ii. Determine basic feasible solutions to the following transportation problem using Northwest Corner rule. **5 4 3**

| | | Sinks | | | | | Supply |
|---|---|---|---|---|---|---|---|
| | | *A* | *B* | *C* | *D* | *E* | |
| Origins | *P* | 2 | 11 | 10 | 3 | 7 | 4 |
| | *Q* | 1 | 4 | 7 | 2 | 1 | 8 |
| | *R* | 3 | 9 | 4 | 8 | 12 | 9 |
| Demand | | 3 | 3 | 4 | 5 | 6 | |

iii. "Assignment Technique is a special case of Transportation Technique". Comment on this statement, giving a suitable example. Also enlist the industrial and non-industrial areas of application where assignment technique is used. **5 4 2**

Q.6 i. What do you understand by queuing models? Write Kendall notation. **3 5 2**

ii. Cars arrive at a service station according to Poissons distribution with a mean rate of 5 per hour. The service time per car is exponential with a mean of 10 minutes. Find the average waiting time in the queue? **7 5 3**

OR iii. Write a short note on following: **7 5 2**
(a) Single server model (M/M/L)
(b) Multicellular model (M/M/S)

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*Total No. of Questions: 6* *Total No. of Printed Pages:4*

**Enrollment No.....**

MEDICAPS UNIVERSITY

# Faculty of Engineering
# End Sem Examination May 2025
## ME3CO30 Industrial Engineering & Operations Research

Programme: B.Tech. Branch/Specialisation: ME

**Duration: 3 Hrs.** **Maximum Marks: 60**

Note: All questions are compulsory. Internal choices, if any, are indicated. Answers of Q.1 (MCQs) should be written in full instead of only a, b, c or d. Assume suitable data if necessary. Notations and symbols have their usual meaning.

| | | | Marks | Co | BL |
|---|---|---|---|---|---|
| Q.1 | i. | A diagram showing the path followed by men and materials while performing a task is known as-<br>(a) String diagram (b) Flow process chart<br>(c) Travel chart (d) Flow diagram | 1 | 1 | 2 |
| | ii. | In process charts, the symbol used for storage is<br>(a) Circle (b) Square<br>(c) Arrow (d) Triangle | 1 | 1 | 2 |
| | iii. | The height of the top of the work bench should be __ the height of the elbow of the workmen.<br>(a) at (b) Above<br>(c) Below (d) None of these | 1 | 2 | 2 |
| | iv. | For longer seating, the most comfort position for the leg is when knee is bent at about _____ degree.<br>(a) 25 (b) 35<br>(c) 45 (d) 55 | 1 | 2 | 2 |
| | v. | The region which satisfies all the constraints of the L.P.P. is called as _____.<br>(a) Convex region.<br>(b) Infeasible region.<br>(c) Feasible region<br>(d) Concave region. | 1 | 4 | 3 |

vi. Simplex problem is considered as infeasible when **1 4 3**
(a) All the variables in entering column are negative
(b) Variables in the basics are negative
(c) Artificial variable is present in basis
(d) Pivotal value is negative

vii. When the total allocations in a transportation model of m×n size do not equal to m+n-1 the situation is known as- **1 4 3**
(a) Unbalanced situation (b) Tie situation
(c) Degeneracy (d) None of these

viii. Which of the following methods is commonly used to solve assignment problems? **1 4 1**
(a) Stepping stone method
(b) Hungarian method
(c) Northwest corner method
(d) Vogel's approximation method

ix. The calling population is assumed to be infinite when **1 4 1**
(a) Arrivals are independent of each other
(b) The capacity of the system is infinite
(c) Both (a) & (b)
(d) None of these

x. Which of the following is used to know the average number of customers in the queue system when arrival rate is denoted by $\lambda$ and service rate by $\mu$ **1 4 2**
(a) $\lambda/\mu$ (b) $1/(\mu - \lambda)$
(c) $\lambda/\mu(\mu - \lambda)$ (d) $\lambda/(\mu - \lambda)$

Q.2 Attempt any two:

i. What are flow process charts? Give their importance. **5 2 1**

ii. What are therbligs? List various therbligs and their use in method study. **5 1 2**

iii. Explain with examples method study symbols for recording the facts. **5 1 2**

Q.3 Attempt any two:

i. Explain the steps involved in time study? What are time study equipments? **5 2 2**



ii. In a time study the observed time is 0.75 min, performance rating factor is 110% and allowances are 20% of the normal time. Find the standard time? **5 2 3**

iii. Define wage incentive plans. What are its objectives and drawbacks? **5 2 2**

Q.4 i. What is linear programming problem? **3 3 2**

ii. Solve the following linear programming problem graphically: **7 3 3**
Minimise $Z = 200x + 500y$ subject to the constraints-
$x + 2y \geq 10$
$3x + 4y \leq 24$
$x \geq 0, y \geq 0$

OR iii. A company produces two types of TVs, one is black and white, while the other is color. The company has the resources to make at most 200 sets a week. Creating a black and white set costs Rs. 2700 and Rs. 3600 to create a colored set. The business should spend no more than Rs. 648000 a week producing TV sets. If it benefits from Rs. 525 per set of black and white and Rs. 675 per set of colors, How many sets of black/white and colored sets should it produce in order to get maximum profit? Formulate this using LPP. **7 3 3**

Q.5 Attempt any two:

i. Obtain an initial basic feasible solution to the following transportation problem by using least- cost method. **5 4 3**

| | $D_1$ | $D_2$ | $D_3$ | Supply |
|---|---|---|---|---|
| $O_1$ | 9 | 8 | 5 | 25 |
| $O_2$ | 6 | 8 | 4 | 35 |
| $O_3$ | 7 | 6 | 9 | 40 |
| demand | 30 | 25 | 45 | |

# Marking Scheme

## ME3CO30 (T) Industrial Engineering & Operations Research

Q.1 i) A diagram showing the path followed by men and materials while performing a task is known as **1**
d) flow diagram

ii) In process charts, the symbol used for storage is **1**
d) Triangle

iii) The height of the top of the work bench should be ___ the height of the elbow of the workmen. **1**
a) at

iv) For longer seating, the most comfort position for the leg is when knee is bent at about _____ degree. **1**
c) 45

v) The region which satisfies all the constraints of the L.P.P. is called as _____. **1**
c) Feasible region.

vi) Simplex problem is considered as infeasible when **1**
c) artificial variable is present in basis

vii) When the total allocations in a transportation model of m×n size do not equal to m+n-1 the situation is known as **1**
c) Degeneracy

viii) Which of the following methods is commonly used to solve assignment problems? **1**
b) Hungarian method

ix) The calling population is assumed to be infinite when **1**
a) arrivals are independent of each other

x) Which of the following is used to know the average number of customers in the Queue system when arrival rate is denoted by $\lambda$ and service rate by $\mu$ **1**
d) $\lambda / (\mu - \lambda)$

Q.2 Attempt any two:

i. What are flow process charts? Give their importance. **5**

ii. What are Therbligs? List various Therbligs and their use in method study. **5**

iii. Explain with examples method study symbols for recording the facts. **5**

Q.3 Attempt any two:

i. Explain the steps involved in time study? What is Time study equipment? **5**

ii. **5**

**Normal time** = $\frac{\text{Rating factor}(\%)}{100}$ × observed time

**Standard time** = normal time × $\left(1 + \frac{\text{allowance}(\%)}{100}\right)$

**Calculation:**

Normal time = 0.75 × (110/100)

∴ **Normal time** = 0.825 min

Standard time = 0.825 × (1 + 0.2)

∴ **Standard time** = 0.99 minutes

iii. Define wage incentive plans. What are its objectives and drawbacks? **5**

Q.4 i. What is Linear programming problem? **3**

ii. **7**

| Corner point | Value of Z |
|---|---|
| (0, 5) | 2500 |
| (4, 3) | 2300← Minimum |
| (0, 6) | 3000 |

OR iii. the minimum value of Z is 2300 is at the point (4, 3) **7**

$x + y \leq 200$ (Quantity constraints)

$2700x + 3600y \leq 648000$ (Cost constraints)

Objective function: $Z = 525x + 675y$ (objective is to maximize profit)

| | |
|---|---|
| O(0,0) | 525(0) + 675(0) = 0 |
| A(200,0) | 525(200) + 675(0) = 105000 |
| C(80,120) | 525(80) + 675(120)= 123000 |

| | |
|---|---|
| B(0,180) | 525(0) + 675(180) = 121500 |

Maximum value of Z occurs at C(80,120), i.e., 123000



Q.5 Attempt any two:

i. $x_{11}=15, x_{13}=10, x_{23}=35, x_{31}=15, x_{32}=25,$ **5**

Total Cost = 580

ii. $x_{11}=3, x_{12}=1, x_{22}=2, x_{23}=4, x_{24}=2, x_{34}=3, x_{35}=6$ **5**

Total Cost = 153

iii. "Assignment Technique is a special case of Transportation Technique". Comment on this statement giving suitable example. Also enlist the industrial and non-industrial areas of application where assignment technique is used. **5**

Q.6 i. What do you understand by queuing model? Write Kendall notation. **3**

ii. **7**

$\lambda$ = 5 cars per hour, $\mu$ = 1 car per 10 minute = 6 cars per hour

$\Rightarrow \rho = \frac{5}{6}$

$L_q = \frac{(5/6)^2}{1-(5/6)} = \frac{25}{6}$

$W_q = \frac{25/6}{5} = \frac{5}{6}$ hours = $\frac{5}{6} \times 60 = 50\ min$

OR iii. Write short note on following: **7**

i. single server model (M/M/L)
ii. multicellular model (M/M/S)

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