ONE-TIME ONLY SET UP INSTRUCTIONS

Begin by verifying that the computer you are using has the **Solver Add-In** enabled. Click on **Data** in the menu across the top of the window. On the far right side, you should see **Solver**. If you do not see this, you must install it.

**Installing the Solver Add-In**
Click on **File** in the top left corner of the window. Select **Options**. In the next window, select **Add-Ins** from the list on the left side. At the bottom, click on **Go**.
In the Add-Ins window, select "Solver Add-in". Click OK.

To check your work, click on Data in the top menu line. You should now see Solver on the right side.

**Working a Maximization or Minimization Problem**

<table>
<thead>
<tr>
<th>Problem: Maximize $z = 4x_1 + 5x_2$</th>
<th>Subject to $x_1 + 4x_2 \leq 9$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$4x_1 + x_2 \leq 6$</td>
</tr>
<tr>
<td></td>
<td>$x_1 \geq 0, x_2 \geq 0$</td>
</tr>
</tbody>
</table>

Microsoft Excel makes it easy to solve a “Maximization Problem” or “Minimization Problem.” The following steps are used to solve the above maximization problem. Minimization problems are also done the same way except for some slight differences.

**Column A** is only used for displaying the parts of the problem and labeling the objective function, variables, and constraints.

**Column B** is used to solve the problem, so formulas will only be typed in **Column B**.
1. Open a new Excel Worksheet by clicking the Start button on the task bar, clicking on All Programs, clicking on Microsoft Office, and selecting Microsoft Excel 2010.

2. Click on cell A1 and type the label: “Maximization Problem” or “Minimization Problem” depending on the problem you are solving for. (You do not type the quotation marks. The quotation marks indicate exactly what is to be typed.) Press Enter after each entry. Stretch Columns A and B to be wider by putting the curser in between the column headers until the curser changes to “+” and then dragging the curser to the desired width.

3. Use the down arrow key to move to cell A3 and type the label: “Objective Function”.

4. Click on cell A4 and type the objective function: “z=4x1+5x2”

5. Click on cell A6 and type the label: “Variables”

6. Using the down arrow key, click on cell A7 and type the first variable, “x1”

7. Using the down arrow key, click on cell A8 and type the second variable, “x2”. If there are more variables, type each variable on the following rows.

8. Skip a row using the down arrow key and type the label: “Constraints”

9. Type each constraint inequality in a separate row of Column A. Leave out the basic restrictions of $x \geq 0$ and $y \geq 0$ because these constraints can be set automatically in the Solver process.
10. Now you are ready to type the equations in **Column B** using cell names in the formulas instead of variable names.

Click on cell **B4** and type the objective function.

The objective function $z = 4x_1 + 5x_2$ *should be typed as* 

"$z = 4 \times B7 + 5 \times B8$"

Notice variable $x_1$ was replaced with its cell location of **B7**. Variable $x_2$ was replaced with its cell location of **B8**. It does not matter whether you use capital letters or lower case letters in these entries. Repeat for all the variables. After you enter each formula, you will see a zero on your Excel worksheet. For the solver to work, you must use the cell names in **Column B** instead of the variables.

11. In **Column B**, use the down arrow to get to the variable rows and type zeros in cells **B7** and **B8**. If you have more variables, continue entering zeros. Below is a screen print with formulas shown. Note: To show formulas, depress "~" and "Ctrl" buttons at the same time; to change back, depress "~" and "Ctrl" buttons again.

12. In **Column B** use the down arrow to get to the constraints rows. Type the following formulas, replacing the variables with the cell names:

In **cell B11**, constraint $x_1 + 4x_2$ *should be typed as* 

"$= B7 + 4 \times B8$"

In **cell B12**, constraint $4x_1 + x_2$ *should be typed as* 

"$= 4 \times B7 + B8$"
Notice that the values will show as zeros on the worksheet.

13. In **Column C**, type the augments (constants on the right side of the constraint inequalities) for each of the constraints.

In **cell C10**, type "Augments".
In **cell C11**, type "9".
In **cell C12**, type "6".
14. Click in cell B4 (the objective function) before going to the Data menu and selecting “Solver.” The Data menu should be located on the far right side of the ribbon.

The Solver Parameters window will open.

![Solver Parameters Window](image)

Make sure the Set Objective box is set to “$B$4” (If not, close the window, click in cell B4, and open the Data Solver option again.) Note: "Objective" refers to the cell location of the objective function formula.

On the To: line select “Max” to find the maximum value or select “Min” to find the minimum value.

Click in the By Changing Variable Cells: box and type variables “B7, B8” separated by commas. Note: Do not type the absolute signs (dollar signs) because Excel will add them in for you. If you have more than two variables, make sure you include them in the list.
Click in the **Subject to the Constraints** box and then click the **Add** button. The **Add Constraint** window will pop up.

![Add Constraint](image1.png)

Type the first constraint cell location. For example, enter "B11" in the **Cell Reference** box. Select the appropriate sign from “\(<=\), ”=", or “\(>=\)" as it appears in the linear programming problem by clicking on the down arrow in the middle box. In the **Constraint** box, enter the first augment cell location of "C11". Click the **Add** button. Enter the rest of the constraints and augments in the same manner. When completed, click **OK**. See below.

![Solver Parameters](image2.png)
15. In the **Solver Parameters** window, click on "Make Unconstrained Variables Non-Negative"

   In the box for **Select a Solving Method:**, choose "Simplex LP".

   (In older versions of Excel, you set these selections by choosing “**Assume Linear Model**” and “**Assume Non-Negative**” in the Options window.)

16. In the **Solver Parameters** window click the **Solve** button.

17. A **Solver Results** window will appear telling you that the solver found a solution. Click beside "Keep Solver Solution". Select **Answer** and **Sensitivity** from the Reports box and then click **OK**.

Finally, the Excel worksheet should look like the screen print on the next page.
18. A sheet tab labeled “Answer Report 1” should now be at the bottom of the screen. Click on it to see the results.

19. If you need to re-run the Solver, type zeros in the cells for the variables. Also, right-click on the tabs displaying the results (Answer Report, Sensitivity Report), and delete each of them.

20. Interpret the results. In this sample problem, the maximum is listed on row 16 under Final Value. It equals 14. The maximum occurs when $x_1 = 1$ and $x_2 = 2$. These answers are shown on row 21 and row 22 under Final Value.
Microsoft Excel 14.0 Answer Report
Worksheet: [Book1]Sheet1
Report Created: 1/31/2013 3:41:56 PM
Result: Solver found a solution. All Constraints and optimality conditions are satisfied.

Solver Engine
- Engine: Simplex LP
- Solution Time: 0 Seconds
- Iterations: 2
- Subproblems: 0

Solver Options
- Max Time Unlimited, Iterations Unlimited, Precision 0.000001
- Max Subproblems Unlimited, Max Integer Solns Unlimited, Integer Tolerance 1%, Assume NonNegative

Objective Cell (Max)

<table>
<thead>
<tr>
<th>Cell</th>
<th>Name</th>
<th>Original Value</th>
<th>Final Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$B$4</td>
<td>$z=4x1+5x2$</td>
<td>0</td>
<td>14</td>
</tr>
</tbody>
</table>

Variable Cells

<table>
<thead>
<tr>
<th>Cell</th>
<th>Name</th>
<th>Original Value</th>
<th>Final Value</th>
<th>Integer</th>
</tr>
</thead>
<tbody>
<tr>
<td>$B$7</td>
<td>$x1$</td>
<td>0</td>
<td>1</td>
<td>Contin</td>
</tr>
<tr>
<td>$B$8</td>
<td>$x2$</td>
<td>0</td>
<td>2</td>
<td>Contin</td>
</tr>
</tbody>
</table>

Constraints

<table>
<thead>
<tr>
<th>Cell</th>
<th>Name</th>
<th>Cell Value</th>
<th>Formula</th>
<th>Status</th>
<th>Slack</th>
</tr>
</thead>
<tbody>
<tr>
<td>$B$11</td>
<td>$x1+4x2&lt;=9$</td>
<td>9</td>
<td>$B$11&lt;=$C$11</td>
<td>Binding</td>
<td>0</td>
</tr>
<tr>
<td>$B$12</td>
<td>$4x1+4x2&lt;=5$</td>
<td>6</td>
<td>$B$12&lt;=$C$12</td>
<td>Binding</td>
<td>0</td>
</tr>
</tbody>
</table>
Sensitivity Analysis

Write a summary of the findings from the Sensitivity Report that will answer these questions.

1. What is the range of values that the coefficient of the first variable can have?
2. What is the range of values that the coefficient of the next variable can have?
   Continue for each variable in the objective function.
3. What is the range of values that constant in each constraint can have?
4. What is the shadow price? Explain what this means in terms of the problem.
5. Is the shadow price binding or non-binding?