

## Using the Excel Solver: Introduction

Most of you have optimization capabilities right on your desktop, so we will take advantage of these during this course. The Solver add-in for Excel is an easy way to solve relatively small and simple linear, nonlinear, and integer programming problems. (For some extra money, you can buy enhanced solver add-ins for Excel that can solve medium to large problems.)

Let's step through an example to get started.

$$\begin{aligned} \text{Maximize } Z &= x_1 + 3x_2 \\ \text{s.t. } 2x_1 + x_2 &\leq 4 \\ x_1 - 2x_2 &\leq 1 \\ x_1, x_2 &\geq 0 \end{aligned}$$

1. If you sit down at a computer that has Excel, there is a chance that the Solver add-in has not been installed. To check this, open a new workbook and go to the **Tools** menu. Look for **Solver...** on the list. If it's not there, go to **Add-Ins...** on the **Tools** menu, scroll down, and look for **Solver Add-in**. Check the box next to it and continue with Step 2. If **Solver Add-In** does not appear on the list, then it has not been installed. Re-install Excel (a custom install may be needed) and be sure to install the Solver add-in.
2. Decide how you will structure your worksheet. This is important for larger models, as a well-structured worksheet makes debugging much easier and also allows someone else to figure out what you did (the key is to avoid "spaghetti models"). One possibility is to reproduce the matrix form of the problem, as shown in Figure 1. "Fixed", "changing", and "target" cells are all terms used in Excel. In this case, the fixed cells are simply the objective and constraint coefficients, set up in block form. The changing cells will eventually contain the optimal values of  $x_1$  and  $x_2$ , but right now they just have some initial values, which may not even be feasible (are they?). The target cell contains the objective function defining  $Z$  in terms of  $x_1$  and  $x_2$  ( $= D6*D5+E6*E5$ ). Similarly, the cells F7 and F8 contain formulas that compute the RHS values of the constraints. For example, F7 contains " $= D7*D5+E7*E5$ ". (Note: This is just one way of doing things—the sample worksheet discussed below shows more realistic examples.)

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File Edit View Insert Format Tools Data Window Help OR\_MS

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	A	B	C	D	E	F	G
1							Fixed cells (coefficients)
2	<b>Example Problem</b>						Changing cells (variables)
3							Target cell (objective value)
4			Z	X1	X2	RHS	
5				1	1		
6	Objective Function	4		1	3		
7	Constraint 1			2	1	3	
8	Constraint 2			1	-2	-1	
9							
10							

Figure 1. Example worksheet.

- Now you are ready to use the Solver. Choose **Solver...** from the **Tools** menu. The *Solver Parameters* window will open. Set the *Target Cell* to the location of your objective function value, select *Max*, and set the *Changing Cells* to the locations of your decision variables, as shown in Figure 2. Now you need to define the constraints.

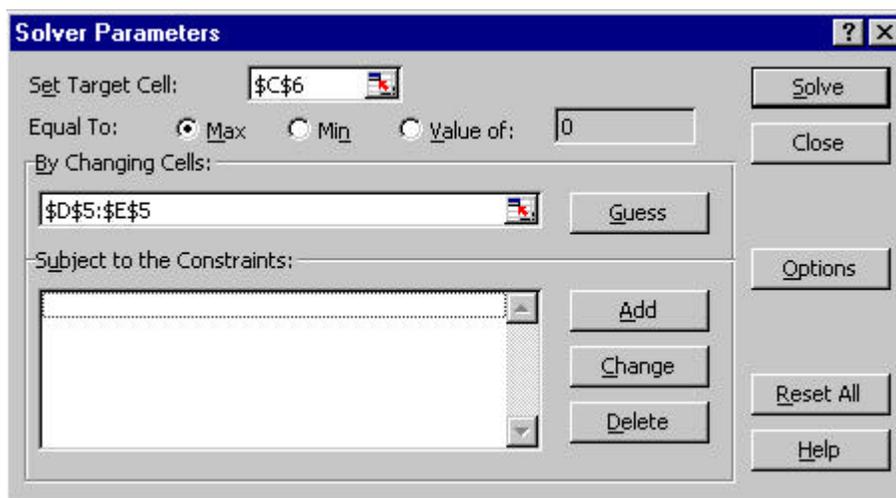


Figure 2. Solver parameters.

- Click on the *Subject to Constraints* box and select *Add*. The *Add Constraint* window will appear, as shown in Figure 3. In this window, you can tell the Solver that a particular cell (or range of cells) must be less than/equal to/or greater than a particular value (which might also depend on one or more variables). In this case, tell the solver that cell F7 must be less than or equal to 4. Select *Add* and repeat for the second constraint (i.e., tell the Solver that cell F8 must be less than or equal to 1). After selecting *Add* for the second constraint, select *Cancel* (there are no more constraints to add). You will return to the *Solver Parameters* window, which should look like Figure 4.

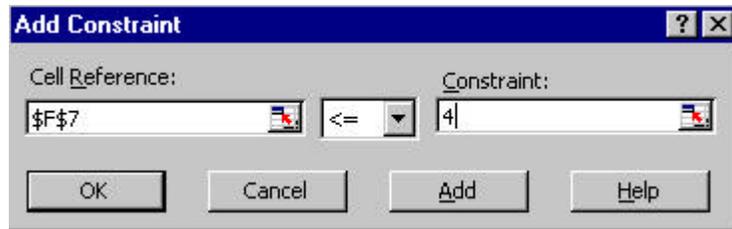


Figure 3. Adding a constraint.

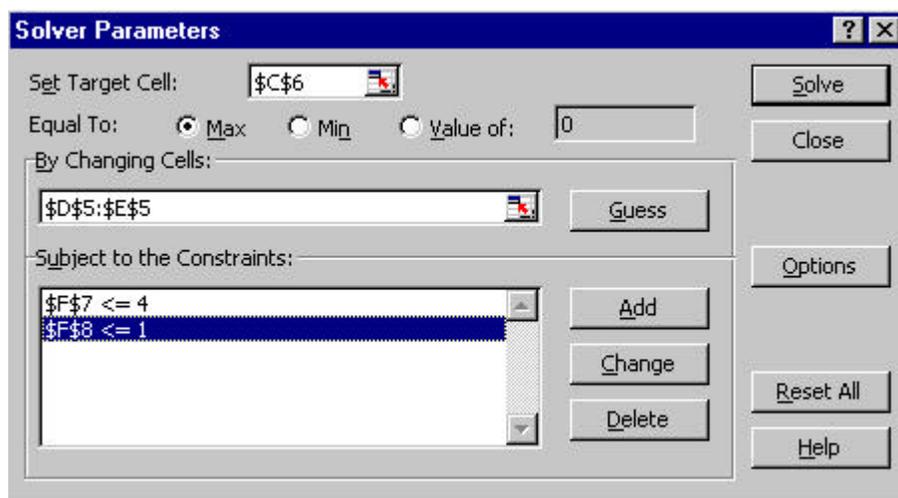


Figure 4. The model fully defined (almost!).

- At this point, you could solve the model, but you will get strange results (try it for fun). The problem, of course, is that we have not told the Solver that the decision variables must be non-negative. You could do this using the *Add Constraint* window, but there is a simpler way. From the *Solver Parameters* window, select *Options*. Check *Assume Linear Model* (it is linear, after all) and *Assume Non-Negative*, as shown in Figure 5. Leave everything else alone (these options will be explained later), and click *OK*.

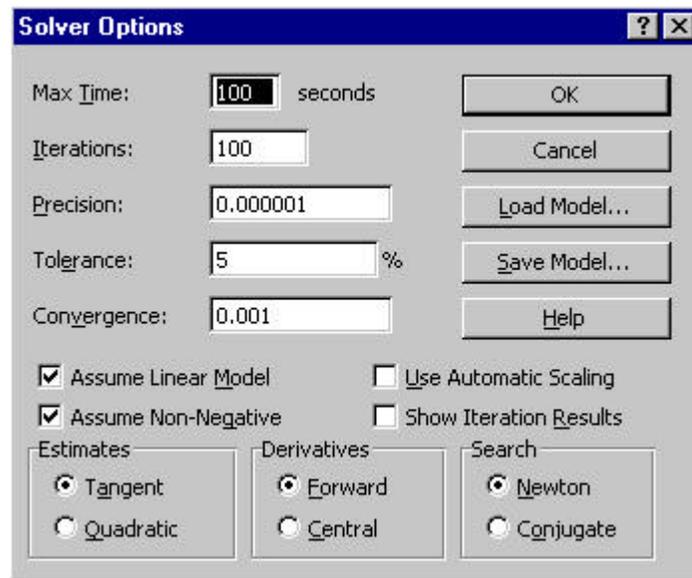


Figure 5. Solver options for a linear programming problem.

6. Return to the *Solver Parameters* window and click *Solve*. Select *Keep Solver Solution* and click *OK*. You should get the following result:  $(x_1 = 0, x_2 = 4, Z = 12)$ . Congratulations! You just solved your first linear programming problem.

### For some more practice...

Microsoft Excel includes a workbook, **Solvsamp.xls** in the **Examples\Solver** folder, that demonstrates the types of problems you can solve. You can use the sample worksheets in **Solvsamp.xls** to help you set up your problems. To use any of the six worksheets (Product Mix, Shipping Routes, Staff Scheduling, Maximizing Income, Portfolio of Securities, and Engineering Design) open the workbook, switch to the worksheet you want to use, and then click **Solver** on the **Tools** menu. The target cell, adjustable cells, and constraints for the worksheet are already specified.

For additional help, use the Excel help, or check out the web site graciously maintained by Frontline Systems, Inc.:

<http://www.frontsys.com/xlhelp.htm>