What-If Analysis

What-If Analysis in **Excel** allows you to try out different values (scenarios) for formulas. The following example helps you master what-if analysis quickly and easily.

Assume you own a book store and have 100 books in storage. You sell a certain % for the highest price of \$50 and a certain % for the lower price of \$20.

C8	}	▼ : × √ f _x	=B4*(1-C4)		
	А	В	С	D	E
1	Book	Store			
2					
3		total number of books	% sold for the highest price		
4		100	60%		
5					
6			number of books	unit profit	
7		highest price	60	\$50	
8		lower price	40	\$20	
9					
10			total profit	\$3,800	
11					

If you sell 60% for the highest price, cell D10 calculates a total profit of 60 * \$50 + 40 * \$20 = \$3800.

Create Different Scenarios

But what if you sell 70% for the highest price? And what if you sell 80% for the highest price? Or 90%, or even 100%? Each different percentage is a different **scenario**. You can use the Scenario Manager to create these scenarios.

Note: You can simply type in a different percentage into cell C4 to see the corresponding result of a scenario in cell D10. However, what-if analysis enables you to easily compare the results of different scenarios.

1. On the Data tab, in the Forecast group, click What-If Analysis.



2. Click Scenario Manager.

<u>S</u> cenario Manager	
Goal Seek	63
Data <u>T</u> able	

The Scenario Manager dialog box appears.

3. Add a scenario by clicking on Add.

Scenario Manag	er	?	\times
S <u>c</u> enarios:			
No Scenarios de	fined. Choose Add to add scenarios.	Ac De Ec Sum	1d
Changing cells:			
Comment:			
	Show	CI	ose

4. Type a name (60% highest), select cell C4 (% sold for the highest price) for the Changing cells and click on OK.

Add Scenario		?	\times
Scenario <u>n</u> ame:			
60% highest			
Changing <u>c</u> ells:			
SCS4			Ť
Ctrl+click cells to select non-adjacent ch	anging cells.		
C <u>o</u> mment:			
Created by excel-easy.com on 1/24/2020			~
			\sim
Protection			
Prevent changes			
Hi <u>d</u> e			
	ОК	Cano	el

5. Enter the corresponding value 0.6 and click on OK again.

Scenario Values	? ×
Enter values for ea <u>1</u> : SCS4	ch of the changing cells. 0.6
<u>A</u> dd	OK Cancel

6. Next, add 4 other scenarios (70%, 80%, 90% and 100%).

Finally, your Scenario Manager should be consistent with the picture below:

Scenario Manag	er			?	×
S <u>c</u> enarios:					
60% highest		~	<u>A</u> do	i	
80% highest			Dele	ete	
90% highest					
100% highest			<u>E</u> di	t	
			<u>M</u> erg	je	
			Summ	ary	
		\sim	_	-	
Changing cells:	\$C\$4				
enunging censi					
Comment:	Created by excel-	easy.co	om on 1/2	4/2020	
			_		
		<u>S</u> h	ow	Clo	se

Note: to see the result of a scenario, select the scenario and click on the Show button. Excel will change the value of cell C4 accordingly for you to see the corresponding result on the sheet.

Scenario Summary

To easily compare the results of these scenarios, execute the following steps.

- 1. Click the Summary button in the Scenario Manager.
- 2. Next, select cell D10 (total profit) for the result cell and click on OK.

Scenario Summary	?	\times
Report type Scenario <u>s</u> ummary Scenario <u>P</u> ivotTable	report	
Result cells: =\$D\$10		Ť
ОК	Car	ncel

Result:

Scenario Summary										
	Current Values:	60% highest	70% highest	80% highest	90% highest	100% highest				
Changing Cells:										
\$C\$4	60%	60%	70%	80%	90%	100%				
Result Cells:										
\$D\$10	\$3,800	\$3,800	\$4,100	\$4,400	\$4,700	\$5,000				
Notes: Current V	Notes: Current Values column represents values of changing cells at									
time Scenario Summary Report was created. Changing cells for each										
scenario are high	lighted in gray.									

Conclusion: if you sell 70% for the highest price, you obtain a total profit of \$4100, if you sell 80% for the highest price, you obtain a total profit of \$4400, etc. That's how easy what-if analysis in Excel can be :-).

Goal Seek

What if you want to know how many books you need to sell for the highest price, to obtain a total profit of exactly \$4700? You can use **Excel's Goal Seek** feature to find the answer.

1. On the Data tab, in the Forecast group, click What-If Analysis.

J I I I I I I I I I I I I I I I I I I I								
Text to	Flash	Remove	Data	Consolidate	Relationships	Manage	What-If	Forecast
Columns	Fill	Duplicates	Validation 🔻			Data Model	Analysis 🕶	Sheet
Data Tools							Fore	cast

2. Click Goal Seek.



The Goal Seek dialog box appears.

- 3. Select cell D10.
- 4. Click in the 'To value' box and type 4700.
- 5. Click in the 'By changing cell' box and select cell C4.
- 6. Click OK.



Result. You need to sell 90% of the books for the highest price to obtain a total profit of exactly \$4700.

C8	C8 • : $\times \checkmark f_x$ =B4*(1-C4)									
	А	В	С	D	E					
1	Book	Store								
2										
3		total number of books	% sold for the highest price							
4		100	90%							
5										
6			number of books	unit profit						
7		highest price	90	\$50						
8		lower price	10	\$20						
9										
10			total profit	\$4,700						
11										

More on Goal Seek

If you know the result you want from a formula, use **Goal Seek** in **Excel** to find the input value that produces this formula result. **It's like working backwards from a solution to the problem (input).**

Goal Seek Example 1

Use Goal Seek in Excel to find the grade on the fourth exam that produces a final grade of 70.

1. The formula in cell B7 calculates the final grade.

		-							
B7	· ·	1 ×	✓ f.	🕯 🛛 =AVE	ERAGE(B2:	B5)			
	Α	В	С	D	E	F	G	Н	- I
1	Exam	Grade							
2	Exam 1	50							
3	Exam 2	80							
4	Exam 3	60							
5	Exam 4								
6									
7	Final Grade	63.33333							
8									

2. The grade on the fourth exam in cell B5 is the input cell.

BS	5 -	: ×	🗸 j	Esc.					
	А	В	С	D	Е	F	G	н	I.
1	Exam	Grade							
2	Exam 1	50							
3	Exam 2	80							
4	Exam 3	60							
5	Exam 4								
6									
7	Final Grade	63.33333							
8									

3. On the Data tab, in the Forecast group, click What-If Analysis.

	8							
Text to	Flash	Remove	Data	Consolidate	Relationships	Manage	What-If	Forecast
Columns	Fill	Duplicates	Validation 🔻			Data Model	Analysis 🕶	Sheet
			Data 1	ools			Fore	cast

4. Click Goal Seek.



The Goal Seek dialog box appears.

- 5. Select cell B7.
- 6. Click in the 'To value' box and type 70.
- 7. Click in the 'By changing cell' box and select cell B5.

8. Click OK.

Goal Seek		? X	
S <u>e</u> t cell:	SBS7	Ţ]
To <u>v</u> alue:	70		
By <u>c</u> hanging cell:	\$B\$5	Ţ]
ОК	2	Cancel	

Result. A grade of 90 on the fourth exam produces a final grade of 70.

BS	; •	: ×	√ f	÷ 90					
	А	В	С	D	E	F	G	н	I.
1	Exam	Grade							
2	Exam 1	50							
3	Exam 2	80							
4	Exam 3	60							
5	Exam 4	90							
6									
7	Final Grade	70							
8									

Goal Seek Example 2

Use Goal Seek in Excel to find the loan amount that produces a monthly payment of \$1500.

1. The formula in cell B5 calculates the monthly payment.

BS	B5 ▼ : × ✓ f _x =PMT(B1/12,B2*12,B3)							
	А	В	с	D	E	F	G	н
1	Annual Rate	6%						
2	Years	30						
3	Loan Amount	\$300,000						
4								
5	Monthly Payment	(\$1,798.65)						
6								

Explanation: the PMT function calculates the payment for a loan. If you've never heard of this function before, that's OK. The higher the loan amount, the higher the monthly payment. Assume, you can only afford \$1500 a month. What is your maximum loan amount?

2. The loan amount in cell B3 is the input cell.

B3	} •	× ✓	<i>f</i> _x 300	000				
	А	В	с	D	E	F	G	н
1	Annual Rate	6%						
2	Years	30						
3	Loan Amount	\$300,000						
4								
5	Monthly Payment	(\$1,798.65)						
6								

3. On the Data tab, in the Forecast group, click What-If Analysis.



4. Click Goal Seek.

<u>S</u> cenario Manager	r
<u>G</u> oal Seek	
Data <u>T</u> able	63

The Goal Seek dialog box appears.

- 5. Select cell B5.
- 6. Click in the 'To value' box and type -1500 (negative, you are paying out money).
- 7. Click in the 'By changing cell' box and select cell B3.
- 8. Click OK.

Goal Seek	?	×
S <u>e</u> t cell:	SBS5	Ţ
To <u>v</u> alue:	-1500	
By <u>c</u> hanging cell:	\$B\$3	<u>1</u>
ОК	3	Cancel

Result. A loan amount of \$250,187 produces a monthly payment of \$1500.

B3	•	× ✓	✓ <i>f</i> _* 250187.421588503					
	А	В	с	D	E	F	G	н
1	Annual Rate	6%						
2	Years	30						
3	Loan Amount	\$250,187						
4								
5	Monthly Payment	(\$1,500.00)						
6								

Goal Seek Precision

Goal seek returns approximate solutions. You can change the iteration settings in Excel to find a more precise solution.

1. The formula in cell B1 calculates the square of the value in cell A1.

B1		Ŧ	:	X 🗸	<i>f</i> _x =A1	L^2				
	А		В	с	D	E	F	G	Н	I.
1		2	4							
2										

2. Use goal seek to find the input value that produces a formula result of 25.

Goal Seek		?	\times
S <u>e</u> t cell:	SBS1		1
To <u>v</u> alue:	25		
By <u>c</u> hanging cell:	SAS1		Ť
ОК	2	Car	icel

Result. Excel returns an approximate solution.

A1	L	•	x 🗸	<i>f</i> _x 4.9	4.99999252400127				
	А	В	С	D	E	F	G	Н	I.
1	4.999993	24.99993	}						
2									

3. On the File tab, click Options, Formulas.

4. Under Calculation options, decrease the Maximum Change value by inserting some zeros. The default value is 0.001.

Excel Options	?	×
General	Change options related to formula calculation, performance,	
Formulas	$\Box - JX$ and error handling.	
Data	Calculation options	
Proofing Save	Workbook Calculation (i) Enable iterative calculation Automatic Automatic Iterations: 100 ‡ Iterations: Iterations: Iterations: Iterations: Iterations: Iterations: Iterations: Iterations: Iterations: 	
Language	data tables Maximum → 0.000000	
Ease of Access	O Manual Change:	
Advanced	✓ Recalculate workbook before	
Customize Ribbon	saving	
Quick Access Toolbar	Working with formulas	
Add-ins	□ <u>R</u> 1C1 reference style ^①	
Trust Center	Formula AutoComplete ^①	
	✓ Use table names in formulas	
	Use Get <u>P</u> ivotData functions for PivotTable references	-
	OK Cance	el .

5. Click OK.

6. Use Goal Seek again. Excel returns a more precise solution.

A1	L	• :	X 🗸	<i>f</i> _x 4.9	4.99999999981501						
	А	В	с	D	E	F	G	Н	I.		
1	5	2	5								
2											

More about Goal Seek

There are many problems Goal Seek can't solve. Goal Seek requires a single input cell and a single output (formula) cell. Use the **Solver** in Excel to solve problems with multiple input cells. Sometimes you need to start with a different input value to find a solution.

1. The formula in cell B1 below produces a result of -0.25.

B1		Ŧ	: :	×	f _x =1/	(A1-8)				
	А		В	с	D	E	F	G	Н	I.
1		4	-0.25							
2										

2. Use Goal Seek to find the input value that produces a formula result of +0.25.

Goal Seek		?	×
S <u>e</u> t cell:	SBS1		<u>↑</u>
To <u>v</u> alue:	0.25		
By <u>c</u> hanging cell:	SAS1		Ť
ОК	2	Ca	ancel

Result. Excel can't find a solution.

Goal Seek Status	?	×			
Goal Seeking with Cell B1 may not have found a solution.	Step				
Target value: 0.25 Current value: -7.88861E-30	Pause				
OK	Ca	ncel			

- 3. Click Cancel.
- 4. Start with an input value greater than 8.

B1	B1 *		X 🗸	<i>f</i> _x =1/	(A1-8)				
	А	В	с	D	E	F	G	Н	I.
1	8.01	10	0						
2									

5. Use Goal Seek again. Excel finds a solution.

A	L	•	\times	~	<i>f</i> _x 11.	99999999920	0539			
	А	В		С	D	Е	F	G	Н	I
1	12	2 0).25							
2										

Explanation: y = 1 / (x - 8) is discontinuous at x = 8 (dividing by 0 is not possible). In this example, Goal seek cannot reach one side of the x-axis (x>8) if it starts on the other side of the x-axis (x<8) or vice versa.

Solver

Excel includes a tool called **solver** that uses techniques from the operations research to find optimal solutions for all kind of decision problems.

Load the Solver Add-in

To load the solver add-in, execute the following steps.

- 1. On the File tab, click Options.
- 2. Under Add-ins, select Solver Add-in and click on the Go button.

Excel Options			? >
General	View and manage Micros	oft Office Add-	ins
Formulas			
Data	Add-ins		
Proofing	Name 🔺	Location	Туре
Save	Active Application Add-ins	-	
anguage	No Active Application Add-ins		
Language	Inactive Application Add-ins		
Ease of Access	Analysis ToolPak	C:\32.XLL	Excel Add-in
Advanced	Analysis ToolPak - VBA	C:\XLAM	Excel Add-in
	Date (XML)	C:\FL.DLL	Action
Customize Ribbon	Euro Currency Tools	C:\XLAM	Excel Add-in
Quick Access Toolbar	Inquire	C:\im.dll	COM Add-in
Quick Access Toolbal	Microsoft Actions Pane 3		XML Expansion Pack
Add-ins	Microsoft Power Map for Excel	C:\LL.DLL	COM Add-in
T 10 1	Microsoft Power Pivot for Excel	C:\dln.dll	COM Add-in
Irust Center	Microsoft Power View for Excel	C:\ent.dll	COM Add-in
	Solver Add-in	C:\XLAM	Excel Add-in 📃 🖵
	Add-in: Solver Add-in		
	Publisher:		
	Compatibility: No compatibilit	v information a	vailable
	Location: C:\Program File	s\Microsoft Offi	ice\root\Office16\Librarv\
	SOLVER\SOLVER	RXLAM	
	Description: Tool for optimiz	zation and equat	tion solving
	Manage: Excel Add-ins	▼ <u>G</u> o	N
			3
		Γ	OK Cancel
		L	Cancer

3. Check Solver Add-in and click OK.

Add-ins		?	×
Add-ins available: Analysis ToolPak Analysis ToolPak - VBA Euro Currency Tools Solver Add-in	^	OK Cance <u>B</u> rowse A <u>u</u> tomati	I on
Solver Add-in Tool for optimization and eq	uatio	n solving	

4. You can find the Solver on the Data tab, in the Analyze group.



Formulate the Model

The **model** we are going to **solve** looks as follows in Excel.

	А	В	С	D	E	F	G	Н	1	J
1	С	ycle Trad	ler							
2										
3			Bicycles	Mopeds	Child Seats					
4		Unit Profit	100	300	50					
5							Resources		Resources	
6							Used		Available	
7		Capital	300	1200	120		0	\leq	93000	
8		Storage	0.5	1	0.5		0	\leq	101	
9										
10										
11			Bicycles	Mopeds	Child Seats				Total Profit	
12		Order Size	0	0	0				0	
13										

1. To formulate this **linear programming model**, answer the following three questions.

a. What are the decisions to be made? For this problem, we need Excel to find out how much to order of each product (bicycles, mopeds and child seats).

b. What are the constraints on these decisions? The constrains here are that the amount of capital and storage used by the products cannot exceed the limited amount of capital and storage (resources) available. For example, each bicycle uses 300 units of capital and 0.5 unit of storage.

c. What is the overall measure of performance for these decisions? The overall measure of performance is the total profit of the three products, so the objective is to maximize this quantity.

2. To make the model easier to understand, create the following named ranges.

Range Name	Cells
UnitProfit	C4:E4
OrderSize	C12:E12
ResourcesUsed	G7:G8
ResourcesAvailable	I7:I8
TotalProfit	I12

3. Insert the following three SUMPRODUCT functions.

E	F	G	Н	1	J
					-
Ohild Casta					-
Child Seats					
50					
		Resources		Resources	
		Used		Available	
120		=SUMPRODUCT(C7:E7,OrderSize)	\leq	93000	
0.5		=SUMPRODUCT(C8:E8,OrderSize)	\leq	101	
Child Seats				Total Profit	
0				=SUMPRODUCT(UnitProfit,OrderSize)	

Explanation: The amount of capital used equals the sumproduct of the range C7:E7 and OrderSize. The amount of storage used equals the sumproduct of the range C8:E8 and OrderSize. Total Profit equals the sumproduct of UnitProfit and OrderSize.

Trial and Error

With this formulation, it becomes easy to analyze any trial solution.

For example, if we order 20 bicycles, 40 mopeds and 100 child seats, the total amount of resources used does not exceed the amount of resources available. This solution has a total profit of 19000.

	А	В	С	D	E	F	G	Н		J
1	С	ycle Trad	ler							
2										
3			Bicycles	Mopeds	Child Seats					
4		Unit Profit	100	300	50					
5							Resources		Resources	
6							Used		Available	
7		Capital	300	1200	120		66000	\leq	93000	
8		Storage	0.5	1	0.5		100	\leq	101	
9										
10										
11			Bicycles	Mopeds	Child Seats				Total Profit	
12		Order Size	20	40	100				19000	
13										

It is not necessary to use trial and error. We shall describe next how the Excel Solver can be used to quickly find the optimal solution.

Solve the Model

To find the **optimal solution**, execute the following steps.

1. On the Data tab, in the Analyze group, click **Solver**.



Enter the solver parameters (read on). The result should be consistent with the picture below.

Se <u>t</u> Objective:		TotalProfit		
To:	() Mi <u>n</u>	O <u>V</u> alue Of:	0	
By Changing Varial	ble Cells:			
OrderSize				
Subject to the Con	straints:			
ResourcesUsed <=	ResourcesAvailabl	e	^	Add
				<u>C</u> hange
				<u>D</u> elete
				<u>R</u> eset All
			~	Load/Save
☑ Ma <u>k</u> e Unconstr	ained Variables No	n-Negative		
S <u>e</u> lect a Solving Method:	Simplex LP		~	O <u>p</u> tions
Solving Method Select the GRG No Simplex engine fo problems that are	onlinear engine for r linear Solver Prot non-smooth.	Solver Problems that plems, and select the	: are smooth nonlir Evolutionary engin	near. Select the LP e for Solver

You have the choice of typing the range names or clicking on the cells in the spreadsheet.

- 2. Enter TotalProfit for the Objective.
- 3. Click Max.
- 4. Enter OrderSize for the Changing Variable Cells.
- 5. Click Add to enter the following constraint.

Add Constraint		×
C <u>e</u> ll Reference: ResourcesUsed	<u></u> ≪= ∨	Co <u>n</u> straint: ResourcesAvailable
<u>o</u> k	Add	<u>C</u> ancel

- 6. Check 'Make Unconstrained Variables Non-Negative' and select 'Simplex LP'.
- 7. Finally, click Solve.

Result:

Solver Results	×						
Solver found a solution. All Constraints and optimal conditions are satisfied.	lity Re <u>p</u> orts						
<u>Keep Solver Solution</u> <u>R</u> estore Original Values	Answer Sensitivity Limits						
Return to Solver Parameters Dialog	☐ O <u>u</u> tline Reports						
<u>OK</u> <u>C</u> ancel	<u>S</u> ave Scenario						
Solver found a solution. All Constraints and optimality conditions are satisfied. When the GRG engine is used, Solver has found at least a local optimal solution. When Simplex LP is used, this means Solver has found a global optimal solution.							

The optimal solution:

	А	В	С	D	E	F	G	Н		J
1	С	ycle Trad	ler							
2										
3			Bicycles	Mopeds	Child Seats					
4		Unit Profit	100	300	50					
5							Resources		Resources	
6							Used		Available	
7		Capital	300	1200	120		93000	\leq	93000	
8		Storage	0.5	1	0.5		101	\leq	101	
9										
10										
11			Bicycles	Mopeds	Child Seats				Total Profit	
12		Order Size	94	54	0				25600	
13										

Conclusion: it is optimal to order 94 bicycles and 54 mopeds. This solution gives the maximum profit of 25600. This solution uses all the resources available.