

THE OPEN UNIVERSITY OF SRI LANKA  
 FACULTY OF MANAGEMENT STUDIES  
 BACHELOR OF MANAGEMENT STUDIES (HONOURS) DEGREE  
 PROGRAMME - LEVEL 6  
 ACADEMIC YEAR: 2024/25  
 OSU6502 - OPERATION RESEARCH  
 FINAL EXAMINATION  
 DURATION: THREE (03) HOURS



DATE: 14<sup>th</sup> JUNE 2025

TIME: 1.30PM – 4.30PM

**Instructions:**

Answer FIVE questions ONLY.

All questions carry equal marks.

Use of a non-programmable calculator is allowed.

This question paper carries 6 questions in 7 pages.

**Question 1**

A wrap stall is preparing for an event and offers three types of wraps: A, B, and C. Each wrap type requires specific ingredients as follows,

Ingredients Availability	Wrap Type			Availability
	A	B	C	
Lettuce (portions)	1	2	3	200
Tomato (slices)	4	2	0	400
Cheese (slices)	1	1	2	900
Tortillas (slices)	2	2	2	252

Each wrap is sold for Rs.100, Determine the maximum number of wraps that can be produced given the available resources.

- Formulate a linear programming model for the above problem. (Use  $X_1$ ,  $X_2$  and  $X_3$  for wrap types A, B and C respectively). (5 marks)
- Prepare the first simplex table. (2 marks)

- c) Find the pivot element, the incoming variable and the outgoing variable. (2 marks)
- d) The final simplex table for the above problem is given below.  
 Note:  $s_1, s_2, s_3$  and  $s_4$  relates to lettuce, tomato, cheese and tortillas 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;

- What is the optimal solution? (2 marks)
- Interpret the shadow price of lettuce and cheese. (2 marks)
- Develop the dual for the problem. (4 marks)
- Find the optimal values for the dual variables. (1 marks)
- Find the range within which the price of wrap 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	-	6	4	60	100
B	-	4	2	60	200
C	A	5	3	50	150
D	A	3	1	45	65
E	B	6	4	90	200
F	C, D	8	4	80	300
G	D	4	2	40	100
H	F, G	3	2	45	80

- a) Construct the network diagram for this project. (8 marks)
- b) Find the critical path and the total project cost for the project. (4 marks)
- c) To shorten the project by 4 days at the lowest possible cost, which task(s) should be shortened? (6 marks)
- d) What would be the new total project cost after the shortening the project? (2 marks)

**(Total: 20 marks)**

**Question 3**

- a) What is an unbalanced transportation problem? Describe how to solve an unbalanced transportation problem using an example. (6 marks)
- b) Gayan Company has three factories A, B and C that produce fruit jam. The weekly capacity of factories A, B and C is 5000, 6000 and 2500 (cans) respectively. This jam is transported to four distribution centers P, Q, R and S where the weekly demand is 6000, 4000, 2000 and 1500 (cans) respectively. The cost of transporting one unit from a given factory to a given distribution center is explained in the table below.

Cost of Installation

FACTORY	DISTRIBUTION CENTER			
	P	Q	R	S
A	3	2	7	6
B	7	5	2	3
C	2	5	4	5

Gayan company wishes to develop the transportation plan that would minimize total cost of transport.

- i. Find an initial feasible solution using least cost method. (4 marks)
- ii. Solve the transportation problem using MODI method. (10 marks)

**(Total: 20 marks)**

**Question 4**

- a) A logistics firm operates 4 trucks, each assigned to one of four delivery paths. The distance (in kilometers) each truck travels per liter of fuel on each path is shown below.

Trucks	Route			
	1	2	3	4
P	4	5	5	3
Q	4.5	6	5	3.5
R	5	5.5	6	4
S	4.8	5.8	5.5	3

Which truck should be assigned to which path to minimize the total fuel consumption for all deliveries? (4 marks)

- b) A team is working on four projects, each varying in complexity and urgency. The estimated productivity points each team member would earn for completing each project are shown in the table below. The productivity points reflect both efficiency and difficulty levels. How should the projects be assigned to the team members to maximize the total productivity points earned?

Team Member	Project 1	Project 2	Project 3	Project 4
A	5	40	20	5
B	25	35	30	25
C	15	25	20	10
D	15	5	30	15

(8 marks)

- c) A small bakery records its weekly demand for bread over a period of 12 weeks as follows,

4775, 5885, 6900, 4200, 4335, 5230, 6520, 7230, 4125, 7425, 6980 and 5895

Randomly identify 8 values out of them in order to carry out a simulation. (Use the random number table below, start from the number marked with an arrow and move vertically downwards)

**Part of a  
Table of Random Numbers**

	61424	20419	86546	00517
	90222	27993	04952	66762
	50349	71146	97668	86523
Starting Point - 8	→85676	10005	08216	25906
	02429	19761	15370	43882
	90519	61988	40164	15815
	20631	88967	19660	89624
	89990	78733	16447	27932

(8 marks)

**(Total: 20 marks)****Question 5**

A retailer is provided with the following details by a supplier regarding a product:

Demand for the product = 9,000 units per year

Unit cost = Rs. 80/- per unit

Inventory holding cost = Rs. 12/- per unit per month

Ordering cost per order = Rs. 500/-

To store one unit of the product, 5 square feet is required.

- a) Calculate the economic order quantity (EOQ) of a product. (2 marks)
- b) Calculate the annual cost of maintaining the inventory. (2 marks)
- c) Calculate the reorder level of the products if lead time is 4 days. (2 marks)
- d) Calculate the reorder level of the products if lead time is 2 months. (4 marks)
- e) If the stock out cost is Rs. 10/- per unit per month, calculate the EOQ level. (2 marks)
- f) If maximum storage capacity is 2000 square feet, calculate the EOQ level. (2 marks)
- g) If a discount of 4% is offered for the orders greater than 250 units but less than 350 units and 5% discount is offered for orders equal or greater than 350 units, calculate the inventory costs for the following scenarios,

- i. Order size  $< 250$
- ii.  $250 < \text{Order size} < 350$
- iii.  $350 < \text{Order size}$

(6 marks)

**(Total: 20 marks)****Question 6**

In a bank there is only one counter. A solitary employee performs all the services required and the counter remains continuously open from 7am to 1pm. It has discovered that an average number of clients arriving a day is 54 and the number of customers that can be served per unit of a day is 72.

- a) What is the probability that the queuing system at the window is empty? (2 marks)
- b) How many hours does the employee spend idle per day? (2 marks)
- c) What is the average length of the queue at the window? (2 marks)
- d) On average, how many clients are present at the bank in a day? (2marks)
- e) What is the average client waiting time at the bank? (2 marks)
- f) What is the probability that there are more than 4 clients in the queue? (2marks)
- g) What is the probability that a client has to spend more than 10mins in the system? (3 marks)
- h) What is the waiting time of a client in the queue? (2 marks)
- i) If the arrival rate of clients has increased to 3 per minute, how many employees are required to provide an equilibrium level of service? (3 marks)

**(Total: 20 marks)**

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Formulae $\lambda$  - Rate of arrival of units $\mu$  - Rate of service completion

$$\theta = \lambda/\mu$$

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

$$P(n) = \theta P(n-1)$$

$$P(n) = \theta^n P(0)$$

$$P(n) = \theta^n (1-\theta)$$

$$[\text{Probability that queuing system empty}] = (1-\theta)$$

$$[\text{Probability that the server is idle}] = (1-\theta)$$

$$[\text{Number of hours server idle per day}] = H(1-\theta)$$

$$L_s = \theta/(1-\theta)$$

$$L_q = \theta^2/(1-\theta)$$

$$L_s = \lambda W_s$$

$$L_q = \lambda W_q$$

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

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

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

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