K. J. SOMAIYA INSTITUTE OF MANAGEMENT STUDIES AND RESEARCH,
Vidyavihar, Mumbai- 400077
Program: *PG/MMS Ops (Batch 2016-18) Trim-IV*
Subject: Quantitative Techniques in Operations
(End Term Examination) (In computer lab)

Maximum Marks: 50 **18th Sep, 2017** **Duration: 3 hours**

Instructions

- **Write all your answers in the answer sheet clearly. Your submission in answer sheet will be primarily used for evaluation, supported by the excel submission.**
- **Use Excel and solver as required and keep saving your work (one single file with reference of your program and roll no) as you proceed. Follow the instructions of data centre personnel and transfer your folder to an appropriate place in the server.**
- **If you assume any data not given, please provide suitable explanation of the same.**

Part A – Problems (Answer any 3 out of 5: 3X11=33 marks)

1. The profit function for two products is

$$\textbf{Profit} = -3x_1^2+42x_1-3x_2^2+48x_2+700$$

where x_1 represents units of production of product 1 and x_2 represents units of production of product 2. Producing one unit of product 1 requires 4 labor-hours and producing one unit of product 2 requires 6 labor-hours. Currently, 24 labor-hours are available. The cost of labor-hours is already factored into the profit function. However, it is possible to schedule overtime at a premium of $5 per hour.

   a. Formulate the problem (describing decision variable, constraints, and objective function) with a suitable optimization model.
   b. Solve in excel.
   c. How much should be produced and how many overtime hours should be scheduled?

2. The Lafferty Company wants to locate a warehouse from which it will ship products to four customers. The location (in the x-y plane) of the four customers and the number of shipments per year needed by each customer are given in the table below. (All coordinates are in miles relative to the point x=0 and y=0). A single warehouse must be used to service all of the customers.

Customer	x-coordinate	y-coordinate	Shipments per Year
1	5	10	200
2	10	5	150
3	0	12	200
4	12	0	300

Lafferty wants to determine the location of the warehouse that minimizes the total distance travelled from the warehouse to the customers.

   a. Formulate the problem (describing decision variable, constraints, and objective function) with a suitable optimization model.
   b. Solve in excel.
   c. Use Solver table to see the effect on the optimal solution of moving one customer farther and farther away from the others. Specifically, let customer 1's coordinates be of the form (5c,

10c), where the factor c is allowed to vary from 1 to 10 in increments of 2. Keep track of the changing cells and the target cell.

3. At a machine tool plant, five jobs must be completed each day. The time it takes to do each job depends on the machine used to do the job. If a machine is used at all, a setup time is required. The relevant times (in minutes) are given in the table below.

Times to do jobs (large times mean machine can't do job) and setup times						
	Job 1	Job 2	Job 3	Job 4	Job 5	Setup time
Machine 1	42	70	93	1000	1000	30
Machine 2	1000	85	45	1000	1000	40
Machine 3	58	1000	1000	37	1000	50
Machine 4	58	1000	55	1000	38	60
Machine 5	1000	60	1000	54	1000	20

Determine how to minimize the sum of the setup and machine operation times needed to complete all jobs.

a. Formulate the problem (describing decision variable, constraints, and objective function) with a suitable optimization model.
b. Solve in excel.
c. Use Solver table to analyse how a change in the setup time of machine 4 changes the optimal solution.

4. The Research and Development Division of the Emax Corporation has developed three new products. A decision now needs to be made on which mix of these products should be produced. Management wants primary consideration given to three factors: total profit, stability in the work force, and achieving an increase in the company's earnings next year from the $75 million achieved this year. In particular, using the units given in the following table, they want to

Maximize $M = P - 6C - 3D$

where

M = Overall measure of performance combining the three factors
P =Total (discounted) profit over the life of the new products
C = Change (in either direction) in the current level of employment
D = Decrease (if any) in next year's earnings from the current year's level

The amount of any increase in earnings does not enter into M, because management is concerned primarily with just achieving some increase to keep the stockholders happy. (It has mixed feelings about a large increase that then would be difficult to surpass in subsequent years.)
The impact of each of the new products (per unit rate of production) on each of these factors is shown in the following table:

	Unit Contribution of Product				
Factor	1	2	3	Goal	(Units)
Total Profit	20	15	25	Maximize	Millions of Dollars
Employment level	6	4	5	=50	Hundreds of employees
Earnings next year	8	7	5	>=75	Millions of dollars

a. Formulate the problem (describing decision variable, constraints, and objective function)

with a suitable optimization model.

b. Solve in excel.

5. The Ranch House, Inc. operates five fast-food restaurants. Input measures for the restaurants include weekly hours of operation, full-time equivalent staff, and weekly supply expenses. Output measures of performance include average weekly contribution to profit, market share, and annual growth rate. Data for the input and output measures are shown in the following tables:

	Input Measures		
Restaurant	Hours of Operation	FTE Staff	Supplies ($)
Bardstown	96	16	850
Clarksville	110	22	1400
Jeffersonville	100	18	1200
New Albany	125	25	1500
St. Matthews	120	24	1600

	Output Measures		
Restaurant	Weekly Profit	Market Share (%)	Growth Rate (%)
Bardstown	$3800	25	8.0
Clarksville	$4600	32	8.5
Jeffersonville	$4400	35	8.0
New Albany	$6500	30	10.0
St. Matthews	$6000	28	9.0

a. Formulate the problem (describing decision variable, constraints, and objective function) with a suitable optimization model.

b. Solve in excel.

c. Is the Clarksville Ranch House restaurant relatively inefficient? Discuss.

Part B - Case Analysis (answer anyone out of two: 1X 17 = 17 Marks)

6. Dorian Auto is considering manufacturing three types of cars (compact, midsize, and large) and two types of minivans (midsize and large). The resources required and the profit contributions yielded by each type of vehicle are shown in the table below:

	Compact car	Midsize car	Large car	Midsize minivan	Large minivan
Steel (tons) /unit	1.5	3	5	6	8
Labour Hours/unit	30	25	40	45	55
Mini. Production (if any)	1000	1000	1000	200	200
Profit contribution/unit	$2000	$2500	$3000	$5500	$7000

At present, 6500 tons of steel and 65000 hours of labour are available. If any vehicles of a given type are produced, production of that type of vehicle is economically feasible only if at least a minimal number of that type is produced. These minimal numbers are also listed in the above table. Determine which types of vehicles to produce and in what quantities to maximize profit.

a. Formulate the problem (describing decision variable, constraints, and objective function)

with a suitable optimization model.

b. Solve in excel.
c. The optimal solution appears to be sensitive to the model inputs. Select suitable ranges for the following inputs and analyse with Solver table the effects of the changes in the input values. Comment on the results.
d. If Solver could handle IF functions correctly, how would you use them in the above model to create a more natural model – without binary variables? Run Solver on the revised model. Do you get the correct solution?

7. During the next four quarters, Dorian Auto must meet (on time) the following demands for cars: 4000 in 1st quarter,; 2000 in 2nd quarter; 5000 in 3rd quarter; and 1000 in 4th quarter. At the beginning of 1st quarter, there are 300 cars in stock. The company has the capacity to produce at most 3000 cars per quarter.
   At the beginning of each quarter, the company can change production capacity. It costs $100 to increase quarterly capacity by 1 unit. It also costs $ 50 per quarter to maintain each unit of production capacity (even if it is unused during the current quarter). The variable cost of producing a car is $ 2000. A holding cost of $ 150 per car is assessed against each quarter's ending inventory.
   At the end of quarter 4, plant capacity must be at least 4000 cars.
   The company wants to minimize the total cost to be incurred during the next four quarters.

   a. Formulate the problem (describing decision variable, constraints, and objective function) with a suitable optimization model.
   b. Solve in excel.
   c. Use Solver table to analyse how much the total cost increases as the required capacity at the end of the 4th quarter increases (from its current value of 4000).

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