

K. J. Somaiya Institute of Management Studies and Research

Program: PGDM-IB Trimester III 2017-19

**Subject: Operations Research
(End Term Examination)**

Maximum marks: 50
Duration: 3 hours

Date: 4th April, 2018

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 division and roll number only (no names). Finally, before handling over the answer sheet, transfer the file to an exam folder, as per on-the-spot instructions given to you.**

1. The Texago Corporation is a large, fully integrated petroleum company based in the United States. The company produces most of its oil in its own oil fields and then imports the rest of what it needs from the Middle East. An extensive distribution network is used to transport the oil to the company's refineries. The locations of these various facilities are given in the following table:

Type of Facility	Locations
Oil Fields	1. Several in Texas 2. Several in California 3. Several in Alaska
Refineries	1. Near New Orleans, Louisiana 2. Near Charleston, South Carolina 3. Near Seattle, Washington

Texago is continuing to increase its market share for several of its major products. Therefore, management has made the decision to expand its output by building an additional refinery and increasing its imports of crude oil from the Middle East. The crucial remaining decision is where to locate the new refinery.

The addition of the new refinery will have a great impact on the operation of the entire

distribution system, including decisions on how much crude oil to transport from each of its sources to each refinery (including the new one). Therefore, the two key factors for management's decision on the location of the new refinery are:

- a. The cost of transporting the oil from its sources to all the refineries, including the new one.
- b. Operating costs for the new refinery, including labor costs, taxes, the cost of needed supplies (other than crude oil), energy costs, the cost of insurance, and so on. (Capital costs are not a factor since they would be essentially the same at any of the potential sites.)

Management has set up a task force to study the issue of where to locate the new refinery. After considerable investigation, the task force has determined that there are three attractive potential sites. These sites and the main advantages of each are spelled out in the following table:

Potential Site	Main Advantages
Near Los Angeles, California	<ol style="list-style-type: none"> 1. Near California oil Fields 2. Ready Access from Alaska oil Fields 3. Fairly Near San Francisco distribution Center
Near Galveston, Texas	<ol style="list-style-type: none"> 1. Near Texas Oil Fields. 2. Ready Access from Middle East Imports 3. Near Corporate Headquarters
Near St. Louis, Missouri	<ol style="list-style-type: none"> 1. Low operating Costs 2. Centrally Located for Distribution Centers 3. Ready Access to Crude oil Via the Mississippi River

The task force needs to gather a large amount of data, some of which requires considerable digging, in order to perform the analysis requested by management. Management wants all the refineries, including the new one, to operate at full capacity. Therefore, the task force begins by determining how much crude oil each refinery would need to brought in annually under these conditions. Using units of 1 million barrels, these needed amounts are shown on the left side of the following table. The right side of the table shows the current annual output of crude oil from the various oil fields. These quantities are expected to remain stable for some years to come. Since the refineries need a total of 360 million barrels of crude oil, and the oil fields will produce a total of 240 million barrels, the difference of 120 million barrels will need to be imported from the Middle East.

Refinery	Crude Oil Needed Annually (Million Barrels)	Oil Fields	Crude Oil Produced Annually (Million Barrels)
New Orleans	100	Texas	80
Charleston	60	California	60
Seattle	80	Alaska	100
New Site (to be chosen)	120	Total	240

Total	360	Total Imports Needed = 360 – 240 = 120
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Since the amounts of crude oil produced or purchased will be the same regardless of which location is chosen for the new refinery, the task force concludes that the associated production or purchase costs (exclusive of shipping costs) are not relevant to the site selection decision. On the other hand, the costs for transporting the crude oil from its source to a refinery are very relevant. These costs are shown in the following table for both the three current refineries and the three potential sites for the new refinery:

Cost per Unit Shipped to refinery or Potential Refinery (Millions of Dollars per Million Barrels)						
	New Orleans	Charleston	Seattle	Los Angeles	Galveston	St. Louis
Texas	2	4	5	3	1	1
California	5	5	3	1	3	4
Alaska	5	7	3	4	5	7
Middle East	2	3	5	4	3	4

The final key body of data involves the *operating costs* for a refinery at each potential site. Estimating these costs requires site visits by several members of the task force to collect detailed information about local labor costs, taxes, and so forth. Comparisons then are made with the operating costs of the current refineries to help refine these data. In addition, the task force gathers information on one-time site costs for land, construction, and other expenses and amortizes these costs on an equivalent uniform annual cost basis. This process leads to the estimates shown in the following table:

Site	Annual Operating Cost (Millions of Dollars)
Los Angeles	620
Galveston	570
St. Louis	560

Armed with these data, the task force now needs to develop the following key financial information for management:

- a. Total shipping cost for crude oil with each potential choice of a site for the new refinery.
- b. Recommended site for the new refinery based on the total cost.
- c. The need for Texago task force to solve three transportation problems instead of just one.

2.

10

Marks

- a. Fundamental Electronics is a new specialty store that sells television sets, video tape recorders, video games and other television related products. A new Japanese-manufactured video tape recorder costs Fundamental Electronics \$600 per unit. Fundamental Electronics annual holding cost rate is 22%. Ordering costs are estimated to be \$70 per order.
- If the demand of the new tape recorder is expected to be constant with a rate of 20 units per month, what is the recommended order for the video tape recorder?
 - What are the estimated annual inventory holding and ordering costs associated with this product?
 - How many orders will be placed per year?
 - With 250 working days per year, what is the cycle time for this product?
- b. A company that produces cleaning products is considering a proposal to begin production of a new detergent that would cost Rs. 1 a bottle to make and distribute, and retail for Rs. 2.19 a bottle. Fixed cost for the operation would be Rs. 3,000 a week.
- Write the expression for total cost.
 - Write the expression for total revenue.
 - Write an expression for total profit.
 - What profit or loss would result if from weekly volume of 10,000 bottles?
 - What is the break-even volume in bottles?

3.

10

Marks

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

$$\begin{array}{ll} \text{Max} & 2x_1 + 1x_2 \\ \text{s.t.} & x_1 + x_2 \geq 10 \\ & 2x_1 - x_2 \geq 40 \\ & x_1, x_2 \geq 0 \end{array}$$

- b. The manager of Harley's Sand and Gravel Pit has prepared the following information on a transshipment problem. Locations labeled as A, B and C are supply points; locations 1 and 2 are intermediate transshipment nodes; and locations D, E and F are

destinations.

Units Shipping Costs from Source to Transshipment Points

From	To	D	E	F
1		2	1	4
2		3	2	5

Units Shipping Costs from Transshipment Points to Destinations

From	To	1	2
A		3	2
B		4	3
C		2.5	3.5

The source supplies and destination demands are shown in the following tables.

Source	Supply
A	100
B	200
C	200

Destination	Demand
D	50
E	150
F	300

Draw a network diagram and formulate this transshipment problem as an LPP. **DO NOT SOLVE.**

4. The manager of a knitting 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:**

$$x_1 = \text{Units of product 1}$$

$$x_2 = \text{Units of product 2}$$

$$x_3 = \text{Units of product 3}$$

$$\text{Max } 7x_1 + 3x_2 + 9x_3 \text{ (Profit)}$$

$$\begin{aligned}
 \text{s.t.} \quad & 4x_1 + 5x_2 + 6x_3 \leq 360 \text{ Hours} && \text{(Labor)} \\
 & 2x_1 + 4x_2 + 6x_3 \leq 300 \text{ Hours} && \text{(Machine)} \\
 & 9x_1 + 5x_2 + 6x_3 \leq 600 \text{ Pounds} && \text{(Material)} \\
 & x_1, x_2, x_3 \geq 0
 \end{aligned}$$

- By how much would you increase the objective function value of x_2 so that it takes non-zero value in the optimal solution?
- Determine the range of optimality for objective function coefficients of x_1 , x_2 and x_3 .
- If the objective function coefficient of x_1 is increased by 3, what will be the new optimal solution?
- What is the range of feasibility of the labor constraint? Interpret.
- If the manager could obtain additional machine hours, how much more could be used effectively?
- What would be the value of the optimal solution if the amount of labor available decreased by 10 hours?
- Interpret the dual prices of 2nd and 3rd constraints.
- If the RHS of 1st constraint is decreased to 300 and RHS of 3rd constraint is increased to 700, will the optimal solution change? **10**

Marks

5.

10 Marks

- The approximate travel times (in hours) for officiating crews for college basketball for four games scheduled over the weekend are shown in the following table:

		Game Site			
		Syracuse	Buffalo	Rochester	Ithaca
Crew	A	1.2	1.4	0.2	1.5
	B	1.0	2.0	0.5	1.0
	C	1.2	3.4	2.4	0.5
	D	2.1	3.1	1.1	--
	E	1.8	0.5	0.6	2.0

Assuming that D-Ithaca assignment is undesirable, determine the optimal set of assignments that will minimize total travel time. What is the total time for the optimal assignment? Which crew remains unassigned?

- A large manufacturing company based in Dayton, Ohio, is trying to optimize its shipping schedule. Currently the monthly manufacturing capacity (supply) at three of its plants are as follows:

Plant	Supply (Units)
Cleveland	1600
Toledo	1000
Cincinnati	2600

The company owns three warehouses - in Columbus, Ohio; Detroit, Michigan; and Ft. Wayne, Indiana. Demand at these destinations is as follows:

Warehouse	Demand (Units)
Columbus	1500
Detroit	1200
Ft. Wayne	1800

The unit shipping cost (in \$) from each plant to each warehouse is given in the following table:

	To	Columbus	Detroit	Ft. Wayne
From				
Cleveland		2.5	3.5	4
Toledo		4.5	1.5	2
Cincinnati		2	3.2	3

Solve the transportation problem to determine the optimal transportation schedule that minimizes the total cost.

6. The Long Last Appliance Sales Company is in the business of selling appliances such as microwave ovens, traditional ovens, refrigerators, dishwashers, washers, dryers, and the like. The company has a monthly advertising budget of Rs. 90,000. Among its options are radio advertising, advertising in the cable TV channels, newspaper advertising, and direct-mail advertising. A 30-second advertising spot on the local cable channel costs Rs. 1,800, a 30-second radio ad costs Rs. 350, a half-page ad in the local newspaper costs Rs. 700, and a single mailing of direct-mail insertion for the entire region costs Rs. 1,200 per mailing.

The number of potential buying customers reached per advertising medium usage is as follows:

Radio	TV	Newspaper	Direct Mail
7,000	50,000	18,000	34,000

Due to company restrictions and availability of media, the maximum number of usages of each medium is limited to the following:

Radio	TV	Newspaper	Direct Mail
35	25	30	18

The management of the company has met and decided that in order to ensure a balanced utilization of different types of media and to portray a positive image of the company, at least 10 percent of the advertisements must be on TV. No more than 40 percent of the advertisements must be on radio. The cost of advertising allocated to TV and direct mail cannot exceed 60 percent of the total advertising budget.

Formulate and solve an LP model for this problem that will determine the optimal number of ads in order to maximize the potential customers reached. **10 Marks**

7. **10 Marks**

- a. To generate leads for new business, Gustin Investment Services offers free financial planning seminars at major hotels in Southwest Florida. Attendance is limited to 25 individuals per seminar. Each seminar costs Gustin \$3500, and the average first-year commission for each new account opened is \$5000. Historical data collected over the past four years show that the number of new accounts opened at a seminar varies from no accounts opened to a maximum of six accounts opened according to the following probability distribution:

Number of New Accounts Opened	0	1	2	3	4	5	6
Probability	0.1	0.04	0.1	0.25	0.4	0.06	0.05

Use the following sequence of random numbers to simulate the number of new accounts opened for 10 seminars.

Random numbers: 03, 91, 38, 55, 17, 46, 32, 43, 69, 72.

Estimate the daily average number of new accounts opened on the basis of simulated data.

Would you recommend that Gustin continue running the seminars?

- b. The following data show the average monthly cellular telephone bill:

Year	1998	1999	2000	2001	2002	2003
Amount (\$)	39.43	41.24	45.27	47.37	48.40	49.91

- i. Graph the time series. Does a linear trend appear?

- ii. Develop the equation for the linear trend component for this time series.
- iii. Use the trend equation to estimate the average monthly bill for 2004.
- iv. What is the average increase in bill amount per year?

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