K. J. SOMAIYA INSTITUTE OF MANAGEMENT STUDIES AND RESEARCH,
Vidyavihar, Mumbai- 400077

Program: PGDM-RM *(Batch 2018-20), Term-III*
Subject: OPERATION RESEARCH

(End Term Examination)

Maximum Marks: 50
Duration: 3 hours

Date: 5th April 2019

Instructions

1. **The question paper consists of 3 sections – Section A (15 Marks), B (20 Marks) and C (15 Marks).**
2. **Section A is compulsory and carries 15 marks. Attempt any 2 questions from section B (each question carries 10 marks) and any 1 question from section C (15 marks).**
3. **Section A & B must be answered on one answer sheet and C on a separate answer sheet.**
4. **Make suitable assumptions if required and state them.**
5. **Write all relevant answers in your answer sheet, with sufficient detail to enable a fast evaluation of your answers.**
6. **Use Excel as required and keep saving the file on the desktop every ten minutes or so.**
7. **Make 1 Excel file for each question with different worksheets pertaining to each sub question (hence, there should be 4 excel files in all).**
8. **Save the 4 excel files in a folder with the name : *<RM_OR_RollNo>* (no names). Finally, before handing over the answer sheet, transfer the folder to an exam folder, as per on-the-spot instructions given to you.**
9. **The question paper consists of 10 pages. Please read carefully.**

SECTION A

QUESTION 1 Case Study: Spring Garden Tools

The Spring family has owned and operated a garden tool and implements manufacturing company since 1952. The company sells garden tools to distributors and also directly to hardware stores and home improvement discount chains. The Spring Company's four most popular small garden tools are a trowel, a hoe, a rake, and a shovel. Each of these tools is made from durable steel and has a wooden handle. The Spring family prides itself on its high-quality tools. The manufacturing process encompasses two stages. The first stage includes two operations—stamping out the metal tool heads and drilling screw holes in them. The completed tool heads then flow to the second stage, which includes an assembly operation where the handles are attached to the tool heads, a finishing step, and packaging. The processing times per tool for each operation is provided in the following table:

Table 1: Processing Time Data for tools of The Spring Company

Operation	**Tool (hr./unit)**				**Total Hours Available per Month**
	Trowel	*Hoe*	*Rake*	*Shovel*	
Stamping	0.04	0.17	0.06	0.12	500
Drilling	0.05	0.14	—	0.14	400
Assembly	0.06	0.13	0.05	0.10	600
Finishing	0.05	0.21	0.02	0.10	550
Packaging	0.03	0.15	0.04	0.15	500

The steel the company uses is ordered from an iron and steel works in Japan. The company has 10,000 square feet of sheet steel available each month. The metal required for each tool and the monthly contracted production volume per tool are provided in the following table:

Table 2: Steel Sheet Details

	Sheet Metal (ft.2)	**Monthly Contracted Sales**
Trowel	1.2	1800
Hoe	1.6	1400
Rake	2.1	1600
Shovel	2.4	1800

The primary reasons the company has survived and prospered are its ability always to meet customer demand on time and its high quality. As a result, the Spring Company will produce on an overtime basis in order to meet its sales requirements, and it also has a long-standing arrangement with a local tool and die company to manufacture its tool heads. The Spring Company feels comfortable subcontracting the first stage

operations because it is easier to detect defects prior to assembly and finishing. For the same reason, the company will not subcontract for the entire tool because defects would be particularly hard to detect after the tool was finished and packaged. However, the company does have 100 hours of overtime available each month for each operation in both stages. The regular production and overtime costs per tool for both stages are provided in the following table:

Table 3: Production and Overtime costs

	Stage 1		Stage 2	
	Regular Cost	**Overtime Cost**	**Regular Cost**	**Overtime Cost**
Trowel	$6.00	$6.20	$3.00	$3.10
Hoe	10.00	10.70	5.00	5.40
Rake	8.00	8.50	4.00	4.30
Shovel	10.00	10.70	5.00	5.40

The cost of subcontracting in stage 1 adds 20% to the regular production cost. The Spring Company wants to establish a production schedule for regular and overtime production in each stage and for the number of tool heads subcontracted, at the minimum cost.

a. Formulate this problem as an LPP by identifying all the decision variables.
b. Solve this problem to establish an optimal production schedule as per the requirements of The Spring Company at the minimum cost.
c. Identify all the controllable and uncontrollable inputs.
d. Which resources appear to be most critical in the production process?

-------- END OF SECTION A --------

SECTION B

a) Each main question carries 10 marks
b) Attempt any TWO questions from this section

QUESTION 2

a. A marketing manager wants to assign salesman to four cities. He has four salesman of varying experience. The possible profit for each salesman in each city is given in the following table. Solve to find an assignment which maximizes the profit.

		Cities			
		1	2	3	4
Salesman	1	25	27	28	38
	2	28	34	29	40
	3	35	24	32	33
	4	24	32	25	28

b. Orient Express is a global distribution company that transports its clients' products to customers in Hong Kong, Singapore, and Taipei. All the products Orient Express ships are stored at three distribution centers—one in Los Angeles, one in Savannah, and one in Galveston. For the coming month the company has 450 containers of computer components available at the Los Angeles center, 600 containers available at Savannah, and 350 containers available at Galveston. The company has orders for 600 containers from Hong Kong, 500 containers from Singapore, and 500 containers from Taipei. The shipping costs per container from each U.S. port to each of the overseas ports are shown in the following table:

	Overseas Port (cost/container)		
Center	Hong Kong	Singapore	Taipei
Los Angeles	$300	$210	$340
Savannah	490	520	610
Galveston	360	320	500

Orient Express, as the overseas broker for its U.S. customers, is responsible for unfulfilled orders, and it incurs stiff penalty costs from overseas customers if it does not meet an order. The Hong Kong customers charge a penalty cost of $800 per container for unfulfilled demand, Singapore customers charge a penalty cost of $920 per container, and Taipei customers charge $1,100 per container. Solve this transportation model to determine the shipments from each U.S. distribution center to each overseas port that will minimize shipping costs.

QUESTION 3

a. Solve the following linear programming model graphically:

Maximize $Z = 1.5x_1 + x_2$

Subject to,

$x_1 \leq 4$

$x_2 \leq 6$

$x_1 + x_2 \leq 5$

$x_1, x_2 \geq 0$

What is the optimum solution to the above model? Also identify redundant constraints (if any).

b. Canning Transport is to move goods from three factories to three distribution centers. Information about the move is given below. Give the network flow model and formulate the linear programming model for this problem. **DO NOT SOLVE**

Source	*Supply*	*Destination*	*Demand*
A	200	X	50
B	100	Y	125
C	150	Z	125

Shipping costs are:

	Destination		
Source	X	Y	Z
A	3	2	5
B	9	10	--
C	5	6	4
	(Source B cannot ship to destination Z)		

QUESTION 4

a. To establish a driver education school, organizers must decide how many cars, instructors, and students to have. Costs are estimated as follows. Annual fixed costs to operate the school are $30,000. The annual cost per car is $3000. The cost per instructor is $11,000 and one instructor is needed for each car. Tuition for each student is $350. Let x be the number of cars and y be the number of students.

i. Write an expression for total cost
ii. Write an expression for total revenue
iii. Write an expression for total profit

iv. The school offers the course eight times each year. Each time the course is offered, there are two sessions. If they decide to operate five cars, and if four students can be assigned to each car, will they break even?

b. Ronald Thump is interested in expanding his firm. After careful consideration, he has determined three areas in which he might invest additional funds: (1) product research and development, (2) manufacturing operations improvements, and (3) advertising and sales promotion. He has $500,000 available for investment in the firm. He can invest in its advertising and sales promotion program every year, and each dollar invested in this manner is expected to yield a return of the amount invested plus 20% yearly. He can invest in manufacturing operations improvements every 2 years, with an expected return of the investment plus 30% (at the end of each 2-year period). An investment in product research and development would be for a 3-year period, with an expected return of the investment plus 50% (at the end of the 3-year period). To diversify the total initial investment, he wishes to include the requirement that at least $30,000 must be invested in the advertising and sales promotion program, at least $40,000 in manufacturing operations improvements, and at least $50,000 in product research and development initially (at the beginning of the first year). Formulate the above problem as a linear program that will tell Ronald how much to invest in each of the three alternatives, during each year of a 4-year period, to maximize the total ending cash value of the initial $500,000 investment. **DO NOT SOLVE**

QUESTION 5

a. The LP problem whose output follows determines how many necklaces, bracelets, rings, and earrings a jewelry store should stock. The objective function measures profit; it is assumed that every piece stocked will be sold. Constraint 1 measures display space in units, constraint 2 measures time to set up the display in minutes. Constraints 3 and 4 are marketing restrictions.

LINEAR PROGRAMMING PROBLEM

MAX 100X1+120X2+150X3+125X4

S.T.

1) X1+2X2+2X3+2X4<108
2) 3X1+5X2+X4<120
3) X1+X3<25
4) X2+X3+X4>50

OPTIMAL SOLUTION
Objective Function Value = 7475.000

Variable	Value	Reduced Cost
X1	8.000	0.000
X2	0.000	5.000
X3	17.000	0.000
X4	33.000	0.000

Constraint	Slack/Surplus	Dual Price
1	0.000	75.000
2	63.000	0.000
3	0.000	25.000
4	0.000	25.000

OBJECTIVE COEFFICIENT RANGES

Variable	Lower Limit	Current Value	Upper Limit
X1	87.500	100.000	No Upper Limit
X2	No Lower Limit	120.000	125.000
X3	125.000	150.000	162.500
X4	120.000	125.000	150.000

RIGHT HAND SIDE RANGES

Constraint	Lower Limit	Current Value	Upper Limit
1	100.000	108.000	123.750
2	57.000	120.000	No Upper Limit
3	8.000	25.000	58.000
4	41.500	50.000	54.000

Answer the following questions based on the output given. **NO NEED TO SOLVE AGAIN.**

i. How much space will be left unused?
ii. Interpret the range of optimality and reduced cost for bracelets.

iii. By how much can the amount of space decrease before there is a change in the profit?

iv. By how much will the second marketing restriction be exceeded?

v. While the available space has been increased by 5 units, the time to set up the space has reduced by 20 minutes with the help of extra labour. Will the dual prices still be applicable?

b. World Foods, Inc., imports food products such as meats, cheese, and pastries to the United States from warehouses at ports in Hamburg, Marseilles, and Liverpool. Ships from these ports deliver the products to Norfolk, New York, and Savannah, where they are stored in company warehouses before being shipped to distribution centers in Dallas, St. Louis, and Chicago. The products are then distributed to specialty food stores and sold through catalogs. The shipping costs ($/1,000 lb.) from the European ports to the U.S. cities and the available supplies (1,000 lb.) at the European ports are provided in the following table:

	U.S. City			
European Port	4. Norfolk	5. New York	6. Savannah	**Supply**
1. Hamburg	$420	$390	$610	55
2. Marseilles	510	590	470	78
3. Liverpool	450	360	480	37

The transportation costs ($/1,000 lb.) from each U.S. city of the three distribution centers and the demands (1,000 lb.) at the distribution centers are as follows:

	Distribution Center		
Warehouse	7. Dallas	8. St. Louis	9. Chicago
4. Norfolk	$ 75	$ 63	$ 81
5. New York	125	110	95
6. Savannah	68	82	95
Demand	60	45	50

Determine the optimal shipments between the European ports and the warehouses and the distribution centers to minimize total transportation costs.

-------- END OF SECTION B --------

SECTION C

a) Each main question carries 15 marks
b) Attempt any ONE question from this section

QUESTION 6

a. Electronic Village stocks and sells a particular brand of personal computer. It costs the store $450 each time it places an order with the manufacturer for the personal computers. The annual cost of carrying the PCs in inventory is $170. The store manager estimates the annual demand for the PCs will be 1,200 units.

   i. Determine the optimal order quantity and the total minimum cost.
   ii. What should be the reorder level if Electronic Village operates only 300 days a year and have a lead time of 2 weeks?
   iii. Assume that shortages are allowed and that the shortage cost is $600 per unit per year. Compute the optimal order quantity and the total minimum cost.

b. Grear Tire Company has produced a new tire with an estimated mean lifetime mileage of 36,500 miles. Management also believes that the standard deviation is 5000 miles and that tire mileage is normally distributed. Use a worksheet to simulate the miles obtained for a sample of 500 tires.

   i. Use the Excel COUNTIF function to determine the number of tires that last longer than 40,000 miles. What is your estimate of the percentage of tires that will exceed 40,000 miles?
   ii. Use COUNTIF to find the number of tires that obtain mileage less than 32,000 miles. Then, find the number with less than 30,000 miles and the number with less than 28,000 miles.
   iii. If management would like to advertise a tire mileage guarantee such that approximately no more than 10% of the tires would obtain mileage low enough to qualify for the guarantee, what tire mileage considered in part (ii) would you recommend for the guarantee

c. Moving averages often are used to identify movements in stock prices. Daily closing prices (in dollar per share) for IBM for August 24, 2005, through September 16, 2005, is given below.

Day	Aug.24	Aug.25	Aug.26	Aug.29	Aug.30	Aug.31	Sep.1	Sep.2	Sep.6
Price($)	81.32	81.1	80.38	81.34	80.54	80.62	79.54	79.46	81.02
Day	Sep.7	Sep.8	Sep.9	Sep.12	Sep.13	Sep.14	Sep.15	Sep. 16	
Price($)	80.98	80.80	81.44	81.48	80.75	80.48	80.01	80.33	

i. Use a three month moving average to smooth the time series. Forecast the closing price for the next trading day.
ii. Use exponential smoothing with a smoothing constant of $\alpha = 0.6$ to smooth the time series. Forecast the closing price for the next trading day.
iii. Which of the two methods do you prefer? Why?

QUESTION 7

a. Hudson Marine has been an authorized dealer for C&D marine radios for the seven years. The following are the quarterly sales data for the number of radios sold in the seven years

Year	1	2	3	4	5	6	7
Qtr 1	6	10	14	9	22	24	28
Qtr 2	15	18	26	28	34	36	40
Qtr 3	10	15	23	25	28	30	35
Qtr 4	4	7	12	18	21	20	27

i. Show the four quarter moving averages values for this time series.
ii. Compute the seasonal indexes for the four quarters.
iii. Identify the bust and boom seasons.
iv. Develop the equation for the trend component in the deseasonalised time series.

b. The Tiernan Gallery and Art Museum distributes to its visitors a printed guide to its collections. There are about 18000 visitors per year. Holding costs for the brochures are 20% and it costs $30 to place an order with the printer. The printer has offered the following discount schedule:

Category	Order Size	Unit Cost
1	0 - 1499	$2.50
2	1500 - 2999	$2.20
3	3000 and over	$1.80

How many brochures should be printed at a time?

----------End of Paper----------