

Graphing on the TI-83/83+ for College Algebra

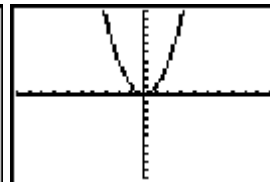
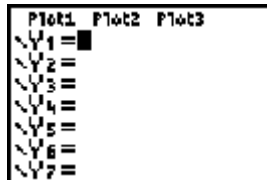
The calculator has the ability to approximate the graphs of functions by plotting 95 points and then possibly connecting them with lines.

NOTE: For the rest of this handout, the X,T,0,n key will be referred to as just X. Since we'll use it to only print a capital X.

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, use **CLEAR** repeatedly until they are gone.
3. Enter the function as Y1.
Type **x x²**.
4. Graph the function in a standard window.
Press **ZOOM 6:ZStandard** and wait.
5. Press **CLEAR** to return to the home screen.



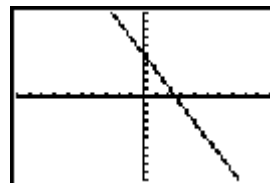
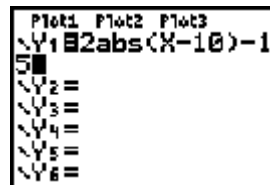
Example#2: More detailed explanation with $y = 2|x-10|-15$

1. Start from the home screen.
2. Go to the function editor.
Press **Y=** .
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 their "=" sign one by one and pressing **ENTER** 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 MATH > 1:abs(X - 10) - 15**.

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 **ZOOM 6:ZStandard**.



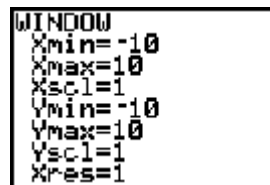
All we see is a line. But, the equation isn't linear, $y=mx+b$. Thus, the graph can't be a line! Therefore, we need to adjust the window manually.

5. Enter the window setup.

Press **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: leave set to 1.



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 **▼** to skip xMin since it's already -10.

Type **20 ENTER** for xMax.

Press **▼** to leave xScl at 1.

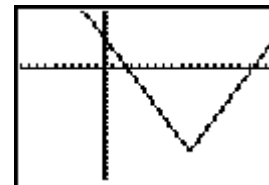
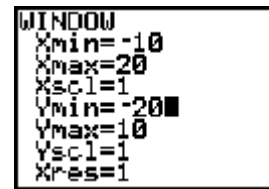
Type (-) 20 ENTER for yMin.

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

6. Graph the function.

Press **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 menu.

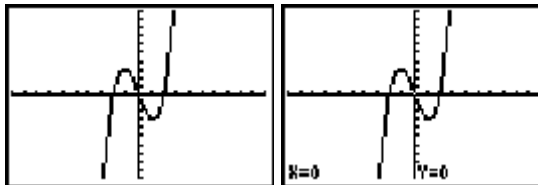
Press **ZOOM**

3. Select zoom-in.

Press **2:Zoom In**.

4. Set center of zoom.

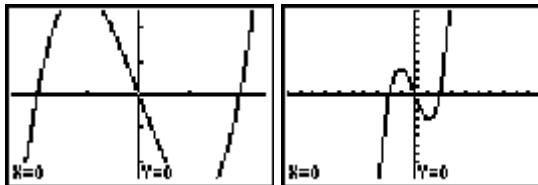
At the center of the screen there will be a flashing pixel (dot) which is another cursor. You can move this point with the cursor keys. Go ahead and move it around



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 **ZOOM** to bring the zoom menu back up.

6. To zoom back out, press **3:Zoom Out**. 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.

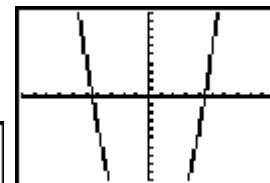
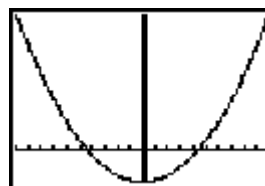


Example#4: Zoom fit.

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 **ZOOM 0:ZoomFIT** and wait. The calculator will try to adjust yMin and yMax to fit the graph on the screen. You can press **WINDOW** to see the new window settings.



Moving around the screen

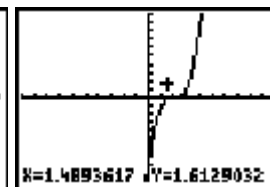
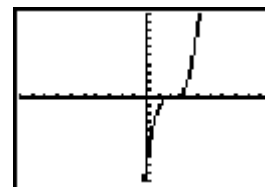
Example#5: Just moving the cursor.

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 **▲**. Note that a flashing pixel and crosshairs appears.

Press and hold **▲** and then **▶** for a few seconds to see it better. Also, note that the coordinates of the cursor appear at the bottom of the screen.

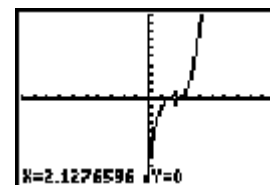


3. Now try to put the cursor on the x-intercept using the cursor keys. What are the problems with doing this?

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

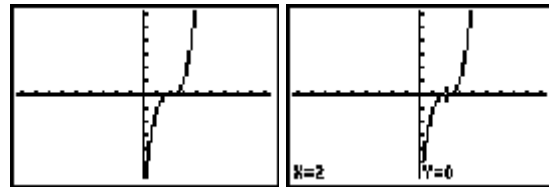
The second problem is that we can't put the cursor at the point $(2,0)$ which we know is the x-intercept by examining the function.

To understand this, first realize that there are 95 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 95 columns, there are 94 spaces between the columns. Thus, the distance between the columns is $[10 - (-10)]/94 = 10/47 = 0.2127659574$. A similar situation is caused when you move up or down from row to row.



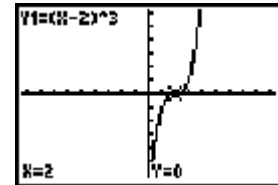
4. Change the window to $[-9.4,9.4]$ by $[-6.2,6.2]$ and regraph.

- 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.

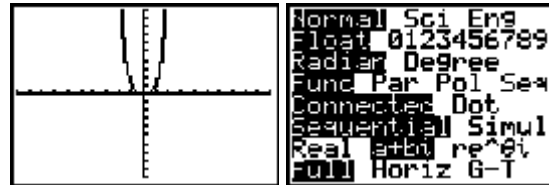
- Graph $y=(x-2)^3$ in the standard window again.
- Enter trace mode.
 - Press **TRACE**. A flashing X, the cursor, appears.
- Move the cursor along the function with **◀** and **▶**. Note the cursor stays on the function. When more than one function is graphed, **▲** & **▼** switches between them.
- Move the cursor to the five 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 five 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 $[-9.4,9.4]$ by $[-6.2,6.2]$. What happens now? Then, remember to return to trace mode.



Format

Example#7: Changing the mode of a graph.

- Graph $y = x^4$ in the standard window.
- Enter the format screen by pressing **MODE**.
- Connected Dot**: Remember at the beginning of this handout I said that the calculator plots 95 points then possibly connects them with lines. Here is where you can set whether it draws the connecting lines or not. To see what I mean, change the setting to Dot by pressing **▼ ▼ ▼ ▼** **▶ ENTER**. Now press **GRAPH**. Do you see the difference? These are the only points that are definitely on the function though approximated to the closest pixel. The rest were just approximating the curve with lines. Go back to the mode screen and change the setting back to Connected.



The Graphing menus explained:

- ZOOM** to change the window in certain ways.
- Zoom In** to zoom-in on a set point. (see ex.3 above)
 - Zoom Out** to zoom-out from a set point. (see ex.3 above)
 - ZDecimal** to set the window to $[-4.7,4.7]$ by $[-3.1,3.1]$ which sets the distance between both columns and rows to 0.1 units.
 - ZSquare** to adjust Xmax & Xmin so that the graph is proportional. (see ex.15 below)
 - ZStandard** to set the viewing window to $[-10,10]$ by $[-10,10]$. (see ex. 1&2 above)
 - ZInteger** to set the window to $[-47,47]$ by $[-31,31]$ which sets the distance between both columns and rows to 1 unit.
 - ZoomFit** to fit the graph on the screen with out changing xMin and xMax. (see ex.4 above)
- the rest aren't needed for college algebra.
- CALC** to perform some mathematical operations. (Explained in later handouts.)
- value** to find the value of a function at a specified value of x.
 - zero** to find a real zero(x-intercept) of a function.
 - minimum** to find a relative(or local) minimum.
 - macimum** to find a relative(or local) maximum.
 - intersect** to find the intersection of two graphs.
- the rest aren't needed for college algebra.

Piece-wise functions and Booleans.

Before we go to an example, let's examine a common mistake by students when trying to use the calculator to solve inequalities such as $3x+2<5$. Solving by hand will get that $x<1$. But many students having discovered the test menu, try to enter the inequality on the command line by typing **3 X + 2 2nd TEST 5:< 5 ENTER**. What happened? Either you got 0, 1 or an error. This is because of two things. First, the variable X is almost always defined to some number as a remnant of the last graph. If it's not defined, you got an error. To see the value of X type **X ENTER**.

The second reason is that the "<" came from the TEST menu. Implying that it was meant for testing variables not solving inequalities. By testing a variable, I mean plugging the value of X into the inequality and comparing the sides. For example, set X to 4 by pressing **4 STO> X ENTER**. Then retype the inequality.

You will get "0" as the result because $x=4$ leads to " $14<5$ " which is false, and the calculator assigns the value of 0 to false statements. What would a value of $x=0$ cause the inequality to return?

Thus, entering inequalities on the command line results in 0 or 1 depending on whether the statement is false or true respectively assuming that x is defined. Statements that are assigned a value of 0 or 1 depending on whether they are false or true are called Booleans, and can be used to graph piece-wise functions.

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 $(X+1)(X>0)+(X^2)(X\leq 0)$ for Y1.

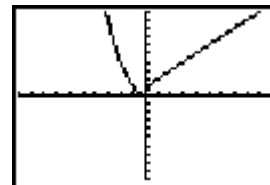
How does this work?

When $X\leq 0$, $(X>0)=0$ and $(X\leq 0)=1$.

Thus when $X\leq 0$, $Y1=(X+1)*0+(X^2)*1=X^2$.

While $X>0$, $(X>0)=1$, $(X\leq 0)=0$ and $Y1=(X+1)*1+(X^2)*0=X+1$.

3. View the graph in the standard window.



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

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

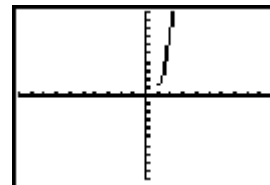
1. Go to the function editor.

2. Enter $(X^3)/(X>1)$ for Y1.

This will work because when $X>1$, $Y1=(X^3)/1=X^3$. And when $X\leq 1$, $Y1=(X^3)/0$ 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.

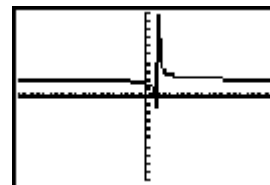
Example#10: Heart beat? (TI-84's don't do this)

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: Missing graph.

1. Graph $y = \begin{cases} \sqrt{x}, & x\geq 0 \\ 3, & x< 0 \end{cases}$ in the standard window.

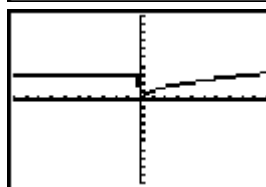
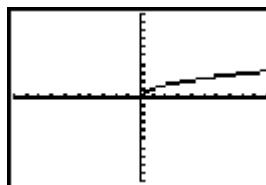
Using $Y1=3(X<0)+(\sqrt{X})(X\geq 0)$

2. What happened to the left side of the graph?

This oddity comes about because the calculator can only graph strictly real numbers. And when for example $x=-1$, $Y1=3(1)+(1i)(0)=3+0i=(3+0i)+(0+0i)=(3+0i)$ which the calculator sees as a complex number, and thus won't graph it.

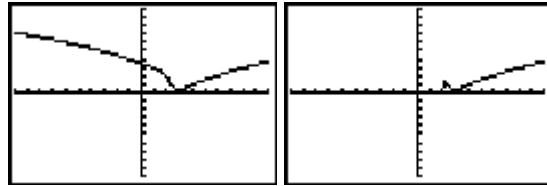
3. Change $Y1=3(X<0)+\sqrt{X(X\geq 0)}$ and graph it.

4. Why does this work?



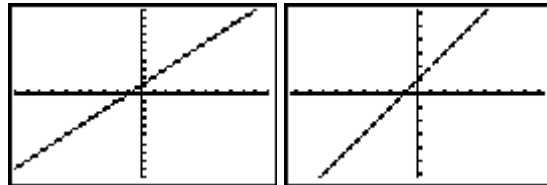
Example#12: Too much graph.

1. Graph $y=2|\sqrt{x-2}-1|$ by hand.
2. Graph $Y1=2\text{abs}(\sqrt{(X-2)}-1)$ 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 Y1. So it graphed them.
5. The only fix I know is $Y1=(2\text{abs}(\sqrt{(X-2)}-1))/(X \geq 2)$.



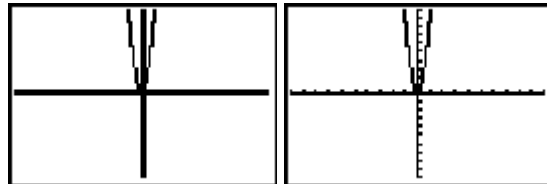
Example#13: Almost a line.

1. Graph $Y1=(X^2-1)/(X-1)$ in the standard window.
2. What does the graph look like? Is that the actual graph?
3. What is the domain of Y1?
4. Change the window to $[-9.4,9.4]$ by $[-6.2,6.2]$.
5. What's the difference? Look closely.
6. Remembering how the calculator graphs, why is there a difference?



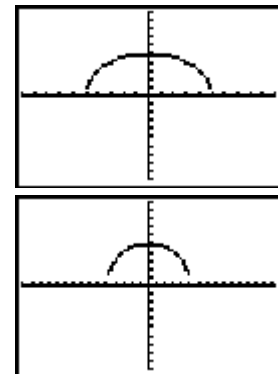
Example#14: Bold axis.

1. Graph $y=x^2$ in the window $[-100,100]$ by $[-100,100]$.
2. The x-axis and y-axis are dark because $Xscl=Xscl=1$. 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#15: Squeezed circle.

1. Graph $Y1=\sqrt{(25-X^2)}$, 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 **ZOOM 5:ZSquare**. The semi-circle will be regraped 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.	horz. 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.