THE OPEN UNIVERSITY OF SRI LANKA
BACHELOR OF MANAGEMENT STUDIES HONOURS DEGREE PROGRAMME
LEVEL 06
FINAL EXAMINATION – 2020
OPERATIONS RESEARCH – MCU4202/ MSU6502
DURATION: THREE (03) HOURS

DATE: 11ᵗʰ January 2020	TIME: 1.30 pm – 4.30 pm

Answer 5 questions only.
Use of a non-programmable calculator is allowed.

Question 1

A sandwich stall is to make sandwiches for a function. It will serve three types of sandwiches as A, B and C. Sandwich A has 1 serving of vegetables, 4 slices of onion, 1 slice of cheese, and 2 slices of bread. Sandwich B has 2 servings of vegetables, 2 slices of onion, 1 slice of cheese and 2 slices of bread. Sandwich C has 3 servings of vegetables, 2 slices of cheese, and 2 slices of bread. A total of 10 bags of onions are available, each of which has 40 slices; 18 loaves of bread are available, each with 14 slices; 200 servings of vegetables are available, and 15 bags of cheese, each with 60 slices, are available. Given the resources, the goal is to maximize the number of sandwiches. The price of each sandwich is Rs 100/-.

a) Formulate a linear programming model for the above problem. (Use X1, X2 and X3 for sandwich types A, B and C respectively). (5 marks)

b) Prepare the first simplex table. (2 marks)

c) If the pivot column is selected as X2, find the pivot element. (2 marks)

d) The final simplex table for the above problem is given below.

Note: s1, s2, s3 and s4 relates to onion, bread, vegetables and cheese respectively.

Basic Variables	Quantity	100	0	100	0	0	0	0
		X_1	X_2	X_3	S_1	S_2	S_3	S_4
X1	100	1	1/2	0	1/4	0	-1	0
X3	26	0	1/2	1	-1/4	1/2	0	0

s2	22	0	0	0	1/2	3/2	1	0
s1	48	0	-1/2	0	1/4	1	0	1
Zj	12,600	100	0	100	1/2	0	10	10
Cj -Zj		0	0	0	-1/2	0	-10	-10

As per the above values;

(i) What is the optimal solution? (2 marks)

(ii) Interpret the shadow price of vegetables and cheese. (2 marks)

(iii) Develop the dual for the problem. (4 marks)

(iv) Find the optimal values for the dual variables. (1 mark)

(v) Find the range within which the price of sandwich A can be changed without affecting the optimal solution. (2 marks)

(Total 20 Marks)

Question 2

The following table gives data on time and cost of a project.

Activity	Preceding activity	Normal Time (days)	Crash time (days)	Normal Cost (Rs.)	Crash cost (Rs.)
A	-	2	1	10000	15000
B	-	8	5	15000	21000
C	A	4	3	20000	24000
D	B	1	1	7000	7000
E	B	2	1	8000	15000
F	C,D	5	3	10000	16000
G	E	6	2	12000	36000

a) Construct the network diagram for this project. (8 marks)

b) Find the critical path of the project. (2 marks)

c) Find the total project cost and duration. (2 marks)

d) To shorten the project by 4 days at the lowest possible cost, which task(s) should be shortened? (7 marks)

e) What would be the incremental cost after shortening of the project? (1 mark)

(Total: 20 marks)

Question 3

A company has three suppliers A, B and C which supply a particular raw material to the factories F1, F2, F3 and F4. Monthly availability of suppliers and factory requirements together with unit transportation costs are given in the below table.

Factory / Supplier	F1	F2	F3	F4	Capacity
A	3	1	7	4	250
B	2	6	5	9	350
C	8	3	3	2	400
Requirements	200	300	350	150	1000

a) Find the initial feasible solution using the North West corner method and compute the transportation cost of the initial feasible solution. (5 marks)

b) The management of the company wishes to minimize the total cost of transportation. Find the optimum solution using MODI method and compute the new cost. (15 marks)

(Total: 20 Marks)

Question 4

a) A marketing manager has four salesmen and sales districts. Considering the capabilities of the salesmen and the nature of districts, the marketing manager estimates that sales per month (in million rupees) for each salesman in each district would be as follows. Find the assignment of salesmen to districts that will result in maximum sales.

Salesman	Districts			
	1	2	3	4
A	90	75	75	80
B	35	85	55	65
C	125	95	90	105
D	45	110	95	115

(10 marks)

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b) Consider the following scores of a cricketer in 20 ODI matches.

72	65	87	100	64	70	16	47	0	72	67	57	60	5	49	85	44	45	83	11

i) Randomly identify 10 values out of them in order to carry out a simulation. (Use the random number table below).

```
73735  45963   78134  63873
02965  58303   90708  20025
98859  23851   27965  62394
33666  62570   64775  78428
81666  26440   20422  05720

15838  47174   76866  14330
89793  34378   08730  56522
78155  22466   81978  57323
16381  66207   11698  99314
75002  80827   53867  37797

99982  27601   62686  44711
84543  87442   50033  14021
77757  54043   46176  42391
80871  32792   87989  72248
30500  28220   12444  71840
```

ii) Briefly explain how you selected the values.

(10 marks)

(Total: 20 Marks)

Question 5

A person repairing radios finds that the time spent on the radio sets follows Exponential distribution with mean 20 minutes. If the radios are repaired in the order in which they come in and their arrival is approximately follows Poisson distribution with an average rate of 15 per 8-hour day.

a) Calculate arrival rate and service rate **per minute.**   (3 marks)

b) What is the probability that the queuing system is empty?   (1 mark)

c) How many hours do the repairman idles per day?   (2 marks)

d) What is the average length in the queue?   (2 marks)

e) On average how many customers are there at the radio store in a day?   (2 marks)

f) What is the average customer waiting time in the radio store?   (2 marks)

g) What is the probability that there are 4 customers at the queue?   (2 marks)

h) What is the probability that there are more than 6 customers in the queue?   (2 marks)

i) What is the waiting time of a customer in the queue?   (2 marks)

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j)   If the arrival rate of customers has doubled per minute, how many repairmen are required to provide an equilibrium level of service?   (2 marks)

(Total: 20 marks)

Question 6

A stockist purchases an item at the rate of Rs 10/- per piece from a manufacturer. The annual requirement is 2000 units of the item, while the cost per order is Rs 15/- and the holding cost is Rs 8/- per annum. There is a requirement of 5 square feet to store the item.

a) Calculate the economic order quantity (EOQ) of a product.   (2 marks)

b) Calculate the cost of maintaining the inventory.   (2 marks)

c) Calculate the reorder level of the products if lead time is 25 days.   (5 marks)

d) If the stock out cost is Rs. 6/- per unit per month, calculate the EOQ level.   (2 marks)

e) If maximum storage capacity is 400 square feet, calculate the EOQ level.   (2 marks)

f) If a discount of 1% is offered for orders greater than 50 units but less than 100 units and 2% discount is offered for orders equal or greater than 100 units, calculate the inventory costs for the following scenarios:

    i.   Order size <=50

    ii.   50 < Order size < 100

    iii.   100 <= Order size   (5 marks)

g) Calculate the EOQ if the total budget available to purchase the material is Rs. 800/-.

      (2 marks)

(Total: 20 marks)

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Formulae

λ Rate of arrival of units

μ Rate of service completion

θ	$=$	λ/μ
H	$=$	Number of working hours per day
$P_{(n)}$	$=$	Probability of "n" units in the queuing system
L_s	$=$	Average number of units in queuing system
L_q	$=$	Average number of units in queue
W_s	$=$	Average time spent by unit in queuing system
W_q	$=$	Average time spent by unit in queue
P(n)	$=$	θP**(n-1)** ——————— **(1)**
P(n)	$=$	θ^n **P(0)** ——————— **(2)**
P(n)	$=$	θ^n **(1-θ)** ——————— **(3)**

$[Probability\ that\ queuing\ system\ empty\ ] = (1-\theta)$ ——————— (4)

$[Probability\ that\ the\ server\ is\ idle\ ] = (1-\theta)$ ——————— (5)

$[Number\ of\ hours\ server\ idle\ per\ day\ ] = H(1-\theta)$ ——————— (5)

L_s	$=$	$\theta/(1-\theta)$ ——————(7)
L_q	$=$	$\theta^2/(1-\theta)$ ——————(8)
L_s	$=$	λW_s ——————(9)
L_q	$=$	λW_q ——————(10)

$$EOQ = \sqrt{\frac{2DA}{C}}$$

$$EOQ = \sqrt{\frac{2DA}{C(1-\frac{D}{R})}}$$

$$K = \frac{DA}{Q} + \frac{QC}{2} - \frac{DRm}{100}$$

$$EOQ = \sqrt{\frac{2DA(C+S)}{CS}}$$

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