Getting started

Texas Instruments TI-85 and TI-86 calculators

OVERVIEW: *Your graphing calculator or computer is a powerful and flexible tool, which you would probably be able to use fairly well without reading any instructions. It is important, however, to learn how to take advantage of some of its not-so-obvious features and how to avoid making errors using it. Study these instructions and be sure you can work the tune-up exercises at the end.*

Topics:

- ***Basic operations***
- ***Priority of operations in calculations***
- ***The dangers of using improper parentheses***
- ***Exact and approximate decimal values of functions***

Basic operations

Press the [ON] key to start the calculator. Press [2nd] followed by the up cursor key [▲] to increase display contrast and by [▼] to decrease it. Change the four AAA batteries as soon as the screen dims when graphs are generated. Press [2nd] [MODE] . The screen should show

Normal Sci Eng	**Func** Pol Param DifEq
Float 012345678901	**Dec** Bin Oct Hex
Radian Degree	**RectV** CylV SphereV
RectC PolarC	**dxDer1** dxNDer

The words printed in bold type here should be highlighted on the screen. If another item is highlighted or you want to change a selection, use the cursor keys to move the flashing box to the correct item and press [ENTER]. <Normal> denotes normal notation for decimals; <Sci> is for scientific notation; and <Eng> for engineering notation. With <Float> selected decimals are printed with twelve digits. Choosing an integer instead of <Float> causes that many digits be shown after decimal points. (Use the second 0 for ten digits and the second 1 for eleven digits.) <Radian> is for radians and <Degree> for degrees. <Func> is selected to generate graphs $y = f(x)$ of functions. <Pol> is for polar coordinates, <Par> is used with parametric equations, and <DifEq> is for differential equations. The other selections will be explained as needed.

Press [EXIT] or [2nd] [QUIT] to return to the home screen and then [GRAPH] for the first row of the graph menu. Press [MORE] to see the second row of the menu and then press [F3] for <FORMT>. The screen should read

RectGC PolarGC	**GridOff** GridOn
CoordOn CoordOff	**AxesOn** AxesOff
DrawLine DrawDot	**LabelOff** LabelOn
SeqG SimulG	

with the words in bold highlighted. With <RecGC> and <CoordOn> selected, rectangular coordinates are used and the coordinates of the cursor are displayed with graphs. Points on graphs are connected if <DrawLine> is chosen and not with <DrawDot>. Use <SeqG> (sequential graphs) to have two or more graphs drawn one after the other, and <SimulG> (simultaneous graphs) to have them drawn at the same time. If <GridOn> were selected, dots would be placed on the screen at the points whose coordinates correspond to the tickmarks on the axes. The axes would not be shown with <AxesOff> and labels would be displayed with <LabelOn>.

The key [2nd] activates the yellow commands above the keys. [EXIT] is used to return to a previous screen and to remove menus. [2nd] [QUIT] returns you to the home screen where calculations are made. [CLEAR] with the cursor on a blank line of the home screen clears the screen. In other cases it clears the line with the cursor or removes a menu.

The key [ALPHA] puts the calculator in upper-case alpha mode, activating the blue letters and

other symbols above the keys. Pressing [ALPHA] [ALPHA] locks the calculator in upper-case alpha mode and then pressing [ALPHA] or [ENTER] takes it out of upper-case alpha-lock mode. [2nd] [ALPHA] puts it in lower-case alpha mode. Entering a number followed by [STO▶], one or more letters, and [ENTER] assigns that number to the letter or letters. The number can then be recalled by entering the letter or letters. The calculator is locked in alpha mode after [STO▶] is pressed.

If you make an error in a command or calculation, the type of error is given and a menu appears. Select <GOTO> to go to the error to correct it or <QUIT> to cancel the incorrect command.

In the home screen, [2nd] [ENTRY] recalls the last expression that was evaluated so it can be edited, if necessary, and used again. The [ON] key stops the generation of graphs, the running of programs, and other operations. The [ENTER] key can be used to interrupt and resume the generation of graphs.

Refer to the owner's manual for further information.

Priority of operations

The meaning of a formula involving functions, powers, sums, differences, products, and quotients depends on how the formula is interpreted to determine the order in which the operations are performed. Texas Instruments TI-86 calculators in most instances interpret formulas with the following rules, which are those generally used in manual calculations.

Rule 1 *Operations are performed from left to right, except as described in Rules 2 through 5 below.*

Rule 2 *Expressions inside parentheses are evaluated as soon as they are reached.*

Rule 3 *Addition and subtraction have the lowest priority. If an addition or subtraction is followed by multiplication, division, a power, or a function, the addition or subtraction is postponed until another addition or subtraction or the end of the expression is reached.*

Rule 4 *Multiplication and division have medium priority. If a multiplication or division is followed by a power or a function, the multiplication or division is postponed until the power or function has been evaluated.*

Rule 5 *The taking of powers and evaluation of functions have the highest priority and are performed as soon as they are reached.*

Example 1 **(a)** Calculating $5 + 2\sqrt{9}$ involves addition, multiplication, and the taking of a square root. In what order are these operations perfomed? **(b)** Find the value of $5+2\sqrt{9}$ with your calculator.

SOLUTION **(a)** By Rule 5 above, finding the square root has the highest priority and is performed first, yielding $5 + 2\sqrt{9} = 5 + 2(3)$. Multiplication has the next priority, by Rule 4, and gives $5 + 2(3) = 5 + 6$. The remaining addition gives $5 + 6 = 11$.
(b) Press [5] [+] [2] [2nd] [√] [9] so the screen reads $5 + 2\sqrt{}9$. Then press [ENTER] for the answer 11. □

Example 2 **(a)** What steps would you use to evaluate $\dfrac{3(4)}{\sqrt{36}} - \dfrac{10}{8-3}$? **(b)** Find the value of $\dfrac{3(4)}{\sqrt{36}} - \dfrac{10}{8-3}$ on your calculator.

SOLUTION **(a)** Working from left to right, you would first multiply the 3 and 4 to have $\dfrac{12}{\sqrt{36}} - \dfrac{10}{8-3}$. Then you would evaluate the square root, yielding $\dfrac{12}{6} - \dfrac{10}{8-3}$. Dividing 12 by 6 would give $2 - \dfrac{10}{8-3}$. Next, you would perform the subtraction in the remaining denominator to have $2 - \dfrac{10}{5}$. Finally, you would divide 5 into 10 to obtain $2 - 2$ and subtract for the answer 0.

(b) Press [3] [(] [4] [)] [÷] [2nd] [√] [(] [3] [6] [)] [−] [1] [0] [÷] [(] [8] [−] [3] [)] so the screen reads $3(4)/\sqrt{}(36) - 10/(8-3)$. Then press [ENTER] for the value 0. □

The next example shows how using the negation symbol ⁻ for subtraction can lead to an error message or give an incorrect result because a product is calculated instead of a difference.

Example 3 Evaluate the expressions $2\pi - \pi$, $2\pi\,^{-}\,\pi$, $8 - 5$, and $8\,^{-}\,5$, where $-$ is the subtraction symbol and ⁻ is the negation symbol. Explain the results.

SOLUTION The calculator gives $3.14159265359 \doteq \pi$ for $2\pi - \pi$, which it obtains by subtracting π from 2π. It gives $-19.7392088022 \doteq -2\pi^2$ for $2\pi\,^{-}\,\pi$, which it interprets as 2π multiplied by $-\pi$. The expression $8 - 5$ equals 3, and you get -40 with $8\,^{-}\,5$, which the calculator either interprets as the product of 8 and -5.

The need to use ∗

Because TI-85 and TI-86 calculators allow words to be used for variables, multiplication signs (∗) must be used between letters that represent numbers to be multiplied.

Example 4 Evaluate AB with $A = 5$ and $B = 2$ by first storing the values of A and B.

SOLUTION Enter [5] [STO▶] [A] [ENTER] [2] [STO▶] [B] [ENTER] to store the values. Then enter [ALPHA] [A] [∗] [ALPHA] [B] [ENTER] for the answer $A \times B = 10$. (Notice that using [ALPHA] [A] [ALPHA] [B] to write AB and then [ENTER] yields an error message since the variable AB has not been defined.) □

The dangers of using improper parentheses

TI-85 and TI-86 calculators interpret certain expressions in unexpected ways because they use the following modification of Rules 3 through 5.

Rule 6 *The taking of powers has priority over the evaluation of functions that appear before their variables, such as the trigonometric functions, logarithms, e^x, $\sqrt{}$, and negation. Also, the parentheses in expressions such as* $\sin(2)$ *and* $e \wedge (2)$ *are ignored.*

Example 5 Evaluate $\sin^3(2) = (\sin(2))^3$.

SOLUTION The seemingly logical expression $\sin(2) \wedge 3$ will not work. By Rule 6, the parentheses are ignored, leaving $\sin\ 2 \wedge 3$. Then the taking of the cube has priority over the evaluation of the sine function, and the calculator gives $0.989358246623 \doteq \sin(2^3) = \sin(8)$.[†]

For the correct answer, use an extra pair of parentheses by entering $(\sin(2)) \wedge 3$. This gives the correct value 0.751826944669. □

The TI-85 also uses the following two additional modifications of Rules 1 through 5

Rule 7 *Multiplication by juxtaposition has priority over division and multiplication represented by* ∗.

Example 6 Attempt to evaluate $\frac{1}{5}(10) = 2$ by entering $1/5(10)$.

SOLUTION The TI-85 evaluates $1/5(10)$ as $1/(50) = 0.02$ because it uses Rule 7 and multiplies the 10 and the 5 before performing the division. Enter $1/5 * 10$ or $(1/5)(10)$ instead.

The TI-86 gives $\frac{1}{5}(10) = 2$, as expected, because it does not use Rule 7. □

Rule 8 *Multiplication represented by juxtaposition, where the second term is a number or a variable, has priority over the evaluation of functions that appear before their arguments.*

[†] If you obtained 0.13917310096 here, then your calculator is using degrees instead of radians. Press [2nd] [MODE], put the cursor on <Radian> and press [ENTER] to select radian mode. Press [2nd] [QUIT] [2nd] [ENTRY] to return to the home screen and recall the last typed line, and then [ENTER] for the correct answer.

Example 7 Attempt to evaluate $\sqrt{4}\pi$ by entering $\sqrt{}4\pi$

SOLUTION The TI-85 calculator reads $\sqrt{}4\pi$ as $\sqrt{(4*\pi)} \doteq 3.54490770181$ because it uses Rule 8 and multiplies the 4 and the π before taking the square root. Enter $(\sqrt{}4)\pi$ or $\sqrt{}4*\pi$ instead to obtain the correct value 6.28318530718.

The TI-86 yields $(\sqrt{4})\pi = 2\pi \doteq 6.28318530718$, as expected, because it does not use Rule 8. □

Example 8 Atempt to evaluate $\sin(5)(10)$ by entering this expression in the calculator.

SOLUTION The TI-85 gives the wrong value $\sin(50) \doteq -0.262374853704$ because it uses Rule 8 and does the multiplication before evaluating the sine. Use $\sin 5*(10)$ or $(\sin 5)(10)$ instead.

The TI-86 yields the correct answer $10\sin(5) \doteq -9.58924274663$ because it does not use Rule 8. □

Exact and approximate decimal values of functions

Since some but not all numbers can be represented exactly as finite decimals, it is important to distinguish exact expressions, such as $\frac{1}{3}$ and π, from decimal approximations, such as 0.33333 and 3.14159. You also need to recognize when coordinates obtained from graphs generated by calculators and computers are approximations.

Example 4 Use your calculator to complete the table below of ten-digit values of $5x^{1/3} = 5\sqrt[3]{x}$ at $x = -27, -30, 4, 6, 8$, and 10. The value $5(-27)^{1/3} = 5(-3) = -15$ is exact, but -15.53616253 is only a decimal approximation of $5(-30)^{1/3}$, which cannot be represented by a finite decimal. Its value to 20 decimal places, for example, is -15.536162529769294339. Which y-values in the completed table in addition to -15 do you recognize as exact?

x	$y = 5x^{1/3} \doteq$	x	$y = 5x^{1/3} \doteq$
-27	-15	-30	-15.5361625298
4		10	
6		8	

SOLUTION You can do these calculations more efficiently by storing the formula for the function. Press [GRAPH] [F1] to access the $y(x) =$ menu and [CLEAR] to erase any previous formula for $y1$. Press [5] [x–VAR] [∧] [(] [1] [÷] [3] [)] to have $y1 = 5x \wedge (1/3)$.

To find the value of the function at $x = -27$, press [2nd] [QUIT] to return to the home screen and press [(–)] [2] [7] [STO▶] [x–VAR] [2nd] [:] [2nd] [ALPHA] [Y] [ALPHA] [ALPHA] [1] so the screen reads $-27 \rightarrow x$: $y1$. The colon (above the period key) separates the two commands on the one line. Then press [ENTER] for the value -15 of $y1$ at $x = -27$.

Press [2nd] [ENTRY] to display the last line again, use [◀] to move the cursor to the 2 and press [3] [0] to have $-30 \rightarrow x$: $y1$. Press [ENTER] for the approximate decimal value -15.5361625298 of $y1$ at $x = -30$.

Press [2nd] [ENTRY] to display the last line again, use [◀] to move the cursor to the minus sign and press [4] [DEL] [DEL] to have $4 \rightarrow x$: $y1$. Press [ENTER] for the approximate decimal value 7.93700525984 of $y1$ at $x = 4$.

Press [2nd] [ENTRY] to display the last line again, use [◀] to move the cursor to the 4 and press [1] [2nd] [INS] [0] to have $10 \rightarrow x$: $y1$. Press [ENTER] for the approximate decimal value 10.7721734502 of $y1$ at$x = 10$.

Repeat this process for the other two values in the table below. Only the values at -27 and $x = 8$ are exact because only -27 and 8 of the x-values are perfect cubes.

x	$y = 5x^{1/3} \doteq$	x	$y = 5x^{1/3} \doteq$
-27	-15	-30	-15.5361625298
4	7.93700525984	10	10.7721734502
6	9.08560296416	8	10

Exercises

Use your calculator or computer to find the approximate decimal values of the expressions in Exercises T1 through T8. Do not simplify the expressions before entering them and be sure your machine is in radian mode for the trigonometric function in Exercise T1. In some cases extra parentheses are needed to express numerators, denominators, and exponents.

1. **(a)** $\sqrt{6}\,\cos(9/7)$ **(b)** $6\cos(\pi/7^3)$ (Edit the expression from part (a).)

2. $(-5 - 1.63 \times 10^{-2})^{-1}$

3. $\dfrac{2+8}{4-6} - 3^{5-1}$

4. $A + BC^D$ with $A = 7$, $B = 6$, $C = 5$, and $D = 4$ (Store the values first.)

5. $\frac{1}{2}\log_{10}(7)$

6. $\dfrac{1.34 \times 10^6 - 4 \times 10^5}{7.12 \times 10^{-8}}$

7. $\sqrt{4 + 7^{8-10}}$

8. $(-32)^{4/5}$

Outlines of solutions

1a. 0.688885143177 • (If your result is 2.44887304686, your calculator is not in radian mode.) • Press [2nd] [$\sqrt{\ }$] [6] [cos] [(] [9] [÷] [7] [)] to have the screen read $\sqrt{\ }6\cos\ (9/7)$. Then press [ENTER] for the answer.

1b. 5.999748331 • If your last operation was the calculation of $\sqrt{\ }6\cos\ (9/7)$, press [2nd] [ENTRY] to put it back on the screen. If you performed other calculations, type $\sqrt{\ }6\cos\ (9/7)$ again. Press [◀] until the cursor is over the square root sign and press [DEL] to delete it. Move the cursor to the 9 and press [2nd] [π] to replace the 9 with π. Put the cursor on the close parenthesis and press [2nd] [INS]. Press [∧] [3] to insert $\wedge\ 3$ before the close parenthesis, so the screen reads $6\cos(\pi/7 \wedge 3)$, and press [ENTER] for the answer.

2. -0.199350118613 • Press [(] [(−)] [5] [−] [1] [.] [6] [3] [EE] [(−)] [2] [)] [2nd] [x^{-1}] to display $(^-5 - 1.63\text{E}^-2)^{-1}$. ($A\,\text{E}\,n$ stands for $A \times 10^n$.) Press [ENTER] for the answer. Notice that [(−)] is for negation, [−] is for subtraction, and [x^{-1}] is for taking reciprocals.

3. -86 • Use [(] [2] [+] [8] [)] [÷] [(] [4] [−] [6] [)] [−] [3] [∧] [(] [5] [−] [1] [)] to display $(2+8)/(4-6) - 3 \wedge (5-1)$. Press [ENTER] for the answer.

4 3757 • To put the commands on one line for possible later editing, press [7] [STO▶] [A] [ALPHA] [2nd] [:] [6] [STO▶] [B] [ALPHA] [2nd] [:] [5] [STO▶] [C] [ALPHA] [2nd] [:] [4] [STO▶] [D] [ALPHA] [2nd] [:] [ALPHA] [A] [+] [ALPHA] [B] [×] [ALPHA] [C] [∧] [ALPHA] [D] so the screen reads $7 \to A : 6 \to B : 5 \to C : 4 \to D : A+B*C\wedge D$. Press [ENTER] to store the values of A, B, C and D and calculate the answer. The colon (above the period key) separates two commands on one line. The [ALPHA] keys are needed because [STO▶] locks the calculator in upper-case alpha mode.

5. 0.422549020007 • Use [(] [1] [÷] [2] [)] [LOG] [(] [7] [)] [ENTER].

6. $1.3202247191 \times 10^{13}$ • Use [(] [1] [.] [3] [4] [EE] [6] [−] [4] [EE] [5] [)] [÷] [(] [7] [.] [1] [2] [EE] [(–)] [8] [)] [ENTER].

7. 2.00509554966 • Use [2nd] [$\sqrt{\ }$] [(] [4] [+] [7] [∧] [(] [8] [−] [1] [0] [)] [)] [ENTER].

8. 16 • TI-85 and TI-86 calculators evaluate $x^{1/n}$ for negative x and odd integers n, but do not always give the correct, real value of $x^{m/n}$ with negative x, odd n, and m an integer > 1. It is generally best to write $x^{m/n}$ as $(x^m)^{1/n}$ for odd n. The keys [(-)] [3] [2] [∧] [(] [4] [÷] [5] [)] [ENTER] give the wrong result(-16) since the negation is perfomed after the power. The symbols [(] [(-)] [3] [2] [)] [∧] [(] [4] [÷] [5] [)] [ENTER] probably yield, on a TI-85, $(-12.94427191, 9.40456403668)$ representing $-12.94427191 + 9.40456403668\,i$, which is the approximate decimal value of one of the complex four-fifth roots of -32, rather than the real four-fifth root 16. These symbols, however, give the correct result on a TI-86. The expressions [(] [(-)] [3] [2] [)] [∧] [4] [∧] [(] [1] [÷] [5] [)] [ENTER] and [(] [(-)] [3] [2] [)] [∧] [(] [1] [÷] [5] [)] [∧] [4] [ENTER] give the correct result, since for any positive odd integer n and negative x, the calculator interprets $x \wedge (1/n)$ as the negative nth root of x.