

CHAPTER 1

In

Focus

WPL_S347

SOLVER

If you have a result that you are trying to reach, multiple values that can change, and multiple constraints for each of these values, then **Solver** is exactly what you need to solve your problem. **Solver** adjusts the values in the cells you specify to produce the result you want from the formula.

Possible uses for **Solver** are:

- **Production** – What is the most profitable mix of items to produce, considering the limitations of inventory and machines?
- **Shipping** – How can the cost of shipping goods from different warehouses be minimised while meeting the demands of clients and not exceeding the capabilities of warehouses?
- **Scheduling** – What is the minimum number of staff required to meet service expectations and union regulations?
- **Investment** – How can the return on capital be maximised considering risk management guidelines?

In this session you will:

- learn how to install Solver
- gain an understanding of the components required for Solver
- learn how to use Solver to solve a simple problem
- learn how to create Solver reports
- learn how to restrict answers using solver options.

INSTALLING SOLVER

Solver is an **Add-In** – a program that can be added when you need it, rather than being included as part of the standard installation of Microsoft Excel. If **Solver** has already been

installed, **Solver** will be listed on the **Tools** menu. If you can't see it, you may need to locate your Microsoft Office CD and insert it in your CD ROM or DVD drive before commencing this exercise.

Try This Yourself:

Before starting this exercise you MUST ensure that Excel has started and that a new, blank workbook is open...

- 1 Select **Tools > Add-Ins** to display the **Add-Ins** dialog box

The options that you see selected will vary depending on the Add-ins previously installed on your computer...

- 2 Scroll down to and click on **Solver Add-in** until it appears with a tick

If the Solver Add-in option does not appear in the list in the Add-ins dialog box, you will need to run the Setup program again and select Solver from there...

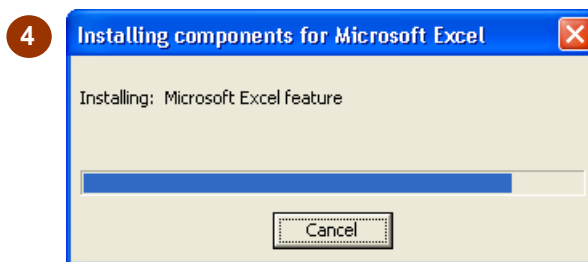
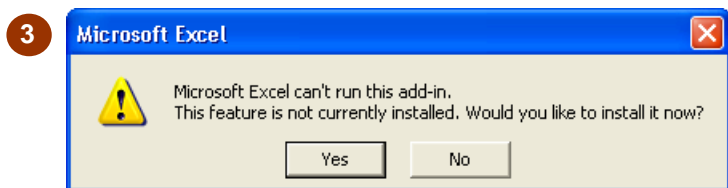
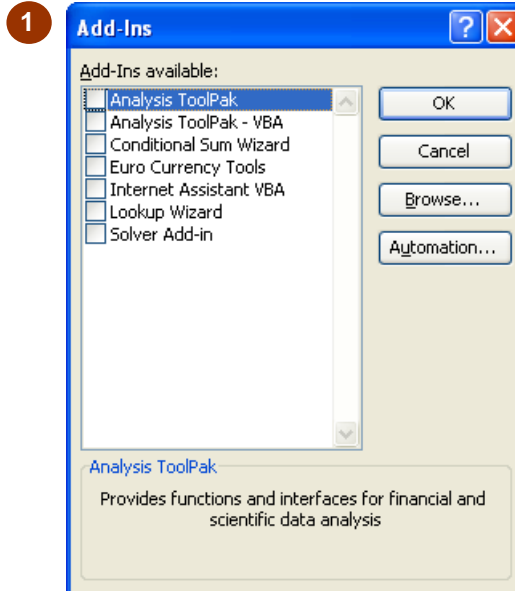
- 3 Click on **[OK]**

If Solver hasn't previously been installed, a message box will appear...

- 4 Click on **[Yes]**

If the Office CD is required, you will be prompted to insert it.

A message box will appear, showing you the progress of the installation. It will disappear when the installation is complete



For Your Reference...

To **install Solver**:

1. Select **Tools > Add-Ins**
2. Scroll down to and click on **Solver Add-in** until it appears with a tick
3. Click on **[OK]** and click on **[Yes]**, inserting the Office CD if required

Handy to Know...

- If you want to install Solver directly from the Office CD, run the CD then select **Add or Remove Features**. Click on the plus sign for **Microsoft Excel for Windows**, then the plus sign for **Add-ins**. Click on the drop arrow for **Solver**, then click on **Run from my computer**. Complete the installation.

SOLVER THEORY

Solver is used to resolve optimisation problems where at least two alternatives are available, and where the goal is to either maximise a return or profit, or minimise expense or effort. There are

generally three components to a problem like this: the **goal**, the **parameters** within which you have to work, and the **variables** that you can juggle. The following explores a simple **Solver** example.

Solver Components: An Advertising Model

The Problem:

Advertising for a coming event is required. The **goal** is to calculate the minimum cost of advertising. The **constraints** are that the advertising must attract at least 28 million female viewers and 24 million male viewers. The **variables** are the numbers of each ad type that you purchase. The **model** incorporates the following information. Each news ad is seen by 7 million women and 2 million men. Each sports ad is seen by 2 million women and 12 million men. Each news ad costs \$50,000 and each sports ad costs \$100,000.

Advertising Model				
Description	Quantity	Viewers		Cost
		Female	Male	
1 minute news ad		0	0	\$0.00
1 minute sports ad		0	0	\$0.00
Total:		0	0	\$0.00
		$\geq 28,000,000$	$\geq 24,000,000$	

The **model** uses formulas in these cells to calculate how many female and male viewers see each ad and how much they cost.

The cells that can change, or **variables**, are the quantities of each ad type. These are the 'by changing cells'.

The **constraints** affect the totals in these cells. Females must be at least 28,000,000 and Males 24,000,000.

The **goal** is to minimise the value of the total cost. This cell is called the **target cell**.

The Solution:

Microsoft Excel Solver takes the calculations and constraints and calculates an answer. In this case, the minimum advertising expense for the required impact can be achieved by running **4** news ads and **1** sports ad.

Advertising Model				
Description	Quantity	Viewers		Cost
		Female	Male	
1 minute news ad	4	28,000,000	8,000,000	\$200,000.00
1 minute sports ad	1	2,800,000	16,800,000	\$140,000.00
Total:		28,000,000	24,000,000	\$320,000.00
		$\geq 28,000,000$	$\geq 24,000,000$	

The **quantities** are varied until the **constraints** are satisfied and the minimum possible **cost** is achieved.

USING SOLVER FOR A SIMPLE PROBLEM

Solver can be used to find the best fit for variables in a model so that you reach the target that you specify. You may want to **maximise** or **minimise** the result, or ask Solver to juggle the


values until you reach a specific value. In this example, we use Solver to calculate the best mix of advertisements so that we reach a particular audience size and mix, and minimise the cost.

Try This Yourself:

Open
File

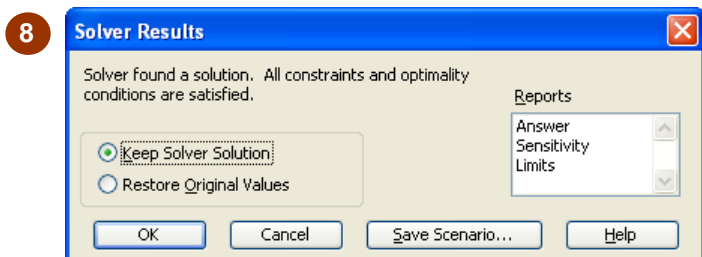
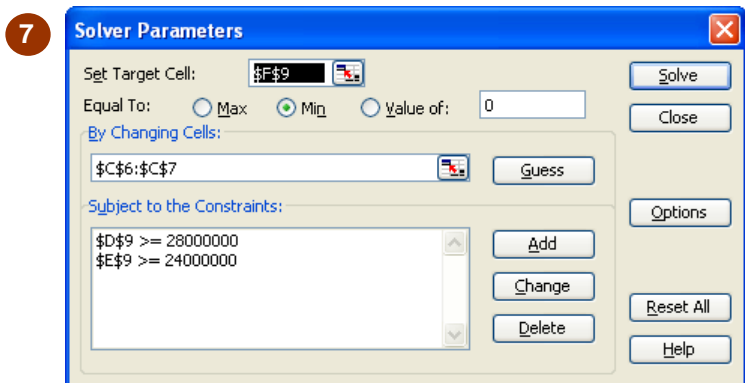
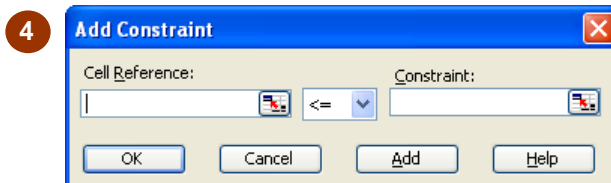
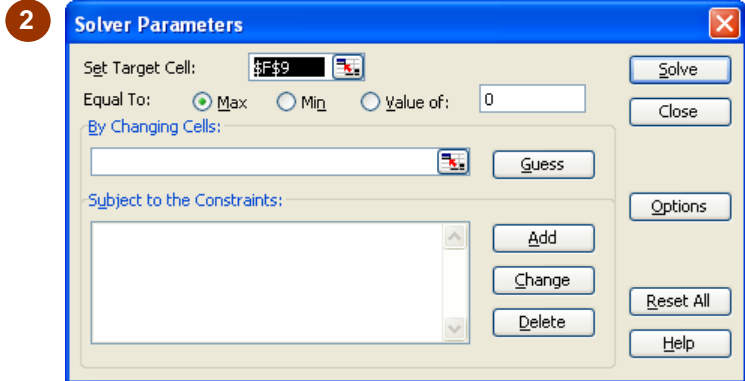
Before starting this exercise you **MUST** open the file *S347 Solver_1.xls...*

- 1 Examine the formulas in the worksheet
- 2 Click on cell **F9**, then select **Tools > Solver** to display the **Solver Parameters** dialog box

The Set Target Cell should be \$F\$9. We want to find its minimum possible value...
- 3 Click on **Min** in **Equal To** then click in the **By Changing Cells** box and type **C6:C7**
- 4 Click on **[Add]** to display the **Add Constraint** dialog box
- 5 Type **D9** in the **Cell Reference**, then click on the drop arrow  and click on **>=**
- 6 Type **28000000** in **Constraint**, then click on **[Add]**
- 7 Repeat steps 5 and 6 to create the constraint **E9 >= 24000000** then click on **[OK]** (not **[Add]**)

The constraints will be listed...
- 8 Click on **[Solve]**

The Solver Results dialog box will appear and the worksheet will display the result...
- 9 Click on **[OK]** to keep the solver solution



For Your Reference...

To **run Solver**:

1. Select **Tools > Solver**
2. Set the **Target Cell**, **By Changing Cells** and **Constraints**
3. Click on **[Solve]**
4. Click on **[OK]**

Handy to Know...

- If **Solver** can't find a solution for you, it will display an error message explaining the problem. If you don't understand the message, search for **Troubleshoot Solver** under Excel Help for more information and helpful suggestions.

SOLVER REPORTS

To record **Solver's** results and settings you can create **reports**. There are three types of reports: **Answer**, **Sensitivity** and **Limits**. **Answer** reports the original and final values for the target, as well

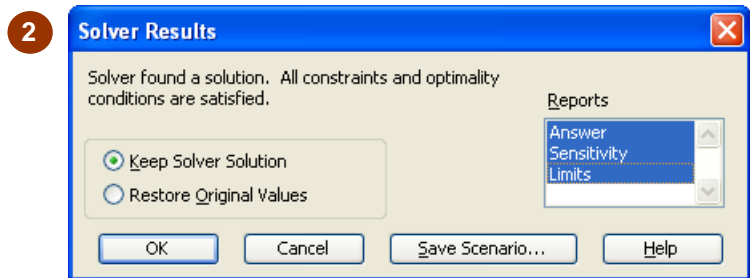
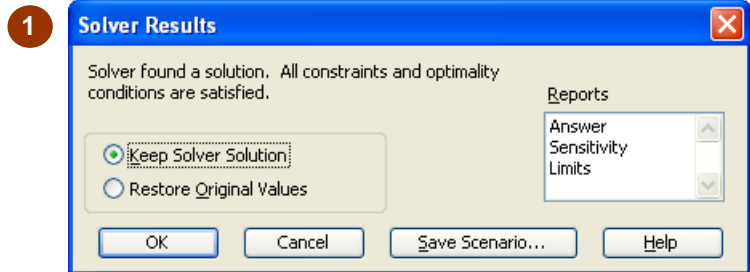
as the settings. **Sensitivity** refers to how sensitive the solution is to small changes in the formula. **Limits** lists the possible upper and lower values between which a solution can be reached.

Try This Yourself:

Same File

Continue using the previous file with this exercise, or open the file S347 Solver_2.xls...

- 1 Select **Tools > Solver** to display the **Solver Parameters** dialog box, then click on **[Solve]**
The Solver Results dialog box will be displayed...
- 2 Click on **Answer** in the **Reports** list, then click on **Sensitivity** and **Limits**
All three should be selected...
- 3 Click on **[OK]** to create the reports
They will appear as new worksheets in the workbook...
- 4 Click on the **Answer Report 1** worksheet tab to see the answer and setting details
- 5 Click on the **Sensitivity Report 1** worksheet tab and the **Limits Report 1** worksheet tab to see these reports
This is a very simple example with only one possible solution. As a result, the Sensitivity and Limits reports do not provide much in the way of additional information



	A	B	C	D	E	F	G
1	Microsoft Excel 11.0 Answer Report						
2	Worksheet: [S347 Solver_2.xls]Advertising						
3	Report Created: 5/07/2004 2:24:18 p.m.						
4							
5							
6	Target Cell (Min)						
7	Cell	Name	Original Value	Final Value			
8	\$F\$9	Total: Cost	\$320,000.00	\$320,000.00			
9							
10							
11	Adjustable Cells						
12	Cell	Name	Original Value	Final Value			
13	\$C\$6	1 minute news ad Quantity	4	4			
14	\$C\$7	1 minute sports ad Quantity	1	1			
15							
16							
17	Constraints						
18	Cell	Name	Cell Value	Formula	Status	Slack	
19	\$D\$9	Total: Female	28,000,000	\$D\$9>=28000000	Binding	0	
20	\$E\$9	Total: Male	24,000,000	\$E\$9>=24000000	Binding	0	
21							
22							

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For Your Reference...

To **create reports** using **Solver**:

1. Run **Solver** to display the **Solver Results** dialog box
2. Click on the report name(s)
3. Click on **[OK]**

Handy to Know...

- An alternative to creating reports to save the settings is to use the **[Save Scenario]** button on the **Solver Results** dialog box. This creates a scenario that can be accessed using the **Scenario Manager** via **Tools > Scenarios**.

RESTRICTING ANSWERS USING SOLVER OPTIONS

If you are working with values, there will be times when you want to restrict the answers to positive numbers and integers. For example, you cannot have a negative number of people, or only a

fraction of an advertisement. You can use the **Solver Options** to define constraints for the answer, as well as the precision, time constraints, the number of iterations to perform, and so on.

Try This Yourself:

Same File

Continue using the previous file with this exercise, or open the file *S347 Solver_3.xls...*

- 1 Click on the **Scheduling** worksheet tab and examine the formulas and roster

Given the minimum daily staff levels, how many staff are required each day in the café?

- 2 Click on cell **E12**, then select **Tools > Solver** to display the **Solver Parameters** dialog box

- 3 Use the information shown to set the solver parameters

- 4 Check the parameters as shown, then click on **[Solve]** then click on **[OK]**

The result includes negative staff!

- 5 Select **Tools > Solver** then click on **[Options]** to display the **Solver Options** dialog box

- 6 Click on **Assume Non-Negative**, then click on **[OK]** and **[Solve]** and **[OK]**

Now fractions of staff!

- 7 Select **Tools > Solver** then add the constraint **E4:E10 int** (operator) then click on **[OK]**, **[Solve]** and **[OK]**

A result is reached – a total of 22 staff, and all constraints met

- 3 Set Target Cell **\$E\$12**
Equal To **Min**
By Changing Cells **E4:E10**
Constraints **D4 >= C4** **D8 >= C8**
D5 >= C5 **D9 >= C9**
D6 >= C6 **D10 >= C10**
D7 >= C7

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Day	Minimum Required	Number of Staff Required on Day	Number of Staff Starting Roster
Monday	9	9	-3.00
Tuesday	14	14	8.00
Wednesday	12	12	4.00
Thursday	16	16	3.00
Friday	18	18	6.00
Saturday	20	20	-1.00
Sunday	16	16	4.00
Total Staff:			21.00

Note: Staff Roster is 5 consecutive days on, 2 days off

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For Your Reference...

To **force non-negative results**:

1. Select **Tools > Solver**, then click on **[Options]**
2. Click on **Assume Non-Negative** until it appears with a tick
3. Click on **[OK]**

For Your Reference...

To **force integer results**:

1. Select **Tools > Solver** and select the **By changing cells**
2. Click on **[Add]** to display the **Add Constraint** dialog box, click on the drop arrow and select **int**, then click on **[OK]**
3. Click on **[OK]**