

GRAPHING TECHNOLOGY GUIDE

BENJAMIN N. LEVY
LAUREL TECHNICAL SERVICES

for use with

Texas Instruments *TI-81*
Texas Instruments *TI-82*
Texas Instruments *TI-83*
Texas Instruments *TI-85*
Texas Instruments *TI-92*
Casio *fx-7700GE/9700GE*
Casio *CFX-9800G*
Casio *CFX-9850G*
Sharp *EL-9200/9300*
Hewlett Packard *HP 48G*
Hewlett Packard *HP 38G*

- Step-by-step, keystroke-level commands and instructions
- Numerous screen displays
- Technology tips

Graphing Technology Guide

Benjamin N. Levy
and
Laurel Technical Services

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Preface

The *Graphing Technology Guide* provides step-by-step, keystroke-level calculator commands and instructions for working through exercises in your textbook. Graphing calculator screens and technology tips are included throughout. The *Guide* will help you to become familiar with your calculator's capabilities and learn how to use it as a tool to learn mathematics. However, it does not replace the instruction manual that comes with the calculator. Refer to that manual to learn how to use additional capabilities of your calculator.

The *Graphing Technology Guide* contains parallel topics for each calculator model. Locate the discussion for your calculator in the appropriate column of numbers on the detailed table of contents. See pages iv-v for the Texas Instruments calculators and pages vi-vii for the Casio, Sharp, and Hewlett Packard calculators.

Please note that different typefaces are used to distinguish keystrokes that you press from the rest of the text. Thus, **MATH** and **ENTER** will represent the labels on your calculator's keys.

Calculators have function keys that assume different behavior in different contexts. To clarify the effect expected from depressing a function key, we sometimes write **F1** [**COMMAND**], where **F1** names the key and [**COMMAND**] represents its corresponding functions in the current menu. In Chapters 10 and 11, since the HP 48G and the HP 38G have six white function keys, we write [**COMMAND**] to represent the function key below the menu item **COMMAND**.

For convenience, when you are asked to type a number, say 345.67, we shall express the keystrokes as **345.67**, without any spaces between the individual keys, instead of writing **3 4 5 . 6 7**.

The calculator manufacturers--Texas Instruments, Casio, Sharp, and Hewlett Packard--have all been cooperative through the writing of this guide, and the authors gratefully acknowledge their helpfulness.

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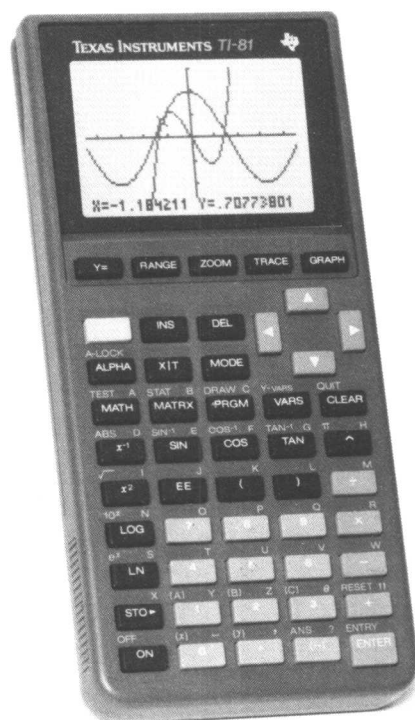
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


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Chapter 1

Texas Instruments TI-81



1.1 Getting started with the TI-81

1.1.1 Basics: Press the ON key to begin using your TI-81 calculator. If you need to adjust the display contrast, first press 2nd, then press and hold  (the *up* arrow key) to increase the contrast or  (the *down* arrow key) to decrease the contrast. As you press and hold  or , an integer between 0 (lightest) and 9 (darkest) appears in the upper right corner of the display. When you have finished with the calculator, turn it off to conserve battery power by pressing 2nd and then OFF.

Check the TI-81's settings by pressing MODE. If necessary, use the arrow keys to move the blinking cursor to a setting you want to change. Press ENTER to select a new setting. To start with, select the options along the left side of the MODE menu as illustrated in Figure 1.1: normal display, floating decimals, radian measure, function graphs, connected lines, sequential plotting, grid off, and rectangular coordinates. Details on alternative options will be given later in this guide. For now, leave the MODE menu by pressing CLEAR.

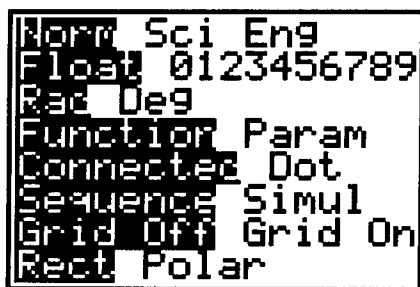


Figure 1.1: MODE menu

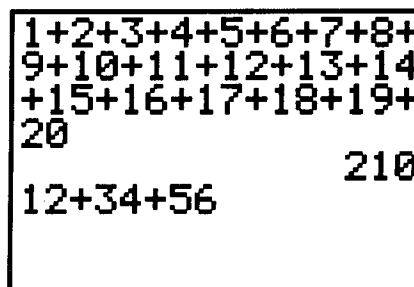



Figure 1.2: Home screen

1.1.2 Editing: One advantage of the TI-81 is that up to 8 lines are visible at one time, so you can *see* a long calculation. For example, type this sum (see Figure 1.2):

$$1 + 2 + 3 + 4 + 5 + 6 + 7 + 8 + 9 + 10 + 11 + 12 + 13 + 14 + 15 + 16 + 17 + 18 + 19 + 20$$

Then press ENTER to see the answer, too.

Often we do not notice a mistake until we see how unreasonable an answer is. The TI-81 permits you to re-display an entire calculation, edit it easily, then execute the *corrected* calculation.

Suppose you had typed $12 + 34 + 56$ as in Figure 1.2 but had *not* yet pressed ENTER, when you realize that 34 should have been 74. Simply press  (the *left* arrow key) as many times as necessary to move the blinking cursor left to 3, then type 7 to write over it. On the other hand, if 34 should have been 384, move the cursor back to 4, press INS (the cursor changes to a blinking underline) and then type 8 (inserts at the cursor position and other characters are pushed to the right). If the 34 should have been 3 only, move the cursor to 4 and press DEL to delete it.

Even if you had pressed ENTER, you may still edit the previous expression. Press 2nd and then ENTRY to *recall* the last expression that was entered. Now you can change it. If you have not pressed any key since the last ENTER, you can recall the previous expression by pressing \blacktriangleleft .

Technology Tip: When you need to evaluate a formula for different values of a variable, use the editing feature to simplify the process. For example, suppose you want to find the balance in an investment account if there is now \$5000 in the account and interest is compounded annually at the rate of 8.5%. The formula for the balance is $P(1 + \frac{r}{n})^n$, where P = principal, r = rate of interest (expressed as a decimal), n = number of times interest is compounded each year, and t = number of years. In our example, this becomes $5000(1+.085)^t$. Here are the keystrokes for finding the balance after $t = 3, 5$, and 10 years.

Years	Keystrokes	Balance
3	5000 (1 + .085) ^ 3 ENTER	\$6386.45
5	\blacktriangleleft \blacksquare 5 ENTER	\$7518.28
10	\blacktriangleleft \blacksquare 10 ENTER	\$11,304.92

```

5000(1+.085)^3
6386.445625
5000(1+.085)^5
7518.283451
5000(1+.085)^10
11304.91721

```

Figure 1.3: Editing expressions

Then to find the balance from the same initial investment but after 5 years when the annual interest rate is 7.5%, press these keys to change the last calculation above: \blacktriangleleft \blacksquare DEL \blacksquare 5 \blacksquare \blacksquare \blacksquare \blacksquare 7 ENTER.

1.1.3 Key Functions: Most keys on the TI-81 offer access to more than one function, just as the keys on a computer keyboard can produce more than one letter (“g” and “G”) or even quite different characters (“5” and “%”). The primary function of a key is indicated on the key itself, and you access that function by a simple press on the key.

To access the *second* function indicated to the *left* above a key, first press 2nd (the cursor changes to a blinking \uparrow) and *then* press the key. For example, to calculate $\sqrt{25}$, press 2nd $\sqrt{}$ 25 ENTER.

When you want to use a letter or other character printed to the *right* above a key, first press ALPHA (the cursor changes to a blinking A) and then the key. For example, to use the letter *K* in a formula, press ALPHA K. If you need several letters in a row, press 2nd A-LOCK, which is like CAPS LOCK on a computer keyboard, and then press all the letters you want. Remember to press ALPHA when you are finished and want to restore the keys to their primary functions.

1.1.4 Order of Operations: The TI-81 performs calculations according to the standard algebraic rules. Working outwards from inner parentheses, calculations are performed from left to right. Powers and roots are evaluated first, followed by multiplications and divisions, and then additions and subtractions.

Note that the TI-81 distinguishes between *subtraction* and the *negative sign*. If you wish to enter a negative number, it is necessary to use the (-) key. For example, you would evaluate $-5 - (4 \cdot -3)$ by pressing (-) 5 - (4 \times (-) 3) ENTER to get 7.

Enter these expressions to practice using your TI-81.

<i>Expression</i>	<i>Keystrokes</i>	<i>Display</i>
$7 - 5 \cdot 3$	$7 - 5 \times 3$ ENTER	-8
$(7 - 5) \cdot 3$	$(7 - 5) \times 3$ ENTER	6
$20 - 10^2$	$120 - 10 x^2$ ENTER	20
$(120 - 10)^2$	$(120 - 10) x^2$ ENTER	12100
$\frac{24}{2^3}$	$24 \div 2 \wedge 3$ ENTER	3
$\left(\frac{24}{2}\right)^3$	$(24 \div 2) \wedge 3$ ENTER	1728
$(7 - -5) \cdot -3$	$(7 - (-) 5) \times (-) 3$ ENTER	-36

1.1.5 Algebraic Expressions and Memory: Your calculator can evaluate expressions such as $\frac{N(N+1)}{2}$ after you have entered a value for *N*. Suppose you want $N = 200$. Press 200 STO ► N ENTER to store the value 200 in memory location *N*. (The STO ► key prepares the TI-81 for an alphabetical entry, so it is *not* necessary to press ALPHA also.) Whenever you use *N* in an expression, the calculator will substitute the value 200 until you make a change by storing *another* number in *N*. Next enter the expression $\frac{N(N+1)}{2}$ by typing ALPHA N (ALPHA N + 1) \div 2 ENTER. For $N = 200$, you will find that $\frac{N(N+1)}{2} = 20100$.

The contents of any memory location may be revealed by typing just its letter name and then ENTER. And the TI-81 retains memorized values even when it is turned off, so long as its batteries are good.

1.1.6 Repeated Operations with *ANS*: The result of your *last* calculation is always stored in memory location *ANS* and replaces any previous result. This makes it easy to use the answer from one computation in another computation. For example, press $30 + 15$ ENTER so that 45 is the last result displayed. Then press $2\text{nd ANS} \div 9$ ENTER and get 5 because $\frac{45}{9} = 5$.

With a function like division, you press the \div key *after* you enter an argument. For such functions, whenever you would start a new calculation with the previous answer followed by pressing the function key, you may press just the function key. So instead of $2\text{nd ANS} \div 9$ in the previous example, you could have pressed simply $\div 9$ to achieve the same result. This technique also works for these functions: $+$ $-$ \times x^2 $^$ x^{-1} .

Here is a situation where this is especially useful. Suppose a person makes \$5.85 per hour and you are asked to calculate earnings for a day, a week, and a year. Execute the given keystrokes to find the person's incomes during these periods (results are shown in Figure 1.4):

<i>Pay period</i>	<i>Keystrokes</i>	<i>Earnings</i>
8-hour day	5.85×8 ENTER	\$46.80
5-day week	$\times 5$ ENTER	\$234
52-week year	$\times 52$ ENTER	\$12,168

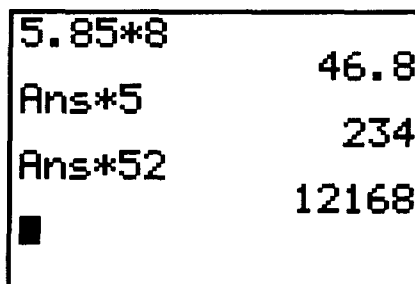


Figure 1.4: *ANS* variable

1.1.7 The *MATH* Menu: Operators and functions associated with a scientific calculator are available either immediately from the keys of the TI-81 or by 2nd keys. You have direct key access to common arithmetic operations (x^2 , $2\text{nd } \sqrt{}$, x^{-1} , $^$, 2nd ABS), trigonometric functions (SIN , COS , TAN) and their inverses (2nd SIN^{-1} , 2nd COS^{-1} , 2nd TAN^{-1}), exponential and logarithmic functions (LOG , $2\text{nd } 10^x$, LN , $2\text{nd } e^x$), and a famous constant ($2\text{nd } \pi$).

A significant difference between the TI-81 and many scientific calculators is that the TI-81 requires the argument of a function *after* the function, as you would see a formula written in your textbook. For example, on the TI-81 you calculate $\sqrt{16}$ by pressing the keys $2\text{nd } \sqrt{}$ 16 in that order.

Here are keystrokes for basic mathematical operations. Try them for practice on your TI-81.

Expression	Keystrokes	Display
$\sqrt{3^2 + 4^2}$	2nd $\sqrt{}$ (3 x ² + 4 x ²) ENTER	5
$2\frac{1}{3}$	2 + 3 x ⁻¹ ENTER	2.333333333
$ -5 $	2nd ABS (-) 5 ENTER	5
$\log 200$	LOG 200 ENTER	2.301029996
$2.34 \cdot 10^5$	2.34 \times 2nd 10 ^x 5 ENTER	234000

Additional mathematical operations and functions are available from the MATH menu (Figure 1.5). Press MATH to see the various options. You will learn in your mathematics textbook how to apply many of them. As an example, calculate $\sqrt[3]{7}$ by pressing MATH and then *either* 4 or $\boxed{\div}$ $\boxed{\div}$ $\boxed{\div}$ ENTER; finally press 7 ENTER to see 1.912931183. To leave the MATH menu and take no other action, press 2nd QUIT or just CLEAR.

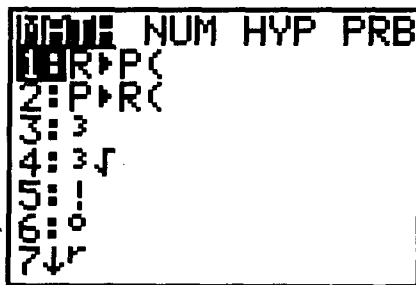


Figure 1.5: MATH menu

The *factorial* of a non-negative integer is the *product* of *all* the integers from 1 up to the given integer. The symbol for factorial is the exclamation point. So 4! (pronounced *four factorial*) is $1 \cdot 2 \cdot 3 \cdot 4 = 24$. You will learn more about applications of factorials in your textbook, but for now use the TI-81 to calculate 4! Press these keystrokes: 4 MATH 5 ENTER *or* 4 MATH $\boxed{\div}$ $\boxed{\div}$ $\boxed{\div}$ ENTER ENTER.

1.2 Functions and Graphs

1.2.1 Evaluating Functions: Suppose you receive a monthly salary of \$1975 plus a commission of 10% of sales. Let x = your sales in dollars; then your wages W in dollars are given by the equation $W = 1975 + .10x$. If your January sales were \$2230 and your February sales were \$1865, what was your income during those months?

Here's how to use your TI-81 to perform this task. Press the Y= key at the top of the calculator to display the function editing screen (Figure 1.6). You may enter as many as four different functions for the TI-81 to use at

one time. If there is already a function Y_1 , press \blacktriangleleft or \blacktriangleright as many times as necessary to move the cursor to Y_1 and then press CLEAR to delete whatever was there. Then enter the expression $1975 + .10x$ by pressing these keys: 1975 + .10 \times IT. (The \times IT key lets you enter the variable x easily without having to use the ALPHA key.) Now press 2nd QUIT to return to the main calculations screen.

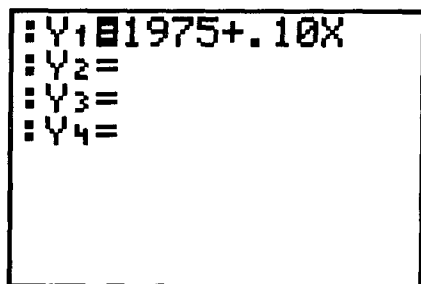


Figure 1.6: Y= screen

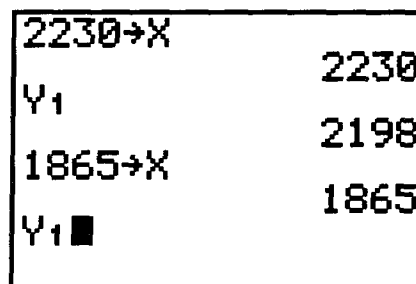


Figure 1.7: Evaluating a function

Assign the value 2230 to the variable x by these keystrokes (see Figure 1.7): 2230 STO \blacktriangleright \times IT ENTER. Next press the following keystrokes to evaluate Y_1 and find January's wages: 2nd Y-VARS 1 ENTER. Repeat these steps to find the February wages. Each time the TI-81 evaluates the function Y_1 , it uses the *current* value of x .

Technology Tip: The TI-81 does not require multiplication to be expressed between variables, so xxx means x^3 . It is often easier to press two or three x 's together than to search for the square key or the cube operation. Of course, expressed multiplication is also not required between a constant and a variable. Hence to enter $2x^3 + 3x^2 - 4x + 5$ in the TI-81, you might save keystrokes and press just these keys: 2 \times IT \times IT \times IT + 3 \times IT \times IT - 4 \times IT + 5.

1.2.2 Functions in a Graph Window: Once you have entered a function in the Y= screen of the TI-81, just press GRAPH to see its graph. The ability to draw a graph contributes substantially to our ability to solve problems.

For example, here is how to graph $y = -x^3 + 4x$. First press Y= and delete anything that may be there by moving with the arrow keys to Y_1 or to any of the other lines and pressing CLEAR wherever necessary. Then, with the cursor on the top line Y_1 , press (-) \times IT MATH 3 + 4 \times IT to enter the function (as in Figure 1.8). Now press GRAPH and the TI-81 changes to a window with the graph of $y = -x^3 + 4x$.

Your graph window may look like the one in Figure 1.9 or it may be different. Since the graph of $y = -x^3 + 4x$ extends infinitely far left and right and also infinitely far up and down, the TI-81 can display only a piece of the actual graph. This displayed rectangular part is called a *viewing rectangle*. You can easily change the viewing rectangle to enhance your investigation of a graph.