

TI 89 *Primer*

This "primer" will provide you with a quick introduction to the TI 89. Read it with a calculator in hand and practice!

Note: The TI89 Titanium has its buttons colored differently. This primer uses the older colors. Here's the translation:

TI89 (old)	TI89 Titanium
Yellow	Light blue
Green	Light yellowish green
Purple	Light purple (lilac?)
Blue (apps button)	Black and purple.

Before you use it:

In this primer, we use a coordinate system to locate keys. Key[i,j] refers to the key in the i^{th} column, and j^{th} row of the keyboard, starting from the bottom left. For example, key[2,3] is two keys over, and three up. It is labeled "4". The yellow 2nd key is key[1,9]. To access the colon ":" (printed in yellow) above 4, press 2nd key[2,3].

1. **Batteries.** Read about changing batteries on page 546 of the manual. **DO NOT** remove the lithium battery when you are changing the AAA batteries. Fading screen contrast and the battery status information will indicate a need to change AAA batteries. **DO NOT** remove the AAA batteries when you change the lithium battery (about once every 4 years).
2. **Contrast.** To increase or decrease contrast, alternate pressing the green diamond, $\pm$, with $+$ (the addition key) or $-$ (the subtraction key).
3. **Restoring Defaults.** To reset the calculator to factory defaults and clear user defined variables, etc., enter the MEM menu (2nd key[4, 3]), press F1 and select your option. (See page 337 in manual.)

MODE

When you set the **MODE** of your calculator, you tell it how to handle numbers (exact or approximate), how to graph functions(rectangular coordinates or polar), what angles to use (radian or degree), etc. Setting the **MODE** is a crucial first step to using the calculator.

1. Press MODE, key (2, 7). Press F1 for page 1, F2 for page 2, and F3 for page 3. Use the up-down cursor arrows to select a category (e.g. Angle). The current setting is displayed. To change it, use the right cursor arrow, and then select the option with the up-down arrows, (e.g. degree), then press ENTER. Press ENTER after each choice. To exit the menu, press ESC or HOME. (You can always go home!)
2. To start, make sure MODE settings are:
Graph – Function,

Display digits- Float 6

Angle- Radian

Exact/Approx- Auto (page 2)

3. About **Exact/Approx**. In the **AUTO** mode, the calculator does exact arithmetic by keeping fractions, radicals, logs, etc., in symbolic instead of decimal form when it can. For instance, to enter $\sqrt{2}$ use 2nd key[5, 4] and close the parentheses on the input line. On the screen, $\sqrt{2}$ will appear as your answer. To get the decimal approximation, simply press the green diamond $\rightarrow$ followed by ENTER.

Alternatively, if you enter $\sqrt{2.}$ (note the decimal point) the decimal answer will be returned. (See the manual, pages 22-24.)

ARITHMETIC

1. The number "-8" (negative 8) is entered with the **negation** key[4,1], "(-)". To do the subtraction, $2 - 8$, use the subtraction key[5,3]. To obtain the answer -6, press the "ENTER" key[5,1]. **The negation key and the subtraction key are not interchangeable.** If you use the subtraction key instead of the negation key, the calculator will subtract your entry from the previously computed answer if it can. If it can't, it will pop up an error message. Press ESC to remove message, then press CLEAR to clear the ENTRY line. Reenter your data.

Note: Pressing **CLEAR** removes all data from the entry line. To clear the entire home screen, press F1 to access the tools menu, cursor down to option 8, **Clear Home**, and press ENTER or simply press the number 8. When menu items are numbered, you can make a choice by either cursoring down and pressing ENTER or simply entering the item number on the keyboard. Press **ESC** or **HOME** to leave the menu.

2. The computer uses the **standard order of operations**. The key strokes -8^2 will return -64 whereas $(-8)^2$ returns 64. **Parentheses** are often necessary and are located at key[2,5] and key[3,5]. The key strokes $8^2 \div 3$ will return $(8^2)/3 = 64/3$ whereas $8^{(2 \div 3)}$ returns 4 which is $8^{2/3}$. (See pages 20ff in manual.)
3. To use **standard functions** like sine, cosine and log, we enter the function name first and then the number to be evaluated, just as you would write them. (This might be different from your previous calculator.) For example to evaluate $\ln(13)$, press $\ln$, (2^{nd} key [1, 6]) followed by 13 **followed by the closing parenthesis**. (You must close the parentheses!) If you are in AUTO MODE, $\ln(13)$ is returned. Press $\rightarrow$ followed by ENTER to obtain the decimal approximation, 2.56495. The TI 89 has many functions available both on the keyboard and hidden within many menus. You can access any of them through the **CATALOG**. Press key[3, 7], CATLOG. A list of all the functions available appears. You can cursor through them until you find the one you want or skip to the group with same initial letter by pressing that letter (without using the purple alpha button). When you find your function, press ENTER, and it will appear on the home screen ready for use. (Manual page 36).

Note: Using CATALOG to invoke a function has the advantage that the syntax (how you need to enter information) is prompted on the bottom of the screen. For example, to find the integral sign look under the functions starting with the letter i. Cursor to it --it's below intDIV--and press ENTER. Note that at the bottom of screen, you are prompted for the expression, name of the variable, the lower limit of integration and the upper limit of integration. Pretty handy!

4. We can **edit** an arithmetic expression with the blue cursor keys and the arrow $\leftarrow$, key [4,7]. If the unevaluated (meaning you have not pressed "ENTER") expression $2 \times 3/5 + 7$ must be **changed** to $2 \times 4/5 - 7$, move the blinking cursor bar until it is to the right of 3, and press $\leftarrow$ to delete the 3 to the left of the bar. Simply press 4 to insert 4 to the left of the bar. **Variations** : 2^{nd} **INS** will toggle the bar to a rectangle that

highlights a symbol. It behaves like the TI85 cursor replacing what it highlights by what you type in. To delete the symbol to the right of the bar cursor, use **DEL**.

5. After you press ENTER, the calculator leaves the entry highlighted in the entry line. To use it again or edit it, press a blue cursor button. To delete it, press CLEAR or, while it is highlighted, simply start a new expression.
6. The **"ENTRY"** key, (2nd key[5,1]) recalls the last evaluated expression back for further editing. For example, if you evaluate $2 \times 3/5 + 98$ and obtain 99.2 but decide you want $2 \times 4/5 + 98$, "ENTRY" will recall the expression for editing. You can place and edit any line from the history area into the Entry line as follows. Use the up-down cursor to highlight the line, and press ENTER. What you highlighted will appear in the entry line. Pressing 2nd **ANS** (key[4,1]) will insert the result of the last computation into the entry line. (See manual, page 34ff.)
7. You can **cut and paste** an expression from the home screen into the entry line. Cursor up the expression you want. When it is highlighted, press **copy** (key[2, 9]). Then cursor back to where you want to insert the expression, and press **paste**, (key[3,9]).
8. To **store** an answer to a memory location, press **STO**, (key[1,2]). What you will see "ans→". You can place your answer to a variable that is a string of letters and symbols (starting with a letter) unless that string is protected. If you want to store 8.33 to q, place 8.33 on the entry line and then press STO. Press the purple alpha button followed by Q. To check, press alpha Q followed by ENTER and 8.33 will be returned. (The default is lower case. To use upper case, press the up arrow on key [2,9] before pressing the alpha key.) (See Manual page 38.)

Exercises

1. Evaluate the following expressions:

a) $2/7 + 3.117$ b) $\frac{2+3.117}{7}$ c) $-5 + 33/\pi$ d) $5-23/(7 \times 4.3)$

e) 39^2 f) $\sqrt{9.33476}$ g) 4.233^{-1} h) $3.7^{\frac{6}{7}}$

i) $48^{-4/5}$ j) $\tan(2.35 \times 5.67)$ k) $\ln(-2.7)^{2/3}$ l) $(\sin 2\pi - \sqrt{2})^{4/5}$

2. Enter $2 + \frac{3}{5\pi}$ and evaluate the expression. Recall it for editing. Change the 3 to 7 and evaluate. Recall the last expression, delete π , and evaluate.

3. a) Enter $2 \times (3.117)^{5/3} - 17$ and evaluate. Recall the expression for editing. Insert a factor of -2.71 to obtain $2 \times (-2.71) \times (3.117)^{5/3} - 17$. Evaluate.
- b) Store your answer in a variable w.
- c) Evaluate π^3 and multiply it by the number in w.

4. a) Evaluate $\sin(23^\circ)$, changing mode if necessary. Change MODE back to radian measure and evaluate $\sin\left(\frac{3\pi}{17}\right)$ and $\frac{\sin(3\pi)}{17}$.
- b) Evaluate $\cos(3.2^2)$. Use "ans" to evaluate $\ln(\cos(3.2^2))$ without typing cos.

GRAPHING

To graph a function $y = f(x)$ we use $\text{F1}(Y=)$ to enter and edit functions, F2 to set the viewing window, and F3 to produce the graph. Here are some details.

1. **Editing f(x).** In MODE, make sure GRAPH is set to FUNCTION. To enter a function $y = f(x)$ or edit a previously entered function, access "y =" by pressing F1 . A list $y_1, y_2, y_3, \dots$, is available. Cursor down to the function number you would like to use or edit. It will appear as " $y_i(x) =$ " on the entry line. Enter your function using the variable x available at key [1,6]. You can enter several functions. You may use the name (say, y_1 or y_2) of another function on your list as part of your expression. For example, suppose $y_1 = \sin(x)$. Then you can use $x*y_1(x)$ for the function $x\sin(x)$.
Selecting the functions to be graphed: The functions that are selected to be graphed are marked on the editing screen by a check $\checkmark$. The key F4 is a toggle. Cursor to the function you want to select or deselect for graphing. Press F4 and the status of the check $\checkmark$ will be changed. To select the format of your axes and grid, press **F1(Tools)**. Cursor down to option 9, **Format**, and enter your selections. You can define a graphing style for each function you want to graph individually. Press F6 (2nd F1) **Style**. Cursor to a function and highlight it. Press F6 (2nd F1) and select Dot or Square, etc. (Check out Animate, Above and Below!)
2. **The WINDOW.** Press F2 , WINDOW, to set the dimensions of the viewing window of your graph. **Wise choices are important!**
3. **To GRAPH,** press F3 (Graph). How you handle the functions to be graphed is controlled in the menus F1 through F6. We give a brief overview. (See manual, page 93 ff.)
 - i. **Zoom, F2.** The options of the sub menu will appear. "**ZoomIn**" magnifies the graph and "**ZoomOut**" displays more of it. To zoom, select your option and press ENTER. You may zoom in or out repeatedly. "**Zoom PREV**" (to access to it, cursor way down the menu to Memory, and then use the right cursor.) returns you

- to the previous level of magnification. "**Zoom Box**" allows you to choose what portion of the graph to zoom to. When you select BOX, a blinking crossed circle will appear on the screen at the coordinates indicated on the screen. Use the cursors to move it to the upper left coordinate of the rectangular region you want to zoom into. Press ENTER and use the cursors to move to the lower right corner of your region. Press ENTER again. Remember, you can always get back to a standard window by selecting **ZoomStd**.
- ii. **Trace, F3.** You can move the tracer with the right-left cursors. The coordinates of the tracer appear on the bottom of the screen. Use the up-down cursor to select the function you wish to trace.
 - iii. **Math, F5.** This menu contains the tools with which you can **analyze your graph**. A brief look indicates that you can, for instance, find the maximum and minimum values over an interval, the roots of a function on an interval, the integral over an interval, and you can evaluate the function at various points. To find the root (or "zero" of a function) of a function, cursor down to 2 and press ENTER. Use the up-down cursor to select your function if several have been graphed on the screen. The number of the graph selected will appear in the upper right corner. You must define an interval over which the calculator will search for a root. First you choose a lower (left) endpoint. Move to it with the left-right cursor and press ENTER. Next choose the right endpoint, cursor to it, and press ENTER. The calculator will display the root if there is one. The other options are handled similarly. **Make sure you become thoroughly familiar with this menu!**
4. **Piecewise functions.** To graph the function $f(x) = x^2$ for $x \geq 1$ and $f(x) = x - 1$ for $x < 1$, use the **when** function available in CATALOG. (See manual, page 194.) The format is **when(condition, f1, f2)**. The condition is an inequality like $x < a$. The function f1 will be graphed where the condition is true and f2 will be graphed where the condition is false. To graph the sample function, go to the Y= editor, and at, say, y1 enter **when($x \geq 1$, x^2 , $x-1$)**. **Note:** The symbols $\geq$ and $\leq$ are available on the keyboard by pressing $\rightarrow$, $.$ or $\rightarrow$, 0 (keys [1,3] and [1,2]). This is **not** marked on the keyboard! Also note that you may want to graph in **DOT** format—go to style F6 in the Y = editor and select DOT—to display the discontinuities of the functions.
 5. **Piecewise con't.** For a function with more than two pieces, we must "nest" the when function. Suppose you want graph four functions f1, f2, f3, and f4 on the four intervals defined by $-\infty < a < b < c < \infty$. You can use the when function as follows:
 $\text{when}(x > c, f4, \text{when}(x > b, f3, \text{when}(x > a, f2, f1)))$. (Use $\geq$ as needed.)
 6. **Making Tables.** To make a table of values of the selected (checked) functions in the y= editor, use $\rightarrow$ F4 (Tblset) and $\rightarrow$ F5 (TABLE). Tblset lets you select the range of x-values and the increment between the values. Pressing $\rightarrow$ TABLE displays the table. For instance, suppose that $y1 = \sin(x)$ is the only function selected in the y= editor, and suppose that

we wish to display the values of $\sin(x)$ starting at $x = 1$ and incrementing in steps of 0.1. Press $\underline{F4}$. At the Tblstart prompt, enter 1. Cursor down to Δtbl and enter .1. The graph $\leftrightarrow$ Table prompt should be set to OFF. (If not, press the right cursor and select OFF.) The Independent prompt should be set to AUTO. (If not, select AUTO.) Press ENTER. Press ENTER again to display the table. You can access the table at any time with $\underline{\text{TABLE}}$. **Variations**: Setting Table $\leftrightarrow$ Graph to Graph will display the points that would be graphed in the current window settings. Setting Independent to ASK allows you to set the independent variable values in the table individually.

Exercises

1. Enter the following functions and graph them in the viewing window

$$-3 \leq x \leq 3, -10 \leq y \leq 10:$$

$$f(x) = 2x - 3 \quad g(x) = x^2 - 4 \quad h(x) = \sin(x)$$

- a) Graph only f and g , then only f and h , and finally only g and h .
- b) Use the tracer to estimate the points of intersection of $f(x)$ and $g(x)$. Zoom in to get a better approximation. Try boxing in the points of intersection. Repeat the process for the other points of intersection.

3. Graph $y_1 = x^3 - 16x^2 + 70$ and $y_2 = 10x^2$ on the same axis. Experiment with the viewing window until you see all the points of intersection. (How many do you expect?) Use Math F5 to find the points of intersection and also to find the local minimum and maximum values and the zeros (roots) of y_1 .

4. Graph the function $f(x) = \begin{cases} x^3 - 1 & x > 1 \\ \text{abs}(x) & -1 \leq x \leq 1 \\ 1/x & x < 1 \end{cases}$ using the “when” option.

5. Make a table of values for the functions $y = \sin(x)$ and the function $y = x - x^3/3 + x^5/5$ starting at $x = 0$ and incrementing by $\Delta x = .2$.

SYMBOLIC MANIPULATION

The principal difference between the TI 89 and earlier models is its ability to manipulate expressions symbolically. In this section we give a brief overview of its many capacities, concentrating on the **algebra** (F2) and **calculus** (F3) menus listed at the top of the home screen. **Please read the manual, pp. 45 ff.**

1. **Entering and evaluating expressions.** If the expression $x^3 - x + 1$ is on the entry line, we can store it to a variable name, say w , by simply pressing STO (alpha) w . Alternatively, we can create a function, say $c(x)$, by pressing STO (alpha) $c(x)$. To evaluate the expression at $x = 3$, we enter $c(3)$. The response is 25. Or we can use the “with” operator | (key[1,4]) to evaluate. Suppose that $x^3 - x + 1$ is stored in w . We type: $w | x = 3$ to obtain the answer 25. We could also type $c(x)|x=3$. We can use the “with” operator for composition. For instance, “ $w|x=y^2+1$ ” yields $y^6+3y^4+2y^2+1$.

Similarly, “c(sin(t))” yields $(\sin(t))^3 - \sin(t) + 1$. **Caution:** Whereas $c(x^2+1)$ yields the correct result $(x^2+1)^3 - (x^2+1) + 1$, $c(x)|x = x^2+1$ results in an error message. **When using “|x = exp”, do not use x in the expression!**

2. **Using solve**(F2 (Algebra), option 1). The **solve** option will solve an expression for a designated variable. We must enter an equation and a variable: **solve(equ, var)**. For instance, to solve the $x^2+y*x+3x = 2$, for x, enter solve ($x^2+y*x+3x = 2, x$). The calculator returns: $x = \frac{\sqrt{y^2+6y+17} - y - 3}{2}$ or $x = -\frac{\sqrt{y^2+6y+17} - y - 3}{2}$. To solve for y, enter solve ($x^2+y*x+3x = 2, y$), which returns $y = \frac{-x^2+3x-2}{x}$. To solve the same expression for x when y = 3, we can use the **with** operator | (key[1,4]): solve ($x^2+y*x+3x = 2, x$)|y = 3 which returns: $x = -(\sqrt{11}+3)$ or $x = \sqrt{11}-3$.

IMPORTANT!!!!!! You must use the multiplication sign between x and y. Otherwise the calculator will interpret the string xy as one variable, not two!!!!

3. **nSolve** (F2, option 8) Often equations cannot be solved symbolically. To obtain a numerical approximation to a solution, use nSolve. It will return one solution from perhaps many. The syntax is nSolve(equation, var or variable guess). For instance, to find a root of $\sin(x^2)$ nearest $x = 8$, enter nSolve($\sin(x^2) = 0, x = 8$). The calculator returns 7.92665.
4. **Simultaneous equations**. To solve the equations $x^2+y^2 = 1$ and $x = 2y$ simultaneously, enter solve($x^2+y^2 = 1$ and $x = 2y, \{x,y\}$). The calculator responds with $x = \frac{2\sqrt{5}}{5}$ and $y = \frac{\sqrt{5}}{5}$ or $x = -\frac{2\sqrt{5}}{5}$ and $y = -\frac{\sqrt{5}}{5}$. The pair of variables must be enclosed in curly brackets. **Note:** to find the boolean operator “and” along with “or,” $\leq$ etc., go to the **MATH** menu 2nd key[3,3], then to the TEST submenu (option 8).
5. **Linear Simultaneous Equations**. You can proceed as above, but for a **square linear system** with several variables, you may want to use the **simult** function. To access simult, go to CATALOG (key[3,7]), press S, and cursor down to simult. simult(will appear on the entry line. You will enter the matrix of coefficients and the column vector of constants. A matrix is enclosed by square brackets. It is entered row by row. The entries within a row are separated by commas; the rows are separated by **semicolons**, 2nd key[4, 4]. A column vector is enclosed by square brackets and semicolons separate its entries. The matrix of coefficients of the system $\{2x + 3y = 5$ and $x - y = 2\}$ is $\begin{bmatrix} 2 & 3 \\ 1 & -1 \end{bmatrix}$ and the vector of constants is $\begin{bmatrix} 5 \\ 2 \end{bmatrix}$. To solve the system

with `simult`, we type `simult([2,3; 1, -1], [5;2])` and press ENTER. **Note: semicolons**

must separate the entries in the vector of constants. The calculator returns $\begin{pmatrix} 11/5 \\ 1/5 \end{pmatrix}$.

6. **The Calc menu F3.** The calculator can differentiate and integrate both symbolically and numerically. (Look over the menu and see the manual, pp. 63 ff, to see its extensive capabilities.)
 - i. To **differentiate** $x\sin(x)$, go to the calc menu (F3) and press 1. ENTER `d(x*sin(x),x)` and the calculator responds with $x\cos(x) + \sin(x)$. **Note:** You must have the multiplication symbol! You must indicate what the variable is, even if there is only one choice!
 - ii. To find the n^{th} derivative, enter `d(function, variable , n)`. For example, `d(x*sin(x),x, 3)` finds the third derivative of $x\sin(x)$.
 - iii. To find the n^{th} derivative of $f(x)$ at $x = a$, enter `d(f(x), x, n) | x =a`.
 - iv. To find the **integral** of $x\sin(x)$, go to the calc menu and pull down $\int$ (option 2). Enter `\int(x*sin(x), x)` and the calculator returns $\sin(x) - x\cos(x)$, having done integration by parts brilliantly. To evaluate $\int_a^b f(x)dx$, enter `\int(f(x), x, a, b)`. For example, `\int(x*sin(x), x, 0, 1)` returns $\sin(1) - \cos(1)$. Press `_ENTER` to obtain the numerical solution, .301169.
 - v. To find the limit as x goes to 0 of $\sin(3x)/x$, select option 3 from the calc menu. The syntax is similar to options 1 and 2: `limit(function, variable, point, direction*)`. For instance, to calculate the limit of the greatest integer or **floor** function –found in CATALOG— at 3 from the **left**, enter `limit(floor(x), x, 3, -1)`. The calculator returns 2. * The direction is optional: 1 means from the right, -1 means from the left, and omitting it returns a the undirected limit. So to calculate the limit per se, enter `limit(floor(x), x, 3)`. In this case the calculator returns “undefined” because the limit does not exist.

Exercises:

1. Create the function $g(x) = x^3 - 1/x$. Evaluate it at $x = 4.5$. Compose it with the function $y = \cos(x)$.
2. Solve the expression $x^2 + 4xy + 4y^2 = 3$ for y .
3. Find a root of $x\sin(x/2)$ near $x = 3$.
4. Solve the set of expression $x^2 + 2y^2 = 9$ and $x + 2y = 1$ simultaneously.
5. Solve the linear system $x + y + z = 1$, $x + 2y + z = 0$, $x - y + 2z = 2$ using the `simult` option.
6. Use the **expand** command in the algebra menu F2 to find the coefficient on the cube term of $(3x - 2)^5$. Use **propFrac** to find the quotient and remainder when the polynomial $x^4 - x + 1$ is divided by $x^2 + 1$. (Be careful with parentheses and be careful interpreting the results.)
7. If you are acquainted with calculus already, find the value of the derivative of $x\sin(x)$ at $x = 1$ and find the value of the integral of $x^2\sin(2x)$ from 1 to 2.

There are other important options in the algebra and calculus menus. **EXPLORE and EXPERIMENT!** The same admonition holds for the **MATH** menu (key[3,3]) which holds such wonderful functions like the mod (m) function, factorial ! , and nCr . Even a brief look at the manual indicates that this primer barely scratches the surface. (Did we mention that you can program the TI89?) Practice, and use it wisely!