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B.E./B.Tech. DEGREE EXAMINATIONS, APRIL/MAY 2026.

Third Semester

Electronics Engineering (VLSI Design and Technology)

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MA3355 — RANDOM PROCESSES AND LINEAR ALGEBRA

(Common to : Electronics and Communication Engineering/Electronics and Telecommunication Engineering)

(Regulations 2021)

Time : Three hours Maximum : 100 marks

(Normal tables to be permitted)

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Write the probability generating function of a Poisson distribution and hence obtain its mean.

2. For each scenario described below state whether or not it follows the binomial distribution.

   (a) A production process produces thousands of temperature transducers. Let X denote the number of nonconforming transducers in a sample of size 30 selected at random from the process.

   (b) From a batch of 50 temperature transducers, a sample of size 30 is selected without replacement. Let X denote the number of nonconforming transducers in the sample.

3. Find the value of k if $f(x,y)=k(x+y), 0<x<1, 0<y<1$ is to be a joint probability density function.

4. If the joint pdf of (X,Y) is $f(x,y)=\frac{1}{4}$, $0\le x,y\le 2$, find $P(X+Y\le 1)$.

5. What is the difference between a random variable and a random process?

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6. State the properties of Poisson process.

7. Check whether the vectors (1, 0, 1), (2, 1, 3), and (3, 1, 4) are linearly dependent

8. Does plane in R^3 passing through origin subspace of R^3?

9. If a 3×8 matrix A has rank 3, find *dim* (*Nul*(A)).

10. Find the standard matrix for the linear transformation of the reflection about the line $y = x$.

PART B — ($5 \times 16 = 80$ marks)

11. (a) (i) In a certain assembly plant, three machines B_1, B_2 and B_3, make 30%, 45% and 25%, respectively, of the products. It is known from past experience that 2%, 3% and 2% of the products made by each machine, respectively, are defective, If a product was chosen randomly and found to be defective, what is the probability that is was made by machine B_3. (8)

(ii) Contamination is a problem in the manufacture of optical storage disks. The number of particles of contamination that occur on an optical disk has a Poisson distribution, and the average number of particles per centimeter-squared of media surface is 0.1. The area of a disk under study is 100 squared centimeters. (8)

(1) Find the probability that 12 particles occur in the area of a disk under study.

(2) Find the probability that zero particles occur in the area of the disk.

Or

(b) (i) Suppose the current measurement in a strip of wire are assumed to follow a normal distribution with a mean of 10 milliamperes and a variance of 4 (milliamperes)^2. (8)

(1) What is the probability that a measurement will exceed 13 milliamperes?

(2) What is the probability that a current measurement is between 9 and 11 milliamperes?

(3) Determine the value for which the probability that a current measurement is below this value is 0.98.

(ii) Let X be a continuous random variable with pdf (8)

$$f(x) = \begin{cases} \frac{x}{12}, in & 1 < x < 5 \\ 0, & otherwise \end{cases}$$

Find the probability density function of $Y = 2x - 3$.

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12. (a) (i) Let the joint probability mass function of random variables X and Y be given by (8)

$$p(x,y)=\begin{cases}\frac{1}{70}x(x+y), & \text{if } x=1,2,3 \quad y=3,4\\ 0, & \text{elsewhere}\end{cases}$$

Find E(X) and E(Y).

(ii) The joint probability density function of random variables X and Y is given by (8)

$$f(x,y)=\begin{cases}\lambda xy^2 & 0\le x\le y\le 1\\ 0 & \text{elsewhere}\end{cases}$$

(1) Determine the value of λ

(2) Find the marginal probability density function of X and Y.

Or

(b) (i) The marks obtained by 8 students in two subjects are given below: (8)

X	40	50	60	70	80	90	100	110
Y	42	48	62	66	78	88	96	104

Compute the correlation coefficient.

(ii) If X and Y are independent random variables with identical uniform distributions on (0, 1), find the probability density function of $U = X + Y$. (8)

13. (a) (i) Explain random process, and all classification of random process with example. (8)

(ii) Customers arrive at a bank according to a Poisson process with a mean rate of 5 customers per hour. (8)

(1) What is the probability that no customer arrives between 9 AM and 11 AM?

(2) What is the distribution (and mean) of the time at which the first customer after 11 AM arrives?

Or

(b) 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 dice and drove to work if and only if a 6 appeared.

(i) Find the probability that he takes a train on the third day.

(ii) Find the probability that he drives to work in the long run.

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14. (a) Let $V = R^2$ with operations

(i) $(x,y) \oplus (x',y') = (x + x',\ y + y' + 3)$

(ii) $\alpha \odot (x,y) = (\alpha x,\ \alpha y)$

Verify whether V is a vector space over R^2 with these operations. If not, indicate which axioms fail.

Or

(b) (i) Let $v_1 = (1, 0, 1)$, $v_2 = (0, 1, 1)$, $v_3 = (1, 1, 2)$. Do $\{v_1, v_2, v_3\}$ span R^3? If they are linearly dependent, write one as a combination of the others. (8)

(ii) Find a basis and the dimension of the subspace of R^4 spanned by

$u_1 = (1, 2, 3, 0)$, $u_2 = (2, 4, 6, 1)$, $u_3 = (1, 0, 1, 2)$, $u_4 = (0, 1, 1, 1)$. (8)

15. (a) (i) Let $A = \begin{bmatrix} -8 & -2 & -9 \\ 6 & 4 & 8 \\ 4 & 0 & 4 \end{bmatrix}$ and $w = \begin{bmatrix} 2 \\ 1 \\ -2 \end{bmatrix}$. Is w in *Nul* A? Justify. (8)

(ii) State and prove dimension theorem. (8)

Or

(b) (i) Use the Gram-Schmidt process to orthogonalize the vectors (8)

$v_1 = (1, 1, 0)$, $v_2 = (1, 0, 1)$, $v_3 = (0, 1, 1)$.

(ii) Find the least squares solution of the system: (8)

$x + 2y = 3$

$2x + 3y = 5$

$3x + 4y = 7$

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