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Translating and Scaling Graphs Studio
Mac Excel 2008 Version

In order to access the spreadsheet this week, you may have to go through the same routine as in the Graphs of Quadratic Functions studio to allow your spreadsheet to enable macros. Go to the class web site and download the file translationstudiomac.xls. (Make sure you grab the "Mac Friendly" version.) This file uses "macros" and when you open it in Excel you will be told that Macros do not work in Office 2008 for Macs. Ignore this and click on the "Open" button (not the "Open and Remove Macro" button!). The file should then open.

Two weeks ago we looked at parabola written in the form $a(x-h)^2+k$ and studied how changing the coefficients a, h, and k changed the graph. This week we look at modifying general functions by replacing $f(x)$ by $f(x+a)+c$ or $sf(rx)$ and considering how changing the coefficients a and c change the graph. Open the translationstudio.xls file if you haven't already and click the Translations tab. Note that the sliders in translationstudio.xls only work in Excel for Windows, not Excel for Mac. There is another Mac-friendly version available, translationstudiomac.xls. The sliders in this version work on both the Windows and Mac versions of Excel, but don't scroll nearly as smoothly. If you are using the Mac-friendly version, you are better off moving the sliders by making distinct clicks on the ends of the sliders, rather than sliding the "thumb" directly.

The first sheet of the spreadsheet, labeled Translations, has a graph that shows a typical function $f(x)$ in blue and its translation $f(x+a)+c$ in magenta (light purple). I happened to choose $f(x)=|x|^{1.3}$ for this sheet but the particular function we are using is irrelevant for what comes next. You can adjust the values of a and c by moving the sliders. Note that the precise values for a and c are given in cells B3 and C3, and can also be seen in the labels in cells A8 and A11. While it is easier to build spreadsheets with the table of values going vertically down the page, I've set the table of values horizontally across rows 7, 8, 10, and 11 because that will make it easier to understand how changing the coefficients changes the graph (since it means the x-values will be going horizontally, just as the x-axis in the graph is horizontal).

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1. Experiment with moving the sliders for a and c. *How does the magenta graph shift as a gets larger (slider to the right)? How does the magenta graph shift as a gets smaller (slider to the left)? How does the magenta graph shift as c gets larger and smaller?*

2. You should have noticed in part 1 that shifting the value of a shifts the graph in the opposite direction as you shift a. This often leads to confusion (and lost exam points) for students, who think if they add something to the x value they should move in the positive direction on the x-axis. But changes in the input often have a reversed effect on the output. To see why this is, look at the tables of input values x and $x + a$ in rows 7 and 8. First set the value of $a = 1$ (it doesn't matter what value c has right now). Fill in the table below with the values for $x + 1$.

x	-10	-9.5	-9	-8.5	-8	-7.5	-7
$x + 1$							

Now draw an arrow connecting values in the x row with the same value where it appears in the $x + 1$ row. *What sort of shift does adding 1 make to the table of inputs?*

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3. Now set the value of a = -1. Fill in the table below with the values for $x - 1$.

x	-10	-9.5	-9	-8.5	-8	-7.5	-7
$x - 1$							

Now draw an arrow connecting values in the x row with the same value where it appears in the $x - 1$ row. *What sort of shift does subtracting 1 make to the table of inputs?*

Now click the Scaling tab to go to the next sheet. This is similar to the previous sheet, except now we are looking at scaling constants instead of translation constants, shifting $f(x)$, graphed in blue, to $sf(rx)$, graphed in magenta. This time I chose to use the function $f(x) = \frac{x(x^2 - 25)(x^2 - 100)}{2500}$ as the base function, but as before it really doesn't matter which function we use as we are interested in how the graph changes rather than what the graph is. The tables are laid out much the same as before, with two small changes. To keep the graph smooth even as the scale changes requires a much finer spacing of points, so now the x values are spaced every 0.1 instead of every 0.5. And since it is easier to see the effects of scaling if you look at x values near 0, I've copied over the section of the table for x between -0.8 and 0.8 to appear below the graph, so you won't have to scroll all the way over to columns CP..DF to find those values.

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4. Experiment with moving the slider for *s* (leave $r = 1$ for now) *How does the magenta graph shift as s gets larger and smaller?*

5. *Summarize these problems in a short paragraph that explains how changing the values of a, c and s change the graph of* $y = f(x)$ *to the graph of* $y = sf(x + a) + c$. Try to write something that you can review later to help you remember how this works when you study for the next exam ☺.

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<u>Bonus</u>

While the text only considers multiplying the output $f(x)$ by a constant s to get $sf(x)$, it is also possible to change things by multiplying the input by a constant r to get $f(rx)$. Just as for addition, changes made to the input (the x) have the reverse effect of changes made to the output (the $f(x)$).

6. Experiment with moving the slider for r. *How does the magenta graph change as r gets larger (slider to the right)? How does the magenta graph change as r gets smaller (slider to the left)?*

You should see that this compresses or expands the graph. If you pay attention, you will see that multiplying by a large r compresses the graph in the x-direction while multiplying by a small positive r expands the graph, and multiplying by a negative r flips the graph over. This may seem a little confusing since we normally think of multiplying by a large number as expanding things, and indeed multiplying by large values of s does have the effect you might expect in the y-direction. As we noted before, changes in the input often have a reversed effect on the output. We can see why multiplying the input has the effect it does y considering how such a multiplication changes the input values, just as in problems 2 and 3 above.

7. Look at the tables of input values x and rx in rows 42 and 43. First set the value of $r = 2$ (it doesn't matter what value s has right now).

(a) Fill in the table below with the values for $2x$.

x	-0.6	-0.5	-0.4	-0.3	-0.2	-0.1	0	0.1	0.2	0.3	0.4	0.5	0.6
$2x$													

Draw arrows connecting values in the x row with the same value where it appears in the $2x$ row. *What sort of effect does multiplying by 2 make to the table of inputs?*

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(b) Next set *r* = 0.5. Fill in the table below with the values for 0.5*x*.

x	-0.6	-0.5	-0.4	-0.3	-0.2	-0.1	0	0.1	0.2	0.3	0.4	0.5	0.6
0.5*x*													

Draw arrows connecting values in the *x* row with the same value where it appears in the 0.5*x* row. *What sort of effect does multiplying by 0.5 (dividing by 2) make to the table of inputs?*

(c) Finally set the value of *r* = -1. Fill in the table below with the values for -*x*.

x	-0.3	-0.2	-0.1	0	0.1	0.2	0.3
-*x*							

Draw arrows connecting values in the *x* row with the same value where it appears in the -*x* row. *What sort of effect does multiplying by -1 make to the table of inputs?*

There is another tab on the spreadsheet where you can adjust values to see the effect on power functions that you may experiment with if you wish, but there are no assigned questions using this tab.