Previously:

Set up a business teaching Algebra and Arithmetic skills to students using a combination of online Instruction and in person tutoring. We have determined that our profit for each algebra student will be $2 and $1.25 for each Arithmetic student.

Another piece of the problem is constraints. Students consume resources and we have to support our students. Algebra students are allotted 2 hours of computer instruction and 1 hour of tutoring each week. Arithmetic students have 1 hour of instruction and 1.5 hours of tutoring allowed to them. Our company has the resources to handle a total of 300 hours of computer instruction and 200 hours of in person tutoring each week. This sets limits not only on the total number of students we can support, but also the mix of students we can support.

Objective Function: Maximize $P = 2x + 1.25y$

Variables: x = # of Algebra students that sign up
y = # Arithmetic students that sign up

Constraints: $2x + 1y <= 300$ (computer Instruction hours)
$1x + 1.5y <= 200$ (tutoring hours)

Excel has a built in function called **Solver** that can be used to solve linear programs. (It is an Add-In, so if you do not find it under Data you may need to load it.) The way it works is that you provide the equation to be optimized, an initial guess for the solutions, and all of the constraint equations, all as interactive cells. Then Solver runs an algorithm and comes up with an answer (if one exists). As always, you need to interpret what it tells you!

Presentation is important, so use a format similar to this:

The objective function and the constraints are all functions of the variable cells. Put in any values for the variables to start. 1 or 0 are good choices.

When it is set up, go to the Data tab, and then click on the Solver tool.

Need to designate the Objective function, whether to Maximize or Minimize, which cells are the variables, and then use Add to enter the constraints.

Steps to use Solver:

1. Select the Data tab in the toolbar.
2. Choose Solver. (If it isn't there, you need to choose Add-Ins and check the Solver Add-In.)
3. Answer the questions in the dialog box:

    Target Cell:(the cell containing the objective function: here it's profit amount

    Equal to: (check appropriate option, max. or min.)

    By changing: (cells containing your values for the variables)

    Subject to: (the cells that contain the formulas and values of the constraints. Use the Add button to enter them)

4. Check the box "Make unconstrained variables non-negative" and for the drop down menu for "Select a Solving Method" select Simplex LP
5. Click the Solve button.

Be sure to watch the videos for this section!

Sensitivity Reports

Would tweaking the profit model alter the optimal solution? If we have access to a little more of a resource is an increase in Profit worth the extra expense? To answer these questions, run solver again, but this time select the Sensitivity Report:
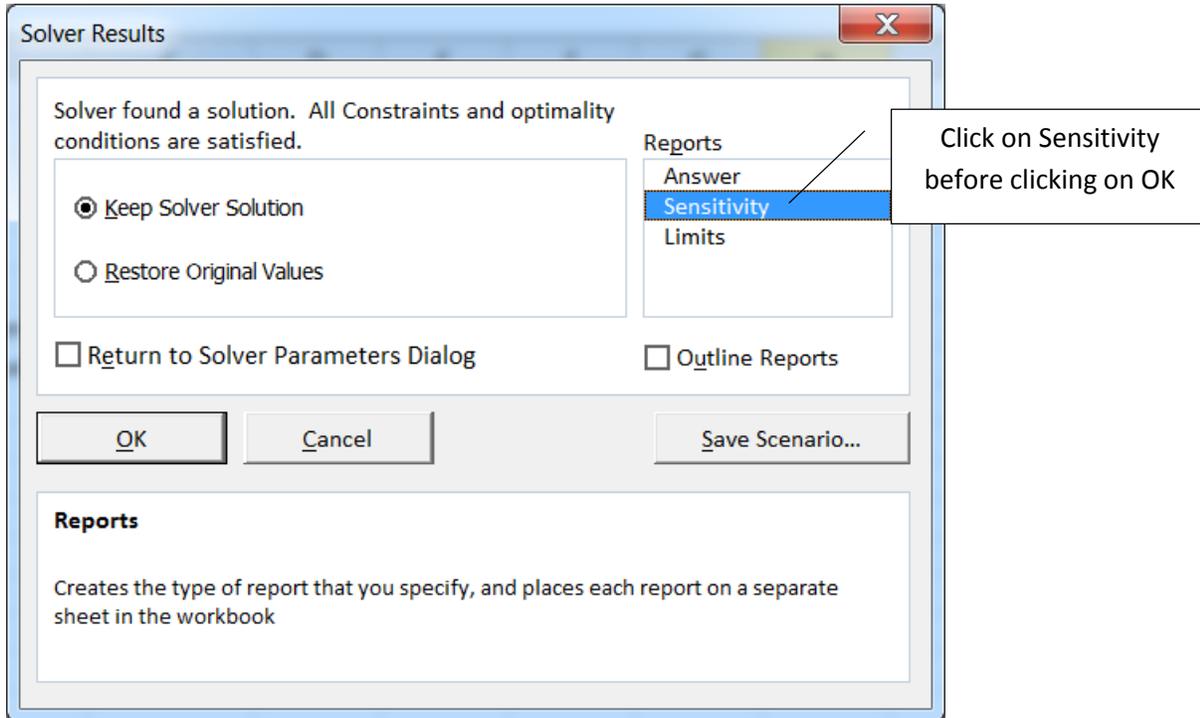
This will insert a new worksheet in your work book, Labeled Sensitivity Report 1:

	Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
Microsoft Excel 14.0 Sensitivity Report							
Worksheet: [Solver and Sensitivity Demo.xlsx]Original set up							
Report Created: 8/18/2014 5:07:24 PM							
Variable Cells							
	D7	x = # Algebra students	125	0	2	0.5	1.166666667
	D8	y = # Arithmetic students	50	0	1.25	1.75	0.25

	Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
Constraints							
	D11	2x + 1y <=300	300	0.875	300	100	166.6666667
	D12	1x + 1.5y <=200	200	0.25	200	250	50

Top section: x = # of alg. students. The Objective coefficient is 2, which is our profit for each algebra student. The allowable increase is 0.5 and the Allowable Decrease is 1.167. That means (assuming the coefficient of y is not changed) the coefficient of x could be decreased by 1.167 to as low as .833 or increased by as much as .5 to as high as 2.5 and the solution of (125, 50) would not change.

With a profit function of 2x + 1.25y =P, our best "product mix" is to have a mix of students: 125 algebra and 50 arithmetic students. If we were to alter our business model so that the profit per algebra student dropped lower than .833 or higher than 2.5 then our profit isolines would tilt enough so that our best solution would jump to another corner of the feasible region.

See the graph below for profit isolines of 2.75x + 1.25y = P. It appears that 150 algebra students and no arithmetic students would maximize our profit now. Which may or may not be a good thing for our business, but either way it would be a significant change.
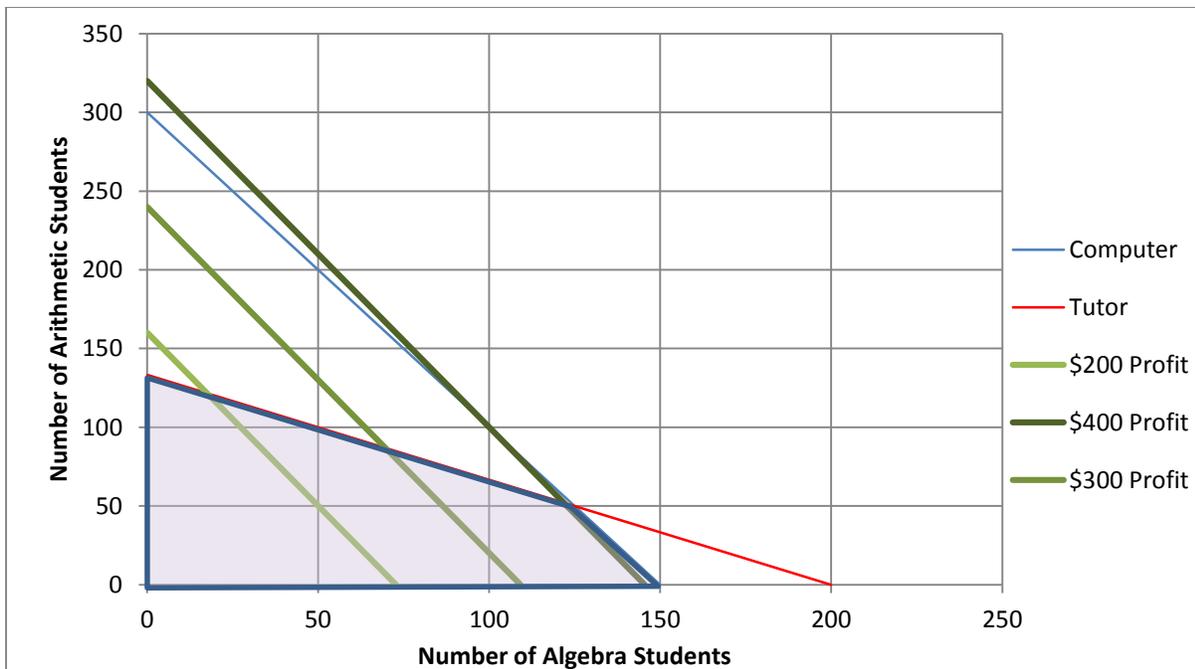
The next line on the sensitivity report is: y = # of arithmetic students. The Objective coefficient is 1.25, the profit on arithmetic students and the allowable increase is 1.75, allowable decrease is 0.25. So the coefficient on y (profit on an arithmetic student) could be as low as 1.00 and as high as 3.00 without changing our mix of 125 algebra students and 50 arithmetic students as being the optimal solution.

	A	B	C	D	E	F	G	H	I	J
1	Microsoft Excel 14.0 Sensitivity Report									
2	Worksheet: [Solver and Sensitivity Demo.xlsx]Original set up									
3	Report Created: 8/18/2014 5:07:24 PM									
4										
5										
6	Variable Cells									
7				Final	Reduced	Objective	Allowable	Allowable		
8		Cell	Name	Value	Cost	Coefficient	Increase	Decrease		
9		D7	x = # Algebra students	125	0	2	0.5	1.166666667		
10		D8	y = # Arithmetic students	50	0	1.25	1.75	0.25		
11										
12	Constraints									
13				Final	Shadow	Constraint	Allowable	Allowable		
14		Cell	Name	Value	Price	R.H. Side	Increase	Decrease		
15		D11	2x + 1y <=300	300	0.875	300	100	166.6666667		
16		D12	1x + 1.5y <=200	200	0.25	200	250	50		
17										
18										

In the lower section of the sensitivity report look at the line where 2x + 1y <=300, that is the constraint for computer instruction. Read across to the Shadow Price for that constraint, which is 0.875. That means that for each additional hour of computer instruction we can come up with, profit would rise by $.875 this is limited by the allowable increase of 100 hours. Could we get an additional 100 hours of computer instruction for less that $875? If so, then it would be worth it.

The shadow price on the tutoring (1x + 1.5y <= 200) is $.25, an increase of one hour of tutoring would increase profit by $.25. It is unlikely that we can get an additional hour of tutoring for that price.