MATH 110
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Using Your TI-89/Voyage 200

Guidebooks for all Texas Instruments calculators can be downloaded (in Adobe PDF format) from
http://education.ti.com/en/us/guidebook/search Just search for your type of calculator. For your convenience I
have also placed them in the Project Directory for our class in the folder *Information*.

Tips to Save Typing, etc.

1. To clear the home screen, press F1 then option 8:Clear Home.
2. To avoid retyping something that already appears on the home screen, scroll up to the item you want so that
it is highlighted, then press ENTER. This will paste that item into the entry line.
3. The minus sign ⊟ is next to the 6, the negative number sign (-) is below the 3.
4. The backspace key ← on the TI-89 is next to the CLEAR button. On the Voyage 200 it is next to = on the
bottom row.
5. To clear the entry line, press the CLEAR button.
6. The absolute value, floor, ceiling, and other functions can be found by pressing 2nd[MATH] (above the 5),
then choosing option 1:Number.
7. To use the algebra capabilities and later other capabilities, you must be on the home screen. On the TI-89
press the HOME button. On the Voyage 200 press the green diamond button ◆ (next to the ON button) and
then the HOME button (above the Q).
8. Always zoom to the standard screen (F2 6:ZoomStd) before moving on to a new graph.
9. Pressing escape ESC gets you out of any menu.
10. If your screen seems too bright or too dim, repeatedly press the green diamond button ◆ followed by ⊟ to
dim it or + to brighten it.
11. You can save something as a variable by typing the value,
followed by the STO button (to the left of the 1 button on the TI-89
and to the left of the spacebar on the Voyage 200) and then typing a
variable name.
12. If you want to clear all the variables you have assigned, press 2nd
F6 option 1:Clear a-z.
13. If you want to clear the home screen, press F1 option 8:
Clear Home.

14. To find an approximate value of a number, for example $\sqrt{2}$, enter the number and press ◆ ENTER to get an
approximation [≈].
15. The entry line uses *overwrite* as the default. If you want to *insert* something in the entry line, use the arrow
buttons ◁ ▷ to get the correct spot, then press 2nd[INS] (above the backspace key ←) and type what you want
to insert.
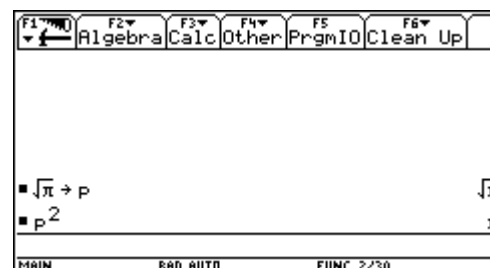
I.   Defining a Function with the TI-89 or Voyage 200

A real-valued function *f* defined on a set of real numbers *D* is a rule that assigns to each number *x* in *D* exactly
one real number, denoted by *f* (*x*). The set *D* is called the domain of *f* and the set of all values $y = f(x)$ is
called the range of *f*.

This can be done from the home screen, which looks like the image
at the right. If you are not at this screen, on the Voyage 200 press the
green diamond button ◆ (next to the ON button) and then the
HOME button (above the Q). On the TI-89 just press the HOME
button.
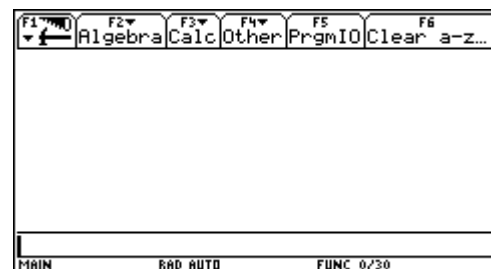
Press ⎡F4⎤ `Other` and choose option `1:Define` (then press ⎡ENTER⎤).
You will see the command `Define` waiting for you in the command
line. (You could also just type the word **define**.)
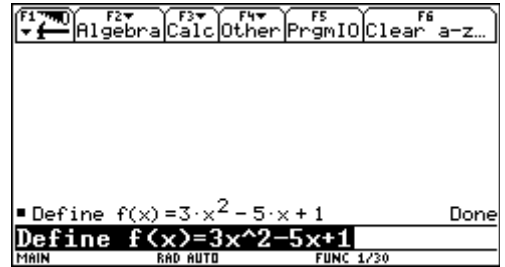
Enter the function using function notation, for example
`f(x)=3x^2-5x+1`, then press ⎡ENTER⎤.

A. Special Functions

  1. Absolute Value Function $|x|$

To define the absolute value function, simply type `abs(x)` for $|x|$. Alternately, press ⎡2nd⎤ then MATH and
choose `1:Number` and then `2:abs(`. Type in what goes inside the absolute
value symbols and don't forget to close the parentheses.

  2. Greatest Integer Function (Step Function)

Simply type `int(x)` for the greatest integer function of *x*. Alternately, press ⎡2nd⎤ MATH
and choose `1:Number` and then `4:iPart(`. Type in what goes inside and don't forget to close the
parentheses.

  3. Piecewise Defined Functions (two pieces only)

This is best illustrated with an example. Suppose you wish to define $f(x) = \begin{cases} 3x-1 & x<1 \\ 2x+5 & x \geq 1 \end{cases}$. After pressing ⎡F4⎤
`1:Define` type `f(x)=when(x` ⎡2nd⎤⎡<⎤ `1,3x-1,2x+5)`. The "less than" symbol ⎡<⎤ is above the 0 button.
The "greater than" symbol ⎡>⎤ is above the ⎡.⎤ button. The "less than or equal to" and "greater than or equal to"
symbols can be found by using ⎡2nd⎤⎡MATH⎤ `8:Test`.

  4. Piecewise Defined Functions (more than two pieces)

This is described on page 206 of the TI-89 Guidebook.

B. Evaluating a Function (at a given input)

Once your function is defined, simply type in the evaluation you wish to
perform.
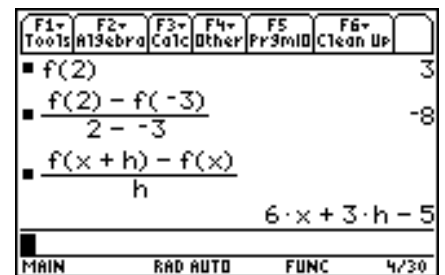
C. Solving an Equation (find the input(s) for a given output)

Once your function is defined, you can use the Solve command. For
example, if `f(x)=3x^2-5x+1` and you wish to find out which
inputs give $f(x) = 0$, use ⎡F2⎤ `1: Solve` and then type `f(x)=0,x`
and close the parentheses. Press ⎡ENTER⎤. You could also simply type
the command `solve(f(x)=0,x)` or `solve(3x^2-5x+1=0,x)`.
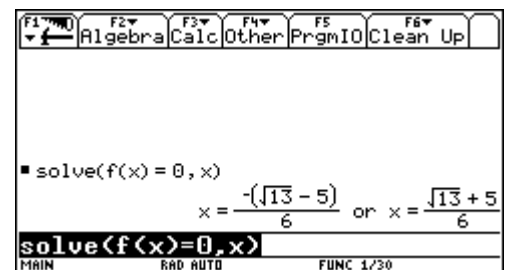
This is the equation you wish to solve, and this is the variable you wish to solve for.

You can also solve *inequalities* by replacing ⎡=⎤ with the appropriate inequality symbol.

D. Graphing a Function

To graph a function (or more than one function at once), on the TI-89 press the green diamond button $\boxed{\bullet}$ and [Y=] (above $\boxed{\text{F1}}$). On the Voyage 200 press the green diamond button $\boxed{\bullet}$ (next to the ON button) and [Y=] (above the W). Enter the function in y1= either by typing the function name if you defined it or the expression itself.
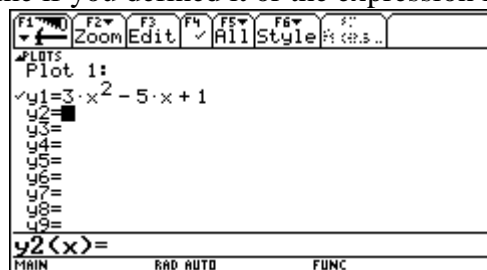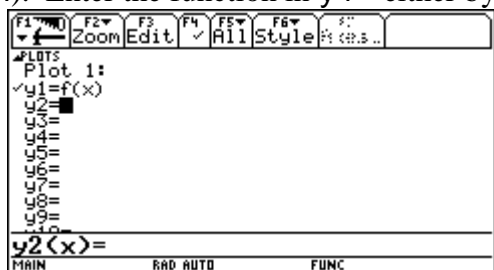
If you have more than one function to graph at the same time, enter the next function in y2= etc.

After the function is entered, press $\boxed{\text{F2}}$ 6:ZoomStd. This will graph your function(s) in a window with the input running from -10 to 10 and the output running from -10 to 10. Each tick mark will be one unit.
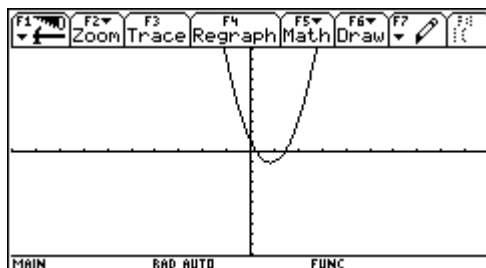

EXCEPTION

When graphing *trigonometric functions*, you should press $\boxed{\text{F2}}$ 6:ZoomTrig. This will graph your function(s) in a window with the input running from about -5π to 5π and the output running from -4 to 4. Each tick mark in the horizontal direction will represent $\dfrac{\pi}{2}$ and each tick mark in the vertical direction will represent $\dfrac{1}{2}$.

### Changing the Window Size (Zooming)

To get a different look at the function, change the window size. I would prefer you change the window size to what you want, rather than using the zoom feature. From the [Y=] window or the graph screen on the TI-89 press the green diamond button $\boxed{\bullet}$ and [WINDOW] (above $\boxed{\text{F2}}$). On the Voyage 200 press the green diamond button $\boxed{\bullet}$ (next to the ON button) and [WINDOW] (above the E).

This will enable you to change the viewing window size in the horizontal direction (xmin, xmax), the vertical direction (ymin, ymax) and the size of each tick mark in the horizontal and vertical directions (xscl, yscl). When you are done adjusting press $\boxed{\bullet}$ and GRAPH (above $\boxed{\text{F3}}$ on TI-89 and above R on Voyage 200).
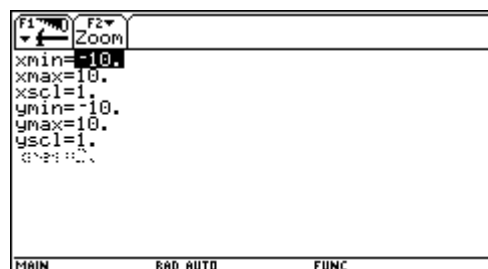
E. Tabulation of Functions

If you already have a function entered into y1(x) or defined [for example as f(x)] you can tabulate values of the function using tables. If the function is not entered, do that first, either into y1 or define it with a function name. On the TI-89 press $\boxed{\bullet}$ TBLSET (above $\boxed{\text{F4}}$). On the Voyage 200 press $\boxed{\bullet}$ TBLSET (above the T). This sets up how you want the table to look.
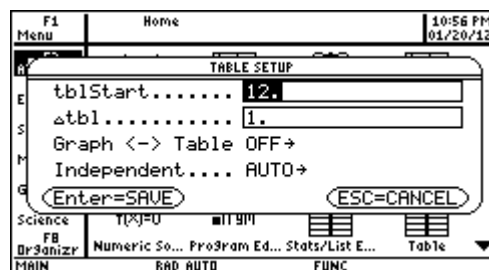
Move the cursors ⊙⊙⊖⊝ to the options you wish to change. The option tblStart represents which input value the table should begin at. The option Δtbl is the step size on the table, Graph <-> Table OFF (do not show the graph), and Independent: Auto (automatically give the y1 value.) After this, on the TI-89 press press ⬥ TABLE (above F5). On the Voyage 200 press ⬥ TABLE (above the Y). You can scroll up and down the table.

## F. Finding the Range of a Function by Graphing

Now consider the problem of finding the range of a function. Again you should graph the function, but this time you look for how high and/or low the graph gets (along the vertical axis). Just be careful that you see the whole picture. Change the window to see more of the graph.

For our example let's look at $a(x) = \frac{3}{5}(30x - x^2)$. Press ⬥ [Y=] and enter the function into y1 (scroll to y1 and use CLEAR if there is already a function there).

Type the function y1=3/5(30x-x^2), then press ENTER. Press F2 6:ZoomStd. The graph you see can be deceiving.
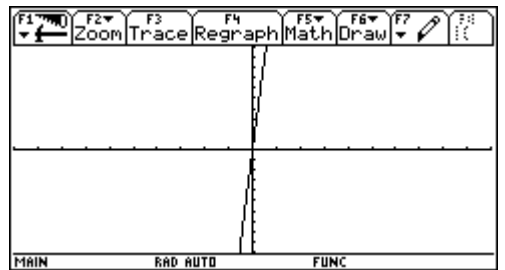
Is this the whole picture? Change the window to something larger ⬥ [WINDOW]. For the next picture I used xmin=-10, xmax=40, ymin=-10 and ymax=150. You will need to experiment to get a good picture.
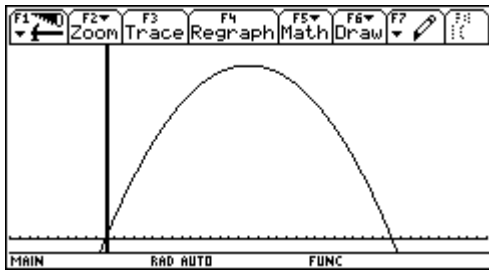
The graph is increasing, then it is decreasing. Where does it switch from increasing to decreasing?

We can now see the maximum, but what *y* value is it? Press F5 Math then option 4:Maximum. You will be asked for a lower bound. Move the cursor to the left of the peak (or type in a number) and press ENTER. You will then be asked for an upper bound. Move the cursor to the right of the peak (or type in a number) and press ENTER. The calculator will then approximate the maximum point.

In this example we get a maximum at the point (15,135).

So, the range of this function is $(-\infty, 135]$. In MATH 125, some techniques of calculus will enable us to do this problem by hand.

Occasionally you may get an answer such as -1.49999995. You can be reasonably certain the answer is -1.5. Also, keep in mind that a calculator answer of 2.3333333 is really $2\frac{1}{3}$ or $\frac{8}{3}$.

If you get a decimal answer for which you do not recognize the rational number equivalent, make sure your instructor allows an approximate answer for the problem. If not, you will need to find the exact answer using algebra or calculus.
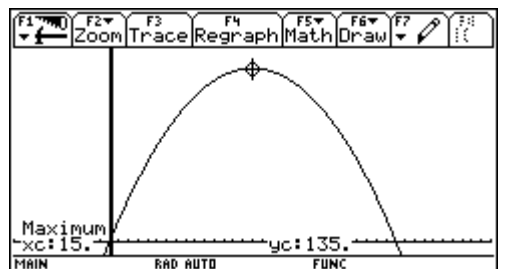
Also, make sure you look at the graph in a larger and/or smaller window. Doing this will ensure that you see all of the maxima/minima. You will need to find them all.

After changing windows, when you are done with a problem, it is a good idea to always press F2 Zoom and choose option 6:ZoomStd. This will take you back to the standard window for the next problem.
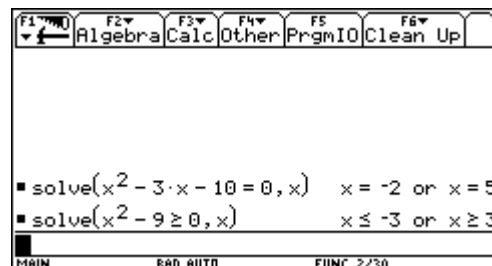
II. Basic Algebra

Most basic algebra is accessed by the F2 menu from the home screen.
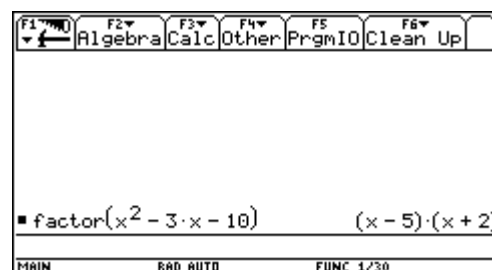
A. Solving Equations or Inequalities

To solve an equation or inequality, use F2 1: solve. The syntax is solve(equation or inequality, variable).

The inequality symbols can be found using 2nd [MATH] 8:TEST.

B. Factoring
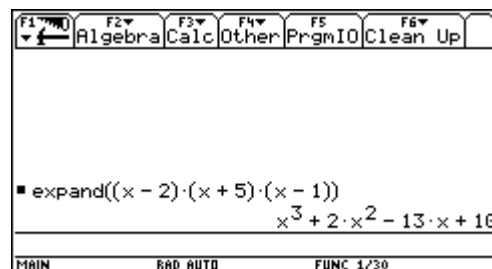
To factor a polynomial, use F2 2: factor. The syntax is factor(polynomial).
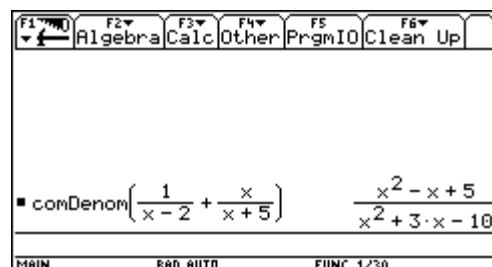
C. Expanding ("Multiplying Out")

Use F2 3: expand. The syntax is expand(expression).

D. Getting a Common Denominator

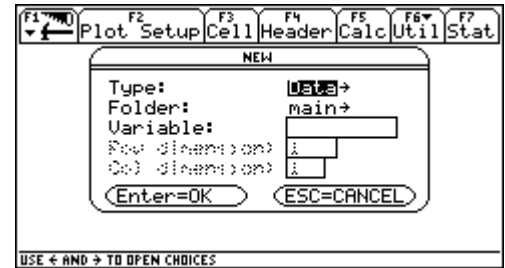You can combine rational expressions into one rational expression by finding a common denominator.
Use F2 6: comDenom. The syntax is comDenom(expression).

III. Plotting Points and Finding Regression (Best Fit) Curves

## A. Enter Your Data Values

Press ⬧ HOME to make sure you are on the main screen. Press APPS and choose `Data/Matrix Editor` on the Apps screen. Then choose `3: New`.

Make sure `Type` is set to `Data` and `Folder` is set to `main`. In the variable box type a variable name, for example `stat`, and press ENTER twice. You will see the Data Editor.

Enter the values of the inputs (independent variable, explanatory variable) in `c1` and the values of the outputs (dependent variable, response variable) in `c2`.
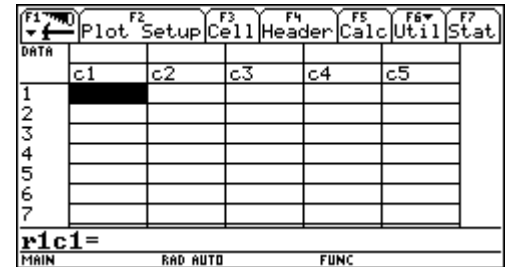
The next time you wish to enter data, you can press APPS and choose `Data/Matrix Editor` and then choose `1: Current`.
Then you can simply clear the old numbers and put in new ones. You can do this by moving the cursor anywhere in the column, pressing F6 and choosing option `5:Clear Column`.

This data at right is the measured viscosity (lbs sec/in^2) of motor oil as a function of the temperature in degrees F.
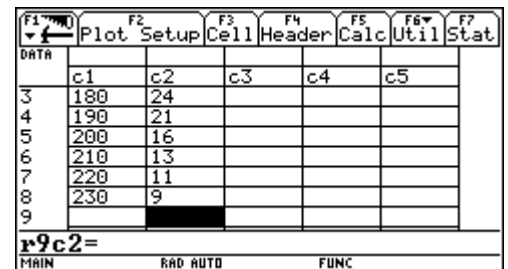
B. Make a Graph/Scatterplot of Your Data

While still in the data editor, press F2 `Plot Setup`. Highlight `Plot1` and press F1 `Define`. Make sure the `Plot Type` is set to `Scatter`. If not, use the right arrow key ⊙ to change to option `1:Scatter`. For `Mark`, use `Box`, You can change it just like you changed `Plot Type` is you want a different symbol to use for your point.

Use the arrow keys to move to the box labeled `x`. Type in `c1`. Use the arrow keys to move the cursor to the box labeled `y`. Type in `c2` and press ENTER. Make sure `Use Freq and Categories`? Is set to `NO`. Press ENTER again. You can see from the image at right that `Plot 1` is set up and ready to go.

Press ESC to return to the `Data Editor`.

Press ⬧ [Y=] and clear any old functions you might have set up, otherwise they will appear on your scatterplot. Then choose F2 and `9:ZoomData`. You should see your scatterplot.

Now is when you determine what type of function would be a good model/fit for this data. Your calculator can fit a linear function, a quadratic function, a cubic function, a quartic function, x^n, an exponential function, a logarithmic function, a sine function, and a logistic function. For this example we will use a line, although the steps are similar for other types of functions

C. Fit a Function to the Data

Press ⊡ HOME to return to the main screen. Press APPS and choose `Data/Matrix Editor` on the Apps screen. Then choose `1: Current`. Press F5 `Calc` to get to the `Calculate` screen. For Calculation Type press the right arrow ⊙ and choose `5:LinReg` (or whichever type   of function best fits the data). In the `x` box type `c1` and in the `y` box type `c2`. Move down to `Store RegEQ to` and use the right arrow ⊙ to choose `y1(x)`. Press ENTER to get the equation of the function that models the data.

This function has been stored in `y1(x)` but you might want to write down the function and `corr` (the correlation, a measure of how good the fit is). Press ENTER to close the screen.

D. Graph the Points and the Model Function

Once the above steps are completed, press ⊡ [GRAPH] to see the points and the function. If it does not show up well, choose F2 and `9:ZoomData`.

Since the function is stored in `y1(x)` you can use it to predict values of the function at points between the lowest and highest input values. Do not go outside this range. This is called *extrapolation* and can often lead to unrealistic predictions.

Press ⊡ HOME to return to the home screen, and, for example, type `y1(192)` to predict the viscosity of a motor oil at 192°F.

E. Return Your Calculator to Normal Mode

You want to make sure you turn off the scatterplot, or it will appear any time you graph something.

Press ⊡ [Y=] and use the up arrow key ⊖ to highlight `Plot 1`. Press F4 to deselect `Plot 1` and then press F2 and choose `6:ZoomStd`. Pressing ⊡ HOME returns you to the home screen.

IV. Finding Points of Intersection of Two Graphs

Ideally, you should use algebra to find the points of intersection. If your functions are defined in `y1` and `y2`, simply use `solve(y1(x)=y2(x),x)` from the home screen. For example, on the screen at right we have `y1(x)=2x-1 and y2(x)=x^2-4`.
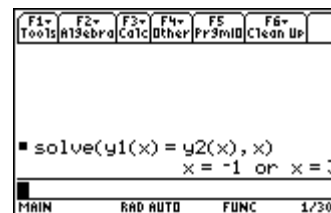
However, if you want an approximate answer from the graph screen, first graph the two functions. For example, on the screen at right we have `y1(x)=2x-1 and y2(x)=x^2-4`. To find the approximate points of intersection, press F5 option 5:Intersection. You will be asked to identify the first curve. Use the up and down arrows to pick the curve you want (or accept the default) and press ENTER. You will then be asked to identify the second curve. Use the up and down arrows to pick the curve you want (or accept the default) and press ENTER.
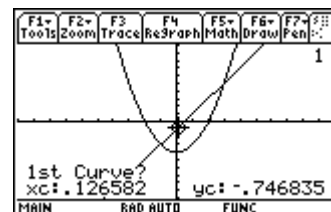
You will then be asked for a lower bound. Use the left and right arrow keys to get to the left of the point of intersection and press ENTER. You will then be asked for an upper bound. Use the left and right arrow keys to get to the right of the point of intersection and press ENTER.

The calculator will identify a point of intersection. Notice in this example there are two points of intersection. You will need to repeat the process to get the other point of intersection.
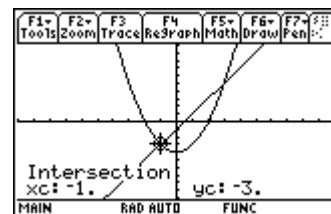
There is plenty to explore or your TI-89/Voyage 200, and I encourage you to do so.