15.053

Excel Solver

1

slides 3-4

Table of Contents

Introduction to Excel Solver

Example 1: Diet Problem, Set-Up
 slides 5-11

• Example 1: Diet Problem, Dialog Box slides 12-17

Example 2: Food Start-Up Problem
 slides 18-19

Note that there is an Excel file that accompanies this tutorial; each worksheet tab in the Excel corresponds to each example problem



Introduction to Excel Solver (1 of 2)

- Excel has the capability to solve linear (and often nonlinear) programming problems with the SOLVER tool, which:
 - May be used to solve linear and nonlinear optimization problems
 - Allows integer or binary restrictions to be placed on decision variables
 - Can be used to solve problems with up to 200 decision variables
- SOLVER is an Add-In program that you will need to load in Excel
 - Microsoft users
 - 1. Click the Microsoft Office Button, and then click "Excel Options"
 - 2. Click "Add-Ins", and then in the "Manage" box, select "Excel Add-ins" and click "Go"
 - 3. In the "Add-Ins available" box, select the "Solver Add-in" check box, and then click "OK"
 - If "Solver Add-in" is not listed in the "Add-Ins available" box, click "Browse" to locate it
 - If you get prompted that Solver is not currently installed, click Yes to install it
 - 4. After you load Solver, the Solver command is available in the "Analysis group" on the "Data" tab

MAC users

- 1. Open Excel for Mac 2011 and begin by clicking on the "Tools" menu
- 2. Click "Add-Ins", and then in the Add-Ins box, check "Solver.xlam" and then click "OK"
- 3. Restart Excel for Mac 2011 (fully quit the program), select the "Data" tab, then select "Solver" to launch

3

Introduction to Excel Solver (2 of 2)

- · There are 4 steps on how to use SOLVER to solve an LP
 - The key to solving an LP on a spreadsheet is:
 - Set up a spreadsheet that tracks everything of interest (e.g. costs, profits, resource usage)
 - 1 Identify the cell that contains the value of your objective function as the Target Cell
 - 2 Identify the decision variables that can be varied, called Changing (Variable) Cells
 - 3 Identify the constraints and enter them into the program to tell SOLVER how to solve the problem
 - At this point, the optimal solution to our problem will be placed on the spreadsheet, with its value in the target cell

Diet Problem: Set-Up (1 of 7)

Problem Statement

- Consider the problem of diet optimization based on cost and different nutritional factors
- There are four different types of food: Brownies, Ice Cream, Cola, and Cheese Cake, with nutrition values and cost per unit as follows:

	Brownies	Ice Cream	Cola	Cheese Cake	
Calories	400	200	200 150 500		
Chocolate	olate 3		0	0	
Sugar	2	2	4	4	
Fat	2	4 1		5	
Cost	\$0.50	\$0.20	\$0.30	\$0.80	

Task:

- · Find a minimum-cost diet that contains
 - at least 500 calories
 - at least 6 grams of chocolate
 - at least 10 grams of sugar
 - at least 8 grams of fat.

5

Example 1

Diet Problem: Set-Up (2 of 7)

- · First, we must format our spreadsheet correctly to be entered into SOLVER
- · Identify the decision variables (changing cells)
 - To begin we enter heading for each type of food in B2:E2
 - In the range B3:E3, we input random trial values for the amount of each food eaten (any values will work, but at least one should be positive)
 - In the example shown below, we indicate that we are considering eating 3 brownies, 0 scoops of chocolate ice cream, 1 bottle of cola, and 7 pieces of pineapple cheesecake:

	Α	В	С	D	E					
1	DECISION VARIABLES									
2	Brownies Ice Cream Cola Cheese Cak									
3	Eaten	3	0	1	7					

Diet Problem: Set-Up (3 of 7)

- Write and enter objective function (target cell)
 - To see if the diet is optimal, we must determine its cost as well as the calories, chocolate, sugar, and fat it provides
 - In the range B7:E7 we reference the number of units, and in B8:E8 we input the per-unit cost for each available food
 - We compute the cost of the diet in cell B10 with the formula
 - = B7*B8 + C7*C8 + D7*D8 + E7*E8
 - ...But it is usually easier to enter the formula
 - = SUMPRODUCT (B7:E7, B8:E8)
 - ...And this is much easier to understand for anyone reading the spreadsheet
 - The **=SUMPRODUCT** function requires two ranges as inputs
 - The first cell in range 1 is multiplied by the first cell in range 2, then the second cell in range 1 is multiplied by the second cell in range 2, and so on
 - · All of these products are then added
 - Thus, in cell B10 the "=SUMPRODUCT" function computes total cost as 3*50 + 0*20 + 1*30 + 7*80 = 740 cents.

7

Example 1

Diet Problem: Set-Up (4 of 7)

· Now, the spreadsheet should look like:

	Α	В	С	D	E						
1	DECISION VARIABLES										
2		Brownies	Ice Cream	Cola	Cheese Cake						
3	Eaten	3	0	1	7						
4											
5	OBJECTIVE FUNCTION										
6		Brownies	Ice Cream	Cola	Cheese Cake						
7	Eaten	=B3	=C3	=D3	=E3						
8	Cost	Cost 50		30	80						
9											
10	Total 740 = SUMPRODUCT (B7:E7, B8:E8)										

Diet Problem: Set-Up (5 of 7)

- Finally, we must set up the given problem constraints (for calories, chocolate, sugar, and fat)
 - To begin, we recreate the table in Excel that defines how many calories and units of chocolate, sugar, and fat are in each type of dessert
 - We can use this information to calculate total amounts based on the quantities of different decision variables
 - Next, take the =SUMPRODUCT of the number of items with the calories in each to calculate total calories in our dessert selection
 - **= SUMPRODUCT (B7:E7, B14:E14)**
 - Finally, indicate the limitations highlighted in the problem
 - Add a >= or <= to identify maximum versus minimum constraints in Column G, and use Column H to indicate those limits:

9

Example 1

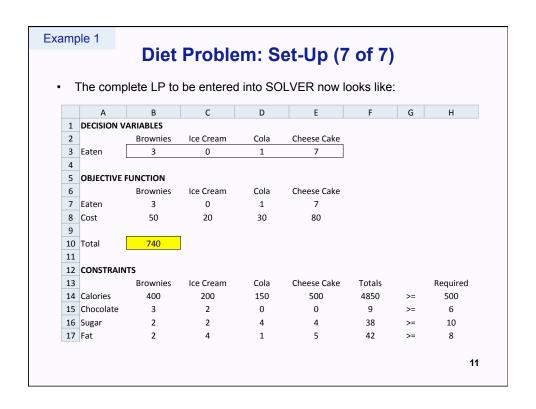
Diet Problem: Set-Up (6 of 7)

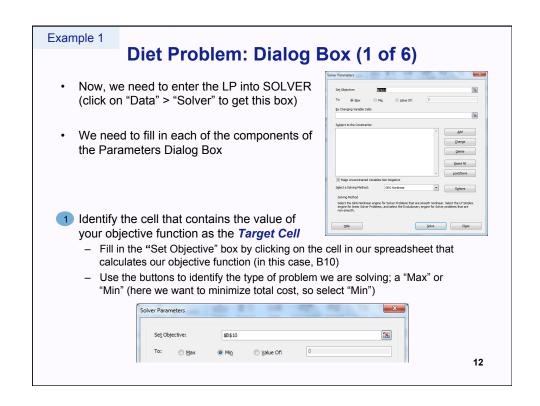
The formulas will look like:

	Α	В	С	D	Е	F	G	Н
13		Brownies	Ice Cream	Cola	Cheese Cake	Totals		Required
14	Calories	400	200	150	500	=SUMPRODUCT(\$B\$7:\$E\$7,B14:E14)	>=	500
15	Chocolate	3	2	0	0	=SUMPRODUCT(\$B\$7:\$E\$7,B15:E15)	>=	6
16	Sugar	2	2	4	4	=SUMPRODUCT(\$B\$7:\$E\$7,B16:E16)	>=	10
17	Fat	2	4	1	5	=SUMPRODUCT(\$B\$7:\$E\$7,B17:E17)	>=	8

• The constraint values that will show up on your screen look like:

	А	В	С	D	E	F	G	Н
13		Brownies	Ice Cream	Cola	Cheese Cake	Totals		Required
14	Calories	400	200	150	500	4850	>=	500
15	Chocolate	3	2	0	0	9	>=	6
16	Sugar	2	2	4	4	38	>=	10
17	Fat	2	4	1	5	42	>=	8





Diet Problem: Dialog Box (2 of 6)

- Identify the decision variables that can be varied, called "Changing Cells" or "Variable Cells"
 - Click into the "By Changing Variable Cells" box
 - Select the decision variable cells of our LP (which are B3:E3)



 SOLVER now knows that it can change the number of brownies, scoops of ice cream, sodas, and pieces of cheese cake to reach an optimal solution

13

Example 1

Diet Problem: Dialog Box (3 of 6)



- Click on the "Add a constraint" button, and a box will appear that allows us to add our constraints
- We can use the "Cell Reference" box to input the totals for each constraint that we calculated
 - Using Calories as an example, we would click on Cell F14, which computed the total calories from all our desserts
- There are several options for constraint type: <=, >=, =, int (integer), bin (binary), or dif (all different)
 - After adjusting the constraint type to be greater than or equal to (>=), click on the cell referencing the minimum quantity permitted (Cell H14)
 - · Note: Instead of a reference, we can also enter a specific number
 - · The complete constraint looks as follows:



Diet Problem: Dialog Box (4 of 6)

- The "Add" button will allow us to include all the other constraints to SOLVER.
 - Instead of entering each constraint individually, you can add them all at once
 - In the "Cell Reference" box and "Constraint" box, you can also specify an array of cell references; if both the Cell Reference and Constraint are specified using an array of cell references, the length of the arrays must match and Solver treats this constraint as n individual constraints, where n is the length of each array
- · We have now created four constraints
 - SOLVER will ensure that the changing cells are chosen so F14>=H14, F15>=H15, F16>=H16, and F17>=H17
- The "Change" button allows you to modify a constraint already entered and "Delete" allows you to delete a previously entered constraint



15

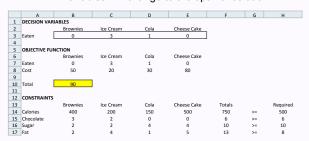
1

Cancel

Example 1

Diet Problem: Dialog Box (5 of 6)

- The final SOLVER Parameters Dialog Box:
 - Note: the checked box titled "Make Unconstrained Variables Non-Negative" allows us to capture nonnegativity constraints (all variables will be constrained to be >= 0)
 - Additionally, you should change the "Select a Solving Method" to "SIMPLEX LP" when you are solving a linear program
- Finally, click "Solve" for your solution
 - The Parameters Dialog Box will close and decision variables will change to the optimal solution:





>= = SH\$14:\$H\$1

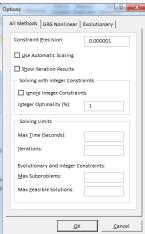
Add

<u>O</u>K

Note: because we referenced these cells in all our calculations, the objective function and constraints will also change

Diet Problem: Dialog Box (6 of 6)

- The Parameters Dialog Box also has a number of options on how to calculate solutions
 - Constraint Precision is the degree of accuracy of the Solver algorithm (for example, how close does the value of the LHS of a constraint have to be before it is considered equal to the RHS)
 - Max Time allows you to set the number of seconds before Solver will stop
 - Iterations, similar to Max Time, allows you to specify the maximum number of steps of the Solver algorithm takes before stopping
 - If you want to learn about other options in SOLVER, please reference the SOLVER website:
 - · www.solver.com



17

Example 2

Food Start-Up Problem (1 of 2)

Problem Statement:

- You create a start-up company that caters food directly to customers. You want to allocate production capabilities to devise a feasible daily production plan that maximizes your profit
 - There are three kinds of food that you order at this early stage of the company:
 Hummus (H), a Moussaka (M), and a Tabouleh (T). Each meal has to be cooked, packaged and delivered; you estimate that total available cooking hours is 4, packaging hours 2, and delivery hours 2
 - Hummus for 10 portions requires 1 hour of time, packaging is done at the rate of 20 portions per hour, and delivery at the rate of 30 per hour; Ingredients for 1 portion cost \$1, and each packaged portion can be sold for \$7
 - In 1 hour, the food cooking team can prepare 5 portions of Moussaka, packaging is done at the rate of 15 per hour, and 15 portions can be delivered in 1 hour; Ingredients for 1 portion cost \$2, and it can be sold for \$12
 - Finally, **Tabouleh** can be prepared at the rate of 15 portions per hour, packaged at 25 portions per hour, and delivered at 30 per hour; one portion only costs \$0.5 in raw ingredients, and can be sold for \$5
 - Customers expressed interest in having the following products delivered every day: 20
 Hummus meals, 10 Moussaka meals, and 30 Tabouleh meals

Task:

Solve this in Excel on your own!

