Introduction to the TI-84+ Graphing Calculator
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This tutorial is intended to provide a general overview of some of the capabilities of the TI-84+ graphing calculator. Examples of the wide range of operations available on this powerful tool are included in the following pages.

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For more detail and resources, refer to:

The TI84Plus Guidebook, available in PDF format at http://education.ti.com/
TI-84 Plus Graphing Calculator for Dummies by C. C. Edwards

or search Google using keywords such as TI-84.
General Layout of the Keypad
The TI-84+ graphing calculator operates on a Zilog Z80 CPU, running at 15 MHz. It retains the same functionality as its predecessor, the TI-83+, but offers more memory, and several updated features. Keypress sequences that work on one usually work on the other.

The keys on the TI-84+ are colour-coded by function.
- The white keys include the number keys, decimal point, and negative sign. When entering negative values, use the [-] white key not the [–] grey key.
- The white keys include the number keys and the minus key [-].
- The grey keys on the right side are the math operations and the [ENTER] key.
- The grey keys across the top are used primarily for graphing.
- The grey arrow keys control the cursor.
- The black keys include commonly-used functions, as well as leading to other menus.
- The primary function of each key is printed on the key.
- The secondary function of each key is printed in blue and is activated by pressing the blue 2ND key first. For example, to find the square root of a number, press 2ND [x] for $\sqrt{}$.
- The alpha function of each key is printed in green and is activated by pressing the green ALPHA key first. For example, to enter an A, press ALPHA then MATH.

Arithmetic Operations
The TI-84+ is programmed to follow standard order of operations.
- Type $2 + 3 \times 4$, and press ENTER.
- Type $(2 + 3) \times 4)$, and press ENTER.

Note the difference in the answer.

Working With Fractions
To display a decimal as a fraction:
- Key in a decimal.
- Press MATH, and select 1: ►Frac. Press ENTER
The decimal will be displayed as a fraction.

To enter fractions in calculations:
- Use the division key ÷ to create fractions as you key them in.
- If you want the result displayed as a fraction, Press MATH, and select 1: ►Frac.
- Press ENTER

For example, to calculate $\frac{3}{4} - \frac{2}{3}$:
- Press 3 ÷ 4 ÷ 2 ÷ 3.
- Then, press MATH, select 1: ►Frac, and press ENTER.
The result will be displayed as a fraction.
To calculate with mixed numbers:
- Use the \( \text{+} \) and \( \div \) keys to enter mixed numbers.
- If you want the result displayed as a fraction, press MATH, select 1: \( \text{►Frac} \), and press ENTER.

For example, to calculate \( \frac{3}{8} + \frac{3}{4} \):
- Press \( 2 \div 3 \div 8 \div 1 \div 3 \div 4 \).
- Then, press MATH, select 1: \( \text{►Frac} \), and press ENTER.
The result will be displayed as a fraction.

Graphing Relations and Functions
You can enter functions using the \( Y= \) editor.
- Press \( Y= \). Enter the equation.
- Press GRAPH.

Tip: If you want to display the graph in a standard window, 10 units in each direction, press ZOOM, then select 6:ZStandard.

For example, enter \( y = \frac{2}{3}x - 4 \) by pressing \( Y= \left( \frac{2}{3} \right)X,T,\theta,n \) – 2.

Press \( Y= \) to return to the equation. Use the cursor keys to move to the space to the left of \( Y_1 \).
Press ENTER repeatedly. You can change the format of the graph, changing the style to a dotted line or a heavy line, or adding shading above or below. Experiment with these options.

Setting Window Variables
The \( \text{WINDOW} \) key defines the appearance of the graph. The standard (default) window settings are 10 units in any direction, with ticks at every unit.

To change the window settings:
- Press \( \text{WINDOW} \). Enter the desired window settings.

In the example shown,
- the minimum x-value is \(-50\)
- the maximum x-value is \(50\)
- the scale of the x-axis is \(10\)
- the minimum y-value is \(-30\)
- the maximum y-value is \(30\)
- the scale of the y-axis is \(5\)
- the resolution is \(1\), so equations are graphed at each horizontal pixel
Tracing a Graph
- Enter a function such as \( y = x^2 \) using the \( Y= \) editor.
- Press TRACE.
- Press ◄ and ► to move along the graph.
The \( x \)- and \( y \)-values are displayed at the bottom of the screen.

Tip: If you or a previous user has entered data for a statistical plot, you may need to turn off all STAT PLOTS before you can trace a function:
- Press 2nd \( Y= \) for [STAT PLOT]. Select 4:PlotsOff.
- Press ENTER.

Setting the Format
You can change the appearance of the viewing window.
- Press 2nd ZOOM for [FORMAT] to view the choices available.

The Default Settings have all the features on the left active.

To turn on the grid:
- Select [FORMAT] by pressing 2nd ZOOM. Cursor down and right to GridOn. Press ENTER.
- Press 2nd MODE for [QUIT].

Using Zoom
The ZOOM key is used to change the area of the graph that is displayed in the graphing window.

You can “zoom in” on one small area of a graph.
- Enter a function such as \( y = (x - 3)(x - 1)(x + 1) \).
- Graph the function in a standard window.

Zoom in on the local maximum.
- Press ZOOM. Select 1:Zbox. The graph screen will be displayed, and the cursor will be flashing.
- If you can’t see the cursor, use the ◄, ►, ▲, and ▼ keys to move the cursor until you see it.
- Move the cursor to approximately \((-2, 5)\).
- Press ENTER to mark that point as a starting point.
- Press the ◄, ►, ▲, and ▼ keys to move the cursor to approximately \((1, 1)\).
- Press ENTER. The area will now appear larger.

You can press TRACE to determine the coordinates of the local maximum.
ZOOM Options
To zoom in on an area without identifying a boxed-in area:
- Press ZOOM. Select 2:Zoom In.

To zoom out of an area:
- Press ZOOM. Select 3:Zoom Out.

To display the viewing area where the origin appears in the centre and the x- and y-axes intervals are equally spaced:
- Press ZOOM. Select 4:ZDecimal.

To reset the axes range on your calculator:
- Press ZOOM. Select 6:ZStandard.

Working With Functions
You can determine various attributes of a function using the CALC menu.
- Enter a function such as \( y = (x - 3)(x - 1)(x + 1) \).
- Graph the function in a standard window.
- Press 2nd, then TRACE to access the CALC menu.
- Select 1:value.
- Type a value such as \( x = 2 \), and press ENTER.

The value of \( y \) at \( x = 2 \) will be displayed.

To find the zero of a function, select 2:zero.
- Move the cursor to the left of the zero, and press ENTER.
- Move the cursor to the right of the zero, and press ENTER.
- Move the cursor close to the zero, and press ENTER.

The zero of the function will be displayed. In a similar manner, you can find maxima and minima. Experiment with these.

You can see a table of values for a function by pressing 2nd, then GRAPH to access the TABLE. Scroll up or down to see other values. If you press 2nd, then WINDOW to access TBLSET, you can change the starting value and increment for the table.

If you enter a second function, you can determine the intersection of the two functions.
- Enter a function such as \( y = x^2 \) as \( Y_2 \).
- Graph the function in a standard window.
- Press 2nd, then TRACE to access the CALC menu.
- Select 5:intersect.
- Press ENTER to select the first function.
- Press ENTER to select the second function.
- Move the cursor close to the intersection, and press ENTER.
Entering Data Into Lists
Lists are primarily used for statistical data.

- Press \texttt{STAT}. The cursor will highlight the \texttt{EDIT} menu.
- Press 1 or \texttt{ENTER} to select \texttt{1:Edit…}.

This allows you to enter new data, or edit existing data, in lists \texttt{L1} to \texttt{L6}.

For example, press \texttt{STAT} select \texttt{1:Edit…}, and enter data as shown in lists \texttt{L1} and \texttt{L2}. The data show shoe size and height for a sample of six students.

- Use the cursor keys to move around the editor screen.
- Complete each data entry by pressing \texttt{ENTER}.
- Press \texttt{2nd MODE} for \texttt{QUIT} to exit the list editor when the data are entered.

You may need to clear a list before you enter data into it. For example, to clear list \texttt{L1}:

- Press \texttt{STAT} and select \texttt{4:ClrList}.
- Press \texttt{2nd 1} for \texttt{L1}, and press \texttt{ENTER}.

To clear all lists:

- Press \texttt{2nd [MEM]} to display the MEMORY menu.
- Select \texttt{4:ClrAllLists} and press \texttt{ENTER}.

Creating a Scatter Plot
To create a scatter plot:

- Enter the data for shoe size and height in lists \texttt{L1} and \texttt{L2}.
- Press \texttt{2nd Y=} for \texttt{STAT PLOT}.
- Press 1 or \texttt{ENTER} to select \texttt{1:Plot1…}.
- Press \texttt{ENTER} to select \texttt{On}.
- Cursor down, then press \texttt{ENTER} to select the top left graphing option, which is a scatter plot.
- Cursor down and press \texttt{2nd 1} for \texttt{L1}.
- Cursor down and press \texttt{2nd 2} for \texttt{L2}.
- Cursor down and select a mark style. Press \texttt{ENTER}.
- Press \texttt{2nd MODE} for \texttt{QUIT} to exit the \texttt{STAT PLOTS} editor when the data are entered.

To display the scatter plot:

- Press \texttt{Y=} and use the \texttt{CLEAR} key to remove any graphed equations.
- Press \texttt{2nd MODE} for \texttt{QUIT} to exit the \texttt{Y=} editor.
- Press \texttt{ZOOM} and select \texttt{9:ZoomStat} to display the scatter plot.

This will adjust the window settings such that all of the points are displayed.
Line of Best Fit
You can add the line of best fit to a scatter plot by using the LinReg function:
- With the scatter plot displayed, press \text{STAT}.
- Cursor to display the CALC menu.
- Select 4:LinReg(ax+b).
- Press \text{2nd} 1 for L₁, followed by \text{,}.
- Press \text{2nd} 2 for L₂, followed by \text{,}.
- Press \text{VARS}, and cursor over to display the Y-VARS menu.
- Select 1:FUNCTION, and then select 1:Y₁.

This will place the results of the linear regression as function Y₁.
- Press \text{ENTER} to get the LinReg screen.

The regression equation is approximately \( y = 9.63x + 65.03 \).
- Press \text{GRAPH}.

The regression line will be displayed over the statistical plot.

You can also perform various non-linear regression operations, such as quadratic regression, exponential regression or sinusoidal regression.

The linear regression equation is stored in the Y= editor. If you press \text{Y=} you will see the equation determined by the calculator.

Note: If the diagnostic mode is turned on, you will see values for \( r \) and \( r^2 \) displayed on the LinReg screen. To turn the diagnostic mode off:
- Press \text{2nd} 0 for CATALOG.
- Scroll down to DiagnosticOff. Press \text{ENTER} to select this option.
- Press \text{ENTER} again to turn off the diagnostic mode.

You can turn diagnostic mode on in a similar manner.

1- Variable Statistics
You can display statistics for a data set. Consider the height data entered in list L₂.
- Press \text{STAT} and cursor right to select the CALC menu.
- Press \text{1} or \text{ENTER} to select 1-Var-Stats.
- Press \text{2nd} 2 for L₂, and press \text{ENTER}.

A set of statistics will be displayed, as shown.

The first line, \( \bar{x} = 156.5 \), is the mean.
The final line on the first screen, \( n = 6 \), is the number of data.
You can cursor down for more statistics.

\[ \text{minX} = 130 \] is the minimum value in the data set.

\[ \text{Med} = 157.5 \] is the median of the data set.

\[ \text{maxX} = 179 \] is the maximum value in the data set.

### Plotting Points

You can draw points on the TI84+ using the DRAW menu.
- Press the [ZOOM] key, and select 4:ZDecimal.
- Press 2ND [PRGM] to access the DRAW menu.
- Use the right cursor to select the POINTS menu.
- Press \text{ENTER}.

This turns on the points plot routine.

- Move the cursor to the point (2, 1).
- Press \text{ENTER}. Move the cursor to (3, –1).

A point has been plotted at (2, 1).

- Press \text{ENTER}.

Another point has been plotted at (3, –1).

### Programming the TI-84+

You can program the calculator to accept data as input, and then, output any desired calculation. This is useful for common calculations, such as the Pythagorean theorem, the Sine Law, or the Cosine Law. As an example, write a program to accept the lengths of the sides of a right triangle, and calculate the length of the hypotenuse. The lengths of the sides are 7 units and 24 units.

1. Input the data.
   - Press [PRGM]. Select NEW, then Create New.
   - Type in a name, such as PYTHHYP, and press \text{ENTER}.
   - Press [PRGM]. Select I/O, and then, 2:Prompt.
   - Press \text{ALPHA}, then [MATH] to type a variable A. Press \text{ENTER}.
   - Press [PRGM]. Select I/O, and then, 2:Prompt.
   - Press \text{ALPHA}, then [APPS] to type a variable B. Press \text{ENTER}.

2. Perform the calculation.
   - Press 2nd and \( x^2 \) to start a square root. Press \text{ALPHA}, then \text{MATH}.
   - Type \( ^2 + \). Press \text{ALPHA}, then \text{APPS}.
   - Type \( ^2 \). Press \text{STO} \text{ALPHA} \text{PRGM} \text{Press} \text{ENTER}.

3. Display the result.
   - Press [PRGM]. Select I/O, and then, 3: Disp.
   - Press \text{ALPHA}[PRGM]. Press \text{ENTER}.

Your screen will appear as shown.
• Press \textbf{2ND} \texttt{MODE} for \texttt{QUIT} to store the program.

4. Run the program.
• Press \texttt{PRGM}. Select PYTHHYP. Press \texttt{ENTER}.
• You are prompted for the value of \( A \). Type 7. Press \texttt{ENTER}.
• You are prompted for the value of \( B \). Type 24. Press \texttt{ENTER}.

The length of the hypotenuse is displayed as 25.

5. Program the calculator to calculate an angle measurement. A possible program screen is shown. When you are finished, run the program. A possible output is shown.

\begin{center}
\begin{tabular}{|c|c|}
\hline
\texttt{PRGM} & \texttt{PYTHHYP} \\
\hline
\texttt{A=?} & \texttt{25} \\
\texttt{Done} & \\
\hline
\end{tabular}
\end{center}

\begin{center}
\begin{tabular}{|c|c|}
\hline
\texttt{PRGM} & \texttt{PYTHHYP} \\
\hline
\texttt{A=?} & \texttt{73.73979529} \\
\texttt{Done} & \\
\hline
\end{tabular}
\end{center}

\textbf{Using the TVM Solver (Time Value of Money)}

The TVM Solver accepts data related to finance problems, and will calculate the unknown. For example, suppose that you make a payment of $100 at the end of each month into an account that pays 3\%\text{a} compounded semi-annually. How much will you have after 5 years?

• Press \texttt{APPS}.
• Select \texttt{Finance}, then \texttt{TVM Solver}.
• Enter 60 for \( N \) (number of payments), and 3 for \( I\% \) (interest rate).
• Enter 0 for \( PV \) (present value), and -100 for \( PMT \) (payment).
• Leave \( FV \) (future value) for now.

\begin{center}
\begin{tabular}{|c|c|}
\hline
\texttt{N=} & \texttt{0} \\
\texttt{I\%=} & \texttt{0} \\
\texttt{PV=} & \texttt{0} \\
\texttt{PMT=} & \texttt{0} \\
\texttt{FV=} & \texttt{12} \\
\texttt{C/Y=} & \texttt{12} \\
\texttt{BEGIN} & \\
\hline
\end{tabular}
\end{center}

Tip: Money paid to the bank is considered as negative. Money that you get from the bank is considered as positive.

• Enter 12 for \( P/Y \) (payments per year) and 2 for \( C/Y \) (compounds per year).
• Cursor back up to \( FV \).
• Press \texttt{ALPHA} then \texttt{ENTER} to access \texttt{SOLVE}.

The future value will be displayed. Note that this number is positive.
Generating Random Integers
The TI-84+ is capable of generating different kinds of random numbers. For example, you can generate random integers to simulate rolling of dice, selection of cards from a deck, or other scenarios.

Suppose you want to simulate five random rolls of a die.
- Press [MATH] key, and cursor right to the PRB menu.
- Select 5:randInt(.
- Type 1,6,5) ENTER.

Five random integers between 1 and 6 will be displayed.

You can also generate random real numbers between 0 and 1 using 1:rand, random numbers from a normal distribution using 6:randNorm(), or random numbers from a binomial distribution using 7:randBin().

A Note About Seeds: Whenever you use any of the random number functions, you will generate the same series of random integers. The start of the series is controlled by the value of the variable rand which is stored internally in the TI84+, and is set to zero by default. If you change the default value to something else, you can generate a different series. For example, you can change the default to 1 using the keystrokes 1 STO MATH " 1.

To ensure random numbers in a classroom, you might ask students to use a seed which is the sum of their birthday plus street number. For example, a student born on April 30 and living at 190 Main St. would use 30 + 190 = 220 as a seed.

Combinatorics
The TI-84+ will calculate permutations and combinations. Suppose you want to evaluate the number of subsets of 10 objects taken 7 at a time, or 10 choose 7.
- Type 10.
- Press the [MATH] key, and cursor to PRB.
- Select 3:nCr.
- Type 7 and press ENTER.

The answer 120 will be displayed.

You can calculate permutations in a similar manner, using option 2:nPr.
Matrix Operations
You can store and perform operations on matrices using the TI-84+.

Consider the matrix shown: \[ A = \begin{bmatrix} 5 & 1 & -2 \\ 4 & -2 & 0 \end{bmatrix} \]

- Press \( \text{2ND} \ \text{x^{-1}} \) to access the \text{MATRIX} menu.
- Cursor to \text{EDIT} and then select 1, which is matrix \([A]\).

The default dimensions are \(1 \times 1\). Change these to \(2 \times 3\). Notice that the matrix enlarges to the desired dimensions.

- Cursor to the first element.
- Type 5 and press \text{ENTER}.

Continue to fill in the elements of the matrix.
- Press \( \text{2ND} \ \text{MODE} \) to QUIT.

In a similar manner, store matrix \([B]\): \[ B = \begin{bmatrix} 7 & 0 \\ -4 & 3 \\ 1 & -6 \end{bmatrix} \]

You can multiply these matrices, and store the result in matrix \([C]\).

- Press \( \text{2nd} \ \text{x^{-1}} \) \(1 \times \) \( \text{2nd} \ \text{x^{-1}} \) \(2 \ \text{STO} \) \( \text{2nd} \ \text{x^{-1}} \) \(3\.

These keystrokes will multiply \([A]\) by \([B]\) and store the result in \([C]\). The elements of \([C]\) will be displayed.

You can perform a host of other operations, including addition, subtraction, finding determinants, or changing to row-reduced echelon form.

List Operations
You can use the List Operations as a “poor man’s spreadsheet”. For example, suppose you want to sort a list of numbers such as 2, 1, 5, 4, 3 into ascending order.

- Enter the numbers into list \(L_1\).
- Press \( \text{2nd} \ \text{STAT} \) and cursor to \text{OPS}.
- Select 1:SortA(.
- Press \( \text{2nd} \) 1 for \(L_1\) and type ).
- Press \text{ENTER}.
- Press \text{STAT} and select 1:Edit.

The ordered list will be displayed. You can sort a list into descending order using the \text{SortD} function.
Resetting the Random Access Memory (RAM) (Use With EXTREME Caution!)

To erase a previous user's settings, including clearing lists, variables, stored programs, and other data, reset the memory. This will set the calculator back to the default settings.

This is a powerful command. All user created programs will be erased from the calculator.

- Press 2ND + for MEM.
- Select 7:Reset.
- Select 1:All RAM.
- Select 2:Reset.

You will see a message "RAM cleared". Press [ENTER] and continue with your activity.

Using the CBR™ (Calculator Based Ranger)

You can use the CBR sonic sensor to gather motion and time data in real time, and then, analyse the data graphically and statistically.

To access the CBR™ through the TI-84+:
- Connect the CBR™ to the TI-84+ with the calculator-to-CBR cable.
- Make sure both ends of the cable are firmly in place.
- Press APPS.
- Select CBL/CBR.
- When the CBL/CBR™ screen is presented, press [ENTER].
- To access the programs available, select 3:Ranger.
- When the Ranger screen is presented press [ENTER].

To record data from the CBR™:
- From the MAIN MENU screen, select 1:SETUP/SAMPLE.

All settings, except TIME (S), can be changed by using the cursor keys to position the ▶ beside the current option and pressing [ENTER] to cycle through the choices. To change the TIME (S) setting, cursor down to TIME (S), enter the desired value and press [ENTER].

Aim the sensor at the moving object.

- Move the cursor up to START NOW at the top of the screen, and press [ENTER] twice.

You can watch the distance vs time graph being generated in real time.

- Press [ENTER] and select 5:QUIT.

The data will be stored in lists 1 to 4 as shown.