press AND HOLD ▼.

While you are adjusting the contrast, the TI-86 will display a number (1–9) in the upper right corner of the screen. This number indicates the contrast setting. A normal setting for a calculator with good batteries is 4 or 5. If you find that, in order to read the display, you need to set the contrast at 8 or 9, then it is time to replace your batteries.

2 Special Keys

2nd The yellow key at the top left of the keyboard is the "2nd" key, denoted 2nd. This key activates the yellow entries over the keys. The cursor changes to an up arrow to indicate that yellow entries are active.

ALPHA The blue key just under 2nd is the the "alphabet" key, denoted ALPHA. It activates the blue entries over the keys (most of which are upper case letters in the alphabet). The cursor changes to a blocked "A" to indicate that blue entries are active.

alpha If you press the sequence 2nd alpha, then the alphabet is changed to lower case letters.

ENTER Most of the time, ENTER acts like an "=" key on a more traditional calculator, but if you press ENTER without entering anything, it assumes that you mean to repeat the previous entry and returns the appropriate answer.

Example 1:
To compute $2+3$, press 2 + 3 ENTER. You should, of course, get 5.

Example 2:
To find the first five powers of 2, enter the keystrokes in the order shown in the table below:

Keystrokes	Result
1 ENTER	1
× 2 ENTER	2
ENTER	4
ENTER	8
ENTER	16
ENTER	32

INS The "insert" key is actually the sequence 2nd INS. The cursor changes to an underline bar to indicate that the calculator is in "insert" mode. It stays in insert mode until 2nd INS is pressed again, a cursor key is pressed, or DEL is pressed.

DEL When pressed, DEL removes text where the solid square is placed.

CLEAR This button clears any entry on the same line as the cursor. On the home screen, if there is no entry on the same line as the cursor, then CLEAR clears the screen.

EXIT This key returns you to the previous menu or to the home screen.

QUIT The sequence 2nd QUIT returns to the home screen immediately.

ANS The sequence 2nd ANS writes "ANS" on the screen. This represents the value of the answer to the last computation and is remembered when the calculator is turned off and on.

ENTRY The sequence 2nd ENTRY puts the immediately previous entry on the screen for editing. This is especially useful if you make a small error in entering a rather complicated expression. Repeatedly pressing 2nd ENTRY will bring up earlier entries. The exact number of steps you can take "backwards" like this depends on the size of the entries.

EE This is the entry key for scientific notation.

Example 3:
To enter the number $3,200,000$ in scientific notation, press 3 . 2 EE 6. The calculator displays "3.2E6". Press ENTER, and you get "3200000".

STO▸ This button is used for storing values in memory banks designated by ALPHA characters. STO▸ sets the TI-86 in ALPHA mode, so do not press ALPHA. ENTER completes the storage operation. The remove a stored value, store 0.

Example 4:
To store 4 as "A", press 4 STO▸ A ENTER. The calculator displays "4" to indicate that 4 was stored.

Example 5:
To store the result of the previous calculation as "K", simply press STO▸ K ENTER.

3 Calculations

Arithmetic operations are typed in as text and are executed with the ENTER key. (ENTER works the same way as "=" does on many calculators.)

Example 6:

$3+5$	3 + 5 ENTER	gives	8
$21 \div 7$	2 1 ÷ 7 ENTER	gives	3
$\sqrt{3}$	2nd √ 3 ENTER	gives	1.73205080757
9^9	9 ^ 9 ENTER	gives	387420489
π	2nd π ENTER	gives	3.14159265359

Try some on your own. Note that the screen scrolls up as your computations reach the bottom of the screen. The screen does not scroll down. Once off the top, text cannot be retrieved.

4 Modes

The sequence [2nd] [MODE] displays the menu for the mode settings. These settings indicate how numbers and graphs are displayed. All default mode settings are on the left side of the screen and are shaded. Each line controls a mode. It is wise to check this screen when starting a problem to see if all the modes are appropriate to the specific problem.

To change a mode setting, move the flashing cursor to the intended mode and state. To change to a different state, have its designator flashing, and press [ENTER]. Leave the MODE screen by pressing [CLEAR], [2nd] [QUIT], or [EXIT].

- The first line controls the nature of the numeric display, i.e. "Normal" is for normal decimal display, "Sci" is for scientific notation, and "Eng" is for engineering notation (all numbers are represented by a number between 1 and 1000 times 10 to a power which is a multiple of three).
- The second line controls the decimal point. "Float" indicates a standard, "floating" decimal. The numbers 012345678901 fix the number of places to the right of the decimal which will be displayed. The second "0" and "1" represent 10 and 11 decimal places, respectively.
- The third line sets what units angles are measured in.
- The fourth line chooses between entering complex numbers in rectangular form $\left([real, imaginary]\right)$ and polar form $\left([r,\theta]\right)$.
- The fifth line controls the type of functions you can graph by pressing the sequence [GRAPH] [F1: y(x) =]. The choices are "Func" (functions of the form $y = f(x)$), "Pol" (polar functions: $r = f(\theta)$), "Param" (parametric functions: $x = f(t)$; $y = g(t)$), and "DifEq" (differential equations: $Q' = f(t)$).
- The sixth line chooses between numeric bases. The choices are "Dec" (decimal, base 10), "Bin" (binary, base 2), "Oct" (octal, base 8), and "Hex" (hexadecimal, base 16).
- The seventh line controls what form vectors can be entered in. The choices are "RectV" (rectangular: $[x,y]$ or $[x,y,z]$), "CylV" (cylindrical: $[r,\angle\theta]$ or $[r,\angle\theta,z]$, and "SphereV" (spherical: $[r,\angle\theta,\angle\phi]$).
- The eighth line chooses how the calculator computes derivatives. "dxDer1" tells the calculator to differentiate exactly, then calculate the value, while "dxNDer" tells the calculator to differentiate numerically, then calculate the value.

5 Graphing

To enter the graphing environment, press [GRAPH]. Notice at the bottom of the screen a menu is listed:

y(x)= | WIND | ZOOM | TRACE | GRAPH ▸

Notice the small triangular arrow at the far right of the menu; this indicates that there are more menu items that can be accessed. To list the other menu items, press [MORE].

MATH | DRAW | FORMT | STGDB | RCGDB ▸

The arrow indicates that there are still more menu items. Press [MORE] again, and the menu becomes

EVAL | STPIC | RCPIC | |

Notice that this time there is no little arrow in the bottom right corner, so we know we have now seen all the possible entries. Press [MORE] again to return to the original menu. The immediately important keys from these three menus are explained below.

[F1: $y(x) =$] This key brings you to the window for entering functions to be graphed.

- A function will be graphed only if the "=" is highlighted. Once a function is entered, it is automatically selected for graphing. To deselect a function for graphing, move to the line of the function and press [F5: SELCT]. If you wish to reselect the same function, follow the same directions. This procedure toggles a function back and forth between "selected" and "unselected".
- Notice that the GRAPH menu is still shown, but is now on the top of a two-level menu. To access these options, it will be necessary to press [2nd] before selecting the option. For example, if you want to edit the viewing window, you should press [2nd] [M2: WIND] (see below for an explanation of this window).
- When you are done editing functions and are ready to view the graph, press [2nd] [M5: GRAPH].

[F2: WIND] This screen gives you manual control over the view of a graph. The "xScl" and "yScl" entries are the values of the tick marks along the axes. You will probably never need to change the "xRes" setting (at the very bottom), so leave it alone unless you know what you are doing.

[F3: ZOOM] Selecting this option brings up the ZOOM menu.

[F1: BOX] This option lest you set the diagonally opposite corners of a new viewing rectangle by using the cursor keys. Press [ENTER] to set one of the corners of the new viewing rectangle. As you move the cursor, the calculator will make a box indicating the new viewing rectangle. When you press [ENTER] again, the opposite corner is set, and the view changes.

[F2: ZIN] This is for "zooming in" on a graph. The factor by which you zoom in is set using [MORE] [MORE] [F2: ZFACT], but this is an advanced feature that you may never care to change. Keeping the default values here is advisable for now.

[F3: ZOUT] Just like [F2: ZIN], except that you zoom OUT instead.

[F4: ZSTD] Gives a viewing rectangle of xMin = -10, xMax = 10, xScl = 1, yMin = -10, yMax = 10, and yScl = 1.

[F5: ZPREV] Returns the viewing rectangle to its previous setting.

[MORE] [F2: ZSQR] Makes circles actually look like circles (as opposed to ellipses).

others There are many other zoom features. Play with them and see what they do. Some you'll be able to figure out on your own, others you may want to ask about.

[F4]: TRACE Pressing [F4]: TRACE causes the cursor to be "locked" to a graph, so that if you push [◄] or [►], then the cursor follows the graph. Notice that the function number of the graph being traced is indicated in the upper right hand corner of the screen. If you wish to trace a different function, press [▲] or [▼] until the appropriate function number appears.

MORE [F1]: MATH This brings up the GRAPH/MATH menu, from which many calculations can be made on a graphed function.

- **[F1]: ROOT** Finds *x*-intercepts.
- **[F2]: dy/dx** Finds the derivative at a point (calculus).
- **[F3]: $\int f(x)$** Finds a definite integral (calculus).
- **[F4]: FMIN** Finds the minimum value of a function.
- **[F5]: FMAX** Finds the maximum value of a function.
- **MORE** There are many more options under this menu that you can play with.

MORE There are many more options in the GRAPH menu. Play with them and learn.

6 Examples

There are many features of the TI-86 that have not been discussed here. Some will be demonstrated in the examples that follow.

1. Find 13!.

   Keystrokes:
   [1] [3] [2nd] [MATH] [F2]: PROB [F1]: ! [ENTER]

   Result: 6227020800

2. How many 5 card poker hands are there in a 52 card deck of playing cards? Note: This requires us to find $\binom{52}{5}$, which is also denoted ${}_{52}C_5$.

   Keystrokes:
   [5] [2] [2nd] [MATH] [F2]: PROB [F3]: nCr [5] [ENTER]

   Result: 2598960

3. Using the formula $A(t) = A_0(1+r)^t$ for compound interest, determine how long it will take for \$500 to double if it is invested at 8.8% interest compounded annually.

   We begin by seeing how much is in the account after 8 years:

   Keystrokes:
   [5] [0] [0] [(] [1] [+] [.] [0] [8] [8] [)] [^] [8] [ENTER]

   Result: 981.750581622
   (or \$981.75)

   This is not quite double, so we change our previous entry to try 9 years:

   Keystrokes:
   [2nd] [ENTRY] [◄] [9] [ENTER]

   Result: 1068.14463281
   (or \$1068.14)

   This is too much, so we try 8.5 years:

   Keystrokes:
   [2nd] [ENTRY] [◄] [8] [.] [5] [ENTER]

   Result: 1024.03692048
   (or \$1024.04)

   This is still too much. You take it from here.

4. Examine and explain the results of the following:

   Keystrokes:
   [5] [5] [ENTER] [LOG] [2nd] [ANS] [ENTER] [ENTER] [ENTER] [ENTER]

   Result: $(-.2028567193057, 1.36437635384)$
   (press and hold [►] until you can see all the digits)

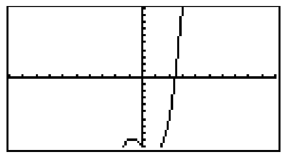
   This seemingly bizarre result is explained by the fact that, upon pressing [ENTER] the last time, you told the calculator to compute $\log(-0.61863260675)$. This is not a real number, but the solution does exist as a complex number. The calculator automatically shifts into complex number mode and displays the result above. What this result means, in slightly more familiar notation, is that

$$\log(-0.61863260675) \approx -0.2028567193057 + 1.36437635384i$$

5. Obtain a complete graph of $f(x) = x^3 - 2x - 10$. (A complete graph shows all of the interesting parts of the function, e.g. all turning points, all intercepts, and the behavior as $|x| \to \infty$.) The following procedure assumes no previously entered functions.

Keystrokes:
[GRAPH] [F1: $y(x) =$] [F1: x] [^] [3] [−] [2] [F1: x] [−] [1] [0]
[2nd] [M3: ZOOM] [F4: ZSTD] [CLEAR] (to get rid of the menu)

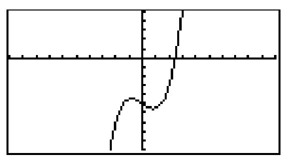
This procedure gives the following incomplete graph:



To fix this, we must play with the viewing rectangle.

Keystrokes:
[GRAPH] [F2: WIND] [▼] [▼] [▼] [(-)] [2] [0] [▼] [▼] [2] [F5: GRAPH]
[CLEAR]

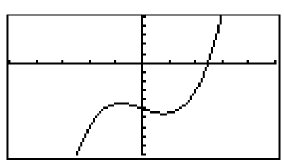
Our new graph is better:



One more change will give us a better complete graph:

Keystrokes:
[GRAPH] [F1: WIND] [(-)] [5] [▼] [5] [F5: GRAPH] [CLEAR]

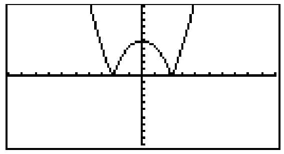
This graph has a viewing window of $-5 \le x \le 5$ and $-20 \le y \le 10$, with an xScl of 1 and a yScl of 2.



6. Graph $f(x) = |x^2 - 5|$.

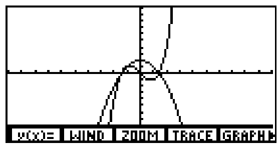
Keystrokes:
[GRAPH] [F1: $y(x) =$] [CLEAR] [2nd] [MATH] [F1: NUM] [F5: abs] [(] [2nd] [M1: x] [x^2]
[−] [5] [)] [GRAPH] [F3: ZOOM] [F4: ZSTD] [CLEAR]

This yields the following graph:

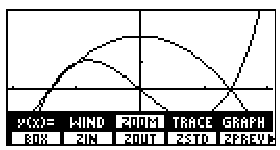


7. How many solutions are there to the system $y = x^3 - 2x$ and $y = 2 - x^2$?

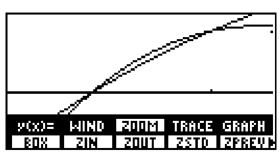
   The keystrokes [GRAPH] [F1: $y(x) =$] [CLEAR] [F1: x] [^] [3] [−] [2] [F1: x] [ENTER] [2] [−] [F1: x] [x^2] [2nd] [M3: ZOOM] [F4: ZSTD] give us an ambiguous graph. (How many times do the two curves intersect on the left side of the y-axis?)



   To get a better picture, press [F3: ZOOM] [F1: BOX], move the cursor to about $(-2,-2)$ and press [ENTER]. Next, move the cursor to about $(2, 2.9)$ and press [ENTER].



   This zooms us in some on the graph, but it's still unclear how many points of intersection there are on the left of the y-axis. Try using BOX to zoom in on the ambiguous part of the graph to get a picture similar to the one below in order and answer the original question.



   Before leaving this problem, we'll do a little more exploration. Enter the following keystrokes.

   Keystrokes:
   [2nd] [M1: $y(x) =$] [▼] [▼] [F2: y] [1] [−] [F2: y] [2] [2nd] [M5: GRAPH]

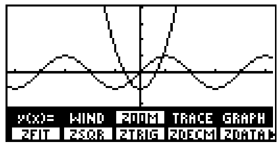
   Note that the x-intercepts of the new graph are at the same x-coordinates as the points of intersection on the old graph. Why?

8. Solve for x to the nearest 0.01: $\sin x = x^2 - 1$.

   First clear all entries in the $y(x) =$ screen. Then perform the following keystrokes.

   Keystrokes:
   [GRAPH] [F1]: $y(x) =$ [SIN] [F1]: x [ENTER] [F1]: x [x^2] [−] [1] [2nd] [M3]: ZOOM
   [MORE] [F3]: ZTRIG

   This gives us the following graph.



   Press [2nd] [M4]: TRACE and move the cursor to one of the intersections. Notice that if you push [◄] and [►] a few times, the x value at the bottom of the screen jumps by more than 0.01. This means that the number you get is not yet to the nearest 0.01. We need to zoom in to get better accuracy.

   Press [GRAPH] [F3]: ZOOM [F2]: ZIN [ENTER]. This zooms in on the point that the cursor was sitting. Notice that your cursor is no longer right on the point of intersection. Press [GRAPH] [F4]: TRACE and move to the point of intersection once again. This value is still not to the nearest 0.01, so you must zoom in again. Continue this process until an accuracy of 0.01 is obtained.

   Result: The points of intersection are at $x \approx 1.41$ and $x \approx -0.64$

9. Justify graphically the identity $\sin 2x = 2 \sin x \cos x$.

   First clear all entries in the $y(x) =$ screen. Graph both sides of the equation and compare by using the following keystrokes.

   Keystrokes:
   [GRAPH] [F1]: $y(x) =$ [SIN] [(] [2] [F1]: x [)] [ENTER] [2] [SIN] [F1]: x
   [COS] [F1]: x [2nd] [M3]: ZOOM [MORE] [F3]: TRIG

   Press [2nd] [M4]: TRACE and trace both graphs (use [▲] and [▼] to change between graphs. Since these graphs are the same, the y-coordinate will not change when you change graphs, regardless of what x-coordinate you are on at the time.

   ALTERNATIVE METHOD: Press [GRAPH] [F1]: $y(x) =$ [F5]: SELCT [▼] [F5]: SELCT [▼]. This unselects y1 and y2 and puts you in a position to edit y3. DO NOT CLEAR y1 AND y2!! Now do the following.

   Keystrokes:
   [F2]: y [1] [−] [F2]: y [2] [2nd] [M5]: GRAPH

Notice that you see no graph. Why not? Press [F4: TRACE] and either [◄] or [►]. Notice that the y-coordinates are always essentially 0. What can you conclude?

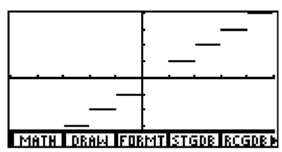
10. Graph the Largest Integer Function.

Start by clearing all entries in the $y(x) =$ screen. Set the viewing window as $[-5,5]$ by $[-5,5]$ and set xScl and yScl both at 1 by doing the following.

Keystrokes:
[GRAPH] [F2: WIND] [(-)] [5] [ENTER] [5] [ENTER] [1] [ENTER] [(-)] [5] [ENTER] [5] [ENTER] [1]

Now we set about entering and graphing the function. The following keystrokes will enter "int(x)" in the $y(x) =$ screen, then switch to the graph format screen and select "DrawDot", and finally will draw the graph.

Keystrokes:
[F1: $y(x) =$] [2nd] [alpha] [ALPHA] [i] [n] [t] [ALPHA] [ALPHA] [(] [F1: x] [)] [EXIT] [MORE] [F3: FORMT] [▼] [▼] [►] [ENTER] [F5: GRAPH]



Before you go on to the next example, be sure to return the format to DrawLine by pressing [MORE] [F3: FORMT] [▼] [▼] [ENTER].

11. Graph $x^2 + y^2 = 36$.

First clear all entries on the $y(x) =$ screen. Then move to y1 and do the following.

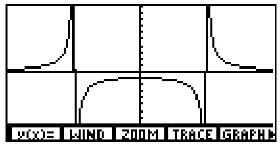
Keystrokes:
[2nd] [$\sqrt{\ }$] [(] [3] [6] [–] [F1: x] [x^2] [)] [ENTER] [(-)] [F2: y] [1] [2nd] [M3: ZOOM] [F4: ZSTD]

Notice that the graph is an egg-shaped circle. Press [F3: ZOOM] [MORE] [F2: ZSQR]. This fixes the window so that the circle looks like a circle.

12. Graph the function $f(x) = \frac{1}{x^2-1}$ on a window which is $[-2,2]$ in the x direction by $[-10,10]$ in the y direction.

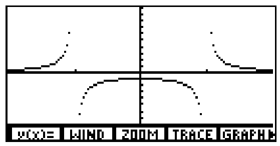
First clear all entries on the $y(x) =$ screen and move to y1.

Keystrokes:
[1] [/] [(] [F1: x] [x^2] [–] [1] [)] [2nd] [M2: WIND] [(-)] [2] [ENTER] [2] [ENTER] [1] [ENTER] [(-)] [1] [0] [ENTER] [1] [0] [ENTER] [1] [F5: GRAPH]



What's with the (nearly) vertical lines? We can get rid of them at the cost of losing some definition in the graph. Try the following.

Keystrokes:
[MORE] [F3: FORMT] [▼] [▼] [►] [ENTER] [F5: GRAPH]



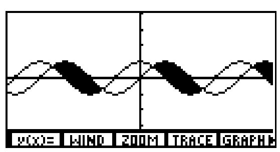
Return to the DrawLine format before continuing.

13. Graph $y = \cos x$ and $y = \sin x$ simultaneously, shading the area between the two graphs–but only when $\sin x > \cos x$.

Clear all function in $y(x) =$. Press [GRAPH] [MORE] [F3: FORMT] [▼] [▼] [▼] [►] [ENTER]. This sets the graphing format to SimulG (simultaneous graphing). Press [EXIT].

Now set the zoom setting to ZTRIG by pressing [GRAPH] [F3: ZOOM] [MORE] [F3: ZTRIG]. Press [EXIT] to return to the home screen. Now we draw the complex sounding graph.

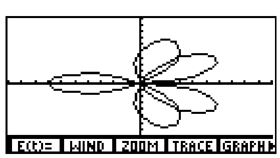
Keystrokes:
[GRAPH] [MORE] [F2: DRAW] [F1: Shade] [COS] [x-VAR] [,] [SIN] [x-VAR] [)] [ENTER]



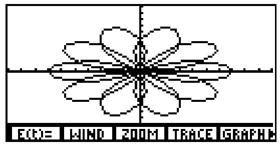
Return the graphing format to SeqG (sequential graphing).

14. Graph the parametric equations $x(t) = 7\sin(2.5t)\cos t$, $y(t) = 7\sin(2.5t)\sin t$.

Keystrokes:
[2nd] [MODE] [▼] [▼] [▼] [▼] [►] [►] [ENTER] [GRAPH] [F1: $E(t) =$] [7]
[SIN] [(] [2] [.] [5] [F1: t] [)] [COS] [F1: t] [ENTER] [7] [SIN]
[(] [2] [.] [5] [F1: t] [)] [SIN] [F1: t] [2nd] [M5: GRAPH]



This graph (using the standard window) is incomplete. To fix this, press [F2: WIND] [ENTER] [4] [2nd] [π] [F5: GRAPH].



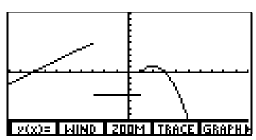
Return the calculator to Func mode before continuing by pressing [MODE] [▼] [▼] [▼] [▼] [ENTER] [EXIT].

15. Graph the function $f(x) = \begin{cases} x+8 & \text{if } x < -3 \\ -4 & \text{if } -3 \leq x < 1 \\ 4x - x^2 - 3 & \text{if } x \geq 1 \end{cases}.$

Begin by clearing all entries in the $y(x) =$ window. Then move to y1 and do the following.

Keystrokes:
[(] [F1: x] [+] [8] [)] [÷] [(] [F1: x] [2nd] [TEST] [F4: ≤] [(-)] [3] [)] [ENTER] [(] [(-)] [4] [)] [÷] [(] [2nd] [M1: x] [F5: ≥] [(-)] [3] [)] [÷] [(] [M1: x] [F2: <] [1] [)] [ENTER] [(] [4] [2nd] [M1: x] [−] [M1: x] [x^2] [−] [3] [)] [÷] [(] [M1: x] [F5: ≥] [1] [)] [2nd] [M5: GRAPH]

Notice that the net effect of these keystrokes is to enter each piece of the piecewise defined function as it's own function DIVIDED BY the restriction on x for each piece. There are other ways of graphing piecewise defined functions, but I have found that gives the best results. The only drawback is that it takes quite a while for the graph to draw since it draws each piece separately. That can, however, be fixed if you change the graphing format from "SeqG" to "SimulG". The results are shown below.



7 Final Comments

This guide is only intended to give you a basic introduction to the TI-86. It is not comprehensive, and it does not cover any class-specific topics. The TI-86, for example, can do extensive calculations with matrices. I have not discussed those operations at all in this introduction.

Your first resource for help with your calculator should be your instructor. If your instructor cannot answer your questions, I am happy to try. My office is in building 9, room 23, my phone number is 566-5236, and my email address is smacdona@ctc.ctc.edu.