

Graphing on the TI-89/92 for College Algebra

The calculator has the ability to approximate the graphs of functions by plotting up to 159 points on the TI-89 and up to 239 points on the TI-92 and then possibly connecting them with lines.

Your screens may look a little different than the ones shown. The following screens are from the TI-89.

Basics

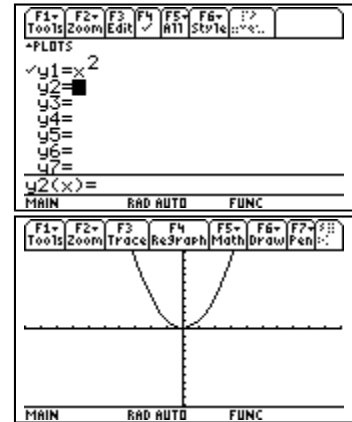
Example#1: Just getting a graph of $y = x^2$.

1. Start from the home screen.
2. Go to the function editor.

Press **◆ Y=** .

If any other functions are there, press **CLEAR** on each of them until they are gone. The functions can also be turned off with **F4:√**.

3. Enter the function as y1.
Type **x ^ 2 ENTER**.
4. Graph the function in a standard window.
Press **F2:Zoom 6:ZoomStd** and wait.
5. Press **EXIT** to return to the home screen.



Example#2: More detailed explanation with $y = 2|x-10|-15$

1. Start from the home screen.
2. Go to the function editor.

Press **◆ y(x)=** .

If any other functions are there, either

- a) delete them by putting the cursor on them and pressing **CLEAR**.
- b) deselect them by putting the cursor on them one by one and pressing **F4:√** until the "=" sign is not reversed.

By deselecting them, they stay in the calculator but are not graphed and they can be selected later with the same process. On the other hand, deleting unneeded functions saves memory and keeps the function editor cleaner.

3. Enter the function as y1.
Type **2 2nd MATH 1:Number 2:abs(x - 10) - 15 ENTER**.
4. Set the viewing window.

Since the calculator can only graph by plotting points, you have to tell it what part of the xy-plane you want to see. In the previous example, we used the standard viewing window, $[-10,10]$ by $[-10,10]$, this means $x=-10$ along the left side of the screen, $x=10$ along the right side, $y=-10$ along the bottom, and $y=10$ along the top. Let's go ahead and do this and see what happens. So press **F2:ZOOM 6:ZoomStd**. ZoomStd stands for "zoom standard".

All we see is a line. But, the equation isn't linear, $y=mx+b$. Thus, the graph can't be a line! Therefore, we need to adjust the window manually.

5. Enter the window setup.

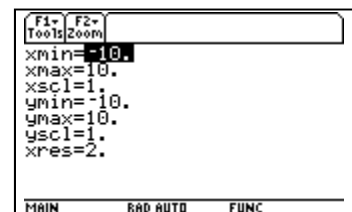
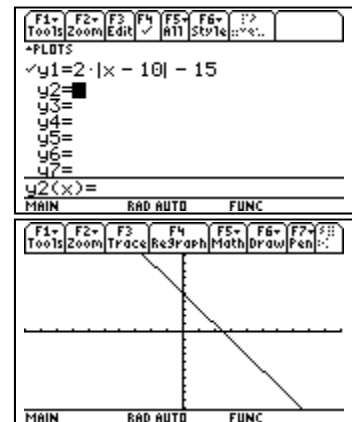
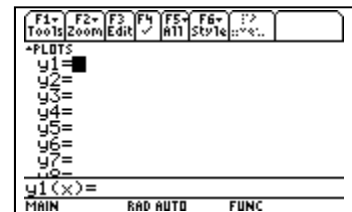
◆ WINDOW.

Here we see the settings for the viewing window.

- xmin: left edge. x's minimum value.
- xmax: right edge. x's maximum value.
- xscl: distance between scale markers on the x-axis.
- ymin: bottom edge. y's minimum value.
- ymax: top edge. y's maximum value.
- yscl: distance between scale markers on the y-axis.
- xres: sets how often to plot points. (1=every column, 2=every other column, etc.)

Now we need to think about the shape and location of the graph. Well the shape of the basic graph $y=|x|$ is a vee opening up and the sharp turn, the vertex, at the origin. The "-10" moves the graph to the right 10 units. The "-15" moves the graph down 15 units. This puts the vertex at the point $(10,-15)$, outside of the standard window. Also, the "2" vertically stretches the graph by a factor of 2.

Therefore, we must make sure that the point $(10,15)$ is in the window. So let's set the window to $[-10,20]$ by $[-20,10]$.



Press \blacktriangledown to skip xmin since it's already -10.

Type **20 ENTER** for xmax.

Press \blacktriangledown to leave xscl at 1.

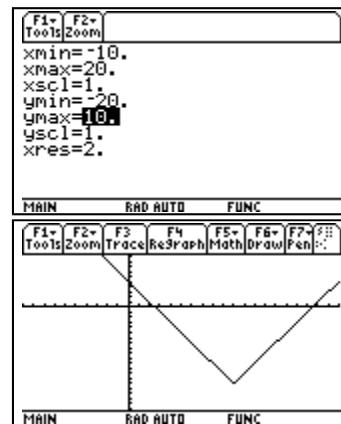
Type **(-) 20 ENTER** for ymin.

That's all I need to do since yMax is already 10.

6. Graph the function.

Press \blacklozenge **GRAPH**.

Now we can see the "complete graph". We can never truly see the entire graph because it keeps going up without stopping. But, we can see the characteristic shape of the graph, a vee.



Zooming

Example#3: Zooming in and out.

1. Graph $y = x^3 - 4x$ in the standard window.

2. Enter the zoom submenu.

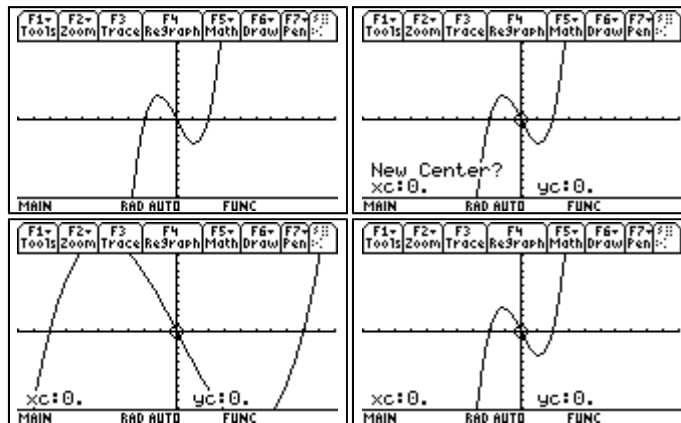
Press **F2:ZOOM**

3. Select zoom-in.

Press **2:ZoomIn**.

4. Set center of zoom.

At the center of the screen there will be a flashing circle which is another cursor. You can move this point with the cursor keys. Go ahead and move it around some. Note, the current value of x and y are displayed at the bottom of the screen. When you're done, move the cursor back to the origin so that we can zoom-in on the origin. When ready, press **ENTER** and wait for the graph to regraph.



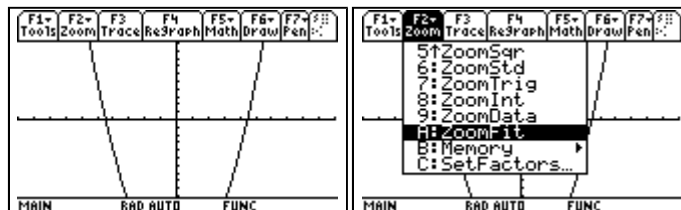
5. At this point, the calculator is waiting for you to reset the center to zoom-in again. But, I want to zoom-out next, so press **F2:ZOOM** to bring the zoom sub-menu back up.

6. To zoom back out, press **3:ZoomOut**. Again the calculator waits for you to set the center of the zoom. Since I want to zoom-out from the origin, press **ENTER** and wait for the graph.

Example#4: Zoom fit.

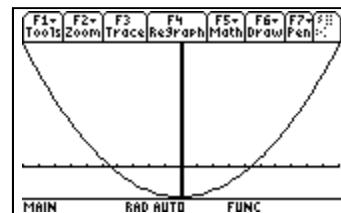
1. Graph $y = x^2 - 20$ in the standard window.

2. You can tell you don't have the complete graph because it disappears off the bottom of the screen and then reappears.



To see the complete graph on the interval $[-10,10]$, press **F2:ZOOM**

A:ZoomFit and wait. The calculator will try to adjust ymin and ymax to fit the graph on the screen. You can press \blacklozenge **WINDOW** to see the new window settings.



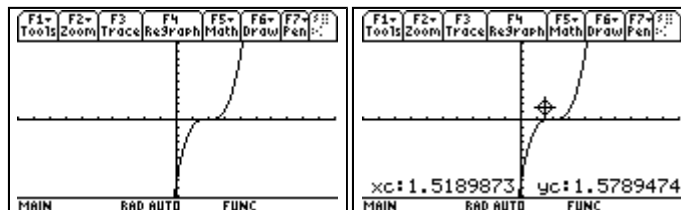
Moving around the screen

Example#5: Just moving the cursor.

1. Graph $y = (x-2)^3$ in the standard window.

2. From here you can call up a cursor by pressing any cursor key. For instance,

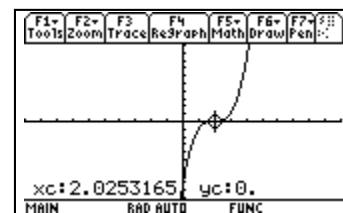
press \blacktriangle . Note that a flashing crosshairs appears. Press and hold \blacktriangle and then \blacktriangleright for a few seconds to see it better. Also, note that the coordinates of the cursor appear at the bottom of the screen.



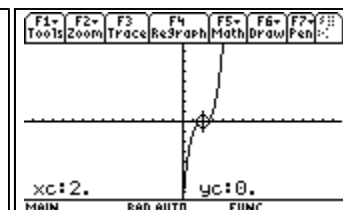
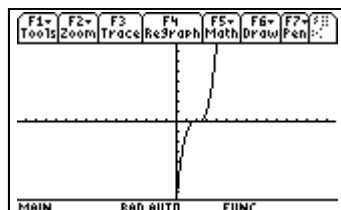
- Now try to put the cursor on the x-intercept using the cursor keys. What are the problems with doing this?

The first problem is that there are four points (pixels) of the curve on the x-axis. (explained in next example)

The second problem is that we can't put the cursor at the point (2,0) which we know is the x-intercept by examining the function. To understand this, first realize that on the TI-89 there are 159 columns of pixels on the screen. The center column is at $x=0$. The right column is at $x=10$, and the left column is at $x=-10$. This is because of the window settings. Since there are 159 columns, there are 158 spaces between the columns. Thus, the distance between the columns is $[10 - (-10)]/158 = 10/79 = 0.126502278481$. A similar situation is caused when you move up or down from row to row or on the TI-92.



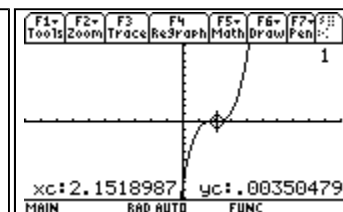
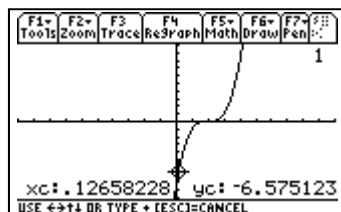
- Change the window to
 TI-89 | [-15.8,15.8] by [-7.6,7.6]
 TI-92 | [-23.8,23.8] by [-10.2,10.2]
 and set xres to 1 on both calculators. Then regraph.



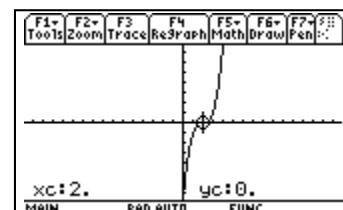
- Now the cursor moves by 0.2 units in any direction. Therefore, we can move the cursor to the point (2,0). But, the y-coordinate is just the y-coordinate of the cursor and not necessarily at a point on the function.

Example#6:Tracing.

- Graph $y=(x-2)^3$ in the standard window again.
- Enter trace mode.
 Press **F3:TRACE**. A flashing crosshairs, the cursor, appears.
- Move the cursor along the function with ◀ and ▶. Note the cursor stays on the function. When more than one function is graphed, ▲ & ▼ switches between them.



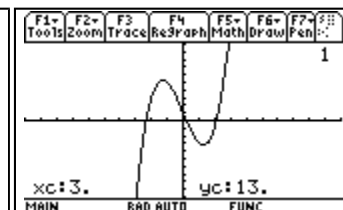
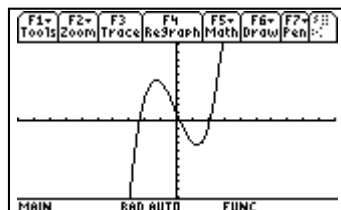
- Move the cursor to the four pixels of the curve on the x-axis. The y value at the bottom of the screen is now the y-coordinate of not only the cursor but also a point on the function. Now we can see why the four points are plotted on the x-axis. Their y-coordinates are so close to zero that the calculator rounded to the same pixel as the x-axis for graphing.
- Move the cursor to the point where the y is closest to 0. Notice that you'll never get y to be 0. Why?
- Now try the window [-15.8,15.8] by [-7.6,7.6] with xres=1 on the TI-89 or [-23.8,23.8] by [-10.2,10.2] with xres=1 on the TI-92. What happens now? Then, remember to return to trace mode.



Eval function

Example#7:Evaluating a function at a value of x.

- Graph $y=x^3-5x+1$ in the standard window.
- Evaluate y at $x=3$ using trace mode.
 Press **F3:Trace**. Enter the value for x by pressing **3 ENTER**.
- Read the value of y across the bottom of the screen. Thus for $y=x^3-5x+1$, $y=13$ when $x=3$.



The Function Editor menu explained:

- F1:Tools**
7:Delete Deletes function.
8:Clear Functions Deletes all functions.
9:Format Adjusts how the graph is displayed.
the rest aren't needed for college algebra.
- F2:Zoom**
2:ZoomIn Zooms-in on a set point.(see ex.3 above)
3:ZoomOut Zooms-out from a set point.(see ex.3 above)
4:ZoomDec Sets the window so that the distance between both columns and rows to 0.1 units.
5:ZoomSqr Adjusts xmax & xmin so that the graph is proportional.(see ex.14 below)
6:ZoomStd Sets the viewing window to [-10,10]by[-10,10].(see ex. 1&2 above)
8:ZoomInt Sets the window so that the distance between both columns and rows to 1 unit.
A:ZoomFit Fits the graph on the screen with out changing xmin and xmax.(see ex.4 above)
the rest aren't needed for college algebra.
- F3:Edit** Edit the function.
F4:✓ Select or deselect the function to graph.
F5:All
1:All Off Sets all functions and plots to not graph.
2:Functions On Sets all functions to graph.
3:Functions Off Sets all functions to not graph.
the rest aren't needed for college algebra.
- F6:Style**
1:Line Sets to draw connecting lines between points.
2:Dot Sets to not draw connecting lines between points.
the rest aren't needed for college algebra.

The Graph menu explained:

- F1:Tools** Same as above.
F2:Zoom Same as above.
F3Trace Enter trace mode(see ex.6 above).
F4:Regraph Graphs all functions again.
F5:Math
1:Value Evaluates a function at a value of x.
2:Zero Finds a zero, x-int., of a function.
3:Minimum Finds a relative mimimum.
4:Maximum Finds a relative Maximum.
the rest aren't needed for college algebra.
F6 & F7 aren't needed for college algebra.

Piece-wise functions and Domain restrictions.

On the TI-89/92 to change the behavior of a function you use the When function.
The syntax is: when(*condition, expression if true, expression if false*)
You can get the when function by typing:

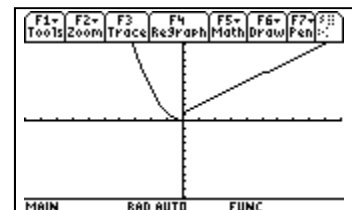
TI-89 | CATALOG w ENTER
TI-92 | 2nd CATALOG w ENTER

Also, the inequalities can be found by pressing **2nd MATH 8:Test**. Also, < and > are on the keypad.

Example#8: Graphing a piece-wise function defined on all reals.

$$\text{For } f(x) = \begin{cases} x+1, & x>0 \\ x^2, & x\leq 0 \end{cases}$$

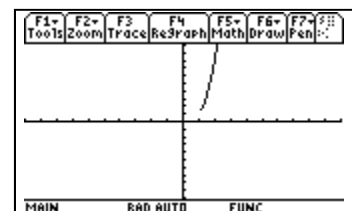
1. Go to the function editor.
2. Enter when(x>0,x+1,x^2) for y1.
3. View the graph in the standard window.



Example#9: Graphing a function with a domain restriction.

$$\text{For } f(x) = x^3, x>1$$

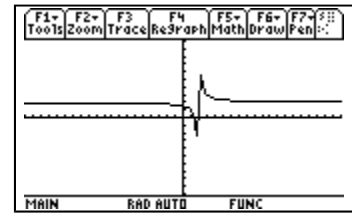
1. Go to the function editor.
2. Enter when(x>1,x^3,1/0) for y1.
This will work because when x>1, y1=x^3. And when x<=1, y1=1/0 which is undefined so the calculator won't graph a point for that x.
3. View the graph in the standard window.
Note the difference between what does happen at (1,1) and what should happen.



Graphing Oddities.

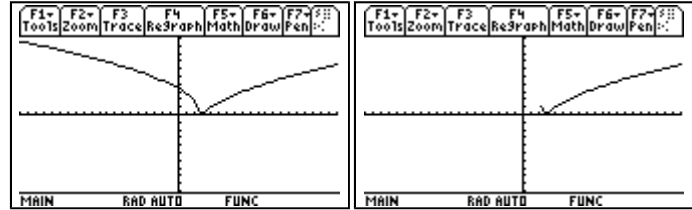
Example#10:Heart beat?

1. Graph $y=(2x-3)/(x-2)$ in $[-20,20],[-10,10]$
2. What happens at $x=2$?
3. Compare this to the same graph in a standard window.
4. What should the real graph look like? Remember how the calculator graphs functions.



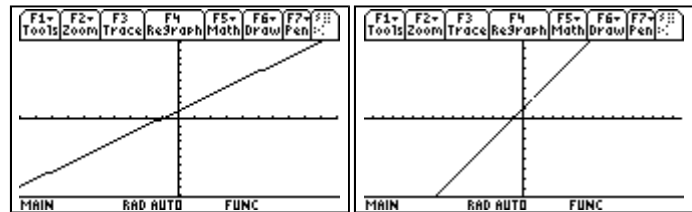
Example#11:Too much graph.

1. Graph $y=2|\sqrt{x-2}-1|$ by hand.
2. Graph $y_1=2\text{abs}(\sqrt{(x-2)-1})$ in the standard window.
3. What's the difference?
4. The difference is the calculator didn't know we wanted to work strictly in real numbers at all steps. Thus, we took the domain to be $\{x|x \geq 2\}$. But, since the calculator knows how to take the absolute value of a complex number, it did and got real numbers for y_1 . So it graphed them.
5. The only fix I know is $y_1=\text{when}(x \geq 2, 2\text{abs}(\sqrt{(x-2)-1}), 1/0)$.



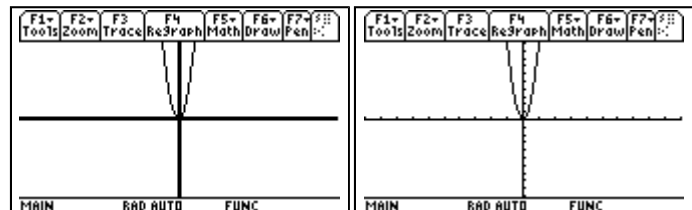
Example#12:Almost a line.

1. Graph $y_1=(x^2-1)/(x-1)$ in the standard window.
2. What does the graph look like? Is that the actual graph?
3. What is the domain of y_1 ?
4. Change the window to $[-15.8,15.8]$ by $[-7.6,7.6]$ with $xres=1$ on the TI-89 or $[-23.8,23.8]$ by $[-10.2,10.2]$ with $xres=1$ on the TI-92.
5. What's the difference? Look closely.
6. Remembering how the calculator graphs, why is there a difference?



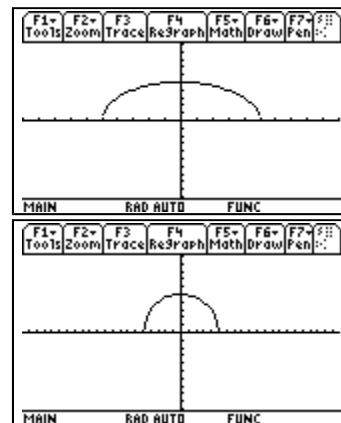
Example#13:Bold axis.

1. Graph $y=x^2$ in the window $[-100,100]$ by $[-100,100]$.
2. The x-axis and y-axis are dark because $xscl=yscl=1$. Thus, the scale markers are right next to each other.
3. To correct this press **◆ WINDOW** and change $xscl$ and $yscl$ to 10.
4. Press **◆ GRAPH**. Now the scale markers represent 10 units.



Example#14:Squeezed circle.

1. Graph $y_1=\sqrt{(25-x^2)}$, the upper semi-circle of radius 5, in the standard window.
2. Notice how it's squeezed. This is because the view screen is wider than it's high and in a standard window both x's & y's range from -10 to 10 causing the graph to be squeezed vertically.
3. Press **F2:ZOOM 5:ZoomSqr**. The semi-circle will be regraphed in a "square" window and will look more like a semi-circle.
4. Notice where the ends of the semi-circle are. Where are they supposed to be?



Appropriate viewing window

An appropriate viewing window shows all of the characteristic parts of a graph. As in,

| <u>Function</u> | <u>Shape</u> | <u>Characteristic Parts</u> |
|-----------------|---------------|--|
| Linear | line | x and y intercepts. |
| Quadratic | parabola | the vertex. |
| Gen. Polyn. | | the x-intercepts, relative extrema, inflection points. |
| Abs. Val. | vee | the vertex. |
| Sq. Root Fn. | half parabola | the endpoint. |
| Cube Rt. | horizontal S | the inflection point. |

(Inflection points are where the graph changes from curving up, like $y=x^2$, to curving down, like $y=-x^2$. For example, both $y=x^3$ and $y=\sqrt[3]{x}$ have inflection points at the origin.)

How do you determine an appropriate viewing window?

Examine the function by hand. The calculator is incapable of determining an appropriate viewing window on its own. Therefore, you **MUST** be able to recognize the possible shape(s) of the graph from the function's expression.