CHAPTER 14 SOLVER

INFOCUS

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:

- ✓ gain an understanding of how ***Solver*** can be used to solve complex problems
- ✓ learn how to install the ***Solver*** add-in
- ✓ learn how to set the base ***Solver*** parameters
- ✓ learn how to add constraints to ***Solver***
- ✓ learn how to use ***Solver*** to solve a modelling problem
- ✓ learn how to run and use ***Solver*** reports.

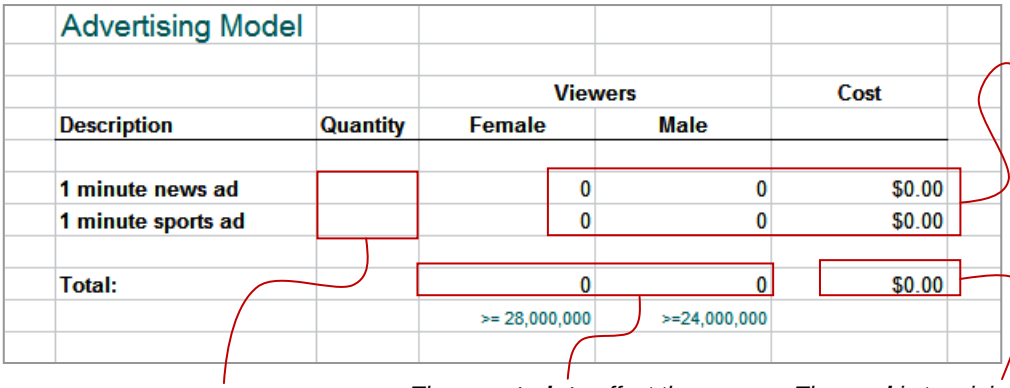
UNDERSTANDING HOW SOLVER WORKS

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

1 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				
		Viewers		Cost
Description	Quantity	Female	Male	
1 minute news ad		0	0	$0.00
1 minute sports ad		0	0	$0.00
Total:		0	0	$0.00
		>= 28,000,000	>=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.*

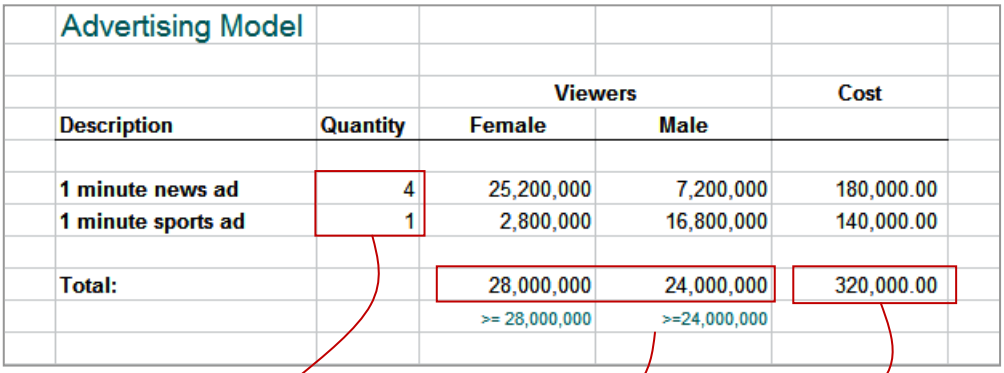
*The cells that can change, or **variables**, are the quantities of each ad type. These are the "**by changing cells**".*

*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**.*

2 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				
		Viewers		Cost
Description	Quantity	Female	Male	
1 minute news ad	4	25,200,000	7,200,000	180,000.00
1 minute sports ad	1	2,800,000	16,800,000	140,000.00
Total:		28,000,000	24,000,000	320,000.00
		>= 28,000,000	>=24,000,000	

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

INSTALLING THE SOLVER ADD-IN

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 it will appear in the ***Analysis*** group on the ***Data*** tab of the ***Ribbon***. If it doesn't appear in the Ribbon then it will need to be installed using the ***Excel Options*** dialog box.

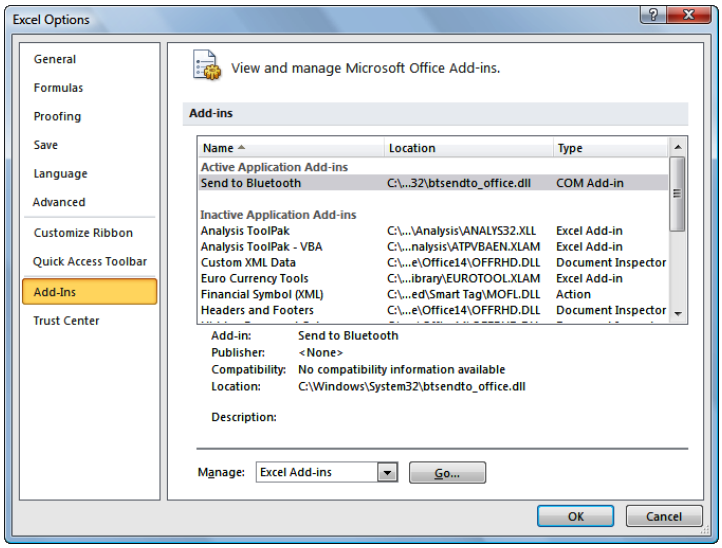
Try This Yourself:

Before starting this exercise you MUST ensure that Excel has started...

1. Click on the ***File*** tab of the ***Ribbon*** and select **Options**, to display the ***Excel Options*** dialog box
2. Click on ***Add-Ins*** to display a list of active and inactive add-ins
3. Click on ***Solver Add-In*** and click on **[Go…]** to display the ***Add-Ins*** dialog box
4. Click on ***Solver Add-In*** until it appears with a tick, then click on **[OK]** – Excel will now ask if you wish to install it
5. Click on **[Yes]**

The installation process will now commence. It may take a few minutes to complete so be patient. The tool will appear on the Data tab of the Ribbon once installed

2



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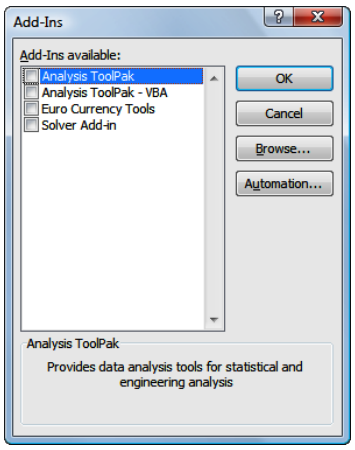

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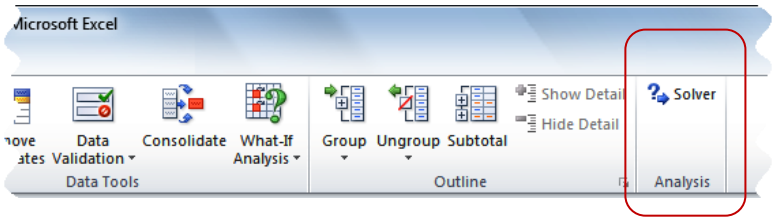


For Your Reference…

To ***install*** the ***Solver add-in***:

1. Click on the ***File*** tab, select **Options**, then click on ***Add-Ins***
2. Click on ***Solver Add-In*** and click on **[Go…]**
3. Click on ***Solver Add-In*** until it appears ticked and click on **[OK]**

Handy to Know…

- The ***Add-Ins*** area of the ***Excel Options*** dialog box shows both active and inactive add-ins. If you are not sure whether an add-in has been installed or where it is found on the ***Ribbon***, open the ***Excel Options*** dialog box and click on the ***Add-Ins*** option to display the list of add-ins.

SETTING SOLVER PARAMETERS

Once you have located a problem to solve it is a matter of starting ***Solver*** and entering the base information. This information includes nominating the ***target cell***, the cells that need to be changed to arrive at a workable solution, and a ***scope*** for the target cell – in other words what the target cell should equal at the end of the calculation.

Try This Yourself:

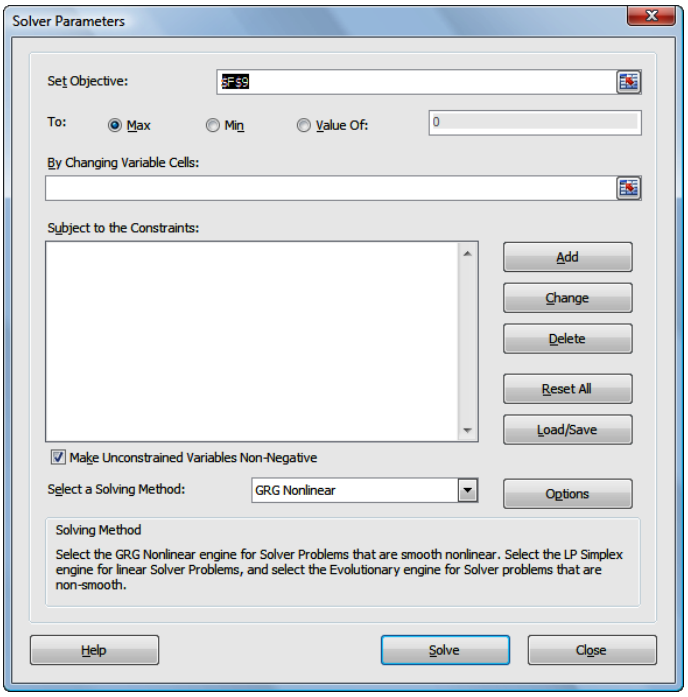
Open File — *Before starting this exercise you MUST open the file E844 Solver_1.xlsx...*

1. Spend a few moments studying the worksheet and its formulas
2. Click on ***F9*** – this is the *target cell* in which we want to have a result
3. Click on the ***Data*** tab of the ***Ribbon*** and click on ***Solver***, in the ***Analysis*** group, to display the ***Solver Parameters*** dialog box

   The selected cell appears in Set Objective…
4. Click on ***Min*** in ***To***
5. Click on the ***range selection*** tool for ***By Changing Variable Cells***
6. Click on ***C6*** and drag down to ***C7*** to select the two cells
7. Click on the ***range accept*** tool to return to the ***Solver Parameters*** dialog box

   Keep the Solver Parameters dialog box open for the next exercise

3



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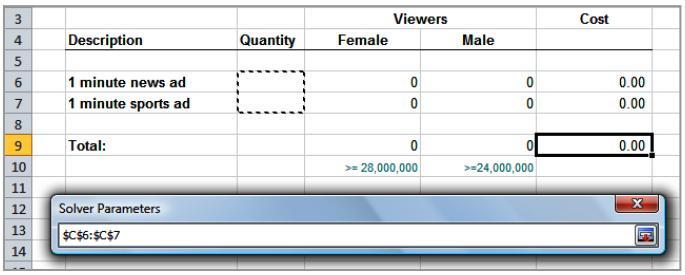

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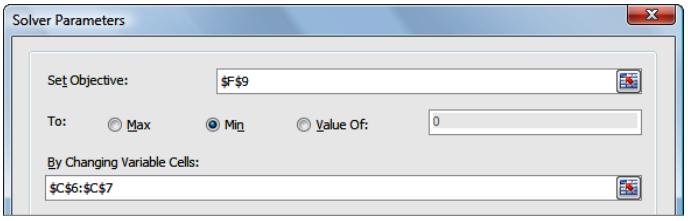


For Your Reference…

To ***set*** the ***base Solver parameters***:

1. Click on ***Solver*** in the ***Analysis*** grouping on the ***Data*** tab
2. Specify the target cell, what it should be equal to, and the changing cells

Handy to Know…

- You can also type in the range and cell location, in the ***Solver Parameters*** dialog box, rather than using the ***range selection*** and ***range accept*** tools.

ADDING SOLVER CONSTRAINTS

Solver ***constraints*** are like ***rules*** that constrain what can be changed in the model. Constraints are created from the ***Solver Parameters*** dialog box and are listed in the dialog box for reference.

While you can have as many constraints as you like, the more constraints you impose, the harder it will be for ***Solver*** to find a solution.

Try This Yourself:

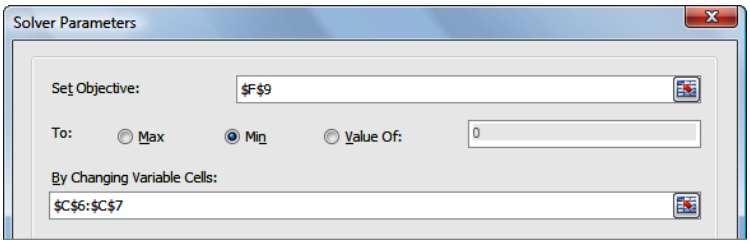
Same File

Ensure that the Solver Parameters dialog box appears from the previous exercise...

1. Ensure that the settings in the ***Solver Parameters*** dialog box are as shown
2. Click on **[Add]** to display the ***Add Constraint*** dialog box
3. Type **D9** in ***Cell Reference***, then click on the drop arrow and click on **>=**
4. Type **28000000** in ***Constraint***

   This rule constrains Solver by telling it that cell D9 must be greater than or equal to 28,000,000 at the end of the Solver operation…
5. Click on **[Add]** to save this constraint and add it to the ***Solver Parameters*** dialog box
6. Repeat the above steps to create a second constraint as shown
7. Click on **[OK]** to return to the ***Solver Parameters*** dialog box where the constraints will be listed

   Keep the Solver Parameters dialog box open for the next exercise



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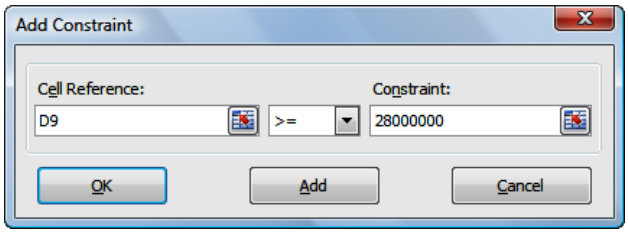

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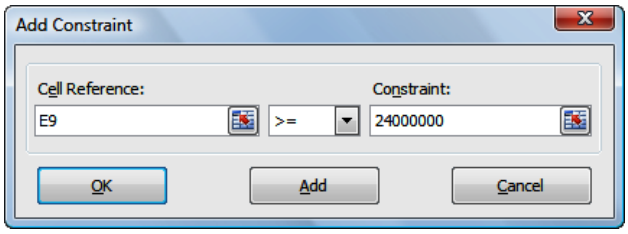

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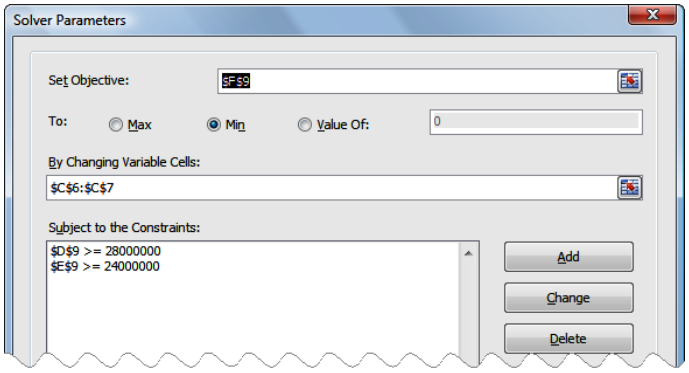


For Your Reference…

To ***add constraints*** to ***Solver***:

1. From the ***Solver Parameters*** dialog box, click on **[Add]**
2. Type the constraint details and click on **[Add]**

Handy to Know…

- You can use the **[Change]** and **[Delete]** buttons in the ***Solver Parameters*** dialog box to make changes to constraints and delete them after they have been created.

PERFORMING THE SOLVER OPERATION

Once all of the parameters have been set you are ready to use ***Solver*** to try and resolve the mathematical problem. Solver actually reiterates through the formulas and constraints in the model until a satisfactory solution is found. The results are then displayed in the model and a dialog box appears with options allowing you to keep or discard the results.

Try This Yourself:

Same File

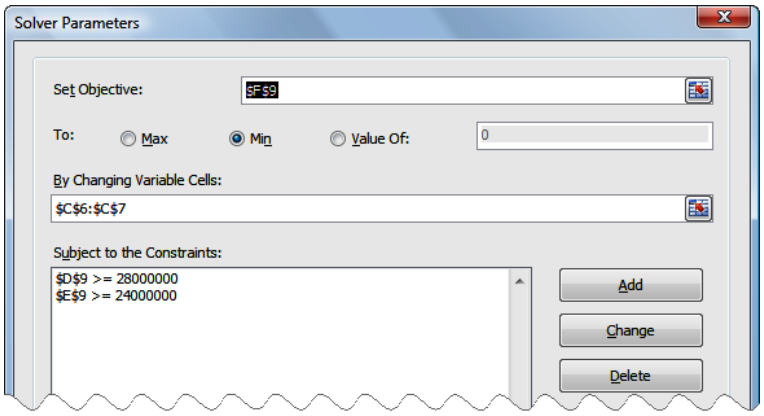
Ensure that the Solver Parameters dialog box appears from the previous exercise...

1. Ensure that the settings in the ***Solver Parameters*** dialog box are as shown
2. Click on **[Solve]** to perform the *Solve* operation

   If the Solver operation can be performed the results will appear in the worksheet and the Solver Results dialog box will appear…
3. Click on **[OK]**

Cool! To reach a target of 28 million female viewers and 24 million male viewers, you'll need to spend 180,000 for 4 one minute ads in the news, and 140,000 for a 1 minute sports time ad

1



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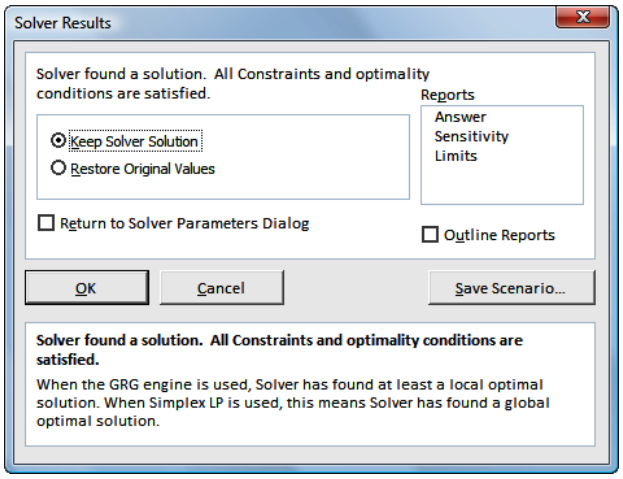


3

	A	B	C	D	E	F
1		Advertising Model				
2						
3				Viewers		Cost
4		Description	Quantity	Female	Male	
5						
6		1 minute news ad	4	25,200,000	7,200,000	180,000.00
7		1 minute sports ad	1	2,800,000	16,800,000	140,000.00
8						
9		Total:		28,000,000	24,000,000	320,000.00
10				>= 28,000,000	>=24,000,000	
11						

For Your Reference…

To ***perform*** the ***solve operation***:

1. Ensure that all of the parameters have been set
2. From the ***Solver Parameters*** dialog box click on **[Solve]**

Handy to Know…

- The ***Solver Results*** dialog box allows you to keep (**[OK]**) or discard (**[Cancel]**) the results of the solve operation. You can also keep the original figures and the new, solved figures by saving the results as a scenario using **[Save Scenario]**.

RUNNING 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.

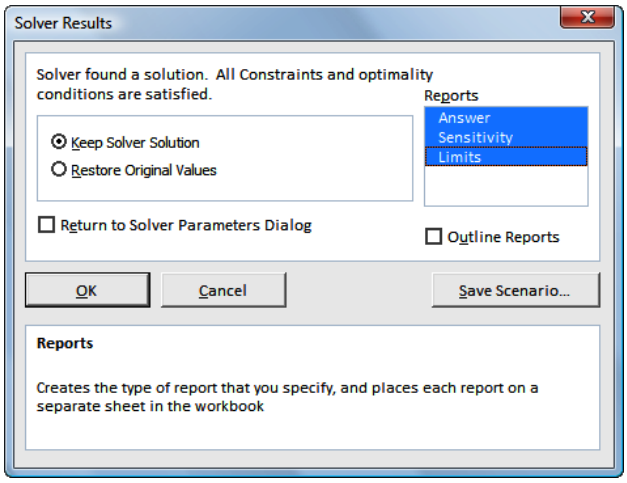
Try This Yourself:

Same File

Continue using the previous file with this exercise, or open the file E844 Solver_2.xlsx...

1. On the ***Data*** tab on the ***Ribbon***, click on ***Solver*** , in the ***Analysis*** group, to see the ***Solver Parameters*** dialog box
2. Click on **[Solve]** to perform the *Solve* operation and see the ***Solver Results*** dialog box
3. Click on ***Answer*** in ***Reports***, then click on ***Sensitivity*** and ***Limits*** to select all three
4. Click on **[OK]** to create the reports which will appear as worksheet tabs at the bottom of the window
5. Click on the ***Answer Report 1*** worksheet tab to see the answer and setting details
6. Click on the other tabs and examine the reports

3



5

	A	B	C	D	E	F	G	H	I
1	**Microsoft Excel 14.0 Answer Report**								
2	**Worksheet: [E844 Solver_3.xlsx]Advertising**								
3	**Report Created: 2/08/2010 12:41:50 PM**								
4	**Result: Solver found a solution. All Constraints and optimality conditions are satisfied.**								
5	**Solver Engine**								
6	Engine: GRG Nonlinear								
7	Solution Time: 0 Seconds.								
8	Iterations: 0 Subproblems: 0								
9	**Solver Options**								
10	Max Time Unlimited, Iterations Unlimited, Precision 0.000001								
11	Convergence 0.0001, Population Size 100, Random Seed 0, Derivatives Central								
12	Max Subproblems Unlimited, Max Integer Sols Unlimited, Integer Tolerance 1%, Assume NonNegative								
13									
14	Objective Cell ()								
15	**Cell**	**Name**	**Original Value**	**Final Value**					
16	F9	Total: Cost	320,000.00	320,000.00					
17									
18									
19	Variable Cells								
20	**Cell**	**Name**	**Original Value**	**Final Value**	**Integer**				
21	C6	1 minute news ad Quantity	4	4	Contin				
22	C7	1 minute sports ad Quantity	1	1	Contin				
23									

For Your Reference…

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

1. Run ***Solver*** until the ***Solver Results*** dialog box appears
2. Select ***Answer***, ***Sensitivity***, and ***Limits*** in the ***Solver Results*** dialog box and click on **[OK]**

Handy to Know…

- The case study example we use is relatively simple with only one possible solution. As a result the ***Sensitivity*** and ***Limits*** reports do not provide much in the way of additional information. These reports however come into their own with more complex Solver models.

NOTES: