K. J. SOMAIYA INSTITUTE OF MANAGEMENT STUDIES AND RESEARCH,
Vidyavihar, Mumbai- 400077
Program: *PGDM – MMS Ops (2018-20), Trim IV*
Subject: Quantitative Techniques in Operations
(End-Term Examination) (In Computer Lab)

Maximum Marks: 50
Duration: 3hours **Date: 16th Sep, 2019**

Instructions

- **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.**
- **If you assume any data not given, please provide suitable explanation of the same.**

Part A (Answer any three questions out of five. 3x11 = 33 marks)

1. A). Four projects are available for investment. The projects require the cash flows and yield the net present values (in millions) shown as below:

Note: All cash amounts are in $millions.				
Cash outflows and NPVs of projects				
	Project 1	Project 2	Project 3	Project 4
Cash outflow	$3	$5	$2	$4
NPV	$5	$8	$3	$7

If $6 million is available now for investment, find the investment plan that maximizes NPV. (5 marks)

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:

	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

A total of 2000 units of the product must be produced. Determine how to minimize the total cost. (6 marks)

2. A). A company has five factories. The *x*- and *y*-coordinates of the location of each factory are given below:

Locations of existing factories		
	x	y
Factory 1	6	-5
Factory 2	8	4
Factory 3	5	2
Factory 4	-5	4
Factory 5	-3	2

The company wants to locate a warehouse at a point that minimizes the sum of the squared distances of the plants from the warehouse. Where should the warehouse be located? (5 marks)

B). If you have to apply a different formula for the distance in place of what is used in A) above, describe the alternate formula and use it to determine the revised warehouse location. (6 marks)

3. Data envelopment analysis can measure the relative efficiency of a group of hospitals. The following data from a particular study involving seven teaching hospitals include three input measures and four output measures:

	Input measures		
Hospital	Full-time Equivalent Nonphysicians	Supply Expenses (1000s)	Bed-days Available (1000s)
A	310.0	134.60	116.00
B	278.5	114.30	106.80
C	165.6	131.30	65.52
D	250.0	316.00	94.40
E	206.4	151.20	102.10
F	384.0	217.00	153.70
G	530.1	770.80	215.00

	Output measures			
Hospital	Patient-Days (65 or older) (1000s)	Patient-Days (under 65) (1000s)	Nurses Trained	Interns Trained
A	55.31	49.52	291	47
B	37.64	55.63	156	3
C	32.91	25.77	141	26
D	33.53	41.99	160	21
E	32.48	55.30	157	82
F	48.78	81.92	285	92
G	58.41	119.70	111	89

A). Formulate a linear programming model so that data envelopment analysis can be used to evaluate the performance of hospital D. (5 marks)

B). Solve the model. Is hospital D relatively inefficient? What is the interpretation of the value of the objective function? (6 marks)

4. LeapFrog Airways provides passenger service for Indianapolis, Baltimore, Memphis, Austin, and Tampa. LeapFrog has two WB828 airplanes, one based in Indianapolis and the other in Baltimore. Each morning the Indianapolis based plane flies to Austin with a stopover in Memphis. The Baltimore based plane flies to Tampa with a stopover in Memphis. Both planes have a coach section with a 120-seat capacity. LeapFrog uses two fare classes: a discount fare D class and a full fare F class. Leapfrog's products, each referred to as an origin destination itinerary fare (ODIF), are listed below with their fares and forecasted demand.

ODIF	Fare Class	ODIF code	Fare	Demand
1	D	IMD	175	44
2	D	IAD	275	25
3	D	ITD	285	40
4	F	IMF	395	15
5	F	IAF	425	10
6	F	ITF	475	8
7	D	BMD	185	26
8	D	BAD	315	50
9	D	BTD	290	42
10	F	BMF	385	12
11	F	BAF	525	16
12	F	BTF	490	9
13	D	MAD	190	58
14	D	MTD	180	48
15	F	MAF	310	14
16	F	MTF	295	11

A). Formulate the problem mathematically as an LP problem. (5 marks)

B). LeapFrog wants to determine how many seats it should allocate to each ODIF. (6 marks)

5. Heller manufacturing has two production facilities that manufacture baseball gloves. Production costs at the two facilities differ because of varying labor rates, local property taxes, type of equipment, capacity, and so on. The Dayton plant has weekly costs that can be expressed as a function of the number of gloves produced:

, where X is the weekly production volume in thousands of units and $TCD(X)$ is the cost in thousands of dollars. The Hamilton plant's weekly production costs are given by

, where Y is the weekly production volume in thousands of units and $TCH(Y)$ is the cost in thousands of dollars. Heller Manufacturing would like to produce 8000 gloves per week at the lowest possible cost.

A). Formulate a mathematical model that can be used to determine the optimal number of gloves to produce each week at each facility. (5 marks)

B). Use Excel Solver to find the solution to your mathematical model to determine the optimal number of gloves to produce at each facility. (3 marks)

C). Discuss the effect of local and global optima with specific reference to this problem. (3 marks)

Part B Case Study (Answer any one out of two, 1x17 = 17 marks).

6. Shoemakers of America forecasts the following demand for the next 6 months: 5000 pairs in month 1; 6000 pairs in month 2; 5000 pairs in month 3; 9000 pairs in month 4; 6000 pairs in month 5; 5000 pairs in month 6. It takes a shoemaker 15 minutes to produce a pair of shoes. Each shoemaker works 150 hours per month plus up to 40 hours per month of overtime. A shoemaker is paid a regular salary of $2000 per month plus $50 per hour for overtime. At the beginning of each month, Shoemakers can either hire or fire workers. It costs the company $1500 to hire a worker and $1900 to fire a worker. The monthly holding cost per pair of shoes is 3% of the cost of producing a pair of shoes with regular-time labor. The raw materials in a pair of shoes cost $10. At the beginning of month 1, Shoemakers has 13 workers.

   In order to help you with the modeling, your assistant has laid out the data in the following table and developed a template for the excel formulation. It's however necessary for you to verify his inputs and the template.

Hours/worker/pair of shoes	0.333					
Regular time hours/month	150					
Maximum overtime hours/month	40					
Regular salary per month	$2,000					
Overtime hourly pay	$20					
Cost to hire a worker	$1,000					
Cost to fire a worker	$1,200					
Raw material cost/pair of shoes	$10					
Holding cost (% of regular-time cost)	5%					
Initial number of workers	15					
Initial inventory	500					
Production/hiring/firing schedule						
Month	1	2	3	4	5	6
Workers from previous month						

Workers hired						
Workers fired						
Workers available						
Regular-time hours						
Overtime hours						
Maximum overtime hours						
Total hours available						
Hours used for producing shoes						
Pairs of shoes produced						
Shoes available to meet demand						
Demand						
Ending inventory						
Regular salary cost						
Overtime cost						
Hiring cost						
Firing cost						
Raw material cost						
Holding cost						
Total cost						

A). Formulate the problem as an LP model describing the decision variables, constraints, and objective function. (5 marks)

B). Determine how to minimize the cost of meeting (on time) the demands of the next 6 months. (6 marks)

C). Describe briefly the concept of rolling horizon approach and explain how that can be used in your model. (3marks)

D). Describe the concept of backlogging and indicate what corrections are required to extend your model to include backlogging. (3 marks)

OR

7. Montega is a developing country that has 15,000,000 acres of publicly controlled agricultural land in active use. Its government currently is planning a way to divide this land among three basic crops (labeled 1, 2, and 3) next year. A certain percentage of each of these crops is exported to obtain badly needed foreign capital (dollars), and the rest of each of these crops is used to feed the populace. Raising these crops also provides employment for a significant proportion of the population. Therefore, the main factors to be considered in allocating the land to these crops are (1) the amount of foreign capital generated, (2) the number of citizens

fed, and (3) the number of citizens employed in raising these crops. The following table shows how much each 1,000 acres of each crop contributes toward these factors, and the last column gives the goal established by the government for each of these factors.

	Contribution per 1000 Acres of Crop			
Factor	1	2	3	Goal
Foreign capital	$3000	$5000	$4000	>= $ 70 million
Citizens fed	150	75	100	>=1,750,000
Citizens Employed	10	15	12	= 200,000

In evaluating the relative seriousness of *not* achieving these goals, the government has concluded that the following deviations from the goals should be considered *equally undesirable:*

(1) Each $100 under the foreign-capital goal, (2) each person under the citizens-fed goal, and (3) each deviation of one (in either direction) from the citizens-employed goal.

A). Describe the two approaches in goal programming methodology. (5 marks)
B). Describe why this problem is a weighted goal-programming problem by formulating quantitative expressions for the goals and the overall objective. Complete the formulation by describing the constraints. (6 marks)
C). Solve this problem as a linear programming model on a spreadsheet. (3 marks)
D). Interpret the solution to the management. (3 marks)

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