

## Using the Graphing Calculator

Some Expectations:

1. Be able to enter expressions correctly. (Correct use of brackets, exponents, etc.)
2. Be able to choose an appropriate window, graph functions, use the **zero**, **value**, **minimum**, **maximum** and **intersect** functions.
3. Be able to **store** values for use in calculations (see last page of handout). 💣 Do not round intermediate calculations!
4. Be able to solve equations and inequalities graphically.
5. Present a graphical solution properly. A graphical solution must include a sketch of the appropriate *GC* window, window dimensions, a statement of what functions  $Y_1$  and  $Y_2$  represent and labels on the graph indicating which function is  $Y_1$  and which is  $Y_2$ . If axes appear in the window, they should be labelled and have arrowheads indicating the positive direction.

I will not cover all of the above topics in this handout. You should also do the Math Department Calculator Workshop. Come to my office hours or go to the MLC if you are having difficulty with the graphing calculator.

The answers to the following examples can be found on my website.

Example 1: Evaluate the following expression to 3 decimal places using your graphing calculator. Watch your brackets!

$$\sqrt{5} + \frac{3}{2 \times 5} - \pi \approx$$

You access the  $\pi$  symbol by pushing 2<sup>nd</sup>, ^ (the exponent button).

$$\frac{21(3^4) + 73}{5 - 7(9.2)} \approx$$

## Table

First, let's set up the table so that we can enter  $x$  values and have the calculator return  $y$  values. (We are not able to enter  $y$  values and have the calculator return  $x$  values.)

Push  $2^{\text{nd}}$ , WINDOW (TBLSET in yellow or blue above this button). Set "Indpnt" to "Ask" by moving the cursor on top of "Ask" and pushing ENTER. "Ask" should now be highlighted (black). Set "Depend" to "Auto" in the same manner.

TABLE SETUP	
TblStart=0	
$\Delta$ Tbl=1	
Indpnt: Auto	<input type="checkbox"/>
Depend: <input checked="" type="checkbox"/> Ask	

Let's enter a function so that we can use the table. Push  $Y=$ . Enter  $Y_1 = \sqrt{x^2 + 3x + 1}$ . The table feature is accessed by pushing  $2^{\text{nd}}$ , GRAPH (TABLE in yellow or blue above this button). Type 3 in the  $x$  column then push ENTER. You should see 4.3589 appear in the  $Y_1$  column. To see a more accurate decimal expansion of the value, move your cursor to highlight 4.3589 and look at the bottom of the screen. To evaluate  $Y_1$  for other values of  $x$ , you may either enter a new value in place of the 3 or enter a new value below the 3. When the  $x$  column is full, just type new values over the old values.

X	Y <sub>1</sub>	
3	4.3589	
Y <sub>1</sub> =4.35889894354		

## The Graphing Window

Push WINDOW. Xmin is the leftmost  $x$  value on your graphing screen, Xmax is the rightmost  $x$  value on your graphing screen. Ymin is the lowest  $y$  value on your graphing screen, Ymax is the highest  $y$  value on your graphing screen. These dimensions can be changed by typing in different values. Note that you will get an error if Xmin is not less than Xmax or Ymin is not less than Ymax. Xscl and Yscl give how often scale marks will appear on the  $x$ - and  $y$ -axes, respectively. On a test, we will state the window dimensions as [Xmin, Xmax] by [Ymin, Ymax]. To quickly get a window with dimensions [-10, 10] by [-10, 10], press ZOOM, 6: ZStandard. Investigate Zoom In and Zoom Out from the ZOOM menu. Choosing either one of these will take you to your graphing screen. If you push the left/right/up/down cursor keys, you should see a "+" on the screen. Move this "+" to where you want the centre of your new window to be. Push ENTER. The calculator will zoom in (or out).

## Solving Equations Graphically

Example 2: Solve  $4|x^2 - 7| + 9 = 8x - \sqrt{3}$  graphically to 3 decimal places.

1. Push the  $Y =$  button. Enter  $Y_1 = 4|x^2 - 7| + 9$  and  $Y_2 = 8x - \sqrt{3}$  (or  $Y_1 = 4|x^2 - 7| + 9 - (8x - \sqrt{3})$  and  $Y_2 = 0$ ) into your calculator. The absolute value function is accessed by pushing MATH, right cursor to highlight NUM, 1:abs(

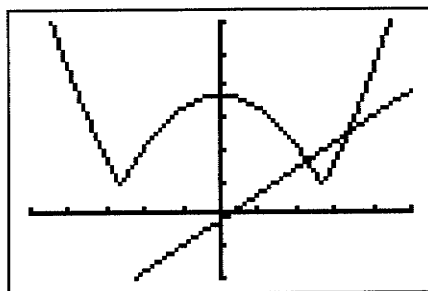
```

Plot1 Plot2 Plot3
\Y1=4abs(X^2-7)+9
\Y2=8X-√(3)
\Y3=
\Y4=
\Y5=
\Y6=
    
```

2. Graph  $Y_1$  and  $Y_2$  (by pushing GRAPH). Adjust your window dimensions so that all intersection points are visible and the graph is not too squished in any direction. For example, you could use the window dimensions shown below.

```

WINDOW
Xmin=-5
Xmax=5
Xscl=1
Ymin=-20
Ymax=60
Yscl=10
Xres=1
    
```



3. Find the intersection points using the Intersect command: 2<sup>nd</sup>, TRACE (CALC in yellow or blue above this button), to get CALCULATE menu. Choose 5:intersect by either pushing 5 then ENTER or by pushing the down cursor button until 5: is highlighted then push ENTER. The calculator will ask you some questions.

```

CALCULATE
1:value
2:zero
3:minimum
4:maximum
5:intersect
6:dy/dx
7:∫f(x)dx
    
```

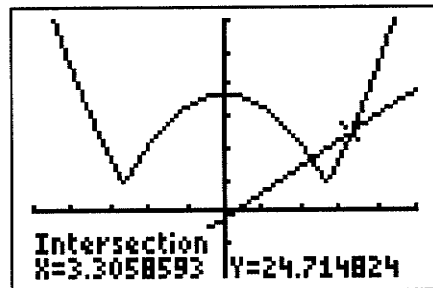
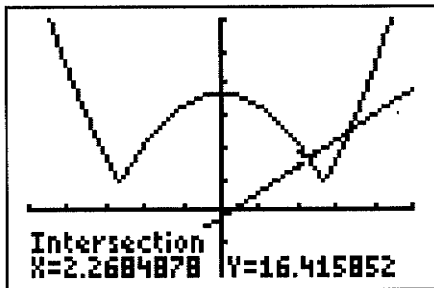
In the upper left hand corner, it will state the function you have entered as  $Y_1$ . In the bottom left hand corner it will say "First curve?" The calculator is asking you if  $Y_1$  is one of the curves involved in the intersection (the calculator can only do an intersection of two curves.) Push ENTER to confirm that  $Y_1$  is desired.

Now the upper left hand corner will say  $Y_2$  and the lower left hand corner will say "Second curve?". To confirm that we want  $Y_2$ , push ENTER. (If we had  $Y_1$ ,  $Y_2$  and  $Y_3$  on the screen and wanted to do the intersection of  $Y_2$  and  $Y_3$ , we would use the up or

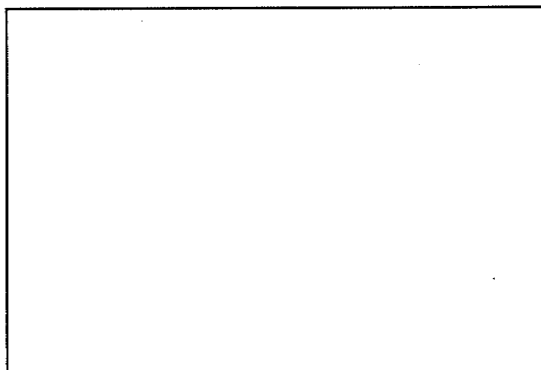
down cursor to scroll through the list of functions on the screen and make the appropriate choice.)

Now the calculator will say "Guess?" in the lower left hand corner. Use the left and right cursor buttons to move the cursor to the intersection point you wish to calculate. Push ENTER.

The calculator will say "Intersection" and state the coordinates of the intersection point. Repeat this procedure (starting at the beginning of step 3) for each different intersection point.



4. Since solving  $4|x^2 - 7| + 9 = 8x - \sqrt{3}$  means finding all values of  $x$  that make the equation true, the  $x$ -coordinates of the intersection points are the solution.
5. Present your solution correctly, including all appropriate details.



Window: [     ,     ] by [     ,     ]

Solution: \_\_\_\_\_

Sometimes we need to find all values of  $x$  so that a function has a given value. We can do this by entering the function in  $Y_1$  and also the horizontal line  $Y_2 =$  (the given value). The  $x$ -coordinates of the intersection points are the desired values of  $x$ .

Example 3: Let  $f(x) = x^3 - x + 4$ . Determine (to 3 decimal places) the value(s) of  $x$  if  $f(x) = 5$ .

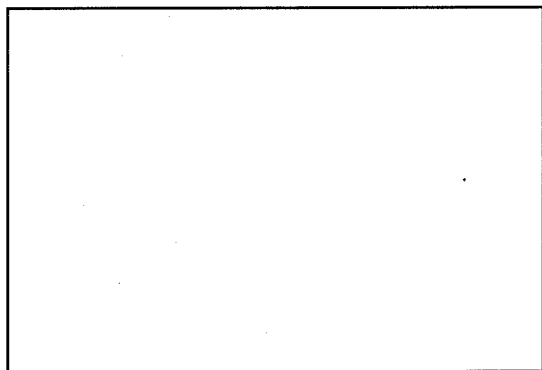
## Solving Inequalities Graphically

Example 4: Solve  $x^3 + 3x^2 - 2x + 1 \geq 2x + 8$  graphically to 2 decimal places.

1. It is usually easiest to solve inequalities graphically if we first add/subtract terms so that one side is zero and all nonzero terms are on the other side. Performing the necessary algebra, we have  $x^3 + 3x^2 - 4x - 7 \geq 0$ . Enter  $Y_1 = x^3 + 3x^2 - 4x - 7$ . Push GRAPH. Adjust the window dimensions so that you can see all the  $x$ -intercepts of the graph.
2. Determine all of the  $x$ -intercepts by either using the Intersect command (you will need to enter  $Y_2 = 0$  for this method so that you have two curves intersecting) or by using the Zero command as follows (do not enter  $Y_2 = 0$ ).

Push 2<sup>nd</sup>, TRACE (CALC in yellow or blue above this button), 2:zero. In the upper left hand corner, it will say  $Y_1 = x^3 + 3x^2 - 4x - 7$ . In the lower left hand corner, it will ask "Left bound?". Use the left/right cursor buttons to move the cursor to the left of one of the  $x$ -intercepts. Push ENTER. Now it will say "Right bound?". Use the left/right cursor buttons to move the cursor to the right of the same  $x$ -intercept. Push ENTER. The calculator will now say "Guess?". Move the cursor on top of the  $x$ -intercept (not really necessary). Push ENTER. The calculator will state "Zero" and give the coordinates of the  $x$ -intercept. Repeat this process (starting from the beginning of step 2) for each  $x$ -intercept.

3. For this example we want to solve  $x^3 + 3x^2 - 4x - 7 \geq 0$ . In other words, we want all the  $x$  values that make  $Y_1$  have zero or positive value. We want all of the  $x$  values that cause  $Y_1$  to lie on or above the  $x$ -axis. Record your solution using interval notation.



Solution: \_\_\_\_\_

## Miscellaneous Calculator Tips

To get back to the home screen where we do arithmetic calculations, push 2<sup>nd</sup> MODE (notice QUIT is written in yellow or blue above MODE button).

The subtraction sign (blue button) is not interchangeable with the negation sign (white button).

The calculator will only graph (or show in the table) the functions whose equal signs are selected (highlighted black). To activate or deactivate function, move the cursor on top of the "=" and push ENTER.

To retrieve the last line you entered, push 2<sup>nd</sup> then ENTER. To retrieve the last answer the calculator provided, push 2<sup>nd</sup> then the white negative sign button.

You can delete characters using the DEL button. You can insert characters by using 2<sup>nd</sup> DEL (INS in yellow or blue above this button).

CLEAR - clears the display. Pushing it once it clears the line you are working on. Pushing it again clears the whole screen if you are on the home screen.

X,T,θ,n - used to enter the variable  $x$  for equations and graphing

STO→ To store a value, enter the value (or push 2<sup>nd</sup> then white negative symbol if you wish to store the previous answer) then push STO→, then green ALPHA button, then the button which has the letter you wish to store it as in green above it, and then ENTER. The STO→ button is second from the bottom on the left side.

### Practice:

1. Let  $y = 2x^3 - 8x^2 + 3$ . Use your graphing calculator to find the following values (rounded to 2 decimal places, where appropriate)

- (a) value of  $y$  when  $x = 1.7$       (b) all values of  $x$  such that  $y = 2$   
(c) value of  $y$  when  $x = -3.6$       (d) all values of  $x$  such that  $y = 15$   
(e) the  $x$ -intercept(s)              (f) the  $y$ -intercept(s)

Answers: (a) -10.29    (b) -0.34, 0.37, 3.97    (c) -193.99    (d) 4.32  
(e) -0.57, 0.67, 3.90    (f) 3

2. Solve  $0.3x^2 - 2x + 17 = 2x + 5$  graphically to 2 decimal places. See website for solution.

3. Solve  $2x^2 - 3x - 1 \leq 3 - 16x + x^2$  graphically to 2 decimal places. See website for solution.