K. J. SOMAIYA INSTITUTE OF MANAGEMENT STUDIES AND RESEARCH,
Vidyavihar, Mumbai- 400077
Program: *PGDM – MMS Ops (2017-19), Trim IV*
Subject: Quantitative Techniques in Operations
(End-Term Examination) (In Computer Lab)

Maximum Marks: 50
Duration: 3hours **Date: 17th Sep, 2018**

Instructions

1. **Use Excel and solver as required and save your files on the computer following the instructions of data centre personnel. Write all relevant answers in the answer sheet.**
2. **If you assume any data not given, please provide suitable explanation of the same.**

Part A – Concepts and Techniques
Solve any three out of five (3*11 = 33 marks)

1.

a. Explain the concept of local and global optima with an example. In how many ways, can you identify the global optimum in an NLP formulation? What is the role of multi-start option in Solver?

b. The weekly box office revenues (in $ millions) for *Terminator 3* are given here. Use these data in the Bass forecasting model given by equations (**See annexure**) to estimate the parameters p, q, and m. Solve the model using Solver.

Week	*Terminator 3*
1	72.39
2	37.93
3	17.58
4	9.57
5	5.39
6	3.13
7	1.62
8	0.87
9	0.61
10	0.26
11	0.19
12	0.35

c. Did you use the multi-solver option? If so, explain whether your solution is local or global optimum.

2.

a. What is the difference between an all-integer, mixed-integer and binary-integer LP problem formulation? Explain these with hypothetical examples. What is the role of an LP relaxation of the integer linear program?

b. A product can be produced on four different machines. Each machine has a fixed setup cost, variable production cost per unit processed and a production capacity, as given below. A total of 2000 units of the product must be produced. Determine how

to minimize the total cost.

Machine data				
	Machine 1	Machine 2	Machine 3	Machine 4
Fixed cost	$1,000	$920	$800	$700
Variable cost	$20	$24	$16	$28
Capacity	900	1000	1200	1600

3.

a. How can Data Envelopment Analysis (DEA) assist in improving branch efficiency in a bank? Explain with a hypothetical example indicating the formulation aspects of DEA.

b. You have been asked to evaluate the efficiency of the Port Charles Police Department. Three precincts are to be evaluated. The inputs and outputs are as follows :

Input 1 = number of policemen
Input 2 = number of vehicles used
Output 1 = number of patrol units responding to service requests (thousands per year)
Output 2 = number of convictions obtained each year (in hundreds)

Port Charles Police Department				
Precinct	Input 1	Input 2	Output 1	Output 2
1	200	60	6	8.0
2	300	90	8	9.5
3	400	120	10	11.0

Use this information to determine which precincts, if any, are inefficient.

4.

Filtron Corporation produces filtration containers used in water treatment systems. Although business has been growing, the demand each month varies considerably. As a result, the company utilizes a mix of part-time and full-time employees to meet production demands. Although this approach provides Filtron with great flexibility, it has resulted in increased costs and morale problems among employees. For instance, if Filtron needs to increase production from one month to the next, additional part-time employees have to be hired and trained, and costs go up. If Filtron has to decrease production, the workforce has to be reduced and Filtron incurs additional

costs in terms of unemployment benefits and decreased morale. Best estimates are that increasing the number of units produced from one month to the next will increase production costs by $1.25 per unit, and that decreasing the number of units produced will increase production costs by $1.00 per unit. In February Filtron produced 10,000 filtration containers but only sold 7500 units; 2500 units are currently in inventory. The sales forecasts for March, April, and May are for 12,000 units, 8000 units, and 15,000 units, respectively. In addition, Filtron has the capacity to store up to 3000 filtration containers at the end of any month.

a. Prepare a spreadsheet model to determine the number of units to be produced in March, April, and May that will minimize the total cost of the monthly production increases and decreases.
b. Write the details of the optimal solution and discuss.

5. Woodco sells 3-foot, 5-foot, and 9-foot pieces of lumber. Woodco's customers demand 25 3-foot boards, 20 5-foot boards, and 15 9-foot boards. Woodco meets its demands by cutting up 17-foot boards. How can it satisfy its customers' demands with the least amount of waste? Assume that all the boards are the same width and thickness.
    a. Produce a suitable list of different patterns in which 17-foot board may be cut up to provide for customers' requirements.
    b. Solve the problem with a suitable model.
    c. How did you define the waste? Explain.

Part B - Case Study (answer any one out of two. 1* 17 = 17 marks)

6. The Lafferty Company wants to locate one or more warehouses from which it will ship products to its four customers. There are two possible locations each with distances to the various customers. The distances, alongwith other inputs are given below. The company can build either or both of these warehouses. The cost to build a warehouse is $ 50000. If only one warehouse is built, it will ship to all customers. However, if both warehouses are built, then the company must decide which warehouse will ship to each customer. There is a traveling cost of $ 1 per mile.

Customer data	Annual shipments	
Customer 1	200	
Customer 2	150	
Customer 3	200	
Customer 4	300	
Distances (miles)	From warehouse 1	From warehouse 2
To customer 1	707	51
To customer 2	118	169
To customer 3	968	474

To customer 4	752	616
Annualized cost of building a warehouse	$50,000	
Shipping cost per mile	$1	

a) Develop an appropriate model to minimize total annual cost, and then use Solver to optimize it. Is this model an NLP or an IP model (or both)?

b) Change the traveling cost per mile to $3, $5, $6, and $7 to see how large the cost must be before the company builds both warehouses rather than just one.

7. The city council of Aberdeen must determine the tax policy for the city for the coming year. Four types of taxes are used to raise money:
   - Property tax
   - Sales tax (a surcharge on the state sales tax)
   - Entertainment tax
   - Utility tax (on city-owned utilities)

   The city consists of three groups of people: low income, middle income, and high income. The amount of revenue (in thousands of dollars), raised from each group by setting a particular tax at a 1 percent level, is given in the following table. (For example, a 3 percent sales tax will raise $1.2 million from low-income people.)

	Thousands of dollars collected per 1% tax rate			
Income group	Property tax	Sales tax	Entertainment tax	Utility tax
Low-income	600	400	50	100
Middle-income	800	350	100	120
High-income	1200	250	120	80

The city council has decided that the tax policy must satisfy the following restrictions.

- The tax burden on middle-income people cannot exceed $2.5 million.
- The tax burden on high-income people cannot exceed $2.3 million.
- The total revenue raised must exceed the current level of $6 million.
- The sales tax must be between 1 percent and 3 percent.

Given these restrictions, the city council has set the following three goals (listed in order of priority):

- Goal 1: Limit the tax burden on low-income people to no more than $2 million.
- Goal 2: Set the property tax rate at no less than 1 percent.
- If their tax burden becomes too high, 20 percent of the low-income people, 20 percent of the middle-income people, and 40 percent of the high-income people may consider moving. This will start to happen if the total tax burden of this subset of the population exceeds $1.5 million.
- Goal 3 is thus to limit the total tax burden on this group of people to no more than $1.5 million.

a. Use preemptive goal programming to determine how the various tax rates should be set.

b. Use weighted goal programming to determine how the various tax rates should be set when using the following penalty weights: 1 per $1,000 in excess of goal 1; 90 per 1percent short of goal 2; and 1 per $1,000 in excess of goal 3.

Annexure

$$\text{Min} \sum_{i=1}^{N} E_i^2 \qquad (8.21)$$

s.t.

$$F_i = (p + q[C_{i-1}/m])(m - C_{i-1}), \quad i = 1, \ldots, N \qquad (8.22)$$

$$E_i = F_i - S_i, \quad i = 1, \ldots, N \qquad (8.23)$$

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