K. J. Somaiya Institute of Management Studies and Research

Program: PGDM-IB 2018-20 Trimester III

Subject: Operations Research
(End Term Examination)

Maximum marks: 50 Date: 30th March, 2019
Duration: 3 hours

Notes:

1. **You have to attempt 4 questions in all. Question 1 is compulsory and carries 20 marks. Do any 3 questions out of remaining 6.**
2. **Make suitable assumptions if required and state them.**
3. **Write all relevant answers in your answer sheet, with sufficient detail to enable a fast evaluation of your answers.**
4. **Use Excel as required and keep saving the file on the desktop every ten minutes or so.**
5. **Make only 1 Excel file with different worksheets pertaining to each question.**
6. **Name the file with your name and roll number. Finally, before handling over the answer sheet, transfer the file to an exam folder, as per on-the-spot instructions given to you.**

1. **Case: Shipping Wood to Market**

Alabama Atlantic is a lumber company that has three sources of wood and five markets to be supplied. The annual availability of wood at sources 1, 2, and 3 is 15, 20, and 15 million board feet, respectively. The amount that can be sold annually at markets 1, 2, 3, 4, and 5 is 11, 12, 9, 10, and 8 million board feet, respectively.

In the past the company has shipped the wood by train. However, because shipping costs have been increasing, the alternative of using ships to make some of the deliveries is being investigated. This alternative would require the company to invest in some ships. Except for these investment costs, the shipping costs in thousands of dollars per million board feet by rail and by water (when feasible) would be the following for each route:

	Unit Cost By Rail ($1,000's) to Market					Unit Cost By Ship ($1,000's) to Market				
Source	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
1	61	72	45	55	66	31	38	24	–	35
2	69	78	60	49	56	36	43	28	24	31
3	59	66	63	61	47	–	33	36	32	26

The capital investment (in thousands of dollars) in ships required for each million board feet to be

transported annually by ship along each route is given as follows:

	Unit Investment for Ships ($1,000's) to Market				
Source	**1**	**2**	**3**	**4**	**5**
1	275	303	238	–	285
2	293	318	270	250	265
3	–	283	275	268	240

Considering the expected useful life of the ships and the time value of money, the equivalent uniform annual cost of these investments is one-tenth the amount given in the table. The objective is to determine the overall shipping plan that minimizes the total equivalent uniform annual cost (including shipping costs). Answer the following questions:

a. Make the network diagram if the wood is transported exclusively by rail. Also formulate the problem as an LPP.

b. You are the head of the OR team that has been assigned the task of determining this shipping plan for each of the following three options.

   i. Option 1: Continue shipping exclusively by rail.

   ii. Option 2: Switch to shipping exclusively by water (except where only rail is feasible).

   iii. Option 3: Ship by either rail or water, depending on which is less expensive for the particular route.

Present your results for each option and compare the results thus obtained.

2. **10 Marks**

a. Management of the Toys R4U Company needs to decide whether to introduce a certain new novelty toy for the upcoming Christmas season, after which it would be discounted. The total cost required to setup the production and market this toy would be $5,00,000 plus $15 per toy produced. The selling price of each toy is $35.

   i. Write the expression for total cost.

   ii. Write the expression for total revenue.

   iii. Write an expression for total profit.

   iv. What profit or loss would result if 35000 toys are sold?

   v. How many units must be produced and sold in order to break even?

b. A compute manufacturing firm sells a particular brand of personal computer. The ordering cost per order is Rs. 450 and annual inventory carrying cost is Rs. 170. The store manager estimates the monthly demand for the PC will be 100 units. Assuming that the shortages are allowed and the shortage cost is Rs. 600 per unit per year.

i. Compute the optimal order quantity

ii. Compute maximum number of backorders

iii. What are the estimated annual inventory holding, ordering and backordering costs associated with this product?

3. **10 Marks**

a. Solve the following LPP **using Excel Solver as well as using graph**.

$$\begin{aligned} \text{Max} \quad & 2x_1 + 2x_2 \\ \text{s.t.} \quad & x_1 + 3x_2 \geq 12 \\ & 3x_1 + x_2 \geq 15 \\ & x_1 - x_2 = 3 \\ & x_1, x_2 \geq 0 \end{aligned}$$

b. An automobile repair shop has 3 different repair bays and 4 jobs to assign to them. Because of differences in equipment available, the people assigned to each bag and the nature of the job, each job requires a different amount of time in each bay. The estimated times for each job in each bay are shown in the table below:

		Job			
		1	**2**	**3**	**4**
Bay	**A**	24	33	24	30
	B	45	48	52	56
	C	25	23	20	21

The manager of the repair shop wants to minimize the total time required. Draw a network diagram and formulate this assignment problem as an LPP. **DO NOT SOLVE.**

4. The manager of a sewing department has developed the following LP model. Solve the model **using Excel Solver and give the complete optimal solution**. Also determine binding and non binding constraints. Generate the sensitivity report and **answer any 4 parts:**

x_1 = Units of product 1
x_2 = Units of product 2
x_3 = Units of product 3

$$\begin{aligned} \text{Max} \quad & 10x_1 + 6x_2 + 5x_3 \text{ (Profit)} \\ \text{s.t.} \quad & 2x_1 + 3x_2 + 4x_3 \leq 25 \quad \text{Hours} \quad \text{(Labor)} \\ & x_1 + 3x_2 + 2x_3 \leq 22 \quad \text{Hours} \quad \text{(Machine)} \\ & 6x_1 + 3x_2 + 4x_3 \leq 32 \quad \text{Pounds} \quad \text{(Material)} \\ & x_1, x_2, x_3 \geq 0 \end{aligned}$$

a) By how much would you increase the objective function coefficient of x_3 so that it takes non-zero value in the optimal solution?

b) Determine the range of optimality for objective function coefficients of x_1, x_2 and x_3.

c) If the objective function coefficient of x_2 is increased by 13, what will be the new optimal solution?

d) What is the range of feasibility of the material constraint? Interpret.

e) Interpret the dual prices of 1st and 2nd constraints.

f) If the objective function coefficient of x_1 is increased by 1 and objective function coefficient of x_2 is decreased by 1, will the optimal solution change? **10 Marks**

5. **10 Marks**

a. Harley's Sand and Gravel Pit has been contracted to provide topsoil for 3 residential housing developments. Topsoil can be supplied from 3 different farms and 2 intermediate nodes are used as transshipment points for temporary storage of topsoil.

Farm	Weekly Capacity (Cubic Yards)
A	100
B	200
C	200

Demand for the topsoil generated by the construction project is:

Project	Weekly Capacity (Cubic Yards)
P	50
Q	150
R	300

The manager of the Sand and Gravel Pit has estimated the cost per cubic yard (in $) to ship over each of the following routes:

To / From	Warehouse 1	Warehouse 2
Farm A	3	2
Farm B	4	3
Farm C	2.5	3.5

To / From	Project P	Project Q	Project R
Warehouse 1	2	1	4
Warehouse 2	3	2	5

Solve the transshipment problem to determine the optimal transshipment schedule that

minimizes the total cost.

b. A sales manager is considering the reallocation of 4 sales executives to 4 sales territories. The table shows the sales revenue (in lakhs rupees) that can be generated by each sales executive in each sales territory. The estimate of sales revenue is based on the previous performance of the sales executives.

		Sales Territories			
		ST1	**ST2**	**ST3**	**ST4**
Sales Executives	**Arnold**	40	20	15	18
	Binny	--	40	40	21
	Charles	24	27	24	35
	David	30	25	--	24

Find the optimal assignment to achieve the maximum total sales revenue.

6. First American Bank issues five types of loans. In addition, to diversify its portfolio, and to minimize risk, the bank invests in risk-free securities. The loans and the risk free securities with their annual rate of return are given in the table below:

Type of Loan Security	Annual Rate of Return (%)
Home Mortgage (First)	6
Home Mortgage (Second)	8
Commercial Loan	11
Automobile Loan	9
Home Improvement Loan	10
Risk-Free Securities	4

The bank's objective is to maximize the annual rate of return on investments subject to the following policies, restrictions and regulations:

1. The bank has $90 million in available funds.
2. Risk-free securities must contain at least 10% of total funds available for investment.
3. Home improvement loans cannot exceed $8 million.
4. The investment in mortgage loans must be at least 60% of all the funds invested in loans.
5. The investment in first mortgage loans must be at least twice as much as the investment in second mortgage loans.
6. Home improvement loans cannot exceed 40% of the funds invested in first mortgage loans.
7. Automobile loans and home improvement loan together may not exceed the commercial loans.
8. Commercial loans cannot exceed 50% of the total funds invested in mortgage loans.

Formulate and solve an LP model for this problem that will determine the optimal investment in different loans and risk free securities in order to maximize the annual rate of return on investments. **10 Marks**

7. **10 Marks**

a. A tourist car operator finds that during the past few months the car's use have varied so much that the cost of maintaining the car has varied considerably. During the past 200 days the demand for the car fluctuated with the following probability:

Demand Per Week	0	1	2	3	4	5
Probability	0.08	0.12	0.15	0.30	0.20	0.15

Use the following sequence of random numbers to simulate the demand for a 10 week period.

Random numbers: 08, 91, 36, 55, 17, 48, 32, 43, 69, 75.

Estimate the weekly average demand on the basis of simulated data.

b. A company gives a standardized test to all of its new recruits. At the end of the first year of employment, each of these people is given a performance rating. Test scores and performance ratings for a randomly selected sample of recruits yielded these values:

Person	**Test Score (X)**	**Performance Rating (Y)**
1	78	6.7
2	112	9.4
3	95	9.1
4	82	8.8
5	104	9.5
6	84	8.6
7	89	9.0
8	110	9.8
9	93	9.1
10	95	9.2
11	86	7.7
12	90	9.2
13	107	9.6

i. Develop a linear regression equation for this data.

ii. Interpret the regression equation.

iii. Forecast the performance rating an employee will receive, given the employee had a test score of 100.

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