Math 1090 Project 4 (Work in groups of two to four.)

Linear Programming

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Use an Excel spreadsheet to solve optimization problems

Example 1: The Solar Technology Company manufactures three different types of hand calculators and classifies them as scientific, business, and graphing according to their calculating capabilities. The three types have production requirements given by the following table.

	Scientific	Business	Graphing
Electronic circuit components	5	7	10
Assembly time (hours)	1	3	4
Cases	1	1	1

The firm has a monthly limit of 90,000 circuit components, 30,000 hours of labor, and 9000 cases. If the profit is \$6 for the scientific, \$13 for the business, and \$20 for the graphing calculators, how many of each should be produced to yield maximum profit? What is the maximum profit?

Let S be the number of scientific, B be the number of business, and G be the number of graphing calculators to be produced.

Then the optimization function is: $\textit{Profit}\,(S, B, G) = 6S + 13B + 20G$.

Subject to the constraints: $\begin{cases} 5S + 7B + 10G \leq 90{,}000 \\ S + 3B + 4G \leq 30{,}000 \\ S + B + G \leq 9{,}000 \end{cases}$ where $\begin{cases} S \geq 0 \\ B \geq 0 \\ G \geq 0 \end{cases}$

Open Excel and set up a workspace like the following to organize the information and work:

	A	B	C
1	Variables		
2			
3	# scientific calculators (*S*)		
4	# business calculators (*B*)		
5	# graphing calculators (*G*)		
6			
7	Objectives		
8			
9	Maximize Profit		
10			
11	Constraints		
12		Amount used	Maximum
13	Circuit components		90000
14	Labor hours		30000
15	Cases		9000

In cell B9 enter the function: =6*B3+13*B4+20*B5 optimization function
In cell B13 enter the function: =5*B3+7*B4+10*B5 function for first constraint
In cell B14 enter the function: =B3+3*B4+4*B5 function for second constraint
In cell B15 enter the function: =B3+B4+B5 function for third constraint

The Solver will have to be Added-In if it hasn't yet been used on the computer you're using. Click on the Office Button, and choose Excel Options. Then select Add-Ins in the left column, and click Go at the bottom. Check Solver Add-in in the new window, and click OK.

Select Solver from the Data tab at the top.

Set Target Cell: B9
Equal to: Max
By changing cells: B3:B5
Click in the Subject to the Constraints box:
Click the Add button:
in the Cell Reference box enter: B13
skip by the <= sign because you want the formula in cell B13 ≤ the maximum
in the Constraint box enter: C13
then click OK
Click the Add button again:
in the Cell Reference box enter: B14
skip by the <= sign because you want the formula in cell B14 ≤ the maximum
in the Constraint box enter: C14
then click OK
Click the Add button again:
in the Cell Reference box enter: B15
skip by the <= sign because you want the formula in cell B15 ≤ the maximum
in the Constraint box enter: C15
then click OK
Click the Add button again:
in the Cell Reference box enter: B3
choose the >= sign because you want the value in cell B3 ≥ the minimum
in the Constraint box enter the number: 0
then click OK
Click the Add button again:
in the Cell Reference box enter: B4
skip by the >= sign because you want the formula in cell B4 ≥ the maximum
in the Constraint box enter the number: 0
then click OK
Click the Add button again:
in the Cell Reference box enter: B5
skip by the >= sign because you want the formula in cell B5 ≥ the maximum
in the Constraint box enter the number: 0
then click OK

Finally, click the Solve button.

Highlight the space you used to work the problem and print it on the paper that your group will turn in. you should also write the system of equations and the optimization function that you used. Finally, write a few sentences that identify the maximum profit; the amount of each of the variables used; and the number of each kind of calculator made.

For example: The optimization function is: $Profit\,(S, B, G) = 6S + 13B + 20G$.

Subject to the constraints: $\begin{cases} 5S + 7B + 10G \le 90{,}000 \\ S + 3B + 4G \le 30{,}000 \\ S + B + G \le 9{,}000 \end{cases}$ where $\begin{cases} S \ge 0 \\ B \ge 0 \\ G \ge 0 \end{cases}$

Variables		
# scientific calculators (*S*)	2,000	
# business calculators (*B*)	0	
# graphing calculators (*G*)	7,000	
Objectives		
Maximize Profit	$152,000	
Constraints		
	Amount used	Maximum
Circuit components	80,000	90,000
Labor hours	30,000	30,000
Cases	9,000	9,000

A maximum profit of $152,000 will be realized by using 80,000 circuit components, all 30,000 labor hours available, and all 9,000 cases available to make 2,000 scientific calculators and 7,000 graphing calculators. No business calculators will be made.

Ref: pp. 339 – 341 in Mathematical Application by Harshbarger & Reynolds, 7th ed.

Assignment

1. a. Matt's Master Photography has $6000 available per year for advertising. Newspaper ads cost $100 each and he can afford a maximum of 21 ads annually. Radio ads cost $300 each and he can afford a maximum of 28 annually at this price. Each newspaper ad is estimated to reach 6000 potential customers (brides and families with children), and each radio ad is estimated to reach 8000 potential customers. Of course Matt wants to maximize the number of ad exposures to potential customers. Write the objective function and the system of constraints, then set up a workspace in an Excel program to find the maximum possible number of exposures to potential customers.

	A	B	C
1	Variables		
2			
3	# newspaper ads (*N*)		
4	# radio ads (*R*)		
5			
6	Objectives		
7			
8	Maximum # of exposures		
9			
10	Constraints		
11		Amount used	Maximum
12	Newspaper ads		21
13	Radio ads		28
14	Cost		6000

b. Copy the space you used to work the problem and print it on your word document after you've solved the problem. Write a sentence that tells the number of newspaper and radio ads used, the cost, and the number of potential customers reached.

c. What if the available cost is $8,000? Since the newspaper ads maximized in the previous constraint conditions, it is decided to let both the radio ads and the newspaper ads be 20; enter these amounts in the cells that maximize these values. Write the new system of constraints, then open the solver menu, and solve with these new constraints. Copy and print the space you used to work the problem and write a sentence to explain it.

d. Write a short paragraph telling how the constraints may be changed, and how they can affect the value of the variables which optimize the problem.

2. a. Suzanne's Supervisory Services has $12,000 available for advertising. The following table gives the costs per ad and the number of people exposed to its ads for three different media (with number in thousands).

Ad Packages	Newspaper	Radio	TV
Cost	2	2	4
Total audience	30	21	54
Working mothers	6	12	8

If the total available audience is 420,000, and if Suzanne wishes to maximize the number of exposures to working mothers, how many ads of each type should she purchase? Set up a workspace in an Excel program and solve the problem. Highlight the space you used to work the problem and print it after you've solved the problem.

b. It is determined that a more realistic expectation for media exposure to working mothers is: 6,000 to the newspaper, 4,000 to the radio, and 8,000 to the TV. Make the change in the optimization function and solve the problem with this new parameter. Highlight the space you used to work the problem and print it after you've solved the problem.

c. Another estimate of the expectation for media exposure to working mothers is: 4,000 to the newspaper, 4,000 to the radio, and 8,000 to the TV. Make the change in the optimization function and solve the problem with this new parameter. Highlight the space you used to work the problem and print it after you've solved the problem.

d. Write a short paragraph telling how the parameters may be changed, and how they can affect the value of the variables which optimize the problem.

3. a. Amir's Asian Deli and Catering has only two menus: I (Ceylonese) and II (Bengali). He prepares these at three different facilities: A (the Avenues), B (Bountiful), and C (Cottonwood). The production capacities and costs per week to operate the three facilities are summarized in the following table:

	A	B	C
I	200	200	400
II	100	200	100
Cost / week	$1000	$3000	$4000

How many weeks should each facility operate to fill Amir's orders at a minimum cost, and what is the minimum cost? Set up a workspace in an Excel program and solve the problem.

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	A	B	C
1	Variables		
2			
3	# of weeks @ Facility A (*A*)		
4	# of weeks @ Facility B (*B*)		
5	# of weeks @ Facility C (*C*)		
6			
7	Objectives		
8			
9	Minimum Cost		
10			
11	Constraints		
12		Amount used	Minimum
13	Menu I Ceylonese		2000
14	Menu II Bengali		1200
15	Cost per week		

b. Highlight the space you used to work the problem and print it after you've solved the problem.

c. Write a short paragraph telling how minimizing constraints changes the problem.

[1] Based on problem #53, page 347, Harshbarger/Reynolds, Mathematical Applications, 7th ed.

[2] Based on problem #56, page 347, Harshbarger/Reynolds, Mathematical Applications, 7th ed.

[3] Based on problem #25, page 357, Harshbarger/Reynolds, Mathematical Applications, 7th ed.