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Spreadsheets and Graphs Studio

This sheet includes both instruction sections (labeled with letters) and problem sections (labeled with numbers). Please work through the instructions and answer the questions in the problem sections. Turn in your answers to the italicized prompts, written in complete sentences on a separate sheet, to the appropriate studio box opposite the Math department office in Cardwell Hall. The boxes for studios are right next to the boxes for written homework.

A spreadsheet is the basic tool used today for data manipulation and financial calculations. We will be working with Excel, but the instructions work almost the same for any other spreadsheet. The idea of a spreadsheet is that it is a grid of cells, each of which can hold either data (usually numbers, but also text and other types of data) or formulas. Let's go through a simple example. We will build a function table for the function $f(x) = 4x^2 + 3$.

A. Open up Excel. Click on the cell A1 in the upper left corner of the grid and type in "x". Then click on cell B1 and type in "f(x)". We now have text data in these two cells, to label the columns as we make a table similar to the function tables we've worked with before, though now we will have a vertical table instead of a horizontal table (the orientation of the table doesn't matter, but for a spreadsheet it's usually a bit easier to work vertically).

B. Next we want to enter the different possible values for x. Go to cell A2 (you can use either the mouse or the arrow keys) and enter the value -5. Then go to cell A3 and enter the value -4. While you could keep typing, the spreadsheet offers a quicker way to continue entering values. Click on cell A2 with the mouse and drag the mouse (without letting up on the mouse button) until both cells A2 and A3 are highlighted (then let up on the mouse button). The cells have a solid border around them, with a small black square in the lower right hand corner. Click on the square and drag it down to cell A12. The spreadsheet will look at your first two values, recognize the pattern, and continue the pattern so it fills in -3, -2, … , 5 in the other cells. While this is a small time saving in this example, if you were trying to fill in the values from 1 to 360 in analyzing the monthly payments for a 30-year mortgage, you'd appreciate not having to type all those numbers in by hand.

C. Next we want to fill in the values for our function. Go to cell B2 and fill in the formula "=4*A2^2+3". (Note that you could write a2 instead of A2; the spreadsheet doesn't care). The = at the beginning tells the spreadsheet you are entering a formula instead of text or other values, and it automatically calculates 4 times the value in cell A2 (which is -5) squared + 3. Note that the rules of precedence (order of operations) is important here; ^ has higher precedence, so you square -5 and then multiply by 4, rather than the other way around. You could now type formulas into the other cells in the table, but you might suspect the spreadsheet would have a faster way to handle this, and you're right. Select cell B2. Note that it is surrounded by a black border with a small square in the lower right hand corner. Click on the square and drag it down to

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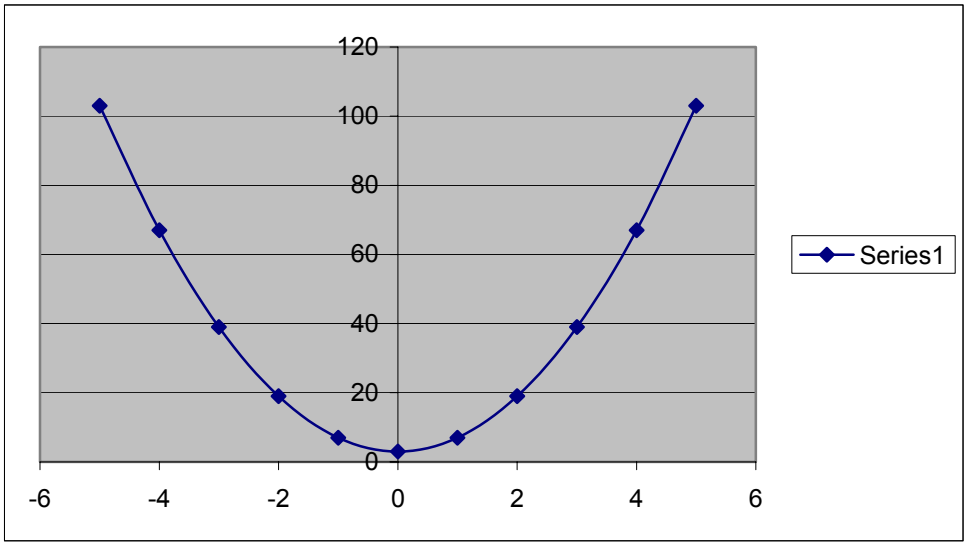
cell B12. Voila, the rest of the cells are filled in. If you now select cell B3, you can see that while it displays the value 67, if you look on the formula line across the top it actually contains the formula =4*A3^2+3. If you next select at cell B4, you'll see it contains the formula =4*A4^2+3, while it displays the value 39. As you drag the formula down, the spreadsheet automatically updates the formula so that the reference to cell A2 in row 2 becomes a reference to cell A3 in row 3, cell A4 in row 4, etc.

D. Now that we have the table of values filled in, let's graph the function. Click and drag your mouse to select the whole range from A2 to B12. Then click on either the Chart wizard (the little icon at the top with a small graph of 3 columns) or select Chart from the Insert menu. You will get a box with a variety of chart types. Select the XY (Scatter) chart type and then pick one of the sub-types on the right (I prefer one of the sub-types with lines for this particular assignment, but you can choose whichever one you want). You can now click Finish, or, you can click Next and add extra details and labels if you want. You should end up with a graph like the following.



In this graph each row from the function table contributes a point on the graph. So row 2 (cells A2 and B2) designates the point at the upper left corner. The x coordinate is -5 (the value in cell A2) and the y coordinate is 103 (the value in cell B2). The other rows define each of the other points marked on the graph. Note that the full function table should have infinitely many rows, one for each real number, and that the graph of the function should therefore have infinitely many points. The lines connecting the marked points are actually made up of the points that would be on the graph if we had a spreadsheet with infinitely many rows, so mathematically speaking the graph is really the lines and the marks at each integer are just window dressing.

1. Change the function from $4x^2 + 3$ to $x^2 + 3$. You can do this by selecting cell B2, entering the formula "=A2^2+3" and then pulling the formula down to cell B12. Note that the spreadsheet is "live" and the graph automatically updates as you change the formula. *What effect does changing the coefficient of x^2 have on the graph?* You will need to pay attention to the scale on the y-axis, which will

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change as you change the function. *What changes in the graph if the coefficient of x^2 is negative instead of positive?* (**Warning**: the formula "-A2^2+3" is interpreted by the computer as $(-A2)^2 + 3$, and the negative vanishes when it is squared. You must enter a formula such as "-1*A2^2+3" or "-4*A2^2+3" to get a negative coefficient).

E. If you right-click on the axis and select "Format Axis" and then the "Scale tab", you can fix things to a constant scale, by deselecting the "Auto" box and setting your own limits for the minimum and maximum y value for the graph (this is how you adjust the "window" when using a spreadsheet to graph). For the next several problems, it will be beneficial to have the y – axis set to limits from -20 to 20. For future reference, it may be helpful to note that if you enter one formula in column B and a second formula in column C, select the block from A1 to C12 and click the Chart wizard icon, you get the graphs of both the function in column B and the function in column C in the same graph window, which can make comparisons easier.

2. Now look at the function $f(x) = 4x + 3$, where we no longer include the square. To do this, enter the formula "=4*A2+3" into cell B2 and then pulling the formula down to cell B12. This is now a linear function, so the graph on the spreadsheet will be a line. Next graph the functions $f(x) = 2x + 3$, $f(x) = -2x + 3$, and $f(x) = 0x + 3$ You will need to decide what formulas to enter into cell B2 (and then pull down to cell B12) for each of these functions. *What changes in the graph as we change the coefficient of x?* Suppose instead of changing the coefficient of x we changed the constant term. Graph $f(x) = 2x + 1$, $f(x) = 2x + 5$, and $f(x) = 2x - 2$ (again you will need to decide what formula to use). *What changes in the graph if we change the constant term?*

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F. So far we've started with a function and built a table of values. Now we'll look at doing the reverse. We will start with some values in a table, and try to determine what function (if any) they represent. First we are going to change the *x* values (which will make it easier to see what's going on in the table). Go to cell A2 and enter the value 0. Enter the value 1 in cell A3. Then click and drag to select cells A2..A3 and pull the pair down to cell A12, just as you did in step B. This next part will be a little different from what came before. Go to cell D1 and enter "Increment". Then go to cell D2 and enter the value 3. Next go to cell B2 and enter the value 1. Then go to cell B3 and enter the formula "=B2+$D$2". You can enter this by typing it in, or you can just type in the = sign, then click on cell B2, then type in the + sign, and click on cell D2, and then press the F4 key at the top of the keyboard to convert D2 to $D$2 (on a Mac you press Apple+T instead of F4 – in either case if you press F4 or Apple+T more than once you will cycle through different patterns of $). In complicated spreadsheets, it can be easier to "point" to the value you want rather than carefully typing in the coordinates of the cell. Now the value in cell B3 should be 4, which is the sum of the values of B2 and D2, 1+3. So why do we have the $ signs? Well, pull the formula in cell B3 down to cell B12 and see what happens. The cell B4 now contains the formula "=B3+$D$2". Note that the B2 in the formula has been updated to B3 when you pulled the formula down, but the $D$2 hasn't changed. The $ signs identify something as an "absolute" address, that won't update as you pull a formula around. (If you had D$2, then only the 2 won't change, but the D might update to a C or an E if you pulled the formula to the left or the right, and $D2 won't change the D but will change the 2.) In any event, we've now built a table of values for a function.

3. *What function does this table of values represent?* Note that looking at the graph may give you a hint. *How does changing the "Increment" change the function?*

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G. Let's try something a little more involved. First we are going to change the labels on the columns. Enter "n" in cell A1, "odds" in cell B1, and "f(n)" in cell C1. Enter the values 1 through 11 in cells A2 through A12 using the procedure from section B (starting with 1 and 2 in cells A2 and A3 this time). Now enter the value 1 in cell B2, 3 in cell B3, 5 in cell B4, and so on down to cell B12 (you can enter the first two numbers and then drag down just as we have been doing). This gives us a list of odd integers in the odds column. Finally, enter the value 1 in cell C2 and enter the formula "=C2+B3" in cell C3, then pull this formula down to cell C12. You can delete the contents of cells D1 and D2 if you find them distracting; we won't be using them now.

4. *Compute (by hand) the sum of the first 2 odd integers (i.e. 1+3), the first 3 odd integers (i.e. 1+3+5), etc.* Convince yourself that *f(n)* (in column C) is the function that gives us the sum of the first *n* odd integers (where *n* refers to column A).

5. *Write a rule in standard algebraic notation for the function f(n).* Looking at a graph of the values may help if you don't recognize the pattern (see instructions below in section H if you want to graph the function).

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H. We would like to graph this new function, but now we need to graph columns A and C. This is a little more complicated than it was in step D since our columns are no longer right next to each other, but there are several ways to create the graph. One was is to start by clicking the Chart Wizard icon, select an XY graph and click next, then rather than selecting a data range (since our data isn't next to each other) click on the Series tab, click to add a series, and click on the funny multi-colored icon at the end of the X Values box. The Chart Wizard box will shrink to a single line. Now click and drag to select cells A2..A12. These cells will automatically be filled into the single visible line of the Chart Wizard box. Now click on the funny icon at the end of that single visible line (which will have changed slightly if you look at it closely) to return to the full Chart Wizard box. This time click on the icon at the end of the Y Values box, which will shrink the Chart Wizard box back down to a single line, click and drag to select cells C2..C12 (which will fill into the line automatically again), and then click on the icon at the end of the single line on last time to go back to the full Chart Wizard box. Click Next to go on and fill into the title and axis labels (if you want) and then click Finish to produce the graph.

Bonus

For bonus points, you may do two more exercises where you create a table of values and then work out the algebraic representation of the function.

6. Enter "=A2" in cell B2, and drag this down to cell B12 (so columns A and B are identical) You may change the label in B1 to read "n" now if you want. *f(n)* in column C is now the function that gives the sum of the first *n* integers, and should start 1, 3, 6, 10, 15, … These values are sometimes called the triangular numbers, because you can arrange them in a nice triangle (consider the way 10 pins are set up for bowling or 15 balls for pool). *Can you find a formula, f* (*n*), *for the* n^{th} *triangular number?*

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7. Create a table on your spreadsheet that gives the values of the first *n* cubes (i.e. $1^3 = 1$, $1^3 + 2^3 = 1 + 8 = 9$, etc.) It is probably easiest to put the cubes of the numbers *n* from column A into column B (what formula do you enter into column B to do this?). As set up, the sums of cubes will then be in column C. *Print out a list of the sums of cubes up to n = 11. Can you find a formula for this function?*