

SRM VALLIAMMAI ENGINEERING COLLEGE
(An Autonomous Institution)

S.R.M. Nagar, Kattankulathur - 603203

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

QUESTION BANK



I SEMESTER

M. E. COMMUNICATION SYSTEMS

**MA3124 - ADVANCED MATHEMATICS FOR COMMUNICATION
ENGINEERING**

Regulation – 2023

Academic Year – 2026 – 2027

Prepared by

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SRM VALLIAMMAI ENGINEERING COLLEGE

DEPARTMENT OF MATHEMATICS QUESTION BANK

**SUBJECT : MA3124 – ADVANCED MATHEMATICS FOR COMMUNICATION
ENGINEERING**

SEM / YEAR: I / I year M.E. COMMUNICATION SYSTEMS

UNIT 1 : Vector spaces – Norms – Inner products – QR factorization – Generalized eigenvectors – Singular value decomposition and applications – Pseudo inverse – Least square approximations

Q.No.	Question	Bloom's Taxonomy Level	Competence	Course Outcome
1.	Define an inner product space	BTL -1	Remembering	CO 1
2.	Define Vector Space .	BTL -1	Remembering	CO 1
3.	Define Subspace of a vector space	BTL -2	Understanding	CO 1
4.	Define norm of a vector space.	BTL -2	Understanding	CO 1
5.	Define Inner Product of a vector space.	BTL -1	Remembering	CO 1
6.	In a Vector Space V (F) if $\alpha v=0$ then either $\alpha=0$ or $v=0$ prove.	BTL -2	Understanding	CO 1
7.	Is $\{(1,4, -6), (1,5,8), (2,1,1), (0,1,0)\}$ is a linearly independent subset of R^3 ? Justify your answer	BTL -1	Remembering	CO 1
8.	Compute the norms of $x = \begin{pmatrix} 1 \\ 1 \\ -1 \\ 2 \end{pmatrix}$ and $y = \begin{pmatrix} 3 \\ -1 \\ 0 \\ -1 \end{pmatrix}$. Also verify that x and y are orthogonal. Find $\langle x, y \rangle$	BTL -1	Remembering	CO 1
9.	Calculate the Frobenius norm for the given matrix $A = \begin{pmatrix} 1 & -i \\ 1+i & 2-i \end{pmatrix}$	BTL -1	Remembering	CO 1
10.	Determine the canonical basis for $A = \begin{bmatrix} 3 & 5 \\ -2 & -4 \end{bmatrix}$.	BTL -2	Understanding	CO 1
11.	Define orthogonal and orthonormal vectors.	BTL -1	Remembering	CO 1
12.	Define singular matrix with an example.	BTL -1	Remembering	CO 1
13.	Find the sum and product of all Eigen values of $\begin{bmatrix} 1 & 2 & -2 \\ 1 & 0 & 3 \\ -2 & -1 & -3 \end{bmatrix}$	BTL -2	Understanding	CO 1
14.	If the sum of two eigenvalues and trace of a 3x3 matrix A are equal find the value of $ A $.	BTL -1	Remembering	CO 1
15.	Find the sum and product of the Eigen values of the matrix $f \begin{bmatrix} 2 & 2 & 0 \\ 2 & 2 & 1 \\ -7 & 2 & -3 \end{bmatrix}$	BTL -2	Understanding	CO 1
16.	Let $A = \begin{pmatrix} 1 & 1 \\ 1 & 3 \end{pmatrix} = A_1$.Compute A_2 using QR algorithm.	BTL -2	Understanding	CO 1

17.	Define the generalized Eigen vector, chain of rank m, for a square matrix.	BTL -2	Understanding	CO 1
18.	Check whether the given matrix is positive definite or not $\begin{pmatrix} 3 & 1 & -1 \\ 1 & 3 & -1 \\ -1 & -1 & 5 \end{pmatrix}$	BTL -2	Understanding	CO 1
19.	Determine the canonical basis for $A = \begin{bmatrix} 3 & 5 \\ -2 & -4 \end{bmatrix}$.	BTL -2	Understanding	CO 1
20.	Write short note on Singular value decomposition of complex matrix A.	BTL -1	Remembering	CO 1
21.	State Singular value decomposition theorem.	BTL -1	Remembering	CO 1
22.	If A is a nonsingular matrix, then what is A^+ ?	BTL -2	Understanding	CO 1
23.	Define singular matrix with an example.	BTL -1	Remembering	CO 1
24.	Find the least square solution to the system $x_1 + x_2 = 3$, $-2x_1 + 3x_2 = 1$ and $2x_1 - x_2 = 2$	BTL -2	Understanding	CO 1
25.	Check whether the given matrix is positive definite or not $\begin{pmatrix} 3 & 1 & -1 \\ 1 & 3 & -1 \\ -1 & -1 & 5 \end{pmatrix}$	BTL -2	Understanding	CO 1

PART-B

1.	Determine whether the following set is linearly dependent or linearly independent $\begin{pmatrix} 1 & 0 \\ -2 & 1 \end{pmatrix}, \begin{pmatrix} 0 & -1 \\ 1 & 1 \end{pmatrix}, \begin{pmatrix} -1 & 2 \\ 1 & 0 \end{pmatrix}$ and $\begin{pmatrix} 2 & 1 \\ 2 & -2 \end{pmatrix}$ generate $M_{2 \times 2}(R)$	BTL -3	Applying	CO 1
2.	Show that the set ,S={ (1,3,-4,2),(2,2,-4,0),(1,-3,2,-4),(-1,0,1,0)} is linearly dependent of the other vectors	BTL -3	Applying	CO 1
3.	Find the QR decomposition of $\begin{pmatrix} 1 & -1 & 1 \\ 1 & 0 & 1 \\ -1 & 1 & 1 \end{pmatrix}$	BTL -4	Analyzing	CO 1
4.	Construct QR decomposition for the matrix $\begin{pmatrix} -4 & 2 & 2 \\ 3 & -3 & 3 \\ 6 & 6 & 0 \end{pmatrix}$	BTL -3	Applying	CO 1
5.	Find the QR factorization of $A = \begin{pmatrix} 3 & 2 \\ 4 & 5 \end{pmatrix}$	BTL -2	Understanding	CO 1
6.	Find the QR factorization of $A = \begin{bmatrix} 0 & 0 & 5 \\ 0 & 4 & 1 \\ 1 & 1 & 1 \end{bmatrix}$	BTL -3	Applying	CO 1
7.	Find the QR factorization of $A = \begin{bmatrix} 1 & 1 & -1 \\ 1 & 0 & 0 \\ 1 & 1 & 1 \end{bmatrix}$	BTL -4	Analyzing	CO 1
8.	Find the eigen values of $\begin{pmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 18 & -1 & -7 \end{pmatrix}$ by using QR transformation	BTL -3	Applying	CO 1
9.	Obtain the singular value decomposition of $\begin{pmatrix} 2 & 2 \\ -1 & 1 \end{pmatrix}$	BTL -4	Analyzing	CO 1
10.	Construct the singular value decomposition for $\begin{pmatrix} 1 & 1 & 3 \\ 1 & 1 & 3 \end{pmatrix}$	BTL -4	Analyzing	CO 1

11.	Obtain the singular value decomposition of $A = \begin{bmatrix} 2 & -1 \\ -2 & 1 \\ 4 & -2 \end{bmatrix}$	BTL -3	Applying	CO 1
12.	Obtain the singular value decomposition $\begin{pmatrix} 1 & 1 & 0 \\ 0 & 1 & 1 \end{pmatrix}$	BTL -3	Applying	CO 1
13.	Solve the following system of equations in the least square sense $x_1 + x_2 + 3x_3 = 1$; $x_1 + x_2 + 3x_3 = 2$	BTL -3	Applying	CO 1
14.	Solve the following system of equations in the least square sense $x_1 + x_2 + x_3 = 1$; $x_1 + x_2 + x_3 = 2$; $x_1 + x_2 + x_3 = 3$.	BTL -4	Analyzing	CO 1
15.	Solve the following system of equations in the least square sense $2x_1 + 2x_2 - 2x_3 = 1$, $2x_1 + 2x_2 - 2x_3 = 3$, $-2x_1 - 2x_2 + 6x_3 = 2$	BTL -3	Applying	CO 1
16.	Fit a straight line in the least square sense to the following data X: -3 -2 -1 0 1 2 3 Y: 8 12 17 25 26 32 40	BTL -4	Analyzing	CO 1
17.	Fit a straight line in the least square sense to the following data X: -3 -2 -1 0 1 2 3 Y: 10 15 19 27 28 34 42	BTL -4	Analyzing	CO 1
18.	Solve the following system of equations in the least square sense $x_1 + x_2 + x_3 = 2$; $x_1 + x_2 + x_3 = 4$; $x_1 + x_2 + x_3 = 6$.	BTL -3	Applying	CO 1

UNIT 2: Probability Concepts – Axioms of probability – Random variables – Probability functions – Two-dimensional random variables – Joint distributions – Marginal and conditional distributions – Correlation – Linear Regression

Q.No.	Question	Bloom's Taxonomy Level	Competence	Course Outcome
1.	Define Probability of an event.	BTL -1	Remembering	CO2
2.	State the Axioms of Probability.	BTL -1	Remembering	CO2
3.	A ball is drawn at random from a box containing 5 red balls, 3 white balls and 4 blue balls. Find the probability that the ball drawn is not red.	BTL -2	Understanding	CO2
4.	What is the Probability that a leap year selected at random will have 53 Sundays?	BTL -2	Understanding	CO2
5.	If a box contains 75 good items and 25 defective items , and 12 items are selected at random, find the probability that at least one item is defective	BTL -2	Understanding	CO2
6.	A and B are events with $P(A) = \frac{5}{8}$, $P(B) = \frac{1}{2}$ and $P(A \cap B) = \frac{1}{4}$. Find $P(\bar{A} \cap \bar{B})$	BTL -2	Understanding	CO2
7.	The joint probability mass function of a two dimensional discrete random variable (X,Y) is given by $P(X = x, Y = y) = C(2x + y)$ $x = 0, 1, 2$ and $y = 0, 1, 2, 3$. Find the marginal distributions of X	BTL -1	Remembering	CO2
8.	Find the value of k , if $f(x, y) = k(1 - x)(1 - y)$ in $0 < x, y < 1$ and $f(x, y) = 0$ otherwise ,is to be the joint density function	BTL -2	Understanding	CO2
9.	Let X and Y be two independent RVs with joint pmf	BTL -2	Understanding	CO2

	$P(X = x, Y = y) = \begin{cases} \frac{x+2y}{18}, & x = 1, 2, y = 1, 2 \\ 0, & \text{otherwise} \end{cases}$ Find the marginal probability mass function of X and E (X)												
10.	If $\bar{X} = 970, \bar{Y} = 18, \sigma_x = 38, \sigma_y = 2$ and $r = 0.6$, Find the line of regression of X on Y.	BTL-2	Understanding	CO2									
11.	Find the probability distribution of X + Y from the bivariate distribution of (X,Y) given below: <table><tr><td>X \ Y</td><td>1</td><td>2</td></tr><tr><td>1</td><td>0.4</td><td>0.2</td></tr><tr><td>2</td><td>0.3</td><td>0.1</td></tr></table>	X \ Y	1	2	1	0.4	0.2	2	0.3	0.1	BTL-2	Understanding	CO2
X \ Y	1	2											
1	0.4	0.2											
2	0.3	0.1											
12.	Find the marginal distributions of X and Y from the bivariate distribution of (X,Y) given below: <table><tr><td>X \ Y</td><td>1</td><td>2</td></tr><tr><td>1</td><td>0.1</td><td>0.2</td></tr><tr><td>2</td><td>0.3</td><td>0.4</td></tr></table>	X \ Y	1	2	1	0.1	0.2	2	0.3	0.4	BTL-2	Understanding	CO2
X \ Y	1	2											
1	0.1	0.2											
2	0.3	0.4											
13.	The joint probability distribution of X and Y is given by $p(x, y) = \frac{x+y}{21}, x = 1, 2, 3; y = 1, 2$. Find the marginal probability distributions of X	BTL-2	Understanding	CO2									
14.	The joint probability function (X,Y) is given by $P(x, y) = k(2x + 3y), x = 0, 1, 2, y = 1, 2, 3$, Find the value of K.	BTL-2	Understanding	CO2									
15.	If the joint probability density function of a random variable X and Y is given by $f(x, y) = \begin{cases} \frac{x^3 y^3}{16}, & 0 < x < 2, 0 < y < 2 \\ 0, & \text{otherwise} \end{cases}$. Obtain the marginal density function of X.	BTL-1	Remembering	CO2									
16.	State any two properties of correlation coefficient	BTL-2	Understanding	CO2									
17.	Write the angle between the regression lines	BTL-1	Remembering	CO2									
18.	The regression equations are $x + 6y = 14$ and $2x + 3y = 1$. Evaluate the correlation coefficient between X & Y.	BTL-1	Remembering	CO2									
19.	If $\bar{X} = 970, \bar{Y} = 18, \sigma_x = 38, \sigma_y = 2$ and $r = 0.6$, Find the line of regression of Y on X	BTL-2	Understanding	CO2									
20.	In a partially destroyed laboratory, record of an analysis of correlation data, the following results only are legible; Variance of X = 9; Regression equations are $8X - 10Y + 66 = 0$ and $40X - 18Y = 214$. Find the mean values of X and Y?	BTL-1	Remembering	CO2									
21.	The regression equations are $3x + 2y = 26$ and $6x + y = 31$. Find the correlation coefficient.	BTL-2	Understanding	CO2									
22.	State central limit theorem	BTL-1	Remembering	CO2									
23.	Prove that $-1 \leq r_{xy} \leq 1$	BTL-2	Understanding	CO2									
24.	The equations of two regression lines are $3x+2y=19$ and $3y+9x=46$. Obtain the mean of X and Y.	BTL-1	Remembering	CO2									
25.	The equations of two regression lines are $3x+2y=19$ and $3y+9x=46$. Derive the correlation coefficient between X and Y.	BTL-1	Remembering	CO2									
PART –B													

1.(a)	4 cards are drawn from a well shuffled pack of cards. Find the probability that (i) All the four are queens (ii) There is one card from each suit. (iii) Two cards are diamonds and two are spades All the four cards are hearts and one of them is jack	BTL-4	Analyzing	CO2																					
1.(b)	The probability mass function of a discrete R. V X is given in the following table <table><tr><td>X</td><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td></tr><tr><td>P(X)</td><td>a</td><td>3a</td><td>5a</td><td>7a</td><td>9a</td><td>11a</td><td>13a</td><td>15a</td><td>17a</td></tr></table> Find (i) the value of a , (ii) $P(X < 3)$, (iii) Mean of X, (iv) Variance of X.	X	0	1	2	3	4	5	6	7	8	P(X)	a	3a	5a	7a	9a	11a	13a	15a	17a	BTL-4	Analyzing	CO2	
X	0	1	2	3	4	5	6	7	8																
P(X)	a	3a	5a	7a	9a	11a	13a	15a	17a																
2.(a)	A random variable X has the following probability distribution: <table><tr><td>X</td><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td></tr><tr><td>P(X)</td><td>0</td><td>k</td><td>2k</td><td>2k</td><td>3k</td><td>k^2</td><td>$2k^2$</td><td>$7k^2+k$</td></tr></table> Find (i) the value of k (ii) $P(1.5 < X < 4.5 / X > 2)$	X	0	1	2	3	4	5	6	7	P(X)	0	k	2k	2k	3k	k^2	$2k^2$	$7k^2+k$	BTL-4	Analyzing	CO2			
X	0	1	2	3	4	5	6	7																	
P(X)	0	k	2k	2k	3k	k^2	$2k^2$	$7k^2+k$																	
2.(b)	Two dice are thrown together once. Find the probabilities for getting the sum of the two numbers (i) equal to 5, (ii) multiple of 3, (iii) divisible by 4.	BTL-4	Analyzing	CO2																					
3.(a)	A box contains 4 bad and 6 good tubes. Two are drawn out from the box at a time. One is tested and found to be good. What is the probability that the other one is also good?	BTL-4	Analyzing	CO2																					
3.(b)	If the joint pdf of (X, Y) is given by $P(x, y) = K(2x+3y)$, $x=0, 1, 2, 3$, $y = 1, 2, 3$ Find all the marginal probability distribution. Also find the probability distribution of $X+Y$.	BTL-4	Analyzing	CO2																					
4.(a)	The joint pdf a bivariate R.V(X, Y) is given by $f(x, y) = \begin{cases} Kxy, & 0 < x < 1, 0 < y < 1 \\ 0, & \text{otherwise} \end{cases}$ (1)Find K. (2) Find $P(X+Y<1)$. (3) Are X and Y independent R.V's.	BTL-3	Applying	CO2																					
4.(b)	The two dimensional random variable (X, Y) has the joint probability mass function $f(x, y) = \frac{x+2y}{27}$, $x = 0,1,2$; $y = 0,1,2$. Find the marginal distributions of X and Y. Also find the conditional distribution of Y given $X = 1$ also find the conditional distribution of X given $Y = 1$.	BTL -3	Applying	CO1																					
5.	From the following table for bivariate distribution of (X, Y). Find (i) $P(X \leq 1)$ (ii) $P(Y \leq 3)$ (iii) $P(X \leq 1, Y \leq 3)$ (iv) $P(X \leq 1/ Y \leq 3)$ (v) $P(Y \leq 3/ X \leq 1)$ (vi) $P(X + Y \leq 4)$ <table><tr><td>Y</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td></tr><tr><td>X</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>0</td><td>0</td><td>0</td><td>$\frac{1}{32}$</td><td>$\frac{2}{32}$</td><td>$\frac{2}{32}$</td><td>$\frac{3}{32}$</td></tr></table>	Y	1	2	3	4	5	6	X							0	0	0	$\frac{1}{32}$	$\frac{2}{32}$	$\frac{2}{32}$	$\frac{3}{32}$	BTL-3	Applying	CO2
Y	1	2	3	4	5	6																			
X																									
0	0	0	$\frac{1}{32}$	$\frac{2}{32}$	$\frac{2}{32}$	$\frac{3}{32}$																			

	1	$\frac{1}{16}$	$\frac{1}{16}$	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{8}$			
	2	$\frac{1}{32}$	$\frac{1}{32}$	$\frac{1}{64}$	$\frac{1}{64}$	0	$\frac{2}{64}$			
6.	Three balls are drawn at random without replacement from a box containing 2 white, 3 red and 4 blue balls. If X denotes the number of white balls drawn and Y denotes the number of red balls drawn, Find the probability distribution of X and Y.							BTL-3	Applying	CO2
7.	If the joint pdf of a two-dimensional RV(X,Y) is given by $f(x,y) = \begin{cases} x^2 + \frac{xy}{3}; & 0 < x < 1, 0 < y < 2 \\ 0, & \text{elsewhere} \end{cases}$ Find (i) $P\left(X > \frac{1}{2}\right)$ (ii) $P\left(Y < \frac{1}{2}, X < \frac{1}{2}\right)$ (iii) $P\left(Y < \frac{1}{2} / X < \frac{1}{2}\right)$							BTL-4	Analyzing	CO2
8.	The joint pdf of X and Y is given by $f(x,y) = \begin{cases} kx(x-y), & 0 < x < 2, -x < y < x \\ 0, & \text{otherwise} \end{cases}$ (i) Find K (ii) Find $f_x(x)$ and $f_y(y)$							BTL-2	Understanding	CO2
9.	Find the Coefficient of Correlation between industrial production and export using the following table							BTL-3	Applying	CO2
	Production (X)	14	17	23	21	25				
	Export (Y)	10	12	15	20	23				
10.	Find the correlation coefficient for the following heights of fathers X, their sons Y and also find the equations of regression lines. Hence find the height of son when the height of father is 71							BTL-3	Applying	CO2
	X	65	66	67	67	68	69	70	72	
	Y	67	68	65	68	72	72	69	71	
11.	Obtain the lines of regression							BTL-4	Analyzing	CO2
	X	50	55	50	60	65	65	65	60	60
	Y	11	14	13	16	16	15	15	14	13
12.	From the following data, Find (i) The two regression equations (ii) The coefficient of correlation between the marks in Mathematics and Statistics (iii) The most likely marks in Statistics when marks in Mathematics are 30 Marks in Maths: 25 28 35 32 31 36 29 38 34 32 Marks in Statistics: 43 46 49 41 36 32 31 30 33 39							BTL-4	Analyzing	CO2
13.	If $f(x,y) = \frac{6-x-y}{8}$, $0 \leq x \leq 2$, $2 \leq y \leq 4$ for a bivariate random variable (X,Y), Evaluate the correlation coefficient ρ .							BTL-4	Analyzing	CO2
14.(a).	The joint distribution of X and Y is given by $f(x,y) = \frac{x+y}{21}$, $x = 1, 2, 3$; $y = 1, 2$. Find the marginal distributions of X and Y.							BTL-4	Analyzing	CO2
14.(b)	The two regression lines are $4x-5y+33=0$ and $20x-9y=107$. Find the mean of X and Y. Also find the correlation coefficient between them							BTL-4	Analyzing	CO2
15.	Two random variables X and Y have the joint density function $f(x,y) = x+y$, $0 \leq x \leq 1$, $0 \leq y \leq 1$. Evaluate the Correlation coefficient between X and Y.							BTL-3	Applying	CO2

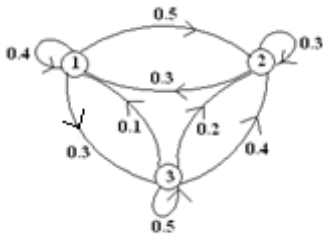
16.	Out of the two lines of regression given by $x + 2y - 5 = 0$ and $2x + 3y - 8 = 0$, which one is the regression line of X on Y? Analyze the equations to find the means of X and Y. If the variance of X is 12, find the variance of Y.	BTL-4	Analyzing	CO2
17.	If X, Y are RV's having the joint density function $f(x, y) = k(6 - x - y), 0 < x < 2, 2 < y < 4$, Find (i) $P(x < 1, y < 3)$ (ii) $P(x < 1 / y < 3)$ (iii) $P(y < 3 / x < 1)$ (iv) $P(X + Y < 3)$	BTL-3	Applying	CO2
18.	The joint pdf of a two dimensional random variable (X, Y) is given by $f(x, y) = xy^2 + \frac{x^2}{8}, 0 \leq x \leq 2, 0 \leq y \leq 1$. Compute (i) $P(X > 1 / Y < \frac{1}{2})$ (ii) $P(Y < \frac{1}{2} / X > 1)$ (iii) $P(X + Y) \leq 1$.	BTL-4	Analyzing	CO2

UNIT-3: RANDOM PROCESSES

Classification – Stationary random process – Markov process – Markov chain – Poisson process – Gaussian process – Auto correlation – Cross correlation

PART –A

Q.No.	Question	Bloom's Taxonomy Level	Competence	Course Outcome
1.	What are the four types of a stochastic process?	BTL-1	Remembering	CO3
2.	Define Discrete Random sequence with example.	BTL-1	Remembering	CO3
3.	Define Discrete Random Process with example.	BTL-1	Remembering	CO3
4.	Define Continuous Random sequence with example.	BTL-1	Remembering	CO3
5.	Define Continuous Random Process with example.	BTL-1	Remembering	CO3
6.	Define wide sense stationary process.	BTL-1	Remembering	CO3
7.	Define Strict Sense Stationary Process.	BTL-1	Remembering	CO3
8.	Define first order stationary Process	BTL-1	Understanding	CO3
9.	Define second order stationary Process	BTL-1	Understanding	CO3
10.	Define stationary process	BTL-1	Remembering	CO3
11.	Define Markov Process	BTL-1	Remembering	CO3
12.	Show that the random process $X(t) = A \cos(\omega_c t + \theta)$ is not stationary if it is assumed that A and ω_c are constants and θ is a uniformly distributed variable on the interval $(0, \pi)$.	BTL-2	Understanding	CO3
13.	A random process $X(t) = A \sin t + B \cos t$ where A and B are independent random variables with zero means and equal standard deviations. Find the mean of the process.	BTL-2	Understanding	CO3
14.	Consider the random process $X(t) = \cos(t + \phi)$, where ϕ is uniform random variable in $(-\pi/2, \pi/2)$. Check whether the process is stationary.	BTL-2	Understanding	CO3
15.	Consider the random process $X(t) = \cos(\omega_0 t + \theta)$, where θ is uniform random variable in $(-\pi, \pi)$. Check whether the process is stationary or not	BTL-2	Understanding	CO3
16.	Define Poisson process.	BTL-1	Remembering	CO3
17.	State and two properties of Poisson process.	BTL-1	Remembering	CO3
18.	Compute the mean value of the random process whose auto correlation function is given by $R_{XX}(\tau) = 25 + \frac{4}{1+6\tau^2}$.	BTL-2	Understanding	CO3

19.	A random process has the autocorrelation function $R_{xx}(\tau) = \frac{4\tau^2+6}{\tau^2+1}$, find the mean square value of the problem.	BTL-2	Understanding	CO3
20.	Define Markov chain	BTL-1	Remembering	CO3
21.	State Chapman- Kolmogorov theorem	BTL-1	Remembering	CO3
22.	Consider the Markov chain with 2 states and transition probability matrix $P = \begin{bmatrix} \frac{3}{4} & \frac{1}{4} \\ \frac{1}{2} & \frac{1}{2} \end{bmatrix}$. Find the stationary probabilities of the chain.	BTL-2	Understanding	CO3
23.	The one-step transition probability matrix of a Markov chain with states (0,1) is given by $P = \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}$. Evaluate whether it is irreducible Markov chain?	BTL-2	Understanding	CO3
24.	Obtain the transition matrix of the following transition diagram. 	BTL-2	Understanding	CO3
25.	Check whether the Markov chain with transition probability matrix $P = \begin{bmatrix} 0 & 1 & 0 \\ 1/2 & 0 & 1/2 \\ 0 & 1 & 0 \end{bmatrix}$ is irreducible or not?	BTL-2	Understanding	CO3

PART-B

1.	The process $\{X(t)\}$ whose probability distribution under certain conditions is given by $P\{X(t) = n\} = \begin{cases} \frac{(at)^{n-1}}{(1+at)^{n+1}}, & n = 1, 2 \\ \frac{at}{(1+at)}, & n = 0 \end{cases}$ Show that it is not stationary.	BTL-3	Applying	CO3
2.(a)	Show that the random process $X(t) = A \sin(\omega t + \theta)$ is wide-sense stationary process where A and ω are constants and θ is uniformly distributed in $(0, 2\pi)$.	BTL-3	Applying	CO3
2.(b)	Find the mean and autocorrelation of the Poisson processes	BTL-4	Analyzing	CO3
3.(a)	Given that the random process $X(t) = \cos(t + \varphi)$ where φ is a random variable with density function $f(x) = \frac{1}{\pi}, -\frac{\pi}{2} < \varphi < \frac{\pi}{2}$. Discuss whether the process is stationary or not	BTL-3	Applying	CO3
3.(b)	A student's study habits are as follows: If he studies one night, he is 70% sure not to study next night. On the other hand, if he does not study one night, he is 60% sure not to study the next nights as well. In the long run how often does he study?	BTL-3	Applying	CO3

4.(a)	Consider a random process $X(t) = B \cos(50t + \Phi)$ where B and Φ are independent random variables. B is a random variable with mean 0 and variance 1. Φ is uniformly distributed in the interval $[-\pi, \pi]$. Determine the mean and auto correlation of the process.	BTL-3	Applying	CO3
4.(b)	Prove that the difference of two independent Poisson process is not a Poisson process.	BTL-3	Applying	CO3
5.(a)	Show that the random process $X(t) = A \cos(\omega t + \theta)$ is wide sense stationary, if A and ω are constant and θ is a uniformly distributed random variable in $(0, 2\pi)$.	BTL3	Applying	CO3
5.(b)	Show that the Random Process $X(t) = A \sin(\omega t + \phi)$, where A and ω are constants, ϕ is a Random variable uniformly distributed in $(0, 2\pi)$. Find the autocorrelation function of the process.	BTL4	Analyzing	CO3
6.(a)	Show that the random process $X(t) = A \cos(\omega t + \theta)$ is not stationary if A and ω are constants and θ is uniformly distributed random variable in $(0, \pi)$.	BTL-3	Applying	CO3
6.(b)	Prove that the inter arrival time of the Poisson process follows exponential distribution	BTL-3	Applying	CO3
7.	Show that the random process $X(t) = A \cos \omega t + B \sin \omega t$ is wide sense stationary process if A and B are random variables such that $E(A) = E(B) = 0, E(A^2) = E(B^2)$ and $E(AB) = 0$	BTL-3	Applying	CO3
8.	A salesman's territory consists of three regions A, B, C. He never sells in the same region on successive days. If he sells in region A, then the next day he sells in B. However, if he sells either B or C, then the next day he is twice as likely to sell in A as in the other region. Explain How often does he sell in each of the regions in the steady state?	BTL-3	Applying	CO3
9.(a)	If the process $X(t) = P + Qt$, where P and Q are independent random variables with $E(P) = p, E(Q) = q, Var(P) = \sigma_1^2, Var(Q) = \sigma_2^2$, find $E(X(t)), R(t_1, t_2)$. Is the process $\{X(t)\}$ stationary?	BTL-3	Applying	CO3
9.(b)	The probability of a dry day following a rainy day is 1/3 and that the probability of a rainy day following a dry day is 1/2. Given that May 1 st is a dry day. Obtain the probability that May 3 rd is a dry day also May 5 th is a dry day.	BTL-3	Applying	CO3
10.(a)	Suppose that customers arrive at a bank according to a Poisson process with a mean rate of per minute; Discuss the probability that during a time interval of 2 minutes (a) exactly 4 customers arrive, and (b) more than 4 customers arrive.	BTL-4	Analyzing	CO3
10.(b)	If customers arrive at a counter in accordance with a Poisson process with a mean rate of 2 per minute, Evaluate the probability that the interval between 2 consecutive arrivals is (a) more than 1 minute, (b) between 1 minute and 2 minutes and (c) 4 minutes or less	BTL-4	Analyzing	CO3
11.	Consider the random process $Y(t) = X(t) \cos(\omega_0 t + \theta)$, where $X(t)$ is wide sense stationary process, θ is a Uniformly distributed	BTL-3	Applying	CO3

	R.V. over $(-\pi, \pi)$ and ω_0 is a constant. It is assumed that $X(t)$ and θ are independent. Show that $Y(t)$ is a wide sense stationary			
12.	The transition probability matrix of a Markov chain $\{X_n\}$, $n = 1, 2, 3, \dots$ having 3 states 1, 2 and 3 is $P = \begin{bmatrix} 0.1 & 0.5 & 0.4 \\ 0.6 & 0.2 & 0.2 \\ 0.3 & 0.4 & 0.3 \end{bmatrix}$ and the initial distribution is $P(0) = (0.7, 0.2, 0.1)$. Evaluate i) $P(X_2 = 3)$ ii) $P(X_3 = 2, X_2 = 3, X_1 = 3, X_0 = 2)$	BTL-3	Applying	CO3
13.	Consider the Markov chain $\{X_n, n = 0, 1, 2, 3, \dots\}$ having 3 states space $S = \{1, 2, 3\}$ and one step TPM $P = \begin{bmatrix} 0 & 1 & 0 \\ 1/2 & 0 & 1/2 \\ 0 & 1 & 0 \end{bmatrix}$ and initial probability distribution $P(X_0 = i) = 1/3, i = 1, 2, 3$. Compute (1) $P(X_3 = 2, X_2 = 1, X_1 = 2, X_0 = 1)$ (2) $P(X_3 = 2, X_2 = 1, X_1 = 2, X_0 = 1)$ (3) $P(X_2 = 2/X_0 = 2)$ (4) Invariant Probabilities of the Markov Chain.	BTL-3	Applying	CO3
14.	A man either drives a car or catches a train to go to office each day. He never goes 2 days in a row by train but if he drives one day, then the next day he is just as likely to drive again as he is to travel by train. Now suppose that on the first day of the week, the man tossed a fair die and drove to work if and only if 6 appeared. Find (i) the probability that he takes a train on the third day (ii) the probability that he drives to work in the long run	BTL-3	Applying	CO3
15.	Three boys A, B and C are throwing a ball to each other. A always throws the ball to B and B always throws the ball to C but C is just as likely to throw the ball to B as to A. Show that the process is Markovian. Find the transition probability matrix and classify the states	BTL-4	Analyzing	CO3
16.	Consider a Markov chain $\{X_n, n = 0, 1, 2, \dots\}$ having states space $S = \{1, 2\}$ and one step TPM $P = \begin{bmatrix} 4/10 & 6/10 \\ 8/10 & 2/10 \end{bmatrix}$. (1) Draw a transition diagram, (2) Is the chain irreducible? (3) Is the state -1 ergodic? Explain. (4) Is the chain ergodic? Explain	BTL-4	Analyzing	CO3
17.	Classify the states of the Markov chain for the one-step transition probability matrix $P = \begin{pmatrix} 0 & 1 & 0 \\ 1/2 & 0 & 1/2 \\ 0 & 1 & 0 \end{pmatrix}$ with state space $S = \{1, 2, 3\}$	BTL-4	Analyzing	CO3

18.	Consider a Markov chain on (0, 1, 2) having the transition matrix given by $P = \begin{pmatrix} 0 & 0 & 1 \\ 1 & 0 & 0 \\ \frac{1}{2} & \frac{1}{2} & 0 \end{pmatrix}$. Show that the chain is irreducible. Find the steady state distribution.	BTL-4	Analyzing	CO3
UNIT-4: QUEUEING THEORY Markovian queues – Single and multi-server models – (M/M/1: ∞ /FIFO) and (M/M/s: ∞ /FIFO) – Little's formula.				
1.	State the characteristics of a Queueing model.	BTL -1	Remembering	CO 4
2.	Write Kendall's notation for Queueing Model.	BTL -1	Remembering	CO 4
3.	What are the service disciplines available in the queueing model?	BTL -2	Understanding	CO 4
4.	Classify the types of Queue.	BTL -2	Understanding	CO 4
5.	For (M/M/1): (∞ /FIFO) model, Write the Little's formula.	BTL -2	Understanding	CO 4
6	Find the probability of at least 10 customers in the system for (M/M/1):(∞ /FIFO) queue system, if $\lambda=6$ per hour and $\mu= 8$ per hour?	BTL -1	Remembering	CO 4
7.	For a (M/M/1): (∞ /FIFO) queue system, if $\lambda=4$ per hour and $\mu=6$ per hour, find the average queue length.	BTL -1	Remembering	CO 4
8	If the inter arrival time and service time in a public telephone booth with a single phone follow exponential distribution with means of 10 and 8 minutes respectively. Find the average number of callers in the booth at any time.	BTL -2	Understanding	CO 4
9.	What is consumer behavior?	BTL -1	Remembering	CO 4
10	Define steady state and transient state queueing systems	BTL -1	Remembering	CO 4
11.	A drive in banking service is modeled as an M/M/1 queueing system with customer arrival rate of 2 per minute. It is desired to have fewer than 5 customers line up 99 percent of the time. How fast should the service rate be?	BTL -4	Analyzing	CO 4
12.	For a (M/M/1): (∞ /FIFO) queue system, if $\lambda=4$ per hour and $\mu=6$ per hour, find the average waiting time in the queue.	BTL -1	Remembering	CO 4
13.	In a bank, 20 customers on an average are served by a cashier in an hour. If the service time has exponential distribution, what is the probability that it will take more than 10 minutes to serve a customer?	BTL -1	Remembering	CO 4
14.	In a 3 server infinite capacity Poisson queue model if $\frac{\lambda}{\mu C} = \frac{2}{3}$ Calculate P_0 .	BTL -2	Understanding	CO 4
15.	Write down the difference equations that give the probability that there are n customers in a Poisson queueing system in steady-state	BTL -2	Understanding	CO 4
16.	Write down the formula for P_0 and P_n in a Poisson queue system in the steady- state	BTL -1	Remembering	CO 4
17.	Give the formula for average number of customers in the system and in the queue for (M/ M/ 1): (∞ : FIFO) model	BTL -1	Remembering	CO 4

18.	Give the formula for average waiting time of customers in the system and in the queue for $(M/M/1):(\infty:FIFO)$ model	BTL -1	Remembering	CO 4
19.	Give the formula for average number of customers in the system and in the queue for $(M/M/s):(\infty:FIFO)$ model	BTL -1	Remembering	CO 4
20.	Give the formula for average waiting time of customers in the system and in the queue for $(M/M/s):(\infty:FIFO)$ model	BTL -1	Remembering	CO 4
21.	In the usual notation of a $(M/M/1):(\infty:FIFO)$ queueing model if $\lambda=12$ per hour and $\mu=24$ per hour, find the average number of customers in the system and in the queue	BTL -2	Understanding	CO 4
22.	In the usual notation of a $(M/M/1):(\infty:FIFO)$ queueing model if $\lambda=12$ per hour and $\mu=24$ per hour, find the average waiting time of customers in the system and in the queue	BTL -2	Understanding	CO 4
23.	In the usual notation of a $(M/M/1):(\infty:FIFO)$ queueing model if $\lambda=12$ per hour and $\mu=30$ per hour, find $P(N > 2)$	BTL -2	Understanding	CO 4
24.	In a 3 server infinite capacity Poisson queue model if $\frac{\lambda}{s\mu} = \frac{2}{3}$ find P_0	BTL -2	Understanding	CO 4
25.	Write down the formula for P_n for $(M/M/s):(\infty:FIFO)$ model in terms of P_0	BTL -1	Remembering	CO 4

PART- B

1.	In a Public telephone booth the arrivals are on the Average 15 per hour. A call on the average takes 3 minutes. If there is just one phone, find expected number of callers in the booth at any time and the proportion of the time the booth is expected to be idle?	BTL -3	Applying	CO 4
2.	Cars arrive at a petrol pump, having one petrol unit, in Poisson fashion with an average of 10 cars per hour. The service time is distributed exponentially with a mean of 3 minutes. Find the following (i) Predict Average number of cars in the system and Average waiting time in the queue (ii) Average queue length and the probability that the number of cars in the system is	BTL -3	Applying	CO 4
3.	A T.V repairman finds that the time spent on his job has an exponential distribution with mean 30 minutes. If he repairs sets in the order in which they came in and if the arrival of sets is Poisson with an average rate of 10 per 8 hour day, how will you calculate the expected idle time day? How much is the queue length and how many TV sets would be in the shop?	BTL -4	Analyzing	CO 4
4.	In a Super market, the average arrival rate of customer is 10 in every 30 minutes following Poisson process. The average time taken by the cashier to list and calculate the customer's purchases is 2.5 minutes, following exponential distribution. What is the probability that the queue length exceeds 6?	BTL -4	Analyzing	CO 4

5.	Customers arrive at a one-man barber shop according to a Poisson with a mean inter arrival time of 20 min Customers spend an average of 15 min in the barber's chair 1. What is the expected number of customers in the barber shop? 2. What is the expected number of customers in the Queue? 3. What is the probability that a customer will not have to wait for a haircut? 4. How much can a customer expect to spend in the barbershop? 5. What are the average time customers spend in the queue?	BTL -3	Applying	CO 4
6.	In a given M / M / 1 queueing system, the average arrivals is 4 customers per minute, $\rho = 0.7$. Find the (i) Mean number of customers L_s in the system (ii) Mean number of customers L_q in the queue (iii) The probability that the server is idle (iv) Mean waiting time W_s in the system (v) Mean waiting time W_q in the queue	BTL -3	Applying	CO 4
7.	There are three typists in an office. Each typist can type an average of 6 Letters per hour .If letters arrive for being typed at the rate of 15 letters per hour, Analyze the following a) What fraction of the time all the typists will be busy? b) What is the average number of letters waiting to be typed? c) What is the average time a letter has to spend for waiting and for being typed? d) What is the probability that a letter will take longer than 20 min waiting to be typed?	BTL -3	Applying	CO 4
8.	A supermarket has two girls attending to sales at the counters. If the service time for each customer is exponential with mean 4 min and if people arrive in Poisson fashion at the rate of 10 per hour a) What is the probability that a customer has to wait for service? b) What is the expected percentage of idle time for each girl? c) If the customer has to wait in the queue, what is the expected length of the waiting time?	BTL -3	Applying	CO 4
9.	On average 96 patients per (24 hour) day require the service of an emergency clinic. Also an average a patient requires 10 minutes of active attention. Assume that the facility can handle only one emergency at a time. Suppose that it costs the clinic Rs.100 per patient treated to obtain an average service time of 10 minutes, and that each minute of decrease in this average time would cost Rs .10 per patient treated .How much would have to be budgeted by the clinic to decrease the average size of the queue from $1\frac{1}{3}$ patients to $\frac{1}{2}$ patient?	BTL -4	Analyzing	CO 4

10.	Customers arrive at a watch repair shop according to a Poisson process at a rate of one per every 10 minutes, and the service time is exponential random variable with 8 minutes a) Find the average number of customers L_s in the shop . b) Find the average number of customers L_q in the queue. c) Find the average time a customer spends in the system in the shop W_s. d) What is the probability that the server is idle ?	BTL -4	Analyzing	CO 4
11.	A supermarket has two girls attending to sales at the counters. If the service time for each customer is exponential with mean 4 min and if people arrive in Poisson fashion at the rate of 10 per hour a) What is the probability that a customer has to wait for service? b) What is the expected percentage of idle time for each girl? c) If the customer has to wait in the queue, what is the expected length of the waiting time?	BTL -4	Analyzing	CO 4
12.	A repairman is to be hired to repair machines which breakdown at the average rate of 3 per hour the breakdown follow Poisson distribution. Non –productive time of machine is considered to cost Rs 16/hour. Two repair men have been interviewed. One is slow but cheap while the other is fast and expensive. The slow repairman charges Rs.8 per hour and he services at the rate of 4 per hour The fast repairman demands Rs .10 per hour and services at the average rate 6 per hour. Which repairman should be hired?	BTL -4	Analyzing	CO 4
13.	A petrol pump station has 2 pumps. The service times follow the exponential distribution with a mean of 4 minutes and cars arrive for service in a Poisson process at the rate of 10 cars per hour. Find the probability that a customer has to wait for service. What proportion of time the pumps remain idle?	BTL -3	Applying	CO 4
14.	A telephone company is planning to install telephone booths in a new airport It has established the policy that a person should not have to wait more than 10 % of the times he tries to use a phone. The demand for use is estimated to be Poisson with an average of 30 per hour. The average phone call has an exponential distribution with a mean time of 5 min. how many phone should be installed?	BTL -3	Applying	CO 4
15.	Arrivals at a telephone booth are considered to be a Poisson with an average time of 10 minutes between one arrival and the next. The length of a phone call is assumed to be distributed exponentially with mean 3 minutes (i) Find the average number of persons waiting in the system (ii) What is the probability that a person arriving at the booth will have to wait in the queue? (iii) What is the probability that it will take him more than 10 minutes altogether to wait for phone and complete his call ?	BTL -4	Analyzing	CO 4

	(iv) Estimate the fraction of the day when the phone will be in use			
16.	If a customer arrive for service according to a Poisson distribution at the rate of 5 per day, how fast they must be serviced on the average (assume exponential service time) in order to keep the average number of customers in the system is less than 4 ?	BTL -3	Applying	CO 4
17.	A service station expects a customer every minutes on the average. Service takes, on the average, 3 minutes. Assume Poisson input and exponential service. (i) What is the average number of customers waiting for service? (ii) How long can a customer expect to wait for service (iii) What is the probability that a customer will spend less than 15 minutes waiting for and getting service? (iv) What is the probability that a customer will spend longer than 10 minutes waiting for and getting service	BTL -3	Applying	CO 4
18.	A dress shop has 3 sales persons. Assume that arrivals follow Poisson pattern with an average of 10 minutes between arrivals. Also assume that any salesperson can provide desired service for any customer. If the time to provide service for a customer is exponentially distributed with a mean of 20 minutes per customer, calculate $E(N)$, $E(N_q)$, $E(W)$ $E(W_q)$ and P_n for $n=0,1,2$.	BTL -4	Analyzing	CO 4

UNIT-5: LINEAR PROGRAMMING

Formulation – Graphical solution – Simplex method – Transportation problems – Assignment models

1.	Discuss the Linear programming problem	BTL -1	Remembering	CO 5
2.	What are the assumptions and requirements of LPP?	BTL -1	Remembering	CO 5
3.	Define Basic Feasible Solution	BTL -2	Understanding	CO 5
4.	Define optimum basic feasible solution	BTL -1	Remembering	CO 5
5.	What is the difference between feasible solution and basic feasible solution?	BTL -2	Understanding	CO 5
6.	What is degenerate solution?	BTL -2	Understanding	CO 5
7.	Compare graphical and simplex methods for solving LPP	BTL -2	Understanding	CO 5
8.	Apply graphical method to find the feasible region of the following LPP Minimize $Z = 6000x_1 + 4000x_2$ Subject to $3x_1 + x_2 \geq 40$ $x_1 + 2.5x_2 \geq 22$ $3x_1 + 3x_2 \geq 40, x_1, x_2 \geq 0$	BTL -2	Understanding	CO 5

9.	Write the standard form of the given LPP Maximize $Z = 6x_1 + 7x_2$ subject to $2x_1 + 3x_2 \leq 12, 2x_1 + x_2 \leq 8$	BTL -2	Understanding	CO 5																														
10	A factory manufactures nails and screws. The profit earned is Rs.2/kg nails and Rs.3/kg screws. Three units of labors are required to manufacture 1 kg nails and 6 units to make 1 kg screws. Twenty four units of labor are available. Two units of raw materials are needed to make 1kg nails and 1 unit for 1 kg screws. Formulate the problem as an LP model which yields maximum profit from 10 units of raw materials.	BTL -2	Understanding	CO 5																														
11.	Formulate the LPP for the following problem. The standard weight of a special purpose brick is 5 kg and it contains 2 ingredients B1and B2, B1 cost Rs.5. per kg and B2 cost Rs.8 per kg. Strength considerations dictate that the brick contains not more than 4 kg of B1 and a minimum of 2 kg of B2. Since the demand for the product is likely to be related to the price of the brick.	BTL -2	Understanding	CO 5																														
12.	Egg contains 6 units of vitamin A and 7 units of vitamin B per gram and costs 12 paise per gram. Milk contains 8 unit of vitamin A and 12 units of vitamin B per gram and cost 20 paise per gram. The daily minimum requirement of vitamin A and vitamin B are 100 units and 120 units respectively. Formulate the above as the Linear programming problem.	BTL -2	Understanding	CO 5																														
13	Sketch the feasible region for the following L.P.P by using graphical method Maximize $Z = 5x_1 + 3x_2$, Subject to $3x_1 + 5x_2 \leq 15, 5x_1 + 2x_2 \leq 10, x_1, x_2 \geq 0$	BTL -2	Understanding	CO 5																														
14.	What are the methods available to find the initial solution for transportation problem	BTL -2	Understanding	CO 5																														
15	Define Transportation problem.	BTL -1	Remembering	CO 5																														
16.	Write down the working procedure of North West Corner rule for solving transportation problem?	BTL -2	Understanding	CO 5																														
17	Write down the working procedure of Least Cost Method for solving transportation problem?	BTL -2	Understanding	CO 5																														
18.	Write down the Mathematical Formulation of Transportation Problem.	BTL -1	Remembering	CO 5																														
19.	Evaluate the initial basic feasible solution of a transportation problem using North West Corner <table><tr><td>Origin/Destination</td><td>D_1</td><td>D_2</td><td>D_3</td><td>Supply</td></tr><tr><td>O_1</td><td>2</td><td>7</td><td>4</td><td>5</td></tr><tr><td>O_2</td><td>3</td><td>3</td><td>1</td><td>8</td></tr><tr><td>O_3</td><td>5</td><td>4</td><td>7</td><td>7</td></tr><tr><td>O_4</td><td>1</td><td>6</td><td>2</td><td>14</td></tr><tr><td>Demand</td><td>7</td><td>9</td><td>18</td><td>34</td></tr></table>	Origin/Destination	D_1	D_2	D_3	Supply	O_1	2	7	4	5	O_2	3	3	1	8	O_3	5	4	7	7	O_4	1	6	2	14	Demand	7	9	18	34	BTL -2	Understanding	CO 5
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20	Construct the basic feasible solution for the following transportation problem. <table><tr><td></td><td>1</td><td>2</td><td>3</td><td>4</td><td>SUPPLY</td></tr></table>		1	2	3	4	SUPPLY	BTL -2	Understanding	CO 5																								
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2	1	0	6	1	1																							
3	5	8	15	9	10																							
DEMAND	7	5	3	2																								
21.	Write down the Mathematical formulation for Assignment Problem.	BTL -1	Remembering	CO 5																								
22.	Explain how the profit maximization transportation problem can be converted to an equivalent cost minimization transportation problem.	BTL -1	Remembering	CO 5																								
23.	Compare Assignment and transportation Problem.	BTL -1	Remembering	CO 5																								
24.	What do you mean by Travelling Salesman Problem?	BTL -1	Remembering	CO 5																								
25.	Compare Assignment Problem and Travelling Salesman Problem?	BTL -1	Remembering	CO 5																								
PART –B																												
1.	Maximize: $Z = 3x + 4y$ Subject to $2x + 5y \leq 60$, $4x + 2y \leq 40$, $x, y > 0$. Solve by Graphical Method (i) Plot the graph (ii) Obtain the optimal solution	BTL -3	Applying	CO 5																								
2.	Minimize: $Z = 20x_1 + 10x_2$ Subject to $x_1 + 2x_2 \leq 40$, $3x_1 + x_2 \geq 30$, $4x_1 + 3x_2 \geq 60$, $x_1, x_2 \geq 0$. (i) Plot the graph Predict the value of x_1 & x_2 that optimizes the objective function	BTL -2	Understanding	CO 5																								
3.	Solve the following LPP by graphical method. Maximize $Z = 3x_1 + 5x_2$ Subject to $-3x_1 + 4x_2 \leq 12$ $x_1 \leq 4$ $2x_1 - x_2 \leq -2$ $2x_1 + 3x_2 \geq 12$ $x_1, x_2 \geq 0$	BTL -2	Understanding	CO 5																								
4.	Analyze the maximum value of $Z = 5x_1 + 7x_2$ Subject to $x_1 + x_2 \leq 4$ $3x_1 + 8x_2 \leq 24$ $10x_1 + 7x_2 \leq 35$ $x_1, x_2 \geq 0$ By Graphical method	BTL -2	Understanding	CO 5																								

5.	Maximize $Z = 6x_1 + 8x_2$ Subject to $5x_1 + 10x_2 \leq 60$ $4x_1 + 4x_2 \leq 40$ $x_1, x_2 \geq 0$ (i) Develop a Simplex Table (ii) Analyze and find the value of x_1 and x_2 .	BTL -4	Analyzing	CO 5																																																	
6.	Solve the following LPP using Simplex method <i>Maximize</i> $Z = 10x_1 + 15x_2 + 20x_3$ Subject to $2x_1 + 4x_2 + 6x_3 \leq 24$ $3x_1 + 9x_2 + 6x_3 \leq 30$ $x_1, x_2, x_3 \geq 0$	BTL -4	Analyzing	CO 5																																																	
7.	Analyze the following LPP and solve by Simplex Method: Maximize $Z = 3x_1 + 2x_2$ Subject to $x_1 + x_2 \leq 4$ $x_1 - x_2 \leq 2$ $x_1, x_2 \geq 0$	BTL -4	Analyzing	CO 5																																																	
8.	Apply the simplex algorithm to solve the following LPP Maximize $Z = x_1 + x_2 + 3x_3$ Subject to $3x_1 + 2x_2 + x_3 \leq 3$ $2x_1 + x_2 + 2x_3 \leq 2$ $x_1, x_2, x_3 \geq 0$	BTL -3	Applying	CO5																																																	
9.	Consider the linear programming model given below and solve it using the simplex method Maximize $Z = 3x_1 + 2x_2 + 5x_3$ Subject to $x_1 + 2x_2 + x_3 \leq 430$ $3x_1 + 2x_3 \leq 460$ $x_1 + 4x_2 \leq 420$ $x_1, x_2, x_3 \geq 0$ (i) Evaluate the simplex table (ii) Analyze the optimal solution	BTL -4	Analyzing	CO5																																																	
10.	Consider the transportation problem shown below <table><tr><td></td><td colspan="5">Market</td><td></td></tr><tr><td>Plant</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>Supply</td></tr><tr><td>1</td><td>10</td><td>2</td><td>16</td><td>14</td><td>10</td><td>300</td></tr><tr><td>2</td><td>6</td><td>18</td><td>12</td><td>13</td><td>16</td><td>500</td></tr><tr><td>3</td><td>8</td><td>4</td><td>14</td><td>12</td><td>10</td><td>825</td></tr><tr><td>4</td><td>14</td><td>22</td><td>20</td><td>8</td><td>18</td><td>375</td></tr><tr><td>Demand</td><td>350</td><td>400</td><td>250</td><td>150</td><td>400</td><td></td></tr></table> Find the initial basic feasible solution using each of the following methods and compare their total costs (a) North west corner method (b) Least cost cell method (c) Vogel's approximation method		Market						Plant	1	2	3	4	5	Supply	1	10	2	16	14	10	300	2	6	18	12	13	16	500	3	8	4	14	12	10	825	4	14	22	20	8	18	375	Demand	350	400	250	150	400		BTL -3	Applying	CO5
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Demand	350	400	250	150	400																																																

11.	Find the feasible solution for the following Transportation Problem by north west corner method, least cost method and Vogel's approximation method. <table><tr><td></td><td colspan="4">Destination</td><td>Supply</td></tr><tr><td></td><td>1</td><td>2</td><td>3</td><td>4</td><td></td></tr><tr><td>I</td><td>21</td><td>16</td><td>25</td><td>13</td><td>11</td></tr><tr><td>II</td><td>17</td><td>18</td><td>14</td><td>23</td><td>13</td></tr><tr><td>III</td><td>32</td><td>27</td><td>18</td><td>41</td><td>19</td></tr><tr><td>Demand</td><td>6</td><td>10</td><td>12</td><td>15</td><td></td></tr></table>		Destination				Supply		1	2	3	4		I	21	16	25	13	11	II	17	18	14	23	13	III	32	27	18	41	19	Demand	6	10	12	15		BTL -3	Applying	CO5						
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Demand	6	10	12	15																																										
12.	Find the Initial Basic Feasible solution for following TP. Using NW Rule, LCM, and VAM. Which method will you select if you want to Minimize Cost? <table><tr><td></td><td>D1</td><td>D2</td><td>D3</td><td>Supply</td></tr><tr><td>S1</td><td>7</td><td>3</td><td>2</td><td>2</td></tr><tr><td>S2</td><td>2</td><td>1</td><td>3</td><td>3</td></tr><tr><td>S3</td><td>3</td><td>4</td><td>6</td><td>5</td></tr><tr><td>Demand</td><td>4</td><td>1</td><td>5</td><td>10</td></tr></table>		D1	D2	D3	Supply	S1	7	3	2	2	S2	2	1	3	3	S3	3	4	6	5	Demand	4	1	5	10	BTL -3	Applying	CO5																	
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Demand	4	1	5	10																																										
13.	Solve the following transportation problem <table><tr><td>1</td><td>2</td><td>6</td><td>7</td></tr><tr><td>0</td><td>4</td><td>2</td><td>12</td></tr><tr><td>3</td><td>1</td><td>5</td><td>11</td></tr><tr><td>10</td><td>10</td><td>10</td><td>30</td></tr></table>	1	2	6	7	0	4	2	12	3	1	5	11	10	10	10	30	BTL -3	Applying	CO5																										
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14.	A batch of 4 jobs can be assigned to 5 different machines. The set up time (in hours) for each job on various machines is given below. <table><tr><td colspan="2"></td><td colspan="5">Machines</td></tr><tr><td>JOB ↓</td><td></td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr><tr><td>1</td><td></td><td>10</td><td>11</td><td>4</td><td>2</td><td>8</td></tr><tr><td>2</td><td></td><td>7</td><td>11</td><td>10</td><td>14</td><td>12</td></tr><tr><td>3</td><td></td><td>5</td><td>6</td><td>9</td><td>12</td><td>14</td></tr><tr><td>4</td><td></td><td>13</td><td>15</td><td>11</td><td>10</td><td>7</td></tr></table>			Machines					JOB ↓		1	2	3	4	5	1		10	11	4	2	8	2		7	11	10	14	12	3		5	6	9	12	14	4		13	15	11	10	7	BTL -3	Applying	CO5
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4		13	15	11	10	7																																								
15.	A company has one surplus truck in each of the cities A, B, C, D, & E and one deficit trucks in each of the cities 1, 2, 3,4,5,6. The distance between the cities in kms is shown in the matrix below. Can you select the assignment of trucks from cities in surplus to cities in deficiency .so that total distance covered by the vehicles is minimum? <table><tr><td></td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td></tr><tr><td>A</td><td>12</td><td>10</td><td>15</td><td>22</td><td>18</td><td>8</td></tr></table>		1	2	3	4	5	6	A	12	10	15	22	18	8	BTL -3	Applying	CO5																												
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	<table><tr><td>B</td><td>10</td><td>18</td><td>25</td><td>15</td><td>16</td><td>12</td></tr><tr><td>C</td><td>11</td><td>10</td><td>3</td><td>8</td><td>5</td><td>9</td></tr><tr><td>D</td><td>6</td><td>4</td><td>10</td><td>13</td><td>13</td><td>12</td></tr><tr><td>E</td><td>8</td><td>12</td><td>11</td><td>7</td><td>13</td><td>10</td></tr></table>	B	10	18	25	15	16	12	C	11	10	3	8	5	9	D	6	4	10	13	13	12	E	8	12	11	7	13	10																	
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16.	The assignment cost of assigning any one operator to any one machine is given in the following table. <table><tr><td>MACHINE↓</td><td colspan="4">OPERATORS →</td></tr><tr><td></td><td>I</td><td>II</td><td>III</td><td>IV</td></tr><tr><td>A</td><td>10</td><td>5</td><td>13</td><td>15</td></tr><tr><td>B</td><td>3</td><td>9</td><td>18</td><td>3</td></tr><tr><td>C</td><td>10</td><td>7</td><td>3</td><td>2</td></tr><tr><td>D</td><td>5</td><td>11</td><td>9</td><td>7</td></tr></table> Find the optimal assignment by Hungarian method.	MACHINE↓	OPERATORS →					I	II	III	IV	A	10	5	13	15	B	3	9	18	3	C	10	7	3	2	D	5	11	9	7	BTL -4	Analyzing	CO5												
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17.	Solve the following travelling salesman problem so as to minimize the cost per cycle. <table><tr><td>FROM↓</td><td colspan="5">TO →</td></tr><tr><td></td><td>A</td><td>B</td><td>C</td><td>D</td><td>E</td></tr><tr><td>A</td><td>-</td><td>3</td><td>6</td><td>2</td><td>3</td></tr><tr><td>B</td><td>3</td><td>-</td><td>5</td><td>2</td><td>3</td></tr><tr><td>C</td><td>6</td><td>5</td><td>-</td><td>6</td><td>4</td></tr><tr><td>D</td><td>2</td><td>2</td><td>6</td><td>-</td><td>6</td></tr><tr><td>E</td><td>3</td><td>3</td><td>4</td><td>6</td><td>-</td></tr></table>	FROM↓	TO →						A	B	C	D	E	A	-	3	6	2	3	B	3	-	5	2	3	C	6	5	-	6	4	D	2	2	6	-	6	E	3	3	4	6	-	BTL -3	Applying	CO5
FROM↓	TO →																																													
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C	6	5	-	6	4																																									
D	2	2	6	-	6																																									
E	3	3	4	6	-																																									
18.	A travelling salesman has to visit 5 cities. He wishes to start from a particular city visit each city once and then return to his starting point, cost of going from one city to another is shown below. Point out the least cost route <table><tr><td></td><td>A</td><td>B</td><td>C</td><td>D</td><td>E</td></tr><tr><td>A</td><td>∞</td><td>4</td><td>10</td><td>14</td><td>2</td></tr><tr><td>B</td><td>12</td><td>∞</td><td>6</td><td>10</td><td>4</td></tr><tr><td>C</td><td>16</td><td>14</td><td>∞</td><td>8</td><td>14</td></tr><tr><td>D</td><td>24</td><td>8</td><td>12</td><td>∞</td><td>10</td></tr><tr><td>E</td><td>2</td><td>6</td><td>4</td><td>16</td><td>∞</td></tr></table>		A	B	C	D	E	A	∞	4	10	14	2	B	12	∞	6	10	4	C	16	14	∞	8	14	D	24	8	12	∞	10	E	2	6	4	16	∞	BTL -3	Applying	CO5						
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