LINEAR PROGRAMMING (LP): Excel Solver Add-in

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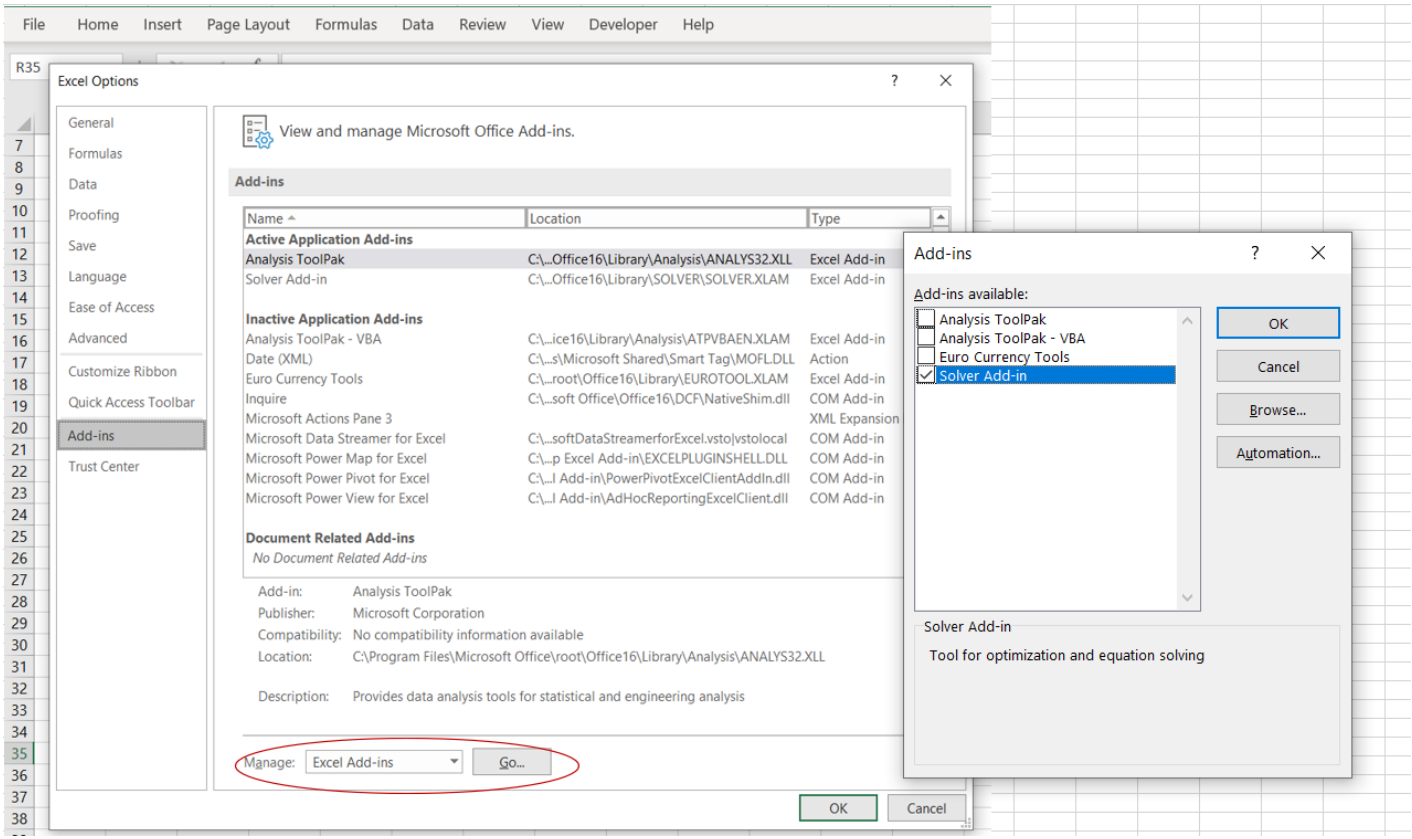
The Solver is an Add-in of Excel that is necessary to install:

- Select File > Options;
- Manage Excel Add-ins > Go;
- Select the Solver Add-in.
- After the Solver Add-in is available in Data.



Solving a LP model using Excel Solver Add-in:

Consider the following linear programming (LP) model to determine the production plan of three products (1, 2 and 3), using 110, 150 and 200 hours (h) in machines M1, M2 and M3, respectively.

$$\begin{aligned} \text{Max } Z &= 3x_1 + 3x_2 + 2x_3 \\ \text{subject to} & \\ 2x_1 + 3x_2 + 4x_3 &\leq 110 \\ 3x_1 + 2x_2 + 3x_3 &\leq 150 \\ 4x_1 + 2x_2 + 3x_3 &\leq 200 \\ x_1, x_2, x_3 &\geq 0. \end{aligned}$$

Set the decision variables x_1, x_2 and x_3 which are the number of units produced of A, B and C products, respectively.

1st step: To define the model in the workbook, including:

- Decision variables will be determined through the cells B4 to D4 after run the Solver;
- Coefficients of the objective function: insert them in the cells B8 to D8.
- The matrix constraints coefficients: insert them in the cells B12 to D14; the constants of the right side of the constraints: insert them in the cells G12 to G14.

	A	B	C	D	E	F	G
1							
2		**Decision Variables**					
3		x_1	x_2	x_3			
4							
5							
6		**OF Coeficients**					
7		x_1	x_2	x_3	**Objetive function (OF)**		
8		3	3	2	0	Maximize	
9							
10		**Constraints Coeficients**					
11		x_1	x_2	x_3	Hours used		Constraint
12	Machine 1	2	3	4	0	≤	110
13	Machine 2	3	2	3	0	≤	150
14	Machine 3	4	2	3	0	≤	200
15							

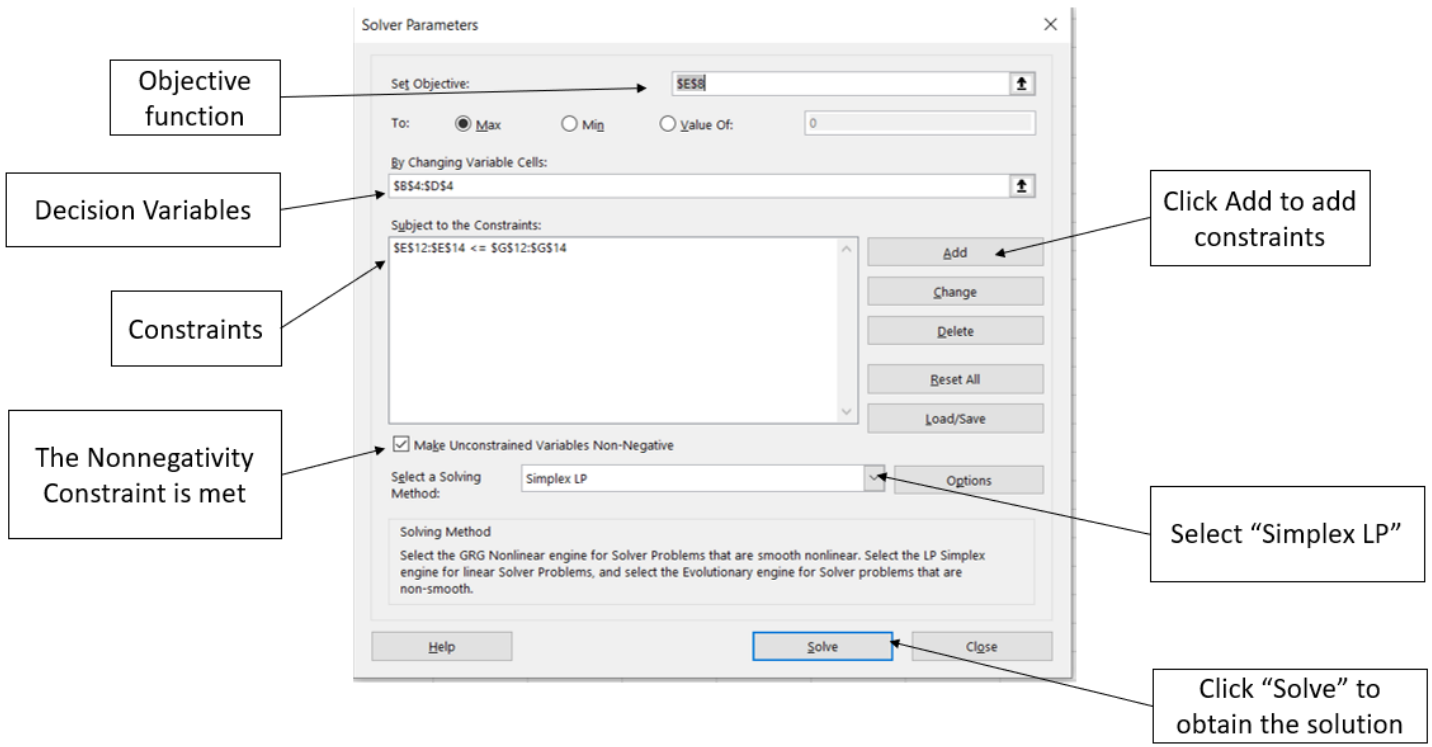
2nd step: To define the formulas of the objective function and the left side of each constraint:

- Objective function (cell E8) - this formula relates the coefficients of the objective function to the decision variables (B8xB4 + C8xC4 + D8xD4), using the "SUMPRODUCT" function.
- Left side of each constraint (cells E12, E13 and E14) - this formula relates the coefficients of each constraint to the decision variables (in E12 is B12xB4 + C12xC4 + D12xD4).

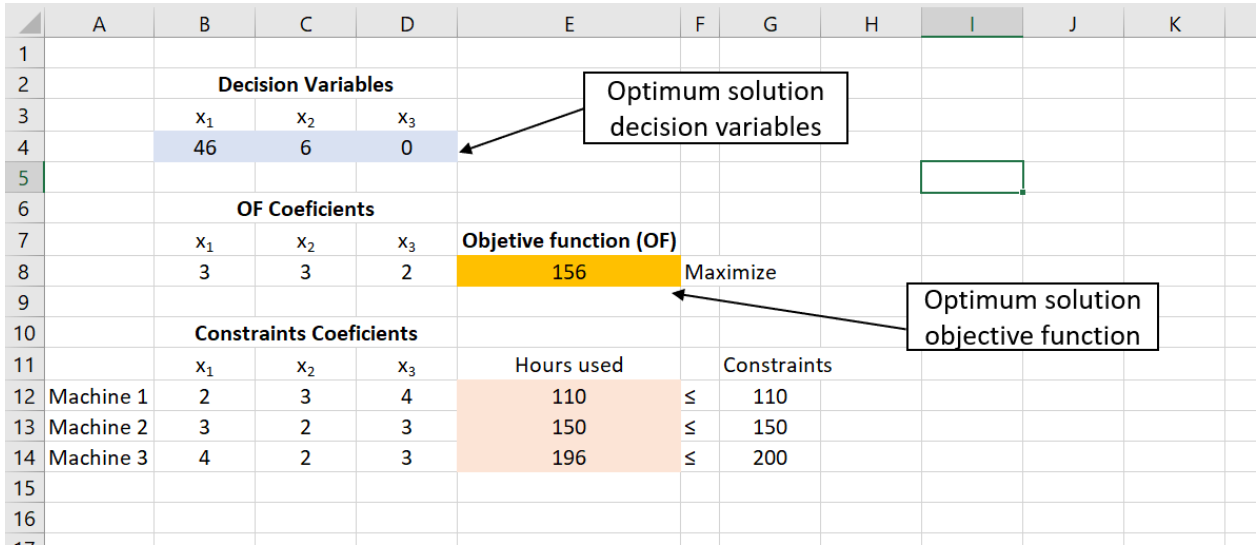
	A	B	C	D	E	F	G
1							
2			**Decision Variables**				
3		x_1	x_2	x_3			
4							
5							
6			**OF Coeficients**				
7		x_1	x_2	x_3	**Objetive function (OF)**		
8		3	3	2	=SUMPRODUCT(B8:D8;$B$4:$D$4)	Maximize	
9							
10			**Constraints Coeficients**				
11		x_1	x_2	x_3	Hours used		Constraint
12	Machine 1	2	3	4	=SUMPRODUCT(B12:D12;$B$4:$D$4)	≤	110
13	Machine 2	3	2	3	=SUMPRODUCT(B13:D13;$B$4:$D$4)	≤	150
14	Machine 3	4	2	3	=SUMPRODUCT(B14:D14;$B$4:$D$4)	≤	200

3rd step: To open the Solver in Data to insert:

- Objective function: select the cell E8
- By Changing Variable Cells: select the cells B4 to D4
- Add for each constraint: selecting the cell on the left side, the sign and the cell on right side. In the example, for the 1st to 3rd constraints: select the cells E12 to E14, the sign $\leq$ and the cells G12 to G14.
- Select a solving method: chose the Simplex LP

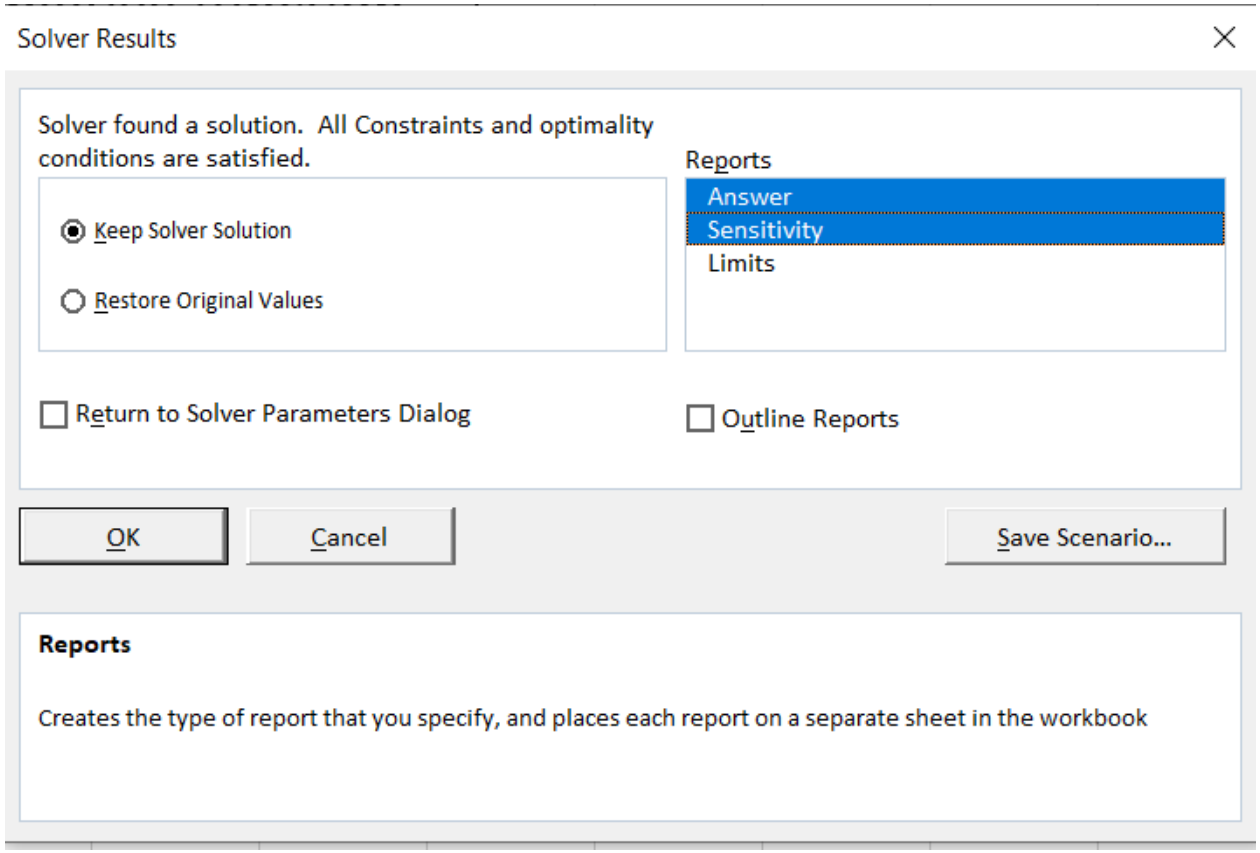


4th step: To obtain the optimum solution: the optimum profit is 156€ which is achieved if the company produces 46 units of A and 6 units of B. There are 4 hours available in the machine M3.



	A	B	C	D	E	F	G	H	I	J	K
1											
2		**Decision Variables**									
3		x_1	x_2	x_3							
4		46	6	0							
5											
6		**OF Coeficients**									
7		x_1	x_2	x_3	**Objetive function (OF)**						
8		3	3	2	156	Maximize					
9											
10		**Constraints Coeficients**									
11		x_1	x_2	x_3	Hours used		Constraints				
12	Machine 1	2	3	4	110	≤	110				
13	Machine 2	3	2	3	150	≤	150				
14	Machine 3	4	2	3	196	≤	200				
15											
16											

5th step: To obtain the Answer and the Sensitivity reports



Answer Report

Objective Cell (Max)

Cell	Name	Original Value	Final Value
$E$8	Z	0	156

Variable Cells

Cell	Name	Original Value	Final Value	Integer
$B$4	x1	0	46	Contin
$C$4	x2	0	6	Contin
$D$4	x3	0	0	Contin

Constraints

Cell	Name	Cell Value	Formula	Status	Slack
$E$12	Hours used in M1	110	$E$12<=$G$12	Binding	0
$E$13	Hours used in M2	150	$E$13<=$G$13	Binding	0
$E$14	Hours used in M3	196	$E$14<=$G$14	Not Binding	4

Sensitivity Report

Variable Cells

Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
$B$4	x_1	46	0	3	1,5	1
$C$4	x_2	6	0	3	1,5	1
$D$4	x_3	0	-2,2	2	2,2	1E+30

Constraints

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
$E$12	Hours used in M1	110	0,6	110	115	10
$E$13	Hours used in M2	150	0,6	150	2,5	76,66666667
$E$14	Hours used in M3	196	0	200	1E+30	4

Reference

Hillier F. S., & Lieberman G.R. (2010). Introduction to operations research (9th ed.). New York: McGraw-Hill.