Q.6 Attempt any two:

i. Arrivals at a telephone both are considered to be Poisson at an average time of 8 min between one arrival and the next. The length of the phone call is distributed exponentially, with a mean of 4 min. Determine- **5**
(a) Expected fraction of the day that the phone will be in use.
(b) Expected number of units in the system & expected number of units in the queue
(c) Expected waiting time in the system & expected waiting time in the queue.
(d) Expected number of units in queue that form time to time.

ii. Two player A and B match coins. If the coins match, then A wins two units of value, if the coin do not match, then B win 2 units of value. Determine the optimum strategies for the players and the value of the game. **5**

iii. Write in detail about elements of a queuing system. **5**

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

Enrollment No.....

Faculty of Engineering
End Sem Examination May-2024
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.

Q.1 i. Work study consists of- **1**
(a) Effective use of plant and equipment
(b) Effective use of human effort
(c) Evaluation of human work
(d) All of these

ii. In process charts, the symbol used for inspection is- **1**
(a) Circle (b) Square (c) Arrow (d) Triangle

iii. Standard time is equal to- **1**
(a) Normal time (b) Allowances
(c) Normal time + allowances (d) Normal time – allowances

iv. PMTS stands for- **1**
(a) Predetermined Motion Time System
(b) Predetermined Motion Time Study
(c) Picture Motion Time System
(d) Previous Motion Time Study

v. Simplex problem is considered as infeasible when- **1**
(a) All the variables in entering column are negative
(b) Variable in the basis are negative
(c) Artificial variable is present in basis
(d) Pivotal value is negative

vi. Linear Programming Problem is a technique of finding the _____. **1**
(a) Optimal value (b) Approximate value
(c) Initial value (d) Infeasible value

vii. The method used for solving an assignment problem is called - **1**
(a) Reduced matrix method (b) MODI method
(c) Hungarian method (d) None of these

viii. The dummy source or destination in a transportation problem is added to- **1**
(a) Satisfy rim conditions
(b) Prevent solution from becoming degenerate
(c) Ensure that total cost does not exceed a limit
(d) None of these

ix. Service mechanism in a queuing system is characterized by- **1**
(a) Server's behaviour (b) Customer's behaviour
(c) Customers in the system (d) All of these

x. What happens when maximin and minimax values of the game are same? **1**
(a) No solution exists (b) Solution is mixed
(c) Saddle point exists (d) None of these

Q.2 Attempt any two:

i. What are the recording techniques of method study? Explain flow process chart with example. **5**

ii. What is a SIMO chart? Explain with suitable example. **5**

iii. Write the procedure for cyclograph & chrono cyclograph. Why are they used? **5**

Q.3 i. If in a time study, the observed time is 0.75 min, rating factor = 110% and allowances are 20% of normal time, then what is the standard time? **2**

ii. What is meant by work measurement? Give its objectives and steps involved. **8**

OR iii. What is meant by rating an operator? What are the techniques used for rating? **8**

Q.4 i. Find graphically the maximum value of $Z = 3x + 4y$ subjected to constraints: **3**
$x + y \leq 4$
$x \geq 0$ and $y \geq 0$

ii. Solve by Simplex Method **7**
Maximize $Z = 40X_1 + 30X_2$
Subject to:
$X_1 + X_2 \leq 12$
$2X_1 + X_2 \leq 16$,
$X_1 \geq 0; X_2 \geq 0$

OR iii. Solve by Simplex Method- **7**
Maximize $Z = 30X_1 + 40X_2$
subject to:
$3X_1 + 2X_2 \leq 600$
$3X_1 + 5X_2 \leq 800$
$5X_1 + 6X_2 \leq 1100$
and $X_1, X_2 \geq 0$

Q.5 i. State the difference between transportation & assignment model. **2**

ii. Find the Ibfs for the following transportation problem by **8**
(a) Least Cost Method
(b) Row Minima Method
(c) Column Minima Method
(d) Vogel's Approximation Method
The transportation cost is given below.

	A	B	C	D	E	*Supply (tons)*
P	4	1	3	4	4	60
Q	2	3	2	2	3	35
R	3	3	2	4	4	40
Demand (tons)	22	45	20	18	30	

OR iii. Solve the following Assignment problem for minimization. **8**

	A	B	C	D	E
1	11	17	8	16	20
2	9	7	12	6	15
3	13	16	15	12	16
4	21	24	17	28	26
5	14	10	12	11	13

Marking Scheme
Industrial Engineering & Operations Research (T) - ME3CO30 (T)

Q.1 i) Work study consists of **1**
a. Effective use of plant and equipment
b. Effective use of human effort
c. Evaluation of human work
d. All of the above
(Ans: d)

ii) In process charts, the symbol used for inspection is **1**
a. Circle
b. Square
c. Arrow
d. Triangle
(Ans: b)

iii) Standard time is equal to **1**
a. Normal time
b. Allowances
c. Normal time + allowances
d. Normal time – allowances
(Ans: c)

iv) PMTS stands for **1**
a. Predetermined Motion Time System
b. Predetermined Motion Time Study
c. Picture Motion Time System
d. Previous Motion Time Study
(Ans: a)

v) Simplex problem is considered as infeasible when **1**
a. All the variables in entering column are negative
b. Variable in the basis are negative
c. Artificial variable is present in basis
d. Pivotal value is negative
(Ans: c)

vi) Linear Programming Problem is a technique of finding the _____. **1**
a. optimal value
b. approximate value
c. initial value
d. infeasible value
(Ans: a)

vii) The dummy source or destination in a transportation problem is added to **1**
a. Satisfy rim conditions
b. Prevent solution from becoming degenerate
c. Ensure that total cost does not exceed a limit
d. None of the above
(Ans: a)

viii) The method used for solving an assignment problem is called **1**
a. Reduced matrix method
b. MODI method
c. Hungarian method
d. None of the above
(Ans: c)

ix) Service mechanism in a queuing system is characterized by **1**
(a) server's behavior
(b) customer's behavior
(c) customers in the system
(d) all of the above
(Ans: a)

x) What happens when maximin and minimax values of the game are same? **1**
(a) no solution exists
(b) solution is mixed
(c) saddle point exists
(d) none of these
(Ans: c)

Q.2 Attempt any two:

i. What are the recording techniques of method study? Explain flow process chart with example. **5**
Ans:
Recording Techniques **3 Marks**
Flow Process Example **2 Marks**

OR ii. What is a SIMO chart? Explain with suitable example. **5**
Ans:
SIMO chart **3 Marks**
Example **2 Marks**

OR iii. Write the procedure for cyclograph & chrono cyclograph. Why are they used? **5**
Ans:

Procedure **3 Marks**
Uses: **2 Marks**

Q.3 i. If in a time study, the observed time is 0.75 min, rating factor = 110% and allowances are 20% of normal time, then what is the standard time? **2**

Ans- c

Standard time = Observed time x Performance rating factor x (1 + Allowances)

Substituting these values into the formula, we get:

Standard time = 0.75 min x 110% x (1 + 0.2)

Standard time = 0.75 min x 1.1 x 1.2

Standard time = 0.99 min **2 Marks**

ii. What is meant by work measurement ? Give its objectives and steps involved **8**

Ans-

Definition **2 Marks**
Objectives **3 Marks**
Steps involved **3 Marks**

OR iii. What is meant by rating an operator? What are the techniques used for rating? **8**

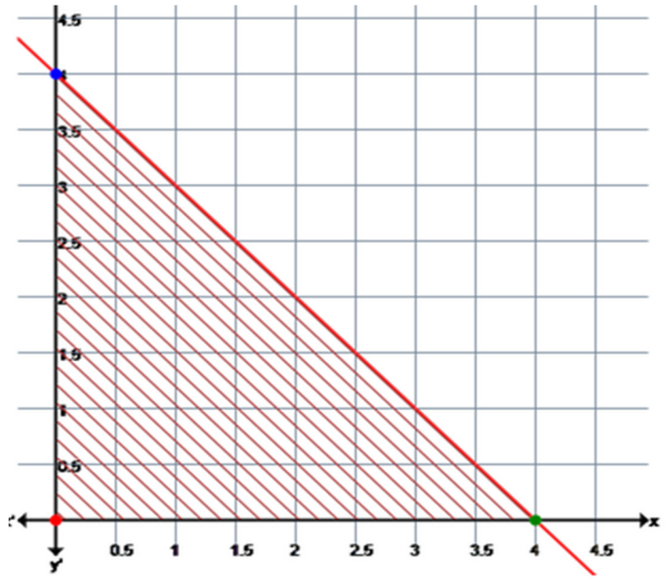
Ans:

Rating an operator **2 Marks**
The techniques used for rating **6 Marks**

Q.4 i. Find graphically the maximum value of Z = 3x + 4y subjected to constraints: - **3**

$x + y \leq 4$,
$x \geq 0$ and $y \geq 0$

Ans:-



x=0, y=4, Zmax= 16
Graph **2 Marks**
Answer **1 Mark**

ii. Solve by Simplex Method **7**
Maximize $Z = 40X_1+30X_2$
Subject to:
$X_1+X_2 \leq 12$
$2X_1+X_2 \leq 16$
$X_1 \geq 0; X_2 \geq 0$

Ans:-

Iteration-1
the entering variable is x1.
the leaving basis variable is S2.
The pivot element is 2.

3 Marks

Iteration-2
the entering variable is x2.
the leaving basis variable is S1.
the pivot element is 1/2.

3 Marks

X1=4 , X2=8, Zmax=400 1 **Mark**

OR iii. Solve by Simplex Method **7**
Maximize $Z = 30X_1 + 40X_2$
subject to
$3X_1 + 2X_2 \leq 600$

$3X_1 + 5X_2 \leq 800$
$5X_1 + 6X_2 \leq 1100$
and $X_1, X_2 \geq 0$

Ans:

Iteration-1
the entering variable is X_2.
the leaving basis variable is S_2.
The pivot element is 5

3 Marks

Iteration-2
the entering variable is X_1.
the leaving basis variable is S_3.
the pivot element is 7/5

3 Marks

X1=100 , X2=100, Zmax=7000 1 **Mark**

Q.5 i. State the difference between Transportation & Assignment Model. **2**

2 Marks

ii. Find the Ibfs for the following transportation problem by **8**
i. Least Cost Method
ii. Row Minima Method
iii. Column Minima Method
iv. Vogel's Approximation Method.

	A	B	C	D	E	*Supply (tons)*
P	4	1	3	4	4	60
Q	2	3	2	2	3	35
R	3	3	2	4	4	40
Demand (tons)	22	45	20	18	30	

Ans:

i. Least Cost Method

	D_1	D_2	D_3	D_4	D_5	Supply
S_1	4	1 (45)	3	4 (5)	4 (10)	60
S_2	2 (22)	3	2	2 (13)	3	35
S_3	3	3	2 (20)	4	4 (20)	40
Demand	22	45	20	18	30	

The minimum total transportation cost
=1×45+4×5+4×10+2×22+2×13+2×20+4×20=295 **2 Marks**

ii. Row Minima Method

	D_1	D_2	D_3	D_4	D_5	Supply
S_1	4	1 (45)	3 (15)	4	4	60
S_2	2 (22)	3	2	2 (13)	3	35
S_3	3	3	2 (5)	4 (5)	4 (30)	40
Demand	22	45	20	18	30	

The minimum total transportation cost
=1×45+3×15+2×22+2×13+2×5+4×5+4×30=310 **2 Marks**

iii. Column Minima Method

	D_1	D_2	D_3	D_4	D_5	Supply
S_1	4	1 (45)	3	4 (5)	4 (10)	60
S_2	2 (22)	3	2	2 (13)	3	35
S_3	3	3	2 (20)	4	4 (20)	40
Demand	22	45	20	18	30	

The minimum total transportation cost
=1×45+4×5+4×10+2×22+2×13+2×20+4×20=295 **2 Marks**

iv. Vogel's Approximation Method.

	D_1	D_2	D_3	D_4	D_5	Supply
S_1	4	1(45)	3	4	4(15)	60
S_2	2(17)	3	2	2(18)	3	35
S_3	3(5)	3	2(20)	4	4(15)	40
Demand	22	45	20	18	30	

The minimum total transportation cost
=1×45+4×15+2×17+2×18+3×5+2×20+4×15=290 **2 Marks**

OR iii. Solve the following Assignment problem for minimization. **8**

	I	II	III	IV	V
1	11	17	8	16	20
2	9	7	12	6	15
3	13	16	15	12	16
4	21	24	17	28	26
5	14	10	12	11	13

Ans:

Optimal solution is

Work	Job	Cost
A	1	11
B	2	7
C	4	12
D	3	17
E	5	13
	Total	60

Optimal solution is

Work	Job	Cost
A	1	11
B	4	6
C	5	16
D	3	17
E	2	10
	Total	60

OR Alternate solution

8 Marks

Q.6 Attempt any two:

i. Arrivals at a telephone both are considered to be Poisson at an average time of 8 min between one arrival and the next. The length of the phone call is distributed exponentially, with a mean of 4 min. Determine **5**
(a) Expected fraction of the day that the phone will be in use.
(b) Expected number of units in the system & expected number of units in the queue
(c) Expected waiting time in the system & expected waiting time in the queue.
(d) Expected number of units in queue that form time to time.

The mean arrival rate = λ = 1/8 x 60 = 7.5 / hour.
The mean service = μ = x 60 = 15 / hour.

(a) Fraction of the day that the phone will be in use $\rho = \lambda / \mu = 7.5/15 = 0.5$ **1 Mark**

(b) $L = L_q + (\lambda / \mu) = 0.5+0.5 = 1$ person
$L_q = \lambda^2/\mu(\mu - \lambda) = 7.5^2/15(15-7.5) = 0.5$ (units) person **1 Mark**

(c) $W = W_q + 1/\mu = 0.066+1/15 = 0.133$
$W_q = L_q/\lambda = 0.5/7.5 = 0.066$ hrs **1 Mark**

(d) **1 Mark**
$D = \mu/(\mu - \lambda) = 15/(15-7.5) = 2$ persons

OR ii. Two player A and B match coins. If the coins match, then A wins two units of value, if the coin do not match, then B win 2 units of value. Determine the optimum strategies for the players and the value of the game. **5**

Ans:

The pay off matrix for player A

	Player B		
Player A	H	T	Row minimum
H	2	-2	-2
T	-2	2	-2
Column Maximums	2	2	

maxmin is not equal to minmax, therefore there is no unique saddle point. **1 Mark**

$P_1 = a_{22}-a_{21}/a_{11}+a_{22}-(a_{12}+a_{21}) = 1/2$ **1 Mark**
$P_2 = 1 - P_1 = 1/2$ **1 Mark**
$Q_1 = a_{22}-a_{12}/a_{11}+a_{22}-(a_{12}+a_{21}) = 1/2$ **1 Mark**
$Q_2 = 1/2$ **1 Mark**

OR iii. Write in detail about elements of a queuing system. **5**

5 Marks

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