Graphing with your TI

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The TI Calculator can:
1. Save time.
2. Increase understanding.
3. Be fun!

This packet will try to reach each of those goals while teaching how to use the graphing utilities provided by the TI calculators[1]. The step-by-step instructions are intended to *save you time*, by helping you to start graphing as quickly as possible.

> Yellow boxes are for those who want to *increase their understanding* of the topics covered. If you just need to learn about the calculator, you can skip these without trouble.

> Blue boxes will provide tinkering and exploring tips for those who have the desire, and the time, to *have fun* with their TI. Feel free to skip these if you want.
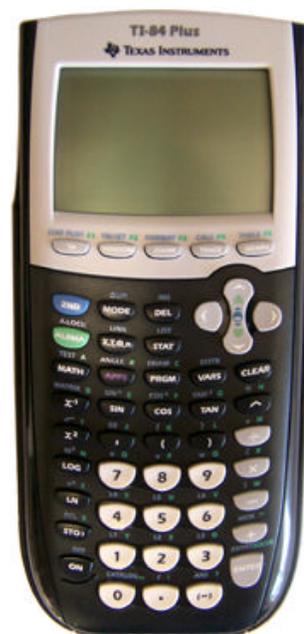
Practice

At the end of each section are some exercises and questions for practice.

This packet contains four sequential tutorials:
1. 1st Time – Clean off any previous work and gain familiarity with screens.
2. Linear Functions – Increase familiarity, apply tools, and graph a linear system.
3. Rational Functions – Re-visit tools and graph rational functions.
4. Parabolic Functions – Apply "Calculate" tools and graph parabolas.

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[1] We will use the TI-84+. The directions should be the same for the TI-83, TI-83+, and the TI-84. They should be similar for other graphing TI's.

1st Time

Up to this point, much of your time with your calculator has probably been spent at the bottom, where live the numbers, operations (add, subtract, multiply, and divide) and enter. This tutorial will take you to new territory at the top of the calculator.

You may have already used the graphing calculator, so we are going to visit several screens and clean off what others have done before us.

The Y= screen.

The Y= screen is where you can enter functions to graph.

> The Y= screen lets you enter functions of Y in terms of X. So $Y = f(x)$.

1. Press Y=. (You can find Y= at the top left, just below the screen.)You should see something like the figure to the right[2].
2. If there is something after the equal signs on one or more lines, use the up and down arrows to move the blinking "cursor" to the line with the junk, and press CLEAR, the button right below the down arrow. That should clear off anything on that line.

```
 Plot1  Plot2  Plot3
\Y1=█
\Y2=
\Y3=
\Y4=
\Y5=
\Y6=
\Y7=
```

> If you want, don't press CLEAR; just leave whatever is on there, and we'll see what it looks like later. You can always come back and clean up later.

The Window Menu

The Window screen is where you enter the "dimensions" of the Graph Screen.
1. Press WINDOW.
   You should see something like the figure to the right.
2. Use the up and down arrows move to different lines, and enter the values until your numbers match those on the figure to the right.

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

---

[2] If the Y= screen looks totally different, it may be necessary to hit MODE and make sure "FUNC" is highlighted.

Picking appropriate values in the window screen is just like picking good units and boundaries when graphing on paper.

You can try many different values in the Window menu, and see what the graph screen looks like.

The Graph Screen

The Graph Screen displays a graph of your function(s).

1. Press GRAPH.
   You should see a blank screen except for two axes.

If you left stuff in the Y= lines, you may see multiple functions. If you tinkered with the numbers in the Window menu, your axis lines may look different, and the tick marks may be spaced differently.

We have now visited the Y= screen, the Window menu, and the Graph Menu. Now we are ready to begin!

Practice

- Try entering different values in the Window menu.
  - o   What happens if a min is greater than a max?

Linear Functions

Linear functions are just straight lines. Lines are great! They're the easiest to draw and graph, and are a great introduction to TI graphing. We will graph a couple of functions, and learn to use the Trace tool and the Zoom menu.

Entering and Graphing a Function

The Y= screen is where you enter functions. We are going to go back there and enter the function $f(x) = 2x + 1$ in the first line, $Y_1=$

> The TI can only graph functions of *y*, or *f(x)*, in terms of *x*. This means that you can only graph lines in slope-intercept form, or $y = mx + b$

1. Press "Y="
2. Press "2"
3. Press "X,T,?,n" button to the right of the ALPHA button. We'll call this "X,T,?,n" button the "variable" button from now on.

> *X*, *T*, *?*, and *n* are the independent variables for function, parametric, polar and sequential functions, respectively.
> If you are feeling *really* adventurous, you can press the MODE button and try highlighting "PAR" "POL" or "SEQ" instead of "FUNC." This will change the way the Y= screen looks, and what variable the "X,T,?,n" button will make. This allows for some very interesting graphs. If you plan to take Calculus II or higher, this will actually be useful.

4. Press +
5. Press 1
6. Press GRAPH.
   You should see something like the figure to the right.
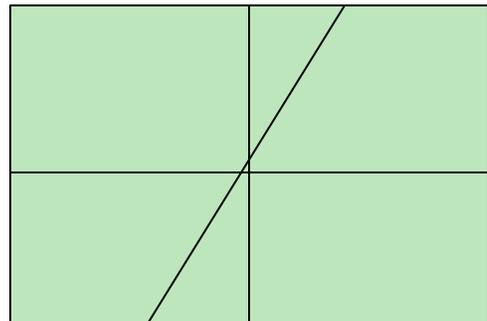
The Trace Tool

The Trace Tool lets you follow the function you graphed, and compare its x and y values.

> The Trace Tool serves a purpose very similar to T-charts in graphing.

1. Press TRACE
2. Use the left and right arrows to follow the graph.
   Notice that the calculator displays x values and corresponding y values at the bottom of the screen.

What happens if you move the cursor off the right or the left of the screen while tracing?

Entering and Graphing Additional Functions

You can graph multiple graphs at once.

Graphing multiple graphs makes for cool pictures! Impress your friends!

1. Press Y=
2. Press the down arrow to move down to the $Y_2=$ line.
3. Enter the function $f(x) = 4x - 1$ as we described earlier
4. Press GRAPH.
   You should see something like the figure to the right.
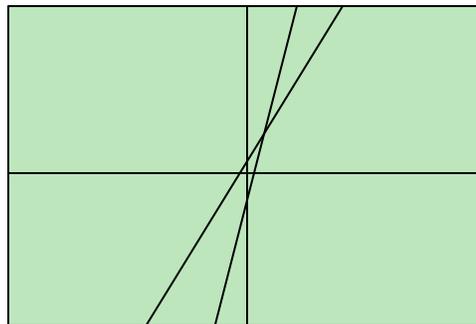
The Zoom Menu

The Zoom menu lets you zoom in and out on your graph without having to go back to the Window menu and enter everything manually.

Don't get to comfortable zooming. It's not that easy on paper. It is still important to get the hang of predicting what window will be best for a particular function.

The zoom tool can be very useful. Certain graph features may only show up at certain zooms. We'll see an example of this in the rational functions section.

1. Press ZOOM.
   You should see something like the figure to the right.
2. Use the up and down arrows to highlight 4:ZDecimal
3. Press ENTER.
   Now the graph screen is set so that each pixel is a .1 by .1 square.

```
ZOOM  MEMORY
1:ZBox
2:Zoom In
3:Zoom Out
4:ZDecimal
5:ZSquare
6:ZStandard
7│ZTrig
```

If you feel the need for speed, you can press the number of the zoom tool you wish to use instead of using the cursor. For example, press 3 to select the "Zoom Out" option.

You should see something like the figure to the right.
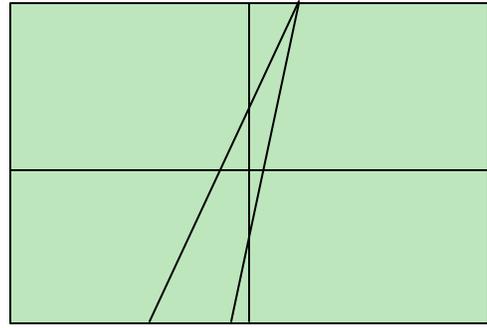
That Zoom tool was pretty easy to use. Other zooms may have you select an area of your graph to zoom in or out from. The ZBox tool is one of these, and it can be very powerful. Give them a shot!

The Trace Tool II

The Trace tool can trace multiple lines.
1. Press Trace
2. Press the left and right arrows to follow one line, and use the up and down arrows to switch between lines.

Two lines make a system of linear equations. If you trace either line to the point (1, 3), you'll notice that switching between lines doesn't change the x or y values. This is the intersection of the two lines, or the solution to the corresponding system of equations. Sometimes graphing is a little easier than solving a system.

If you press "2ND" and then TRACE, you will enter the CALC, or Calculate menu. The intersect tool can help you find intersections of lines, even if the intersection is at some ugly point like (2.355783547, -3.816751132). Of course, the calculator won't tell you that .5714285714 is probably $4/7$, which may be what your professor wants to see.

Now, armed with a basic understanding of the Y= menu, the Zoom menu, and the Trace tool, you're ready to take on rational functions.

Practice

- Experiment with the parameters of your lines.
    - Can you make a flat line? A vertical line? *(Hint: Is a vertical line a function?)*
    - How flat can you make a line without making it horizontal? How steep can you make a line?
    - How do you move the line up or down on the graph? (*Hint: graph some of the suggested lines)*
    - Can you create two perpendicular lines? (*Hint: graph some of the suggested lines)*
- Some suggested lines to graph:
    - $y = 5x$
    - $y = 5x - 10$
   - $y = -5x$
    - $y = \dfrac{1}{5}x$

Rational Functions

Rational functions can be scary, but with a TI they're not much more difficult to graph than linear functions. This section assumes you've completed the first two sections, and it moves more quickly.

Entering a Rational Function

There's just one thing that makes rational expressions tricky to graph: remembering parentheses. $2x + 1/3$ is much different than $(2x + 1)/3$.

1. Go to the Zoom menu.
2. Select option ZDecimal.
3. Go to the Y= screen, and make sure the lines are cleared.
4. Enter the following into the Y_1= line: $1/(X - 1)$
5. Go to the Graph Screen.
   You should, at this point, see something like the figure to the right.
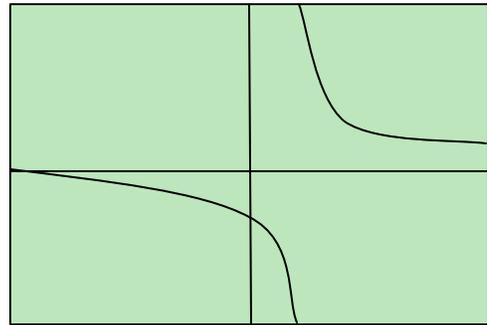
Notice the gap where $X = 1$? Why is the graph below the axis when $X < 1$? Why is it above the axis when $X > 1$?

6. Go back to the Y= screen.
7. Press the left arrow once, to move the cursor over the = symbol.
8. Press Enter. This removed the highlight from the =. This way you can keep your first line from graphing without losing it. This is how you "deselect" a function. Pressing enter again will "select" the function once more.
9. Enter the following into the Y_2= line: $(X - 1)/((X - 1)(X + 1))$
10. Go to the Graph Screen
    You should, at this point, see something like the figure to the right.
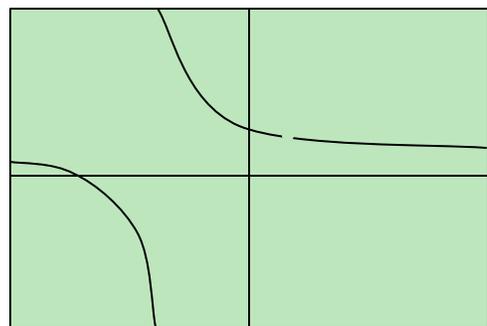
Notice the very small gap where $X = 1$? Why does the line around the gap seem to act as if there's no gap at all?

We chose ZDecimal in step 2 so that we could see the gap at $X = 1$. Try other zooms to see if the gap is still visible.

The Trace Tool III

Rational Functions show just how nice the Trace tool can be.

    11. Trace our function to $X = -1$, and notice that $Y =$ is blank.

    12. Trace our function to $X = 1$, and notice that $Y =$ is again blank.

> If you were making a T-chart, what values would you have put for $X = 1$ and $X = -1$?
> Why does this happen with rational functions?

> How close can you get to the hole without Y going blank? What if you zoom in? Will the gaps ever get bigger?
> Also, what happens to the gap if you go to ZStandard? Why is this so?

When you're ready, feel free to move on to the parabolas section.

Practice

- Experiment with the parameters in your rational functions.
  - Can you make a function with a big jump at $X = 5$?
  - Can you make a function with a tiny hole at $X = 5$? *(Hint: Tinker with the 2nd suggested curve.)*
  - How many jumps can a graph have? Can you make one with 4 jumps? 8 jumps? *(Hint: Tinker with the 4th suggested curve.)*
- Some suggested curves to graph:
  - $y = \dfrac{1}{x}$
  - $y = \dfrac{x+1}{x+1}$
  - $y = \dfrac{(x+1)^2}{x+1}$
 - $y = \dfrac{1}{(x-1)(x+1)}$

Parabolic Functions

While this section covers parabolas, it also shows the importance of an appropriate viewing window. As before, it assumes you have covered the earlier sections.

Our first Parabola

1. Clear or deselect any functions currently entered in the Y= screen.
2. Enter the following in a free $Y =$ line: $(X + 2)^2 + 1$
   a. You can square the parenthesis two ways:
      i. Press the "x^2" button above the "7" button, or
      ii. Press the "^" above the "÷" and then the "2."
3. Press Graph.
   Here's what you should see if you are at the "ZDecimal" zoom.
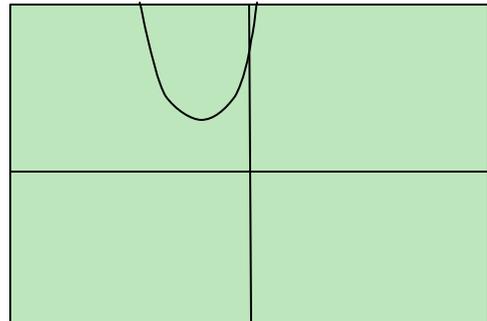
> Where is the parabola's vertex (the turning point), based on the graph? Is this where you would expect from the equation? Remember that a parabola of the form
> $y = a(x - h)^2 + k$ has a vertex at (h, k).

> Try replacing ^2 or ^{2} in your parabolic functions with ^3 and ^4. It's interesting. Why are all the functions with even exponents symmetric? *(hint: what happens to a negative number when it is squared?)*

The Viewing Window

We have briefly visited the Window and Zoom menus. It is time to give these menus a better look. Both of these windows adjust what is called the "Viewing Window," or the imaginary window through which you are looking at your graph. This window can be moved up and down, or from side to side, and can grow or shrink.

1. Select ZStandard from the Zoom menu.
   Observe the values in the window menu.

> ZStandard is the TI's default zoom. It's a pretty useful zoom to start at, if you're not sure how to best view a function.

2. Go to the Graph Screen. Press the up, down, left, or right arrows. This makes a cursor appear. How far to the left does the screen show, right? Up and down? Where about are each of the tick marks on the axis?

3. Select ZDecimal from the Zoom menu.
   Observe the values in the window menu.
4. Go to the Graph Screen, and again move the cursor around. How far in each direction does the graph screen show?
5. Go to the Window screen. Decrease the Xmin by 1 (from -4.7 to -5.7 on the TI-84+)
6. Decrease the Xmax by 1 as well.
7. Change the Xscl from 1 to .5
8. Take a look at the graph. What changes do you see? What do you think Xmin, Xmax, Xscl, Ymin, Ymax, and Yscl mean? (scl stands for scale.)
9. Select "Zoom In" from the Zoom menu.
10. Move the cursor wherever you want and press Enter.
11. Take one last look at the Window menu. Notice the value changes.

> You can make the parabola appear flat or skinny depending on your window. How far can the calculator zoom out? In? *(Hint: You'll need scientific notation.)*

Our Second Parabola

1. Clear or deselect any functions in the Y= menu.
2. Enter the following in a free $Y =$ line: $-2(X+100)^2 - 200$ (This is the first time we have used the negative symbol in this tutorial. Make sure you pressed the "(-)" button and not the subtract button.)
3. Press Graph.

Do you see anything? If not, good! It's because of the viewing window. (That is unless one small step went wrong. If you're worried, feel free to make sure you entered the function correctly and that its = sign is highlighted).

4. Use Trace to find where our line went. What values of Y do you get?
5. Adjust the viewing window until you can see the function, particularly so you can see clearly that it is a parabola. This can be done by:
   a. Zooming out repeatedly, and then zooming back in on the parabola once you find it, or
   b. Entering values that ought to work into the Window menu, based on your knowledge of parabolas.
   c. Entering the values[3] at the bottom of this page; just to get you started.

> Can you imagine what it would have been like graphing this function on paper without having seen what it looks like on the calculator? It would take some thought to get a good looking graph!

The Calculate Menu

The Calculate menu gives a list of useful calculations the TI can perform for you. This is great for experimentation, or for checking work. Remember, however, to do the work by hand. The calculator is limited in the kind of answer it can give, and performing all your work on he calculator may hinder more than help.

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[3] Xmin=-150, Xmax=-50, Xscl=10, Ymin=-250, Ymax=-150, Yscl=10

1. Press "2ND"
2. Press "TRACE"
   You should see something like the figure to the right.
3. Push "4" to select 4:maximum.
4. The calculator will ask you for a "Left Bound?" Move your cursor till it traces to the left of the vertex of the parabola, and press "ENTER"
5. Trace to the right of the hump and press "ENTER"
6. Trace as close as you can to the vertex and press "ENTER" for the "Guess?"
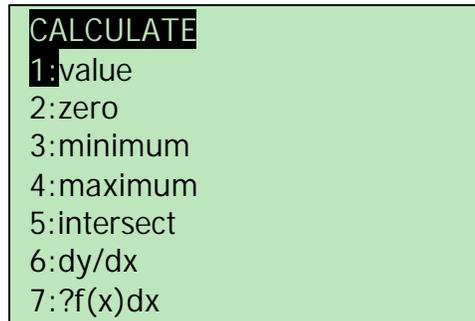
```
CALCULATE
1:value
2:zero
3:minimum
4:maximum
5:intersect
6:dy/dx
7:?f(x)dx
```

Some other tools useful for parabolas are the Zero, Minimum and Maximum tools.

> The Zero tool basically solves the quadratic equation for a parabolic function. This function never hits the axis, so it won't have any zeros.

> Another menu that can be useful is the Format menu ("2ND" + "WINDOW"). You can change the way your graphs are displayed depending on your needs.

In this section, we learned about the viewing window, and some calculation tools which make TI graphing quite useful for a variety of problems, not just those involving parabolas.

Practice

- Experiment with the parameters in your parabolic functions.
  - o Try making parabolas with different centers.
  - o Try making really squished/stretched parabolas
- Some suggested curves to graph:
  - o $y = x^2$
  - o $y = -x^2$
  - o $y = 2x^2 - 1$ *(Suggestion: try the Zero tool with this one)*
  - o $y = \dfrac{x^2(x-1)}{x-1}$ *(Suggestion: look for a gap)*

Acknowledgments