# An Introduction to Graphing Calculator Basics: Graphing Functions and Solving Equations

**Audience:** Teachers of mathematics who have little or no experience with graphing calculators.

**Required Technology:** Texas Instruments TI-83 Plus Graphing Calculator.

**Goal:** To develop a basic familiarity with your graphing calculator (GC) - especially graphing basic functions. In particular, you will learn how to plot several linear functions simultaneously, alter your viewing window, zoom in and out, and determine where two graphs intersect.

**Prerequisites:** None - but patience is a plus!

### Entering and Graphing Functions

First we will learn how to enter a few functions in your GC.

1. After your GC been turned on, find the [Y=] key in the upper left corner of your GC. Press the key and the cursor should be blinking next to the $\backslash Y_1 =$ area of your view window.

2. Type 2 [X,T,$\theta$,n] + 1 to enter the function $y = 2x + 1$. Then press [ENTER] in the bottom right corner of your GS.

Likewise, enter the functions $y = -x + 1$ and $y = x + 2$ next to the $\backslash Y_2 =$ and $\backslash Y_3 =$ areas of your view screen. Note: To enter the minus sign for $y = -x + 1$ you must use the [(-)] key near the bottom right corner. If you try to use the blue [-] key you will get an error.

3. Now press the [GRAPH] key in the upper right corner of your GS. You should see three lines displayed in your view window.

### Altering Your View Window

Next we will see how to change parameters that affect your view window.

1. Press the [WINDOW] key which is next to the [Y=] key. You will see several parameters listed including Xmin = -10 and Xmax = 10. Change the first parameter so that it reads Xmin = -5. Use the "down arrow" key to move down and then make the change Xmax = 5.

2. Then press the [GRAPH] key again. How did your plot change?

3. Press the [WINDOW] key again. Experiment with the Xscl and the Yscl parameters. Re plot your functions. What is the purpose of Xscl and Yscl?

### Using the Zoom Options

You may view the ZOOM Menu by pressing the [ZOOM] key which is next to the [WINDOW] key. We will look at the first three options: ZBox, Zoom In, and Zoom Out. For each of these the zoom cursor will appear as a blinking (+) on your screen.

**ZBox:** This allows you to create your own viewing box in the display.

1. Select 1:ZBox from the ZOOM menu.

2. Move the zoom cursor to the desired location using the arrow keys. Then press [ENTER]. This defines a corner of your new box.

3. To create your box, use the arrow keys to expand the zoom cursor into the desired area. Then press [ENTER] again to see the contents of your new box magnified.

**Zoom In and Zoom Out:** These options allow you to magnify a portion of the screen around the zoom cursor or display a greater portion of the plot around the cursor.

1. In the ZOOM menu choose 2:Zoom In.

2. Position the zoom cursor by using the arrow keys. Then press [ENTER] and new display will be a "zoomed-in" rendering of your previous graph about the zoom cursor. You can continue to press [ENTER] for further zooms.

3. The zoom out option works the same way as zoom in - just choose 3:Zoom Out from the Zoom menu.

*Note*: You can always return to the original graph using the default settings by choosing 6:ZStandard from the zoom menu. This is often useful if you have zoomed in or out too much.

*Exercise*: Go back to the three linear functions you graphed earlier. You will see three points of intersection - one for each pair of lines. Use the zoom options that you have just learned to graphically estimate where these lines intersect. See if you can do this using both the ZBox and Zoom In approaches. Later we will learn other techniques for finding the point(s) of intersection of two graphs.

**How to Trace with your GS**

In this section we will learn the simple technique of tracing on your GC. This allows you to move your cursor along a graph and see the $x$- and $y$-coordinates change in real time as the cursor moves. This is another way you can graphically estimate where two graphs intersect.

1. Display your graph containing the three linear functions.

2. Press the [TRACE] key which is next to the [ZOOM] key. The cursor should be blinking on one of the graphs. The equation of that particular graph should be displayed in the upper left corner of your view window. On the bottom of the window you should see the $x$- and $y$- coordinates of the point

on the graph corresponding to the cursor.

3. Using the left and right arrow keys, move your cursor along the graph. You should see the $x$- and $y$- coordinates changing with the cursor. Estimate where this line intersects each of the other two lines by moving the cursor. You may need to use some zoom options as well to get a better view of these intersections.

4. To switch the cursor from one graph to another, use the up and down arrow keys. Repeat (3) above to look for points of intersection.

### A Few Special Calculations

There are some nice operations that you can perform using the CALCULATE Menu. You can find zeros ($x$-intercepts) of functions, maximum and minimum values, and points of intersection for two graphs. (There are some other more sophisticated operations as well).
**Zero:** To find a zero or $x$-intercept of a function, do the following:

1. To get to the CALCULATE Menu, press [2nd] [TRACE] and the menu should appear.

2. Choose 2:zero from this menu. You should see a blinking cursor and a prompt for Left Bound? To enter this bound move the cursor to the left of where the zero appears to be. Then press [ENTER].

3. Now you will be prompted for a right bound. Move the cursor to the right of where the zero appears to be. Again, press [ENTER].

4. Finally you will be prompted for a Guess? Move the cursor to where the zero appears to be and press [ENTER]. The GC will then use this information to numerically compute the zero. The $x$-coordinate will be displayed in the lower left corner of the display.

**Maximums and Minimums:** Your GC can also find maximum and minimum values of functions over given intervals. You can apply these using 3:minimum and 4:maximum from the CALCULATE menu. Like the zero option, you will be prompted for a Left Bound, a Right Bound, and a Guess. After inputting this data you GC will display the $x$- and $y$- coordinates of the minimum (respectively maximum) in the lower portion of your display

window. These options are not very interesting for linear functions (why?). However, when we look at quadratics and other functions later on, these options will be more useful.

**Intersect:** The intersect option will allow you to find the coordinates of a point where two or more graphs intersect.

1. Display the graphs of your three linear functions once again.

2. Under the CALCULATE menu, choose 5:intersect.

3. You will be prompted by First curve? You will see the cursor on one line and the corresponding equation in the upper left corner. Press [ENTER].

4. Now you will be prompted by Second Curve? You can switch to the other functions by using the up and down arrow keys. Choose one of the functions and then press [ENTER].

5. Finally, you will be prompted by Guess? Move the cursor using the left and right arrow keys until the cursor appears to be on the point of intersection. Then press [ENTER]. The GC will display the $x$- and $y$- coordinates of the point of intersection in the lower left corner of your display.

### Further Exploration

Now you should experiment with some other functions.

1. Try graphing the quadratic $f(x) = -x^2 + 2$. To do an exponent on your GC you will need to use the [^] key, i.e $x^2$ is entered as [X,T,$\theta$,n] [^] 2. Also graph $g(x) = x^2$.

a. Find the roots (zeros) of $f(x)$. Do this graphically using window and/or zoom options. Also do this by tracing and using the zero option under the calculate menu.

b. Use multiple approaches like you did in part (a) to determine the point(s) where $f(x)$ and $g(x)$ intersect.

c. Determine where maximum and/or minimum values are for $f(x)$ and $g(x)$. Do this graphically as well as using the maximum and minimum options under your CALCULATE menu.

2. a. Graph the function $h(x) = x + 50$ using the default window (which means just graph it without altering the window). What do you see? Why do you think this happened?

b. Use both window techniques and then zoom techniques to fix the problem you encountered in (a).

3. For both (1) and (2), make the graphs by hand on paper.

**Note**: It is very important not to become too dependent on graphing calculators. Students should use them as a tool, not as a crutch. Thus it is wise to make sure that many of the tasks being performed on the GC can also be done by hand on paper. This also helps students build intuition about how to interpret the output of a GC and when that output is incorrect (whether the result of faulty input or some other error). You do not want your students to think of their GC as "The Black Box of Truth", which is a problem with many students these days. Just because something is output from a GC does not mean it should not be questioned or examined.