Strathmore University Business School

Bachelor of Supply Chain Management

End of Semester Examinations

SCM 4105: Operations Research

Date: 9th December, 2024 Time: 2 Hours

Instructions: Answer Question ONE and ANY other TWO questions.

Question One [30 marks]

(a) Briefly explain any **two** roles of operations research in supply chain management. **[4 marks]**

(b) Express the given Linear Programming Problem below in standard form. **[4 marks]**

$$\begin{aligned} Minimize \quad & X_0 = 30X_1 + 60X_2 + 20X_3 \\ Subject\ to: \quad & 5X_1 + 10X_2 + 15X_3 \geq 2000 \\ & 2X_1 + 3X_2 + X_3 \geq 300 \\ & 8X_1 + 6X_2 + 4X_3 \leq 650 \\ & X_1 \geq 0, X_2 \geq 0, X_3 \geq 0 \end{aligned}$$

(c) Formulate Linear Programming Problems for the following scenarios:

(i) A company has been given a tender to supply maize to four drought zones. The cost of transporting each unit from the grains depot to the drought zone is given below. **[4 marks]**

	1	2	3	4	Supply
1	21	16	25	13	11
2	17	18	14	23	13
3	32	27	18	41	19
Demand	6	10	12	15	43

(ii) *Litex* company produces both interior and exterior paints from two raw materials, X and Y. Tons of raw material per ton of exterior paint and interior paint are given. The following table provides the basic data of the problem:

Raw Materials	Exterior paint (tons)	Interior paint (tons)	Maximum daily availability (tons)
X	6	4	24
Y	1	2	6
Profit per ton (in $ 1000)	5	4	

A market survey indicates that the daily demand for interior paint cannot exceed that of exterior paint by more than 1 ton. Also, the maximum daily demand for interior paint is 2 tons. **[4 marks]**

(iii) Four captain pilots ($CP1$, $CP2$, $CP3$ and $CP4$) have evaluated four flight officers ($FO1$, $FO2$, $FO3$ and $FO4$) according to perfection, adaptation, morale and motivation in a 1 - 20 scale (1: Very Good, 20: Very Bad). Evaluation grades are given in the table below. Flight company wants to assign each flight officer to a captain pilot according to these evaluations. **[4 marks]**

		Flight Officers			
		$FO1$	$FO2$	$FO3$	$FO4$
Captains	$CP1$	92	90	94	91
	$CP2$	84	88	96	82
	$CP3$	90	90	93	86
	$CP4$	78	94	89	84

(d) Develop the dual of the given Linear Optimization Model below. **[4 marks]**

$$\begin{aligned} Minimize \quad & W = 10y_1 + 80y_2 \\ Subject\ to: \quad & y_1 + 2y_2 \geq 2 \\ & y_1 + y_2 \geq 5 \\ & y_1 \geq 0, y_2 \geq 0 \end{aligned}$$

(e) Precedence table for a supply chain project is given as follows:

$Activity$	$Pre-requisite$	$Duration$
A	-	4
B	-	7
C	-	5
D	A	6
E	B	3
F	C	11
G	D,E	4
H	G, F	3

Determine the earliest start time (EST), latest start time (LST), earliest finishing time (EFT) and latest finishing time (LFT). **[6 marks]**

Question Two [20 marks]

(a) Define the following terms as used in in network analysis:

(i) Free float. **[2 marks]**

(ii) Critical activity. **[2 marks]**

(iii) Most likely time. **[2 marks]**

(iv) Latest start time. **[2 marks]**

(b) The chartered institute of quantitative decision makers runs an annual programme of meetings for its members. The staff of the institute's Head Office begin to prepare the programme for the year after the previous financial year. The programme includes details of the speakers and their talks as well as list of current members. The activities necessary in the preparation of its programme, together with the immediate preceding activities are given below:

Activity	*Preceding Activity*	*Optimistic time*	*Most likely time*	*Pessimistic time*
A	-	2	3	4
B	A	1	2	3
C	A	4	5	12
D	A	3	4	11
E	B	1	3	5
F	C	1	2	3
G	D	1	8	9
H	E,F	2	4	6
I	H	2	4	12
J	G	3	4	5
K	I,J	2	8	8

Draw the network diagram and find the critical path. **[12 marks]**

Question Three [20 marks]

(a) Briefly explain any **three** components of a linear optimization model. **[6 marks]**

(b) The following linear optimization model was generated from a certain supply chain management environment.

$$\begin{aligned} Maximize \quad & Z = 4X_1 + X_2 \\ Subject\ to: \quad & 3X_1 + X_2 = 3 \\ & 4X_1 + 3X_2 \geq 6 \\ & X_1 + 2X_2 \leq 4 \\ & X_1 \geq 0, X_2 \geq 0 \end{aligned}$$

(i) Express the model in standard form as required by simplex algorithm. **[4 marks]**

(ii) Solve the linear problem using the $Big - M$ method. **[10 marks]**

Question Four [20 marks]

(a) A company has been given a tender to supply maize to four drought zones. The distance between each grains depot and each drought zone is given below.

	Distance in Miles			
Grain Depot	(i)	(ii)	(iii)	(iv)
A	168	172	175	183
B	156	160	158	163
C	138	140	135	145
D	147	142	140	145

Use the *Hungarian algorithm* to determine how the maize should be distributed to the zones in order to minimize the total distance travelled, hence calculate the distance to be covered. **[10 marks]**

(b) There are four areas that urgently need emergency food aid due to the effects of climate change. Government has food storage in the following towns. The amount available, the amount needed per station together with the associated transportation costs are given in the table below.

	Transport costs per bag in $Kshs.$ to emergency area				
From Go-down	Turkana	Kitui	Kwale	Marsabit	Total Available
Eldoret	18	11	15	20	200
Nakuru	17	14	12	13	600
Kitale	18	18	15	12	700
Total required	300	300	400	500	

Using the $North - West$ corner method:

(i) Determine the initial solution. **[4 marks]**

(ii) Find the optimal way of distributing the food. **[4 marks]**

(iii) Obtain the total cost of transportation. **[2 marks]**

Question Five [20 marks]

The ABC manufacturing company can make two products, X_1 and X_2. Each of the products requires time on a cutting machine and a finishing machine as shown below.

	Products	
	X_1	X_2
Cutting Hours (per unit)	2	1
Finishing Hours (per unit)	3	3
Profit (per unit)	6	4
Maximum Sales (units per week)	-	200

The number of cutting hours available per week is 390 and the number of finishing hours available per week is 810.

(a) Express the problem as a linear programming problem. **[4 marks]**

(b) Write the linear programming problem in standard form as required by the *simplex method*. **[4 marks]**

(b) Use *simplex method* to determine how much should be produced of each product in order to achieve maximum profit for the company. **[9 marks]**

(d) Fully interpret the final *simplex tableau*. **[3 marks]**