Advanced Functions on the TI-83/84

Polynomial Solver (Requires PolySmlt flash application. Its free at education-ti.com)(TI83+/84 only)

The polynomial solver can be used to solve polynomial equations of degree 2 or higher.

Example #1: Solve $x(x^2 - 3x) = 4$

1. Put the equation in standard form.
   $x^3 - 3x^2 - 4 = 0$
2. Enter the polynomial solver.
   Type **APPS :PolySmlt ENTER 1:PolyRootFinder**.
3. Enter the degree(order) of the polynomial.
   Type **3 ENTER**.
4. Enter the coefficients starting with the leading coefficient.
   Type **1 ENTER (-) 3 ENTER 0 ENTER (-) 4**. Note: you have to type in 0 for the missing x term's coefficient.
5. Press **GRAPH:SOLVE** and wait.
6. Read the solutions. Note, if there are non-real solutions the calculator will display all solutions, even the real ones, in complex form. a+b***i*** = (a,b) .

   It returns x_1= 3.35530139761

   x_2= -.177650698804+1.07730381285***i***

   x_3= -.177650698804-1.07730381285***i***

   To see the rest of the second and third solutions, put the cursor on the solution and press **(cursor right)** to scroll through that solution.

   Thus, rounded to the 4th decimal place, the solutions are

   3.3553

   -0.1777 + 1.0773***i***

   -0.1777 - 1.0773***i***

Note: This function is prone to approximation errors, i.e. 0's quite often show up as numbers like 3E-12=0.000000000003 . So if you get an answer like 1.9999999324, plug 2 in for x to see if the solution is 2 or 1.9999999324 . For example, try solving $x^5+5x^4+10x^3+10x^2+5x+1=0$ which has only one solution of x=-1 with multiplicity of 5.

Simultaneous Equations Solver (Requires PolySmlt flash application. Its free at education-ti.com) (TI83+/84 only)

The Simultaneous equations solver is used to solve linear systems of square dimensions 2 by 2 or higher and have exactly one solution.

Example#4 :Solve 3x - 4y = 13
x + 6y = 8

1. Put all equations into general form, i.e. Ax + By = C.
2. Enter the Simultaneous equation solver.
   Press **APPS :PolySmlt ENTER 2:SimultEqnSolver**.
3. Enter the number of equations.
   In this case type **2 ENTER**.
4. Enter the number of Unknowns, variables.
   In this case type **2 ENTER**.
5. Enter the coefficients, in order, and the result for 1st equation.
   Type **3 ENTER (-) 4 ENTER 13 ENTER**.
6. Repeat step #4 for the rest of the equations.
   Type **1 ENTER 6 ENTER 8 ENTER**.
7. Press **GRAPH:SOLVE**.
8. Read the answer.
   It returns x_1=5, and x_2=.5 which means that x=5 and y=0.5. Thus the solution set is {(5,1/2)} .

Equation editor's menu options:

Y=:MAIN	go to main screen.
WINDOW:NEW	enter a new system.
ZOOM:CLR	clear all equations.
TRACE:SOLVE	load a system.

Answer screen's menu options:

Y=:MAIN	go to main screen.
WINDOW:BACK	go back to equation editor.
ZOOM:STOsys	store the system on the calculator.
TRACE:STOx	store the results on the calculator.

Tables

The table feature on the TI-83 can be used to see a table of values for the function(s) in Y1, and/or Y2, etc.

Example#5 :Demonstrate that $(1 + 1/x)^x$ approaches e=2.71828182845... as x approaches ∞.

1. Enter the function into Y1.
   Press **Y= (1 + 1 ÷ X) ^ X**.
2. Enter the table setup screen.
   Press **2nd TBLST**.
3. Set TblStart to the value of x that you what the table to start at.
   Set this to 1 by typing **1 ENTER**.
4. Set ΔTbl to how much you want x to change between rows of the table.
   Set this to 1 by typing **1 ENTER**.
5. Leave Indpnt and Depend to AUTO.
6. Enter table screen.
   Press **2nd TABLE**.
7. Examine the table.
   Well the numbers under Y1 seem to be heading toward 2.7182818... , but they aren't really near it yet.
8. Experiment with the table setup.
   Let's try ΔTbl=1,000. So type **2nd TBLST (cursor down) 1000 2nd TABLE**.
   It looks better. At least it is accurate to the 3rd decimal place.
   Let's try ΔTbl=1,000,000. So type **2nd TBLST (cursor down) 2nd (cursor right) 000 2nd TABLE**.
   Much better. Now it's accurate to the 4th decimal place and the last entry, 2.7183, is what you get when you round e to the 4th decimal place.
   From this we can conclude that $(1+1/x)^x$ seems to approach e as x approaches ∞. But note that this is not proof that $(1+1/x)^x$ approaches e, see problem in next section. A formal proof requires calculus. But, this is enough for you to take my word that it does approach e.

When Good Calculators Go Bad

I came across this problem when working with the example used in the table section above (Example#5 :Demonstrate that $(1 + 1/x)^x$ approaches e=2.71828182845... as x approaches ∞). We'll examine this both with tables and with graphs. So you with TI-85's just skip to the "With Graphs" subsection. Those with TI-86s should do both.

With Tables:

1. If it's not still there, set $y1=(1+1/x)^x$.
2. Set ΔTbl=10,000,000 and go to the table.
   Does anything look a little peculiar? Look at when x=30000001.
3. Set ΔTbl=3,000,000,000 and go to the table. Note that you can use the EE key to type in ΔTbl a bit quicker.
   Does it still look like it's converging to e=2.7182818285...?
4. Set ΔTbl=$1x10^{13}$ and go to the table.
   How about now? Are you questioning the conclusion we made in example#5?

With Graphs:

1. If not already done, set $y1=(1+1/x)^x$.
2. Set the window to [0,10] by [0,8] and graph.
   Does it look like it could have a horizontal asymptote at y=e=2.7182818285...?
3. Set the window to [0,1000000] by [0,8] and go into trace mode.
   Does it look like the function is approaching 2.7182818285...?
4. Set the window to [0,$1x10^{12}$] by [0,8].
   How about now? Does it still look like it has a horizontal asymptote?
5. Try [0,$1x10^{13}$] by [0,8].
   Any ideas yet?
6. Finally, try [0,$5x10^{13}$] by [0,8] and this time set xScl to $1x10^{13}$.
   What happened at $2x10^{13}$?

The Limit of the Calculator.

First a couple of definitions. By a small number I mean a number close to 0, and by a large number I mean a number far from 0. Thus, 0.00000000005 is smaller than -5,000,000,000 even though 0.00000000005 is greater than -5,000,000,000.

The calculator can deal with numbers as small as $1\text{x}10^{-999}$ and as large as $9.9999999999999\text{x}10^{999}$ with no problem as long as it doesn't try to mix large, small or average sized numbers at the same time. Then, there can be a problem depending on what you try to do with them. Multiplication is no problem, but addition is another story.

The next thing to understand is that the calculator stores at most 14 consecutive digits of any number. It displays the 1st 10 of those digits and keeps the other 4 hidden. To see this. On the command line, type **1 EE (-) 12 ENTER**. It returns "1E-12". Now type **+ 1 ENTER**. It returns "1" because 1.000000000001 has 13 digits so the last digit of 1 is hidden and rounds to 10 digits for display purposes only. To show you it's still there type **- 1 ENTER**. It returns "1E-12".

Now let's try this with $1\text{x}10^{-14}$. Type **1 EE (-) 14 ENTER**. It returns "1E-14". Type **+ 1 ENTER**. Like before, it returns "1". Again, type **- 1 ENTER**. But, now it returns "0". This happened because $1+1\text{x}10^{-14}$=1.00000000000001 which has 15 digits so to store it the calculator rounds to 14 digits, 1.0000000000000, losing the last digit of 1 instead of hiding it. Thus, when we subtracted 1, we subtracted it from 1 not 1.00000000000001. Which is why it returned "0".

So when $x > 2\text{x}10^{13}$

$1/x < 1/(2\text{x}10^{13})=0.5\text{x}10^{-13}=5\text{x}10^{-14}$

$1+1/x < 1.00000000000005$

which the calculator rounds to 1.0000000000000 . Therefore, when $x > 2\text{x}10^{13}$, the calculator rounds 1+1/x to 1. So when it then does $(1+1/x)^x$, it actually does $1^x=1$. This is why the calculator graphed a horizontal line from $2\text{x}10^{13}$ to the right.

When x is large but less than $2\text{x}10^{13}$ such as 30,000,001.

1/x	$= 1/30{,}000{,}001 = 3.33333322222\text{x}10^{-8}$	
1+1/x	= 1.0000000333333	rounding to 14 digits
	$= 1 + 333333/1\text{x}10^{13}$	from calculator $1\text{x}10^{13}/333333=30{,}000{,}030$
	= 1 + 1/30,000,030	so to the calculator 1+1/30,000,001=1+1/30,000,030

$(1+1/x)^x = (1 + 1/30{,}000{,}030)^{30{,}000{,}001}$

so in effect the exponent is too small.

A strange partial fix.

Set Y2=(1+1/X)^(1/(1/X+1-1)) , graph in the window of $[0,2\text{x}10^{12}]$ by [0,8] with a $\text{xScl}=1\text{x}10^{12}$ and go into trace mode. Remember, that Y1 will graph also unless you unselect it.

Now, as long as $x<2\text{x}10^{12}$, this function approaches 2.7182818285 which is e rounded to the 10th decimal place.

This works because in the exponent, adding 1 to 1/x then subtracting 1 forces the calculator to round it to the 13th decimal place. Then, doing the reciprocal of that rounded number, makes the exponent the value of x that was equivalently used in the base.

For example, when x=30,000,001

1/x + 1	= 1 + 1/ 30,000,030	(from above)
1/x + 1 - 1	= 1/30,000,030	
1/(1/x + 1 - 1)	= 30,000,030	
$(1+1/x)^{(1/(1/x+1-1))}$	$= (1+1/30{,}000{,}030)^{30{,}000{,}030}$	

which at least is in the form that I want. Thus, it gives a better result.

The problem with this method is we still have the $2\text{x}10^{13}$ limit. Unfortunately, there's no way around this limit. Even the most advanced of computers have a limit to the number of digits they store. Therefore, there would be some point at which 1+1/x would become 1.

Note the TI-83/83+ has an oddity with number between $(1+2\text{x}10^{12})$ and $(1+2\text{x}10^{13})$. Even though it does store 14 digits, on this calculator $1+1\text{x}10^{13}-1=0$ instead if $1\text{x}10^{13}$. This why this partial fix only works up to $2\text{x}10^{12}$ and not to $2\text{x}10^{13}$.

Thus, the conclusion is:

YOU MUST BE SMARTER THAN THE CALCULATOR TO KNOW WHEN IT'S GIVING YOU GARBAGE!