

## **USE OF GRAPHING CALCULATOR WITH FUNCTIONS**

Although some functions' graphs are relatively easy to understand and analyze, many others are not. The use of the TI-83+ graphing calculator can greatly expand your knowledge of functions over a wide range of possibilities. However, the calculator's technology may sometimes cause misinterpretations of explorations because the calculator is designed to graph only functions and not relations. You will utilize the calculator's features and learn to recognize situations where you must reassess the calculator's results in order to gain a truer understanding of the functions you wish to investigate.

Graphing with the Graphing Calculator

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*Example #1:* Graph the function,  $f(x) = 33x^3 - 22x^2 + 11x - 1$ .

The large coefficient values for this function make calculating  $y$ -values in a table of values cumbersome and time consuming. For relatively small values of  $x$  in the domain, the range values become large. For example, letting,  $x = 3$  we have:

$$\begin{aligned}f(x) &= 33x^3 - 22x^2 + 11x - 1 \\f(3) &= 33(3)^3 - 22(3)^2 + 11(3) - 1 \\&= 33 \times 27 - 22 \times 9 + 33 - 1 \\&= 891 - 198 + 33 - 1 \\&= 725\end{aligned}$$

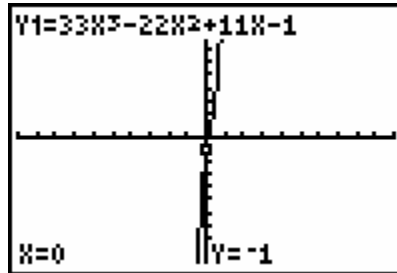
Fortunately the TI-83+ can accommodate these excessively large (or excessively small) values with relative ease.

**Note:** For the majority of units in this course, which require the use of the graphing calculator, exact keystroke commands will be given. However, students are expected to already possess a level of familiarity with the calculator's menus and features from previous math courses. Students should have some knowledge of how to troubleshoot common errors that may arise. Consult your calculator's handbook to insure that your calculator functions correctly.

Graph the function,  $f(x) = 33x^3 - 22x^2 + 11x - 1$ , on the TI-83+, and estimate the root(s) of the function.

*Step #1:* Press the  $\boxed{Y=}$ , then type in the equation as written. The  $\boxed{X^2}$  command is on the front of the calculator. The  $\boxed{X^3}$  command, and higher powers, can be obtained by typing  $X \boxed{\wedge} 3$ . The X can be entered using the  $\boxed{X,T,\theta,n}$  button.

Step #2: Press **ZOOM**, then #6: ZStandard, then **TRACE** on the keypad to select the standard  $-10$  to  $10$  graphing window. Your results should display the following:



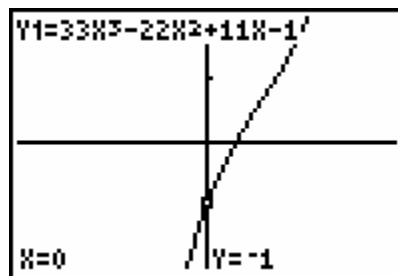
As you can see, the graph of the function is barely discernible from the  $y$ -axis. To see the graph more clearly, we will adjust the viewing window. Particularly, we will narrow our view horizontally by shortening the  $x$ -axis.

Step #3: Press **WINDOW**, and set  $X_{\min} = -3$ ,  $X_{\max} = 3$ , then press **GRAPH**. The new graph displays more detail but is still narrowly centered about the  $y$ -axis. Reselect **WINDOW**, and set  $X_{\min} = -1.75$ ,  $X_{\max} = 1.75$ . (Readjust the window as often as needed to see more detail).

Step #4: Because we wish to estimate the ‘zero(s)’ or ‘root(s)’ of this function, we need to see more detail for function values close to the  $x$ -axis. Recall that the roots of a function are found when  $f(x) = 0$  or when

$f(x) = 33x^3 - 22x^2 + 11x - 1 = 0$ . Graphically, roots are found when  $y = 0$ , or when the graph of the function is crossing the  $x$ -axis.

Press **WINDOW**, and set  $Y_{\min} = -2$ ,  $Y_{\max} = 2$ , then press **GRAPH**, **TRACE**. Continue to readjust the window as often as needed to see a graph similar to the following:



The horizontal detail is now strong and we can view more details about the function as it crosses the  $x$ -axis.

*Step #5:* Press **TRACE** once you have selected a proper viewing window. At the bottom of the graph, the  $x$  and  $y$  values of your flashing cursor are displayed. Use your right or left arrows to trace to a point that is closest to the  $x$ -axis. For this example we have selected the following values:

$$x = 0.11170213; \quad y = 2.1506 \times 10^{-4}$$

This  $y$  value is approximately  $2/10,000$  above the  $x$ -axis. Therefore, in this example we can conclude that for:  $x \approx 0.11170213, f(x) \approx 0$

*Example #2:* Graph the relation,  $(x-3)^2 + y^2 = 4$ , and estimate values for the domain and range that will analyze this relation as a restricted function.

As noted earlier, the TI-83+ will only graph functions and not relations. In addition, the calculator's graphing editor, found under the, **Y=** key, will only accept expressions for  $y$  in terms of  $x$ . In order to graph this equation as a relation, then as a restricted function, we will need to solve the equation for  $y$ .

*Step #1:* Solve  $(x-3)^2 + y^2 = 4$  for  $y$ .

*Note:* For the calculator to properly accept our equations, it is necessary to quantify each step in the process by inserting a new set of ( )'s.

$(x-3)^2 + y^2 = 4$	
$y^2 = 4 - (x-3)^2$	Subtract the quantity, $(x-3)^2$ .
$y^2 = (4 - (x-3)^2)$	Insert ( )'s to quantify the right side of the equation.
$y = \pm\sqrt{(4 - (x-3)^2)}$	Find square root of both sides.

Remember that in so doing we must consider both  $\pm$  results. We therefore have two equations for  $y$ . They are:

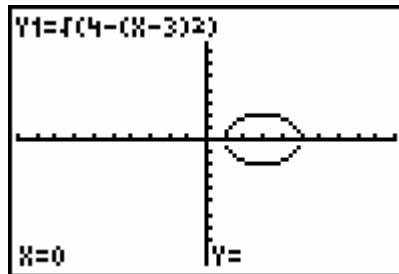
$$y = +\sqrt{(4 - (x-3)^2)} \quad y = -\sqrt{(4 - (x-3)^2)}$$

*Step #2:* Type both equations into the calculator's **Y=** graphing editor.

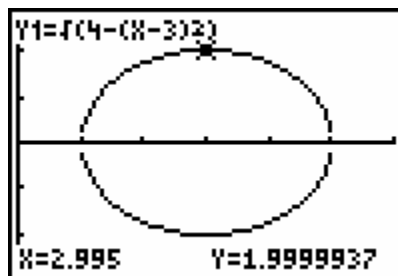
For  $Y_1 = \sqrt{(4 - (x-3)^2)}$ , the, "  $\sqrt{(\quad)}$  " symbol is found by pressing, **2nd**,  **$x^2$** .

For  $Y_2 = -\sqrt{4-(x-3)^2}$ , be sure to select the white  $(-)$  key and not the blue  $(-)$  subtraction key in front of the radical.

Press **ZOOM** 6 to view your graph. Your graph should appear as the following:



*Step #3:* Select **WINDOW** and adjust your Xmin, Xmax, Ymin, & Ymax to view the graph in an appropriate window. After some adjustments, you should see a display similar to the one below.



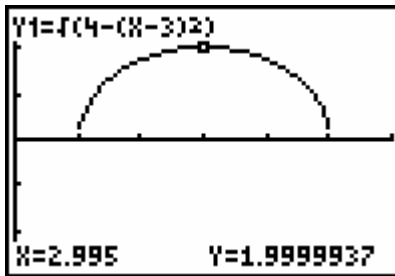
*Step #4:* Press **TRACE** and record the left most and right most values for  $x$  as the values for the domain. To switch from the top half of the curve to the bottom half use your up and down arrows. Record the uppermost and lowermost  $y$  values as your range.

*Step #5:* State your recorded domain and range values in interval notation.

$$D_x = [1.011, 4.957] \quad R_y = [-1.9999, 1.9999]$$

*Step #6:* View the relation as a restricted function.

Press  $\boxed{Y=}$ , highlight the '=' sign on  $Y_2$ , then press,  $\boxed{\text{ENTER}}$ . This turns the graph of  $Y_2$  off. Press  $\boxed{\text{GRAPH}}$ . You only see the top half of the relation.



If we imagine a vertical line intersecting this curve at any point, we see that the top half (or the bottom half –try this on your own) is a restricted function. We can state this function as:

$$f(x) = \sqrt{4 - (x - 3)^2} \text{ for } D_x = [1.011, 4.957] \quad R_y = [0, 1.9999]$$