MCSD1133 Operations Research & Optimization

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CHAPTER 3 (Part 2): LINEAR PROGRAMMING WITH EXCEL

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Innovating Solutions

Introduction

- Spreadsheet software, such as Excel and its Solver, is a popular tool for analyzing and solving small linear programming problems.
- The spreadsheet offers very convenient data entry and editing features which allows the user to gain a greater understanding of how to construct linear programs.
- A spreadsheet requires that column and row headings for the specific model be set up and that constraint and objective function formulas be input in their entirety.
- Much of the power of the spreadsheet lies in its ability to immediately reveal the results of any changes made in the solution.

Setting up the Problem in Excel

1 Defining the Objective Function

In Excel, we use cell references and formulas to represent the objective function. This allows us to easily optimize for maximum or minimum values.

2 Specifying Constraints

We represent constraints in Excel using inequalities. By setting up the constraints properly, we can ensure that the solution lies within the feasible region.

3 Applying Solver

Excel's Solver tool can be utilized to find the optimal solution to the linear programming problem by adjusting the values of decision variables.

Solver and Its Features

Solver Add-In

Excel's Solver Add-In is a powerful tool that enables us to find optimal solutions by adjusting decision variables, subject to constraints.

Objective Cell

The objective cell in Solver specifies the cell that contains the objective function. We can maximize or minimize this cell to find the optimal solution.

Decision Variables

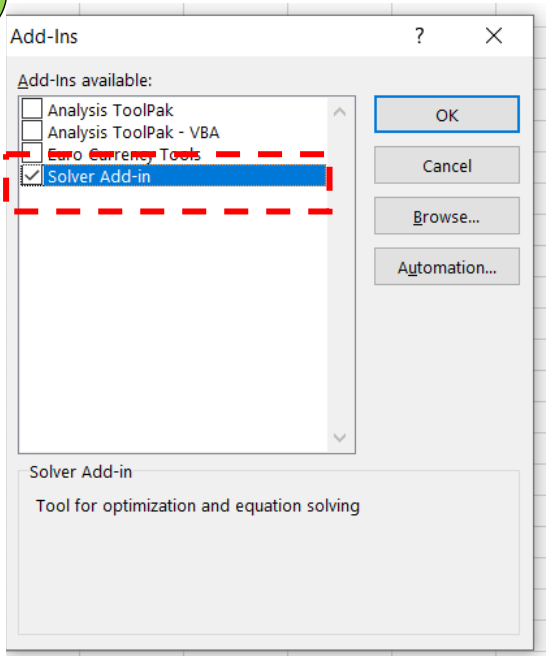
Decision variables represent the values to be adjusted to optimize the objective function. Solver allows us to specify the range and constraints for these variables.

Solver Add-Ins

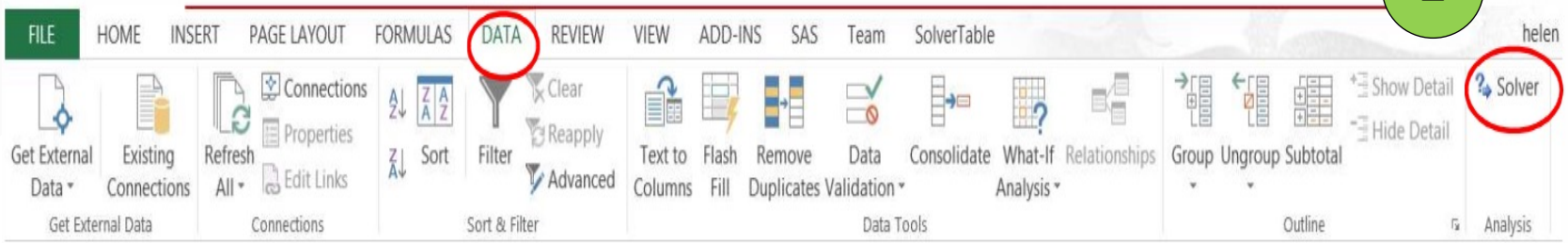
The Solver Add-In must be added to the Tools menu by carry out the following steps (once-only):

- Select the menu: File > More > Options > Add-ins > Excel Add-ins (this will take a few moments to load the necessary file).
- From the dialogue box presented, check the box for Solver Add-In.
- After clicking OK, you will then be able to access the **Solver** option from the **Data** tab.

1



2



Example: Reddy Mikk Company Case Study

Variables:

X_1 = tons produced daily of exterior paint

X_2 = tons produced daily of interior paint

Z = total daily profit (in thousands of dollars)

Objective: Maximize, $Z = 5X_1 + 4X_2$

Constraints:

1. $6X_1 + 4X_2 \leq 24$ (raw material M1)
2. $X_1 + 2X_2 \leq 6$ (raw material M2)
3. $X_2 - X_1 \leq 1$
4. $X_2 \leq 2$
5. $X_1 \geq 0;\ X_2 \geq 0$

Example: Reddy Mikk Company Case Study

Formulating the Model on a Spreadsheet

Three types of information required to begin the process of using the spreadsheet to formulate a linear programming model for the problem.

(1) Input data cells (B5:C9 and F6:F9)

(2) Cells representing the variables and the objective function (B13:D13)

(3) Algebraic definitions of the objective function and the left-hand side of the constraints (cells D5:D9)

Maximize $z = 5x_1 + 4x_2$

$$
\begin{aligned}
6x_1 + 4x_2 &\leq 24 \quad (1)\\
x_1 + 2x_2 &\leq 6 \quad (2)\\
-x_1 + x_2 &\leq 1 \quad (3)\\
x_2 &\leq 2 \quad (4)\\
x_1, x_2 &\geq 0 \quad (5)
\end{aligned}
$$

	A	B	C	D	E	F
1						
2	Input data:					
3		x1	x2			
4		Exterior	Interior	Total		Limits
5	Objective	5	4	0		
6	M1	6	4	0	<=	24
7	M2	1	2	0	<=	6
8	Market	-1	1	0	<=	1
9	Demand	0	1	0	<=	2
10						
11	Output result					
12		x1	x2	Z		
13	Solution	0	0	0		
14						

Algebraic Definition

- Place the resulting formulas appropriately in cells D5:D9, as the following table shows:

	Algebraic expression	Spreadsheet formula	Entered in cell
Objective, z	$5x_1 + 4x_2$	=B5*$B$13+C5*$C$13	D5
Constraint 1	$6x_1 + 4x_2$	=B6*$B$13+C6*$C$13	D6
Constraint 2	$x_1 + 2x_2$	=B7*$B$13+C7*$C$13	D7
Constraint 3	$-x_1 + x_2$	=B8*$B$13+C8*$C$13	D8
Constraint 4	$0x_1 + x_2$	=B9*$B$13+C9*$C$13	D9

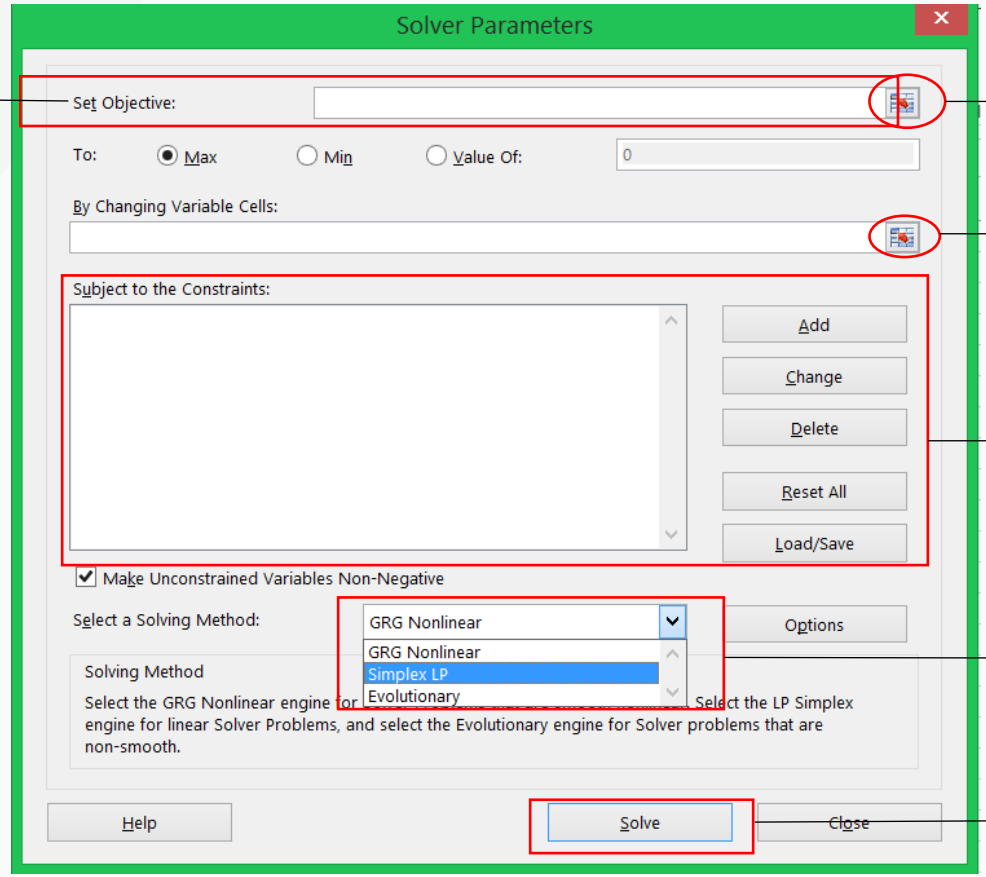
- Actually, you only need to enter the formula for cell D5 and then copy it into cells D6:D9
- To do so correctly, it is necessary to use fixed referencing of the cells representing X_1 and X_2 ($B$13 and $C$13).
- The explicit formulas just described are impractical for large LPs. Instead, the formula in cell D5 can be written compactly as = SUMPRODUCT(B5:C5,$B$13:$C$13)

Example: Reddy Mikk Company Case Study

Apply Excel Solver

- Click **Solver** from the spreadsheet menu bar to access Solver parameters dialogue box.

Max: maximum objective
Min: minimum objective
Value of: define a value that you want



choose the cell of objective

Choose cells of decision variables

Define Constraints

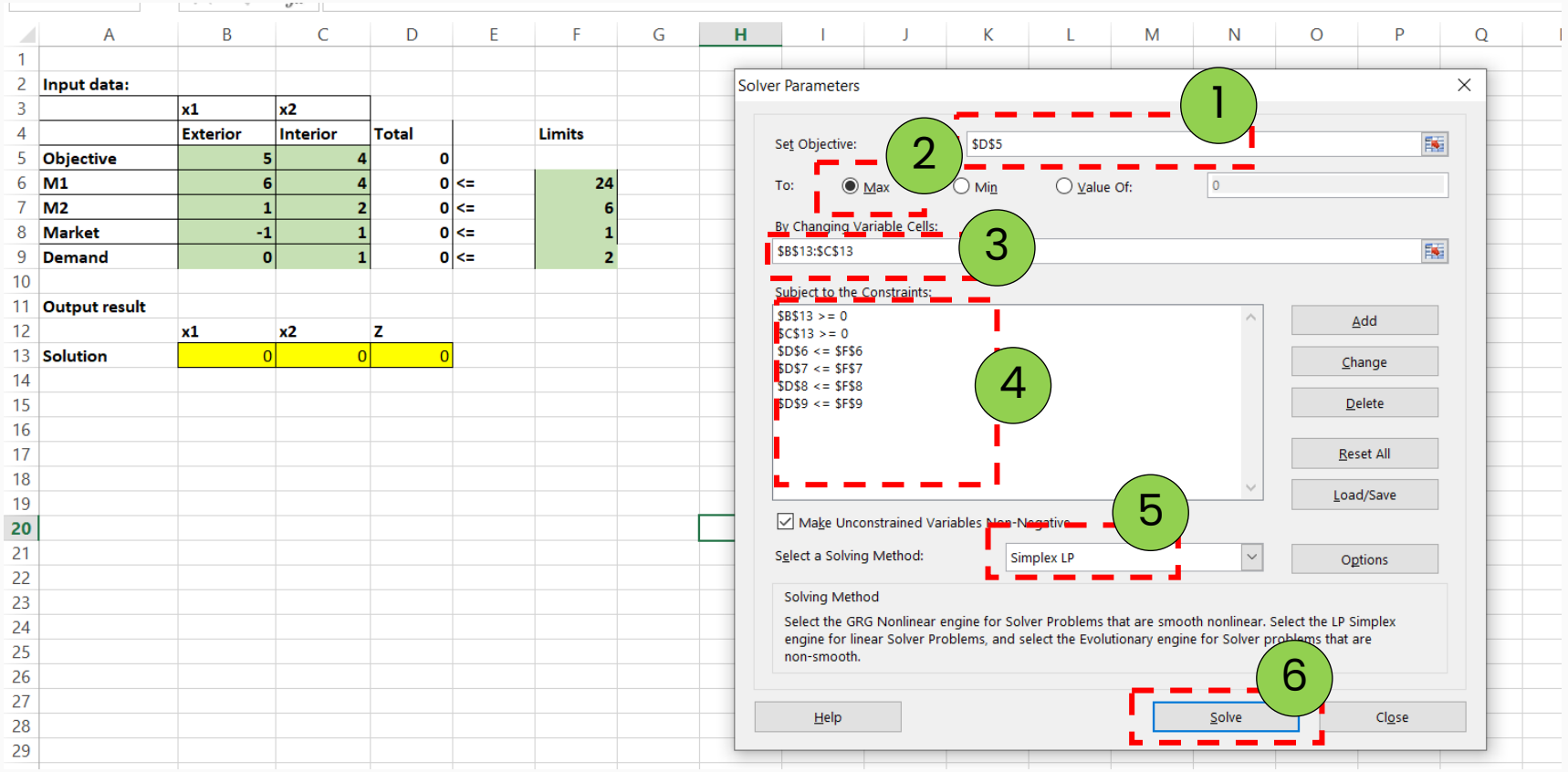
Choose solving method

Finally click Solve. Then, it will give you optimized result.

Example: Reddy Mikk Company Case Study

Apply Excel Solver (cont'd)

- Update the dialogue box as follows:

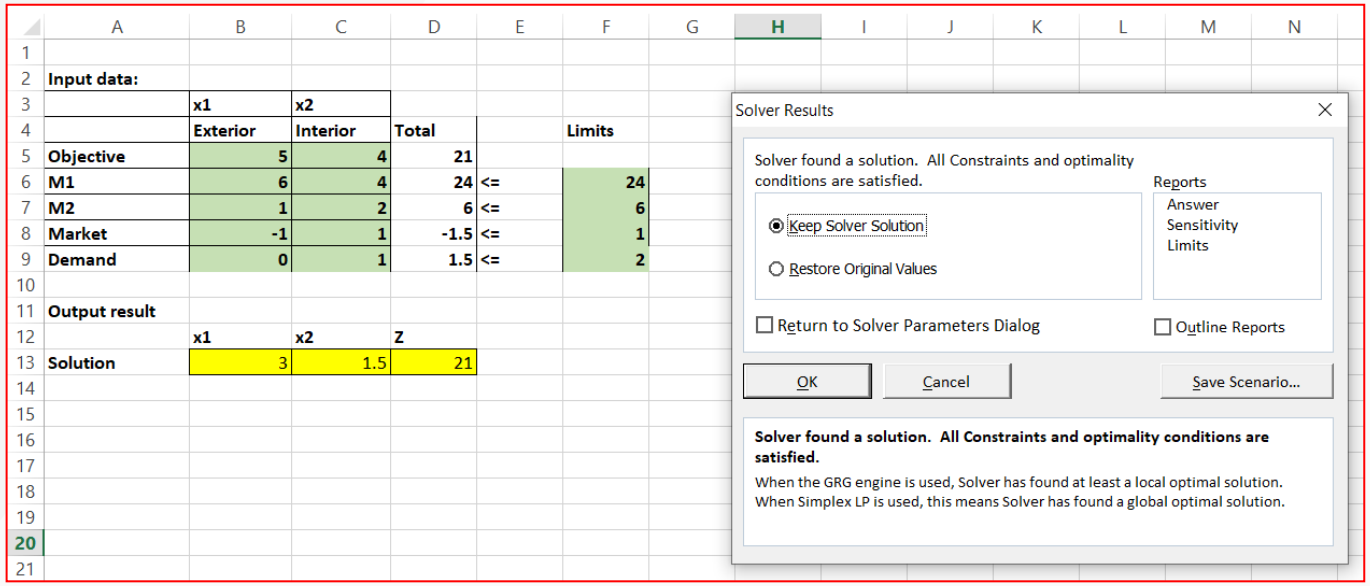


	A	B	C	D	E	F
1						
2	**Input data:**					
3		**x1**	**x2**			
4		**Exterior**	**Interior**	**Total**		**Limits**
5	**Objective**	**5**	**4**	**0**		
6	**M1**	**6**	**4**	**0**	**<=**	**24**
7	**M2**	**1**	**2**	**0**	**<=**	**6**
8	**Market**	**-1**	**1**	**0**	**<=**	**1**
9	**Demand**	**0**	**1**	**0**	**<=**	**2**
10						
11	**Output result**					
12		**x1**	**x2**	**Z**		
13	**Solution**	0	0	0		

Example: Reddy Mikk Company Case Study

Apply Excel Solver (cont'd)

- A new dialogue box "Solver Results" will prompt. Then, it show the status of the solution.



	A	B	C	D	E	F
2	Input data:					
3		x1	x2			
4		Exterior	Interior	Total		Limits
5	Objective	5	4	21		
6	M1	6	4	24	<=	24
7	M2	1	2	6	<=	6
8	Market	-1	1	-1.5	<=	1
9	Demand	0	1	1.5	<=	2
11	Output result					
12		x1	x2	Z		
13	Solution	3	1.5	21		

- The optimum value of Z will appear in cell D5 and the values of X_1 and X_2 will go to cells B13 and C13, respectively.
- For convenience, cell D13 exhibits the optimum value of Z by entering the formula = D5 in cell D13, thus displaying the entire optimum solution in contiguous cells.

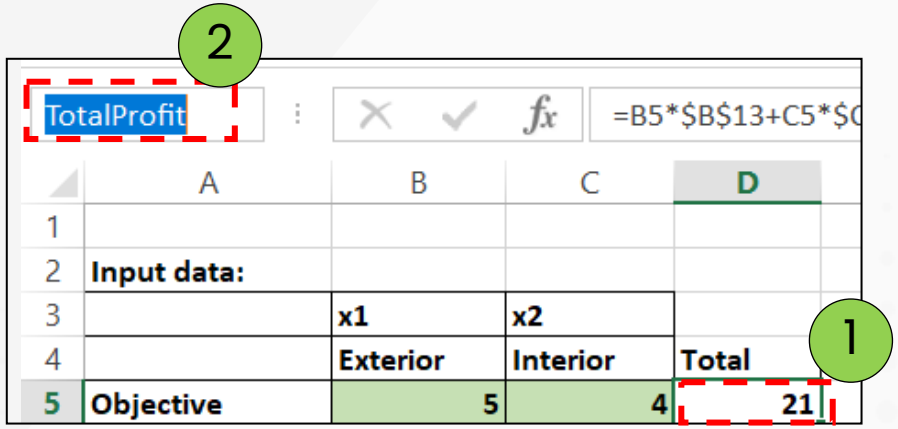
Solution from Solver

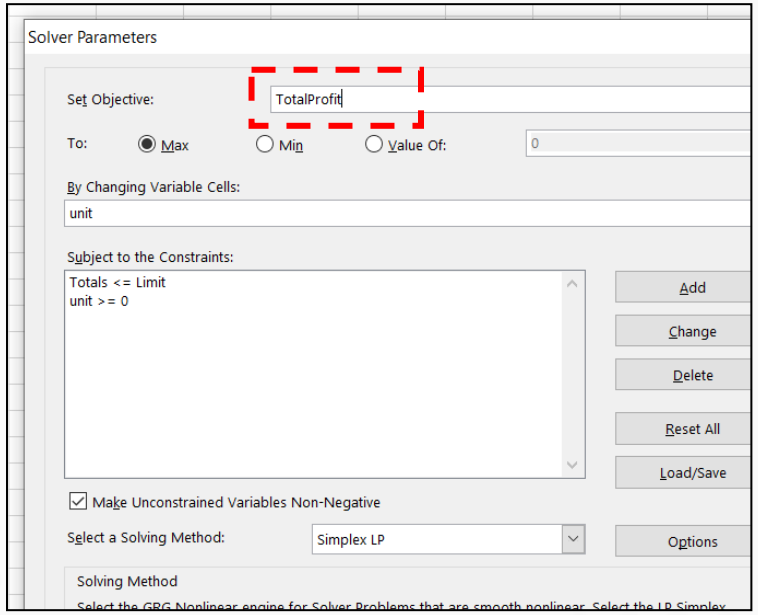
If a problem has no feasible solution, Solver will issue the explicit message "**Solver could not find a feasible solution**". If the optimal objective value is unbounded (not finite), Solver will issue the somewhat ambiguous message "**The Set Cell values do not converge**".

The Solver results dialogue box provides the opportunity to request further details about the solution, including the sensitivity analysis report. We will discuss these topic in Chapter 4.

Solution from Solver (cont'd)

- Descriptive Excel range names can be used to enhance readability.
- A range is created by highlighting the desired cells (Example: D5), typing the range name in the top left box of the sheet, and then pressing Return.





EXERCISES

Use Excel Solver to solve the following problem.

#1: The Alex Garment Company manufactures men's shirts and women's blouses. The production process includes cutting, sewing, and packaging. The company employs 25 workers in the cutting department, 35 in the sewing department, and 5 in the packaging department. The factory works one 8-hr shift, 5 days a week. The following table gives the time requirements and profits per unit to produce the two garments. **Determine the optimal** weekly production schedule for Alex Garment Company.

	Minutes per unit			
Garment	*Cutting*	*Sewing*	*Packaging*	Unit profit ($)
Shirts	20	70	12	8
Blouses	60	60	4	12

#2: In Hamid grocery store, shelf space is limited and must be used effectively to increase profit. Two cereal items, Grano and Wheatie, compete for a total shelf space of 60 ft^2 . A box of Grano occupies 0.2 ft^2 and a box of Wheatie needs 0.4 ft^2 . The maximum daily demands of Grano and Wheatie are 200 and 120 boxes, respectively. A box of Grano nets $1.00 in profit and a box of Wheatie $1.35. Hamid thinks that because the unit profit of Wheatie is 35% higher than that of Grano, Wheatie should be allocated 35% more space than Grano, which amounts to allocating about 57% to Wheatie and 43% to Grano. **Determine the optimal** value for the items to be allocated on the shelf to maximise the profit.

EXERCISES

Use Excel Solver to solve the following problem.

#3: A firm has two bottling plant. One plant located at Coimbatore and other plant located at Chennai. Each plant produces three types of drinks; Coca-Cola , Fanta and Thumps-up. The following table show the data.

	Number of bottles produced per day by plant at	
Product	Coimbatore	Chennai
Coca-Cola	15000	15000
Fanta	30000	10000
Thumps-Up	20000	50000
Cost per day (per unit)	600	400

Market survey indicates that during the month of April there will be a demand of 200,000 bottles of Coca-cola , 400,000 bottles of Fanta and 440,000 bottles of Thumps-up. For how many days each plant be run in April to **minimize the production cost**, while still meeting the market demand?