Using the

TI-84 Plus CE Calculator

(www.mathguy.us)

Prepared by: Earl L. Whitney, FSA, MAAA

Version 1.2

August 5, 2024

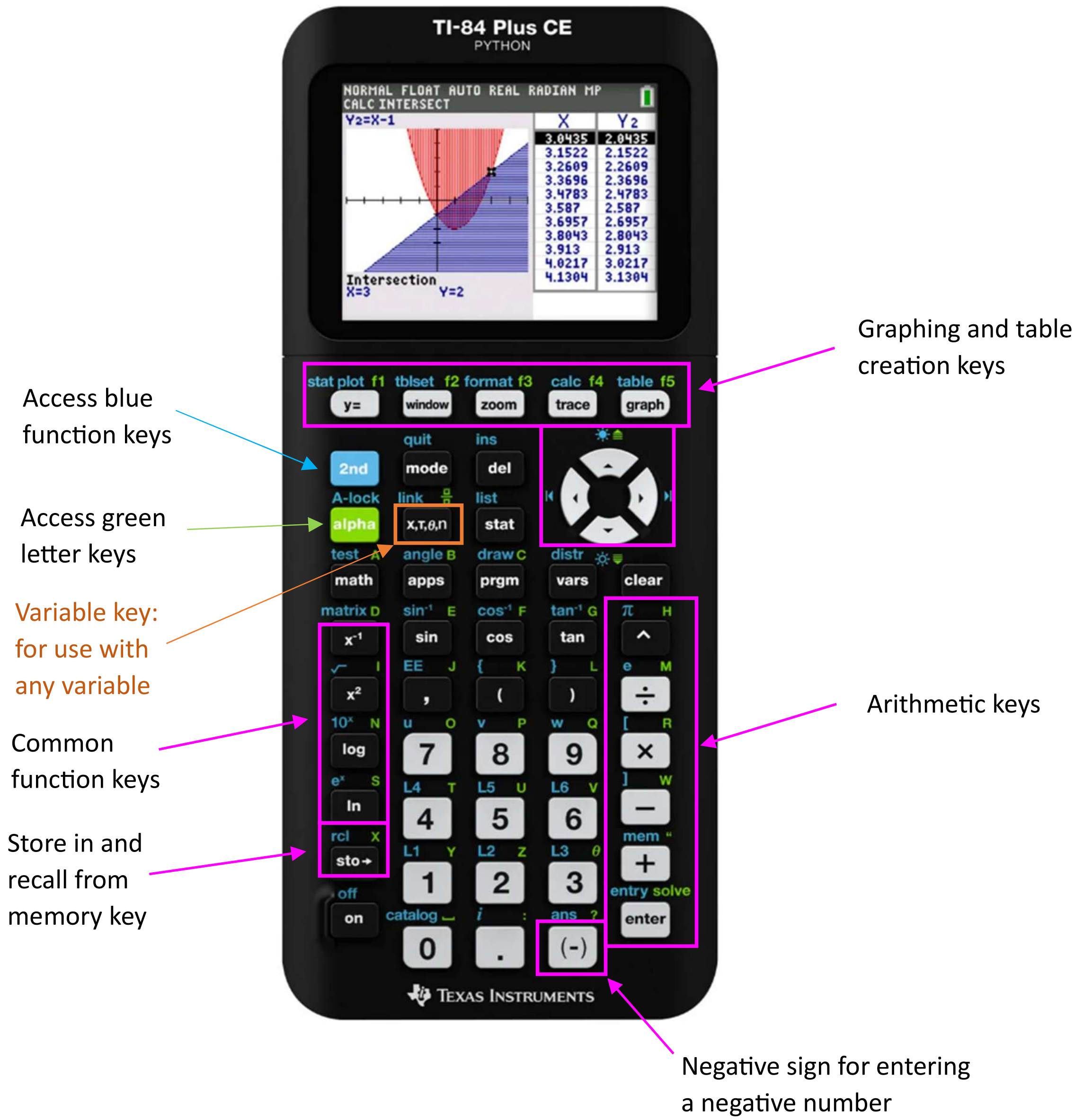
Using the TI-84 Plus CE Calculator

Table of Contents

Page	Topic Description
3	Most Used Keys
4	Setting Up the TI-84 Plus CE
5	Tips for Using the TI-84 Plus CE
7	Factory Reset
8	Math Key
8	Fractions
9	Function Maxima and Minima
9	Scientific Notation
10	Angles
10	Trigonometric Functions
11	Switching between Degrees and Radians
12	Switching between Rectangular and Polar Coordinates
13	Matrices
14	Complex Numbers
14	Apps on the TI-84 Plus CE
15	Graphing Tutorial
21	Problems

In the Microsoft Word version of this document, you can move to a section using **[ctrl] click** on the page number above.

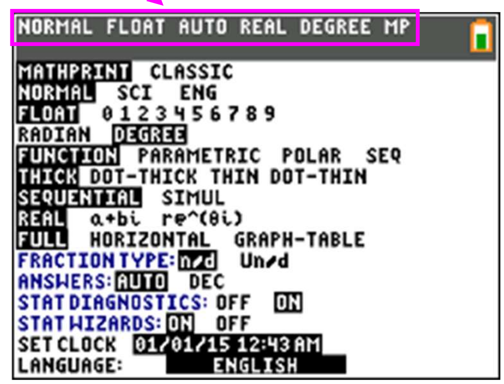
The Most Used Keys



Setting Up the TI-84 Plus CE

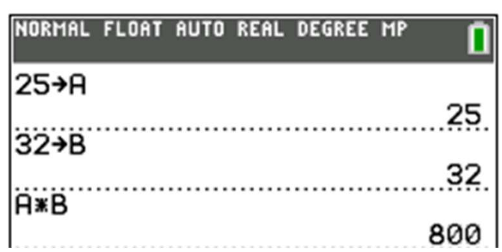
- Turn the calculator on
  - Press: on clear
- Turn the calculator off:
  - Press: 2nd off
- Set the mode for use:
  - Press: mode
  - Setup should look like the image to the right
  - Use the arrow keys →  to move around and set the mode the way you want. Start with:
    - 2^{nd} line: **NORMAL**
    - 3^{rd} line indicates the number of digits to display when doing calculations. Initially, use **FLOAT**
    - 4^{th} line: **DEGREE**
    - 5^{th} line: **FUNCTION**
    - 8^{th} line: **REAL**
    - Other lines: as shown in the illustration.
  - Get out of the mode screen by pressing: 2nd quit
    - Note that you can get out of any screen and back to the standard calculator screen by pressing: 2nd quit
- Reset the graphing window by pressing: zoom **6:ZStandard**.
- Reset any previously entered functions for graphing by pressing: y= clear
  - If more than one function is shown, move to each one using the up and down arrow keys and press: clear
- Clear previously entered lines that may be in the display or above it:
  - Press: 2nd mem **3:Clear Entries** Note: mem key is over the + sign).
  - Press: clear to blank-out the display if you prefer a clean display.

Notice that the window always shows what modes you are in at the top. This is useful if you ever wonder which modes are set as you work, e.g., RADIAN or DEGREE.



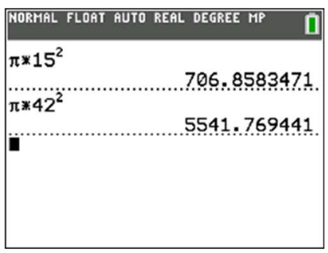
Tips for Using the TI-84 Plus CE

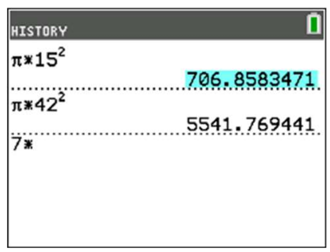
- 2nd quit and clear are your **friends**. They will get you out of most situations you don't know how to get out of otherwise.
- To **break** or interrupt an extended calculation or program in a loop, press and hold on for several seconds until the error message [Break] appears on the screen.
- Use lots of **parentheses** in complex inputs. It's better to use too many parentheses than not enough. It is a common error for students to enter expressions without enough parentheses to allow the TI-84 to provide the answer desired by the student.
- **Clearing the contents** on a line or the screen
  - Press: clear once to clear a line.
  - Press: clear twice to clear the entire screen. The calculations that were on the screen will remain, but are above the clean window. Scroll up to reach them, if desired.
- **Delete a character.**
  - Move the cursor over the character with the arrow keys and press: del
- **Insert a character.**
  - Move the cursor over a character with the arrow keys and press: 2nd ins
  - The new character will be inserted before the one the cursor was on.
- Use memory to **store values** you will use often. You can give values one-letter variable names by typing the value you want stored, then pressing: sto→ alpha followed by a one-letter variable name in green.
  - To use the stored variable, simply refer to it by name.

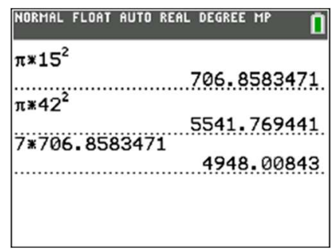


- When **using variables**, be careful that they are what you entered and not what a prior user entered. If you want to zero out a variable, store 0 in the variable name.

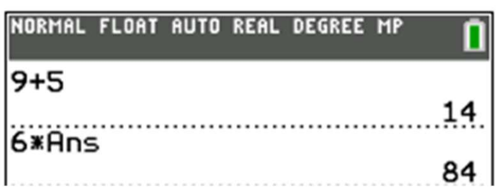
- To **use information previously entered**, you may use the arrow keys to move up or down to the previous expression or value and press the enter key at any point in a calculation.
    - See the screen sequence below, in which I calculate areas for a couple of circles, then multiply the first of those by 7 to get the volume of a cylinder with base radius of 15 units, that is 7 units long.
    - Notice in the second screen that I have moved up from the line I was working in to capture the result of a previous calculation, which is highlighted in aqua by the calculator.
    - Press: enter after highlighting what you want to use in order to enter it in the input line, and continue working.

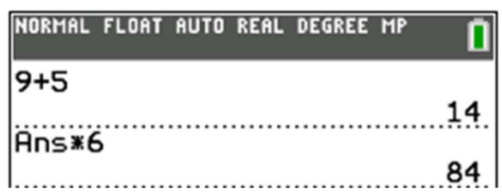






- To **use the answ**er in the previous line, press: 2nd ans (see below left) or simply start typing an operation or function key and the TI-84 will assume you wanted to start the expression with the previous answer (see below right).





- The **absolute value function** is located at: math **NUM 1: abs(**
- If you **define variables** for the tasks at hand, you might want to zero them out at the end of your session. For example, if you used the variable Z, zero it out by pressing: 0 sto→ alpha Z enter at the end of your session.
- When using the **trace function** to find a specific point on a graph, remember that the x- and y-values produced may not be precise. If precision is paramount, use 2nd calc (see p. 16) to find your point.

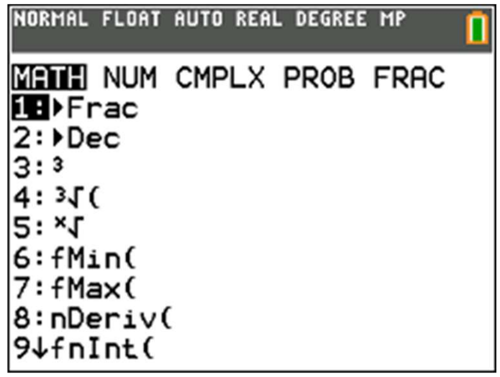
- When graphing, make sure **Xres** is set to 1 for best resolution (see p. 15).
- After completing a graphing problem, you may want to **reset the graphing window** by pressing: zoom **6:ZStandard** enter 2nd quit
- Some things that **the TI-84 can't do or does poorly**:
  - Show vertical asymptotes.
  - Show holes in graphs.
  - Show precise points on a graph at most x-values.
  - Show precise x- or y-values on a graph.
- If you use a TI-84 that was **last used by another student**, follow the setup instructions on page 4, before using it.
- When dealing with **angles**, be careful to set the 4^{th} line of the mode screen to either **RADIAN** or **DEGREE**, depending on your goal.
  - When graphing Trig functions, you will want to use **RADIAN** mode.
  - When doing problems with angles, you will probably want to use **DEGREE** mode.
  - You may have to move back and forth between modes during a test or other exercise. Alternatively, you can use the techniques described on p. 11. In any case, be careful; students often make mistakes with degree and radian modes when first using the TI-84.

TI-84 Factory Reset (in an emergency)

- A factory reset will delete all information entered in the TI-84 and restore it to the settings it had when new.
- This is not recommended except in extreme circumstances.
- Press: 2nd mem **7:Reset… 1:All Memory 2:Reset**
- *In general, it's not a good idea to mess with the memory of the TI-84.*

Special Keys and Functions

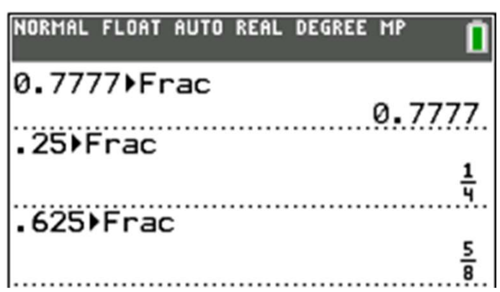
Math Key



- Provides access to additional math functions, as shown in the illustration to the right.
- Press: **math**
- Across the top of the screen are menus with various functions.
    - Move the cursor right or left with the arrow keys to see the menus.
    - When you see the function that you wish to use, move the cursor up and down with the arrow keys and press: **enter**
    - There may be more functions available than are shown on the screen. To see them, scroll down with the arrow keys.
    - Example: move right to **NUM** and down to **5: int(** to insert a function that returns the integer part of whatever value you are working with.
        - To get the integer portion of 8.2^3, press:

          math **▸** **NUM** **5: int(** 8.2 **^** 3 **▸**) **enter**
        - The TI-84 will show the window to the right because $8.2^3 = 551.368$ and $\text{int}(551.368) = 551$.

Fractions

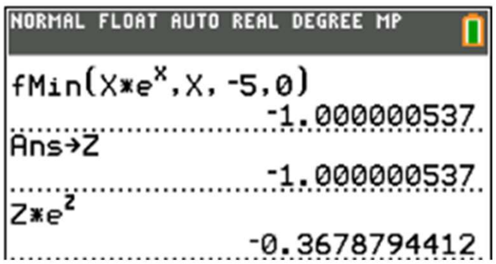


- Converting from a fraction to a decimal.
    - Enter the fraction as a division.
- Converting from a decimal to a fraction.
    - Enter the decimal, then press:

      math **1:→ Frac** **enter** **enter**
    - The TI-84's ability to do the conversion is clearly limited (we would prefer that 0.7777 return 7/9). However, this capability may be useful on occasion.

Finding a Function Maximum or Minimum with the Math Key

- math **6:fMin(** *expression, variable, low x-value, high x-value*)
- For the example below, the function is $y = xe^x$ and the range of x-values over which we seek the minimum is $[-5, 0]$.
  - To obtain the x-coordinate of the local minimum:
    math **6:fMin(** x,T,θ,n × 2nd eˣ x,T,θ,n) , x,T,θ,n , $-5, 0)$
  - To store the resulting value as the variable Z:
    sto→ alpha Z enter
  - To obtain the y-coordinate of the local minimum, substitute the value of Z found above into the expression of the function:
    Press: alpha Z × 2nd eˣ alpha Z) enter



  - Note: it is not preferred to use X as the variable in this process because every time you use X after this, the TI-84 would use the value you stored as X instead of treating it as a variable.
  - A better approach to finding a minimum or maximum of a function is to graph the function as described below. Why? Because the range of x-values selected in the **fMin** function may not be where the minimum or maximum truly is. Using a graph, you can easily see the location.

Scientific Notation

- To enter a number in scientific notation, you can enter it as, for example, 1.5 × 10 ^ 14 (for 1.5×10^{14}) or use the EE key as a shortcut:
  1.5 EE 14 is a good way to type in 1.5×10^{14}.
- It's a good idea to place numbers in scientific notation inside parentheses, regardless of which of the above methods you use.

Angle Operations

Trigonometric Functions

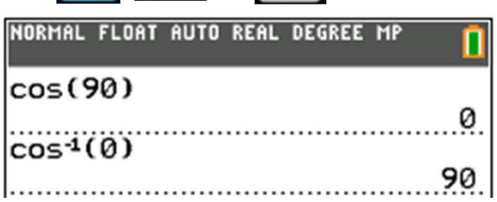
- There are three trigonometric (Trig) function keys on the TI-84 Plus CE calculator.
- **sin** **cos** **tan** are used to find the sine, cosine, and tangent values of angles expressed in either radians or degrees, depending on the which mode you have chosen.
- If you are graphing Trig functions, you should be in radians mode.
- If you are not graphing, you may prefer to be in degrees mode.
- Set the angle mode in the 4th line of **mode**. See p. 4.
- To find the cosecant, secant, or cotangent values of angles, use 1÷ the corresponding Trig function because:

$$\csc\theta = \frac{1}{\sin\theta} \qquad \sec\theta = \frac{1}{\cos\theta} \qquad \csc\theta = \frac{1}{\tan\theta}$$

- Inverse Trig functions answer the question: what angle has a particular trigonometric function value?
  - The keys for the inverse Trig functions are above the keys for the Trig functions and are accessed using the **2nd** key.
  - Example, $\cos 90° = 0$, so $\cos^{-1} 0 = 90°$. In degrees mode, you can get these by pressing the following keys:

    cos 90) **enter**

    2nd **cos** 0 **enter**

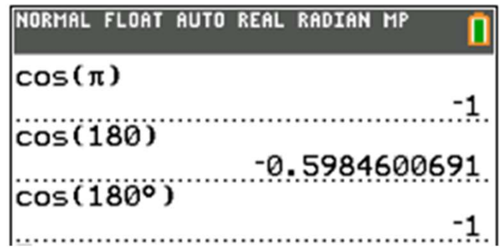
    

  - The result of the expression entered will be given in the angle mode selected by the user, either radians or degrees.

Switching Between Degrees and Radians

Entering Degrees when in Radian mode

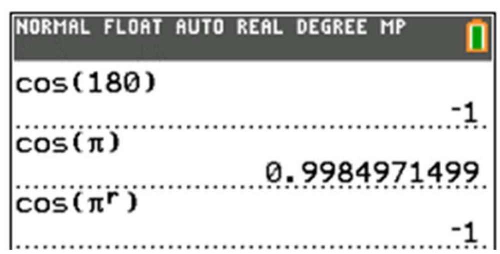
- Sometimes, it is useful to have your calculator in RADIAN mode but enter an angle in degrees, e.g., if you are doing graphing problems and also working problems in degrees.
- After entering the angle in degrees, press: 2nd angle **1:°** enter .
  Example: cos 180 2nd angle **1:°**) enter



- In the calculator window shown …
  - The first line finds the cosine of π radians (i.e., 180°) in RADIAN mode.
  - The second line incorrectly tries to find the cosine of 180° in RADIAN mode. The answer given is incorrect.
  - The third line finds the cosine of 180° in RADIAN mode using the process shown above.

Entering Radians When in Degree Mode

- If your calculator is in DEGREE mode but you want to enter an angle in radians, you can.
- After entering the angle in radians, press: 2nd angle **3:ʳ** enter .
  Example: cos 2nd π 2nd angle **3:ʳ**) enter

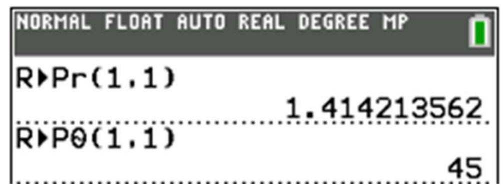


- In the calculator window shown …
  - The first line finds the cosine of 180° (i.e., π radians) in DEGREE mode.
  - The second line incorrectly tries to find the cosine of π radians in DEGREE mode. The answer given is incorrect.
  - The third line finds the cosine of π radians in DEGREE mode using the process shown above.

Switching Between Rectangular and Polar Coordinates

Converting Rectangular to Polar Coordinates

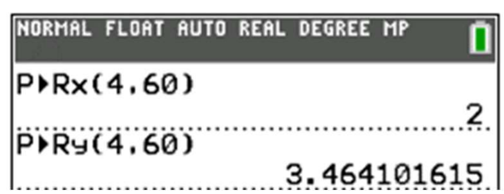
- Converting rectangular to polar coordinates requires two calculations – one to get the magnitude (r), and one to get the angle, θ.
- Example: convert the point (1, 1) from rectangular to polar coordinates:
  - To get r, press: 2nd angle **5:R→Pr(** 1, 1) enter
  - To get θ, press: 2nd angle **6:R→Pθ(** 1, 1) enter
  - The results are shown in the calculator window to the right.



- Note that the angle will be given in either radians or degrees depending on the mode of the calculator.
- You must put the two answers together for the conversion. That is, (1, 1) in rectangular coordinates is approximately (1.414, 45°) in polar coordinates.

Converting Polar to Rectangular Coordinates

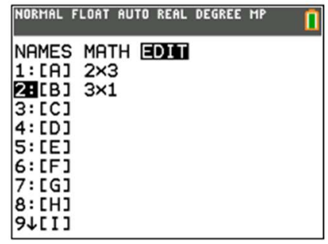
- Converting polar to rectangular coordinates requires two calculations – one each to calculate x and y.
- Example: convert the point (4, 60°) from polar to rectangular coordinates:
  - To get x, press: 2nd angle **7:P→Rx(** 4, 60) enter
  - To get y, press: 2nd angle **8:P→Ry(** 4, 60) enter
  - The results are shown in the calculator window to the right.



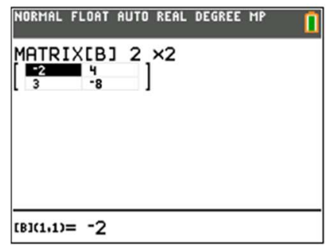
- Note that the angle must be entered in either radians or degrees depending on the mode of the calculator.
- You must put the two answers together for the conversion. That is, (4, 60°) in polar coordinates is approximately (2, 3.464) in rectangular coordinates.

Entering Matrices

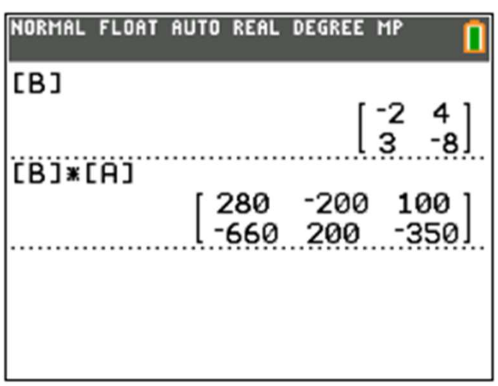
- To enter data in a matrix, first define its name: 2nd matrix will bring up the matrix menu.
- Move to the right at the top to **EDIT.** Select the matrix you want to define using the up and down arrow keys. Press: enter . Matrix names are typically A, B, or C.



- You will next be asked to define the dimensions of the matrix. The first number is the number of rows and the second number is the number of columns. After you define the dimensions, press: enter and presto, a matrix of the dimensions you chose will appear.
- The matrix you chose may already have numbers in it. No worries, just change them by using the arrow keys to move around within the matrix and type the values you want in each position. Press: enter after entering each value.



- The matrix is now defined. Press: 2nd quit to get back to the main window.
- If you want to see your matrix, press: 2nd matrix , scroll up or down to the matrix you want to see, and press: enter twice.
    - If you want to use your matrix, use this same procedure, but press: enter only once.
    - Example: to multiply matrix A (previously defined) by the new matrix B from the left, press: 2nd matrix **2:[B]** × 2nd matrix **1:[A]** enter . See the results below:

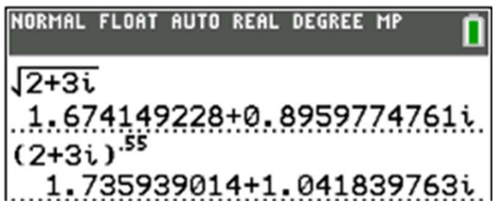


- Note: matrices can be added, subtracted and multiplied if they have the proper dimensions. They cannot be divided.

Complex Numbers

- Complex numbers have the form $a + bi$. That's exactly how they are entered in the TI-84, except it's a good idea to put parentheses around them.
  - Example: to calculate $(2 + 3i)^4$, press: (2+3 2nd i) ^ 4 enter
  - The i key is over the period.

- Taking a root or a fractional power of a complex number will provide the principal value only, with lots of decimals.



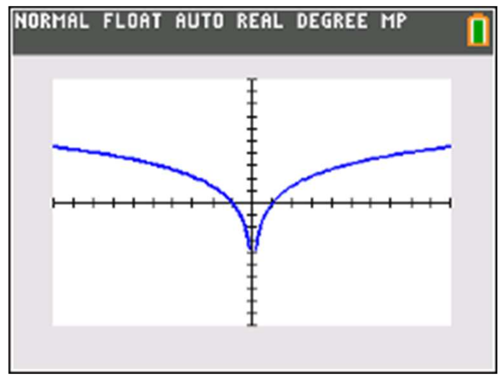
Apps on the TI-84

The TI-84 CE comes with a number of pre-loaded apps. You may want to check them out, but a full description of how to use them is beyond the scope of this document. Among the most useful apps are:

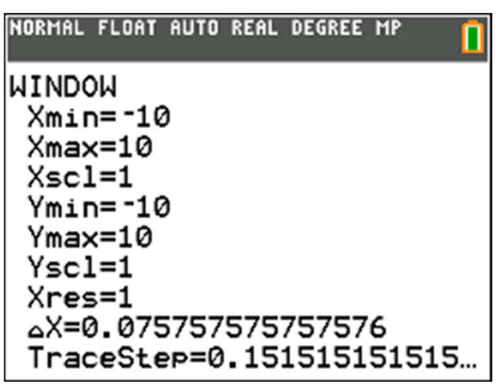
- apps **9:PlySmlt2 –** provides a polynomial root finder and a simultaneous equation solver.
- apps **4:Conics –** is a conics graphing app: circles, ellipses, hyperbolas, and parabolas.
- Check out the others. You may find a gem.

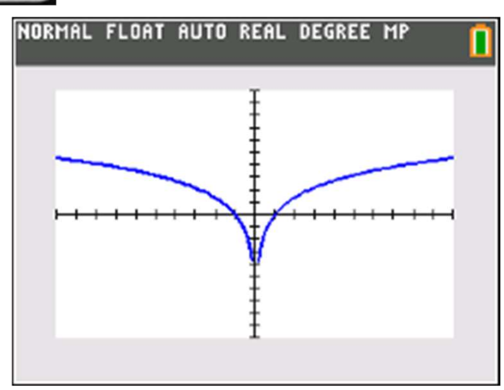
Graphing a Function – Tutorial

- Keys:
  - [y=] To define the function you want to graph.
  - [window] To change the x- and y- limits that are graphed on the screen, and to set the resolution of the function being graphed.
  - [zoom] To zoom in or out on a portion of the graph.
  - [trace] To move the cursor along the graph to an interesting point.
  - [graph] To graph the function that you defined on the screen
- Example: Graph the function: $y = \ln(x^2) + 2$
  - [y=] [ln] [x,T,θ,n] [x^2])+2 [graph]
  - The calculator may show something like what is shown to the right:

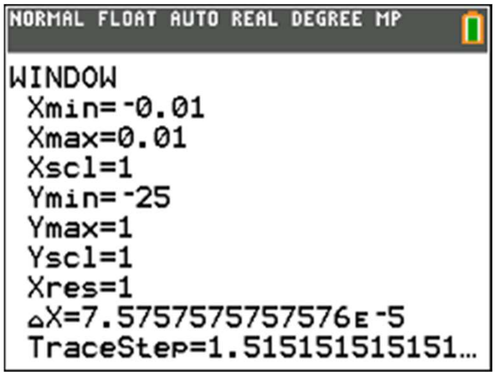


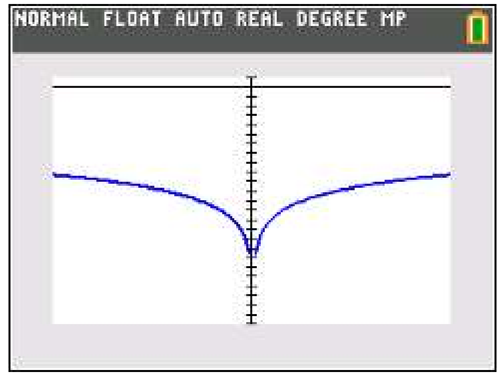
  - If your calculator does not show the graph above, change the settings in [window] to be as shown below. Make sure you use the [(-)] key at the bottom of the calculator to enter a negative number.
    - Scroll up and down the fields shown to enter the values you want.
    - Don't change any entries below the **Xres** line.
    - Make sure **Xres** (x-resolution) is set to a value of 1.
    - When you are finished, press: [graph] to see the resulting graph.





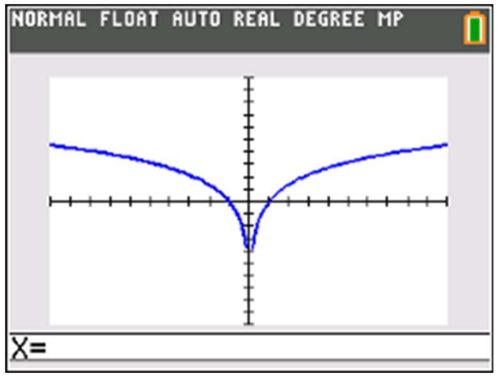
- You may notice that something interesting is happening to the graph when $x = 0$. To see what is happening better, change the **window** settings for x and y to be the following, and press: **graph**



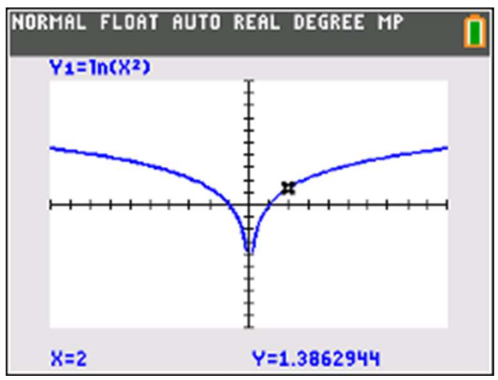


- Well, that's not much better. Something is clearly going on at $x = 0$, and we have reached a limit to what the calculator can do.
    - We can understand, without the calculator, what is going on by substituting $x = 0$ into the equation $y = \ln(x^2) + 2$. The problem is that $\ln(0^2) = \ln(0)$ is not defined. There is no natural log of zero, and the graph approaches $-\infty$ from both sides of $x = 0$. Unfortunately, the calculator cannot show that, so we have to use our math brains instead.
- Here are some things the TI-84 Plus CE can't do or does poorly:
    - Show vertical asymptotes.
    - Show holes in graphs.
    - Show precise points on a graph at most x-values.
    - Show precise x- or y-values on a graph.

* In order to determine precise values we use the **calc** function, which is over the **trace** key. That is, **2nd** **calc** will allow us to determine precise values.
    - Example:
        - Reset your window settings: **zoom** **MEMORY 1:ZPrevious** **enter**
        - To determine y when $x = 2$, press: **2nd** **calc** **1:value** **enter**
        - The calculator will show the screen below with the cursor blinking after **X=**.



- Type the number 2 and press: [enter]
- The calculator will show the value of y at the bottom of the screen, the function used at the top of the screen, and a point on the graph, as shown below.

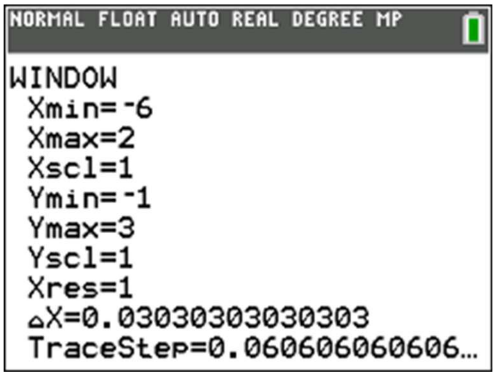


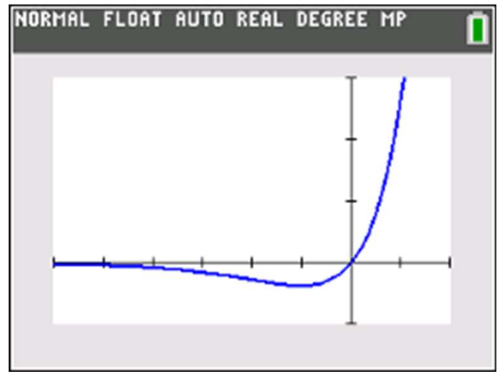
- It's a good idea to check to make sure the correct function is displayed and that the point on the graph makes sense. The y-value shown at the bottom of the screen is what you were looking for.

- Locating key points on the graph
  - There will be times when you want to get a better idea where a key point on a graph is. In this case you have two choices. If you know something special about a point, e.g., it is a minimum, a maximum, or a zero of the function, you can use [2nd] [calc] ; otherwise you can [trace] the graph to obtain an approximate x- and y- value at the key point.
  - Example: Using [trace]
    - Let's start be redefining our function. To get rid of the function we previously defined and enter a new one:

      [y=] [clear] [x,T,θ,n] × [2nd] [eˣ] [x,T,θ,n] [enter] [graph]

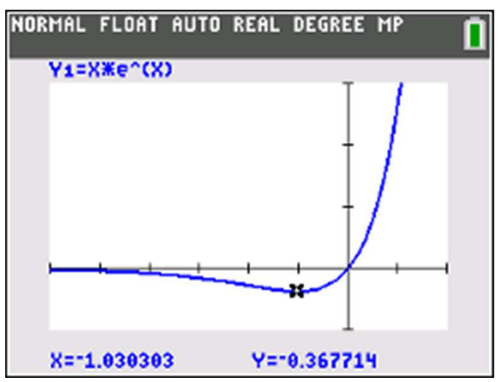
- This function is $y = xe^x$. It's a weird function, but those are the ones that teach the most about graphing.
- Adjust your window settings for x- and y- as follows and re-graph. Your settings and graph should look something like this:





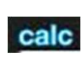
- Now, this is an interesting graph. Let's try to find the minimum with a trace. With the graph still displayed, press: 

- A point cursor, x- and y-values, and the function definition will appear on the graph. Move the cursor until it looks like it is at the lowest point of the graph. As you move the cursor, look at the changing y-values and stop the cursor at that point.



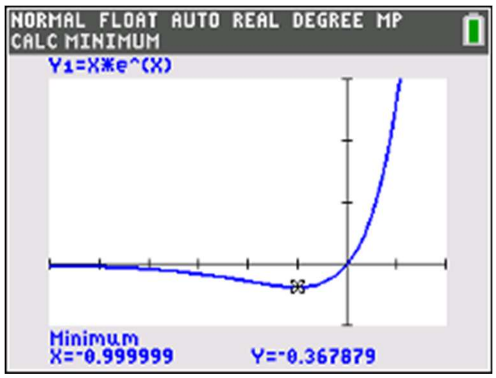
- It appears that the lowest value of the function occurs at the point $(-1.030303, -0.367714)$. Your teacher will probably ask you to round these values because we know the graph is not accurate to six decimals.

○ Example: Using 



- To get a more accurate estimate of the lowest point on the graph, we will use the calculator's calculation capability.

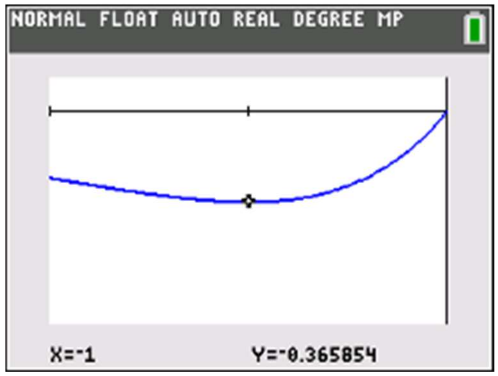
- Press: 2nd calc **3:minimum**. Again, a point cursor, x- and y-values, and the function definition will appear on the graph.
- Hold down the left arrow key to move the cursor so that it is clearly to the left of the minimum point. Press: enter
- Next, hold down the right arrow key to move the cursor so that it is clearly to the right of the minimum point. Press: enter twice.
- The calculator will find the minimum point and display its coordinates at the bottom of the screen:



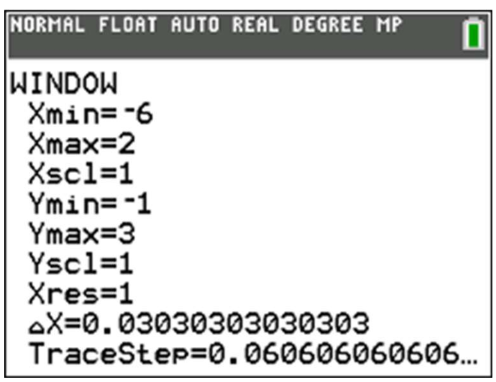
- The point identified, $(-0.999999, -0.367879)$, is a much more accurate estimate of the value of the function's local minimum. For those who are interested, the actual value can be determined with Calculus to be $(-1, -1/e) \approx (-1, -0.367879)$, to six decimals. So you can see how much more accurate this approach is.
- Notice that, even with this approach, the x-value determined by the calculator is not accurate to six decimal places. However, any rounding at all will give an accurate value of $x = -1$.
- If you look at the menu under 2nd calc, you will see that this approach also works in finding graph zeros, maxima, and the intersection of two function graphs.

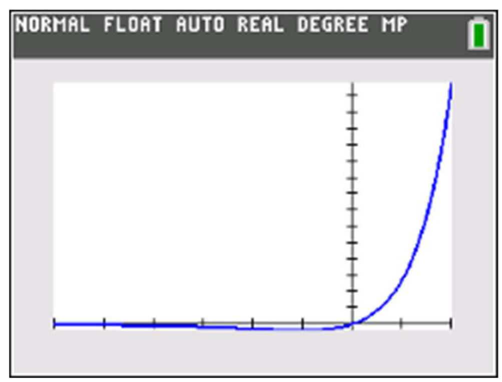
- Suppose you want to look a little closer at the part of the graph where the minimum exists.
  - Press: zoom **2:Zoom In** to zoom in. You will see a flashing point cursor. This cursor will be the center of the zoomed-in graph once you press: enter

- If you want the center to be somewhere else, move the cursor to that location and then press: enter
- In the illustration below, I moved the cursor to be near the minimum point before zooming in, though this is of little value in this situation.



- Notice that the zoom button has an option to zoom out, as well as other options. One very useful option is zoom **0:ZoomFit**, for which the calculator does its best to fit the most useful part of the graph in the display window.
- Rest the window x- and y-values to those shown below. Then, press: zoom **0:ZoomFit** to display the window on the right.





- From here, you could choose to zoom in on the minimum using the technique described above, if that is what you are interested in. In any case, this gives you a helpful look at more of the graph.

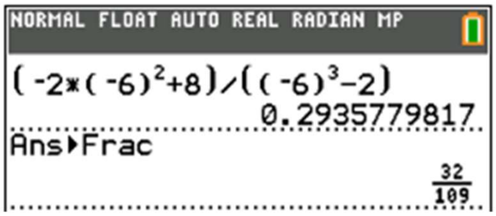
- You may graph multiple functions if you like, simply by pressing y= and entering up to 10 functions. However, the more graphs you show, the more complex the resulting display will be.

Some Problems to Try:

Problem 1: $g(x) = \frac{-2x^2+8}{x^3-2}$; $find\ g(-6)$.

Solution: $(-2 \times (-6)$ **x²** $+ 8) \div ((-6)$ **^** 3 **▸** $- 2)$ **enter**

If you want a fraction for an answer: **math** **1:Frac** **enter**



So, the answer is: $\frac{32}{109} = 0.294$

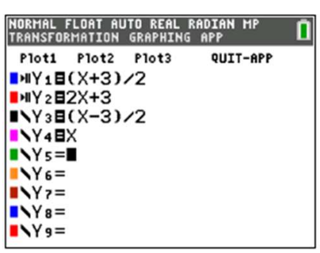
Problem 2: Which two functions below are inverses of each other?

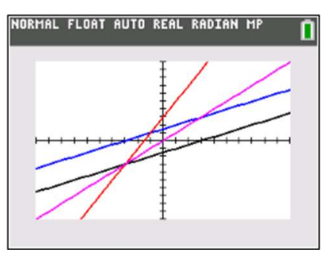
$$f(x) = \frac{x+3}{2} \qquad g(x) = 2x + 3 \qquad h(x) = \frac{x-3}{2}$$

Solution: There are multiple ways to do this, let's graph them.

y= **clear** (**x,T,θ,n** +3) ÷ 2 — $f(x)$ is set up as Y1
▾ **clear** 2 **x,T,θ,n** + 3 — $g(x)$ is set up as Y2
▾ **clear** (**x,T,θ,n** −3) ÷ 2 — $h(x)$ is set up as Y3
▾ **clear** **x,T,θ,n** **graph** — Y4 is the line $y = x$

- The TI-84 will graph these functions using the colors in the **y=** screen.
- We want two functions that reflect over the line $y = x$.
- Here's the trick we want to use. The two functions that are inverses of each other will often intersect the line $y = x$ (pink) at the same point.
- The red and gray lines clearly intersect the pink line at the same point, so they are inverses. Looking back at the **y=** screen, we see that these two functions are **$g(x)$ and $h(x)$**, which is our answer.

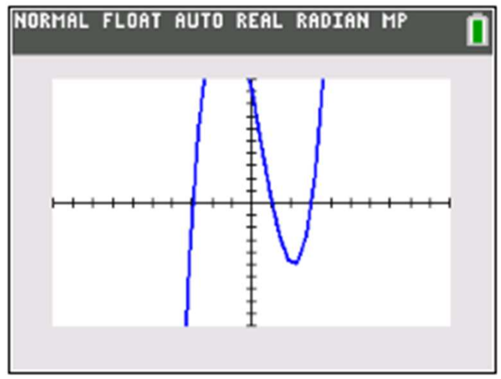




Problem 3: Given that $y = x^3 - x^2 - 9x + 9$, find the zeros and give the multiplicity of each.

Solution: We can do this by factoring, but let's practice our graphing.

- First, clear all of the functions in the [y=] screen by using the up and down arrows and the [clear] button.
- Next, [y=] [x,T,θ,n] [^] 3 [▸] $-$ [x,T,θ,n] [x^2] -9 [x,T,θ,n] $+ 9$ [graph]
- We can see on the graph that zeros appear to be at $x = -3, 1, 3$ and, in fact these are what we are looking for.



- Further, a cubic equation had at most 3 real solutions and since we have found them, there are no more.
- One more thing. The multiplicities of each zero must be odd because the function passes through the x-axis at each zero. Therefore, the **multiplicities of each zero must be 1**.
- Note that if a function has an even multiplicity at a zero, the curve will bounce off the x-axis and not pass through it.

Problem 4: Find all values of x for which $\ln x = e^x$.

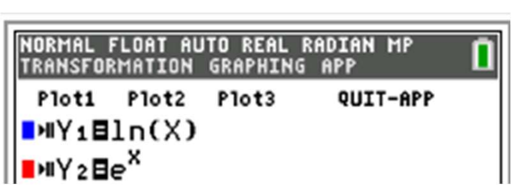
Solution: This is very difficult algebraically, and tailor-made for graphing.

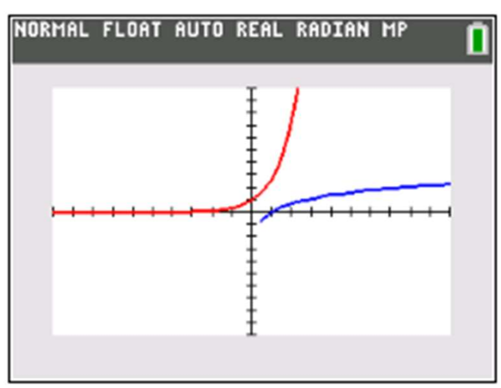
- Let's graph both functions.

  [y=] [clear] [ln] [x,T,θ,n]) — $\ln x$ is set up as Y1

  [▾] [clear] [2nd] [e^x] [x,T,θ,n] [graph] — e^x is set up as Y2

- Notice that the two graphs never intersect, so **there are no values of x for which $\ln x = e^x$**. The graph is the proof of this.

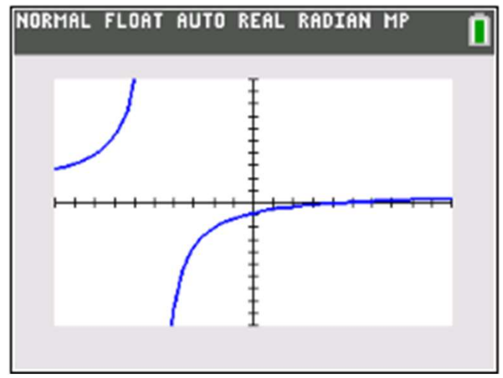




Problem 5: Solve the rational equation: $f(x) = \frac{x-4}{x+5} < 0$

Solution: We can do this problem purely algebraically, but it's instructive to look at its graph.

- First, clear all of the functions in the [y=] screen by using the up and down arrows and the [clear] button.
- Next, [y=] ([x,T,θ,n] $-4) \div ($ [x,T,θ,n] $+5)$ [graph]
- Let's look at the graph, at $f(x)$, and exercise our brains.



- This function has a vertical asymptote where the denominator is zero, so at $x = -5$.
- $f(x)$ has a horizontal asymptote at $x = 1$ because the fraction $\frac{x-4}{x+5}$ divides out to 1 if we ignore the constants in both the numerator and denominator. Good trick, huh!
- So, the function is never below zero on its left side, and is below zero on its right side from the vertical asymptote until it intersects with the x-axis. We know the $f(x) = 0$ at $x = 4$ because that makes the numerator zero, so the solution is all values of x between -5 and 4.
- We can write the solution in set notation as $\{x \mid -5 < x < 4\}$.
- We can write the solution in interval notation as $(-5, 4)$. Note that this is arrange of x-values and not a coordinate.
- Note that the left endpoint of the range of x-values is not included in the solution because it lies on a vertical asymptote. The right endpoint of the range of x-values is not included in the solution because at $x = 4$, $f(x) = 0$ and we want $f(x) < 0$.