

Question Paper

MS : JAM 2023

Section A: Q.1 – Q.10 Carry ONE mark each.

Q.1

Let $M = \begin{pmatrix} 1 & -1 & 0 \\ -1 & 2 & -1 \\ 0 & -1 & 1 \end{pmatrix}$. If a non-zero vector $X = (x, y, z)^T \in \mathbb{R}^3$ satisfies

$M^6 X = X$, then a subspace of $\mathbb{R}^3$ that contains the vector X is

- (A) $\{(x, y, z)^T \in \mathbb{R}^3 : x = 0, y + z = 0\}$
- (B) $\{(x, y, z)^T \in \mathbb{R}^3 : y = 0, x + z = 0\}$
- (C) $\{(x, y, z)^T \in \mathbb{R}^3 : z = 0, x + y = 0\}$
- (D) $\{(x, y, z)^T \in \mathbb{R}^3 : x = 0, y - z = 0\}$

Q.2 Let $M = M_1 M_2$, where M_1 and M_2 are two 3×3 distinct matrices. Consider the following two statements:

- (I) The rows of M are linear combinations of rows of M_2 .
- (II) The columns of M are linear combinations of columns of M_1 .

Then,

- (A) only (I) is TRUE
- (B) only (II) is TRUE
- (C) both (I) and (II) are TRUE
- (D) neither (I) nor (II) is TRUE

Q.3 Let $X \sim F_{6,2}$ and $Y \sim F_{2,6}$. If $P(X \leq 2) = \frac{216}{343}$ and $P\left(Y \leq \frac{1}{2}\right) = \alpha$, then 686α equals

- (A) 246
- (B) 254
- (C) 260
- (D) 264

Q.4 Let $Y \sim F_{4,2}$. Then, $P(Y \leq 2)$ equals

- (A) 0.60
- (B) 0.62
- (C) 0.64
- (D) 0.66

Q.5

Let $X_1, X_2, \dots$ be a sequence of *i. i. d.* random variables each having $U(0,1)$ distribution.

Let Y be a random variable having the distribution function G . Suppose that

$$\lim_{n \rightarrow \infty} P\left(\frac{X_1 + X_2 + \dots + X_n}{n} \leq x\right) = G(x), \quad \text{for all } x \in \mathbb{R}.$$

Then, $\text{Var}(Y)$ equals

- (A) $\frac{1}{12}$
- (B) $\frac{1}{32}$
- (C) $\frac{1}{48}$
- (D) $\frac{1}{64}$

Q.6 Let X_1, X_2, X_3 be a random sample from an $N(\theta, 1)$ distribution, where $\theta \in \mathbb{R}$ is an unknown parameter. Then, which one of the following conditional expectations does NOT depend on θ ?

- (A) $E(X_1 + X_2 - X_3 \mid X_1 + X_2)$
- (B) $E(X_1 + X_2 - X_3 \mid X_2 + X_3)$
- (C) $E(X_1 + X_2 - X_3 \mid X_1 - X_3)$
- (D) $E(X_1 + X_2 - X_3 \mid X_1 + X_2 + X_3)$

Q.7 For the function $f : \mathbb{R} \times \mathbb{R} \rightarrow \mathbb{R}$ defined by

$$f(x, y) = 2x^2 - xy - 3y^2 - 3x + 7y,$$

the point $(1, 1)$ is

- (A) a point of local maximum
- (B) a point of local minimum
- (C) a saddle point
- (D) NOT a critical point

Q.8 Let E_1 , E_2 and E_3 be three events such that

$$P(E_1 \cap E_2) = \frac{1}{4}, \quad P(E_1 \cap E_3) = P(E_2 \cap E_3) = \frac{1}{5} \quad \text{and} \quad P(E_1 \cap E_2 \cap E_3) = \frac{1}{6}.$$

Then, among the events E_1 , E_2 and E_3 , the probability that at least two events occur, equals

(A) $\frac{17}{60}$

(B) $\frac{23}{60}$

(C) $\frac{19}{60}$

(D) $\frac{29}{60}$

Q.9 Let X be a continuous random variable such that $P(X \geq 0) = 1$ and $\text{Var}(X) < \infty$. Then, $E(X^2)$ is

(A) $2 \int_0^\infty x^2 P(X > x) dx$

(B) $\int_0^\infty x^2 P(X > x) dx$

(C) $2 \int_0^\infty x P(X > x) dx$

(D) $\int_0^\infty x P(X > x) dx$

Q.10 Let X be a random variable having a probability density function

$$f(x; \theta) = \begin{cases} (3 - \theta) x^{2-\theta}, & \text{if } 0 < x < 1, \\ 0, & \text{otherwise,} \end{cases}$$

where $\theta \in \{0, 1\}$. For testing the null hypothesis $H_0: \theta = 0$ against $H_1: \theta = 1$, the power of the most powerful test, at the level of significance $\alpha = 0.125$, equals

(A) 0.15

(B) 0.25

(C) 0.35

(D) 0.45

Section A: Q.11 – Q.30 Carry TWO marks each.

Q.11 Let X_1 and X_2 be *i. i. d.* random variables having the common probability density function

$$f(x) = \begin{cases} e^{-x}, & x \geq 0, \\ 0, & \text{otherwise.} \end{cases}$$

Define $X_{(1)} = \min\{X_1, X_2\}$ and $X_{(2)} = \max\{X_1, X_2\}$. Then, which one of the following statements is FALSE?

(A) $\frac{2X_{(1)}}{X_{(2)} - X_{(1)}} \sim F_{2,2}$

(B) $2(X_{(2)} - X_{(1)}) \sim \chi^2_2$

(C) $E(X_{(1)}) = \frac{1}{2}$

(D) $P(3X_{(1)} < X_{(2)}) = \frac{1}{3}$

Q.12 Let X and Y be random variables such that $X \sim N(1, 2)$ and $P\left(Y = \frac{X}{2} + 1\right) = 1$. Let $\alpha = \text{Cov}(X, Y)$, $\beta = E(Y)$ and $\gamma = \text{Var}(Y)$. Then, the value of $\alpha + 2\beta + 4\gamma$ equals

- (A) 5
- (B) 6
- (C) 7
- (D) 8

Q.13 A point (a, b) is chosen at random from the rectangular region $[0, 2] \times [0, 4]$. Then, the probability that the area of the region

$$R = \{(x, y) \in \mathbb{R} \times \mathbb{R} : bx + ay \leq ab, \quad x, y \geq 0\}$$

will be less than 2, equals

- (A) $\frac{1 + \ln 2}{4}$
- (B) $\frac{1 + \ln 2}{2}$
- (C) $\frac{2 + \ln 2}{4}$
- (D) $\frac{1 + 2 \ln 2}{4}$

Q.14 Let $X_1, X_2, \dots$ be a sequence of independent random variables such that

$$P(X_i = i) = \frac{1}{4} \quad \text{and} \quad P(X_i = 2i) = \frac{3}{4}, \quad i = 1, 2, \dots$$

For some real constants c_1 and c_2 , suppose that

$$\frac{c_1}{\sqrt{n}} \sum_{i=1}^n \frac{X_i}{i} + c_2 \sqrt{n} \xrightarrow{d} Z \sim N(0,1), \quad \text{as } n \rightarrow \infty.$$

Then, the value of $\sqrt{3} (3c_1 + c_2)$ equals

- (A) 2
- (B) 3
- (C) 4
- (D) 5

Q.15 Let $X_1, X_2, \dots$ be a sequence of *i. i. d.* random variables such that

$$P(X_1 = 0) = P(X_1 = 1) = P(X_1 = 2) = \frac{1}{3}.$$

Let $S_n = \frac{1}{n} \sum_{i=1}^n X_i$ and $T_n = \frac{1}{n} \sum_{i=1}^n X_i^2$, $n = 1, 2, \dots$. Suppose that

$$\alpha_1 = \lim_{n \rightarrow \infty} P\left(\left|S_n - \frac{1}{2}\right| < \frac{3}{4}\right), \quad \alpha_2 = \lim_{n \rightarrow \infty} P\left(\left|S_n - \frac{1}{3}\right| < 1\right),$$

$$\alpha_3 = \lim_{n \rightarrow \infty} P\left(\left|T_n - \frac{1}{3}\right| < \frac{3}{2}\right) \quad \text{and} \quad \alpha_4 = \lim_{n \rightarrow \infty} P\left(\left|T_n - \frac{2}{3}\right| < \frac{1}{2}\right).$$

Then, the value of $\alpha_1 + 2\alpha_2 + 3\alpha_3 + 4\alpha_4$ equals

(A) 6

(B) 5

(C) 4

(D) 3

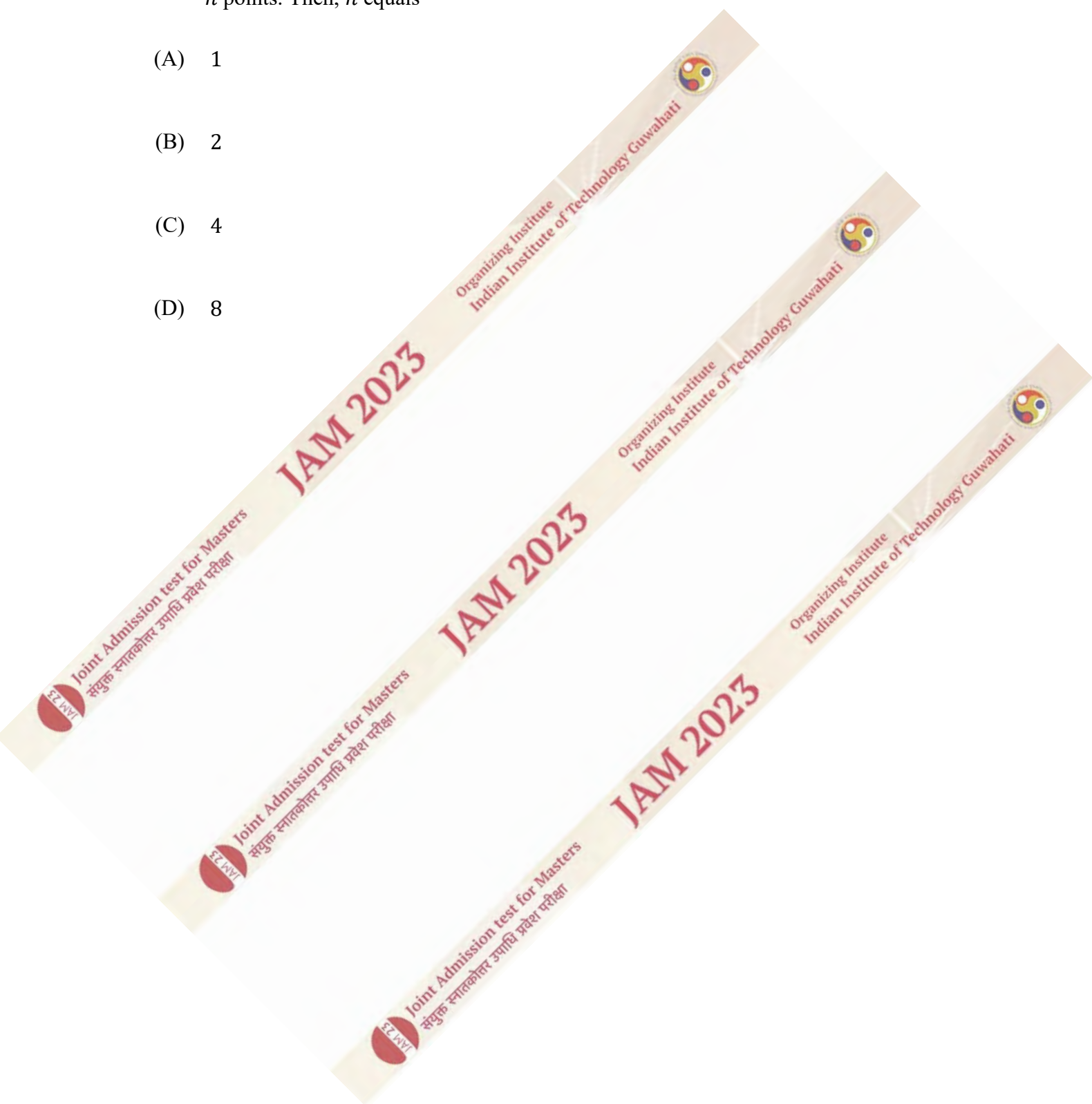
Q.16 For $x \in \mathbb{R}$, the curve $y = x^2$ intersects the curve $y = x \sin x + \cos x$ at exactly n points. Then, n equals

(A) 1

(B) 2

(C) 4

(D) 8



Q.17 Let (X, Y) be a random vector having the joint probability density function

$$f(x, y) = \begin{cases} \alpha |x|, & \text{if } x^2 \leq y \leq 2x^2, \quad -1 \leq x \leq 1, \\ 0, & \text{otherwise,} \end{cases}$$

where α is a positive constant. Then, $P(X > Y)$ equals

(A) $\frac{5}{48}$

(B) $\frac{7}{48}$

(C) $\frac{5}{24}$

(D) $\frac{7}{24}$

Q.18 Let X_1, X_2, X_3, X_4 be a random sample of size 4 from an $N(\theta, 1)$ distribution, where $\theta \in \mathbb{R}$ is an unknown parameter. Let $\bar{X} = \frac{1}{4} \sum_{i=1}^4 X_i$, $g(\theta) = \theta^2 + 2\theta$ and $L(\theta)$ be the Cramer-Rao lower bound on variance of unbiased estimators of $g(\theta)$. Then, which one of the following statements is FALSE?

- (A) $L(\theta) = (1 + \theta)^2$
- (B) $\bar{X} + e^{\bar{X}}$ is a sufficient statistic for θ
- (C) $(1 + \bar{X})^2$ is the uniformly minimum variance unbiased estimator of $g(\theta)$
- (D) $Var((1 + \bar{X})^2) \geq \frac{(1+\theta)^2}{2}$

Q.19 Let $X_1, X_2, \dots, X_n$ be a random sample from a population having the probability density function

$$f(x; \mu) = \begin{cases} \frac{1}{2} e^{-\left(\frac{x-2\mu}{2}\right)}, & \text{if } x > 2\mu, \\ 0, & \text{otherwise,} \end{cases}$$

where $-\infty < \mu < \infty$. For estimating μ , consider estimators

$$T_1 = \frac{\bar{X} - 2}{2} \quad \text{and} \quad T_2 = \frac{nX_{(1)} - 2}{2n},$$

where $\bar{X} = \frac{1}{n} \sum_{i=1}^n X_i$ and $X_{(1)} = \min\{X_1, X_2, \dots, X_n\}$. Then, which one of the following statements is TRUE?

(A) T_1 is consistent but T_2 is NOT consistent

(B) T_2 is consistent but T_1 is NOT consistent

(C) Both T_1 and T_2 are consistent

(D) Neither T_1 nor T_2 is consistent

Q.20

Let $X_1, X_2, \dots, X_n$ be a random sample from a $U\left(\theta + \frac{\sigma}{\sqrt{3}}, \theta + \sqrt{3}\sigma\right)$ distribution, where $\theta \in \mathbb{R}$ and $\sigma > 0$ are unknown parameters. Let $\bar{X} = \frac{1}{n} \sum_{i=1}^n X_i$ and $S = \sqrt{\frac{1}{n} \sum_{i=1}^n (X_i - \bar{X})^2}$. Let $\hat{\theta}$ and $\hat{\sigma}$ be the method of moment estimators of θ and σ , respectively. Then, which one of the following statements is FALSE?

(A) $\hat{\sigma} + \sqrt{3} \hat{\theta} = \sqrt{3} \bar{X} - 3S$

(B) $2\sqrt{3} \hat{\sigma} + \hat{\theta} = \bar{X} - 4\sqrt{3} S$

(C) $\sqrt{3} \hat{\sigma} + \hat{\theta} = \bar{X} + \sqrt{3} S$

(D) $\hat{\sigma} - \sqrt{3} \hat{\theta} = 9S - \sqrt{3} \bar{X}$

Q.21

Let (X, Y, Z) be a random vector having the joint probability density function

$$f(x, y, z) = \begin{cases} \frac{1}{2xy}, & \text{if } 0 < z < y < x < 1, \\ \frac{1}{2x^2}, & \text{if } 0 < z < x < y < 2x < 2, \\ 0, & \text{otherwise.} \end{cases}$$

Then, which one of the following statements is FALSE?

- (A) $P(Z < Y < X) = \frac{1}{2}$
- (B) $P(X < Y < Z) = 0$
- (C) $E(\min\{X, Y\}) = \frac{1}{4}$
- (D) $\text{Var}\left(Y \mid X = \frac{1}{2}\right) = \frac{1}{12}$

Q.22 Let X be a random variable such that the moment generating function of X exists in a neighborhood of zero and

$$E(X^n) = (-1)^n \frac{2}{5} + \frac{2^{n+1}}{5} + \frac{1}{5}, \quad n = 1, 2, 3, \dots$$

Then, $P\left(\left|X - \frac{1}{2}\right| > 1\right)$ equals

(A) $\frac{1}{5}$

(B) $\frac{2}{5}$

(C) $\frac{3}{5}$

(D) $\frac{4}{5}$

Q.23 Let X be a random variable having a probability mass function $p(x)$ which is positive only for non-negative integers. If

$$p(x+1) = \left(\frac{\ln 3}{x+1}\right)p(x), \quad x = 0, 1, 2, \dots,$$

then $\text{Var}(X)$ equals

- (A) $\ln 3$
- (B) $\ln 6$
- (C) $\ln 9$
- (D) $\ln 18$

Q.24 Let $\{a_n\}_{n \geq 1}$ be a sequence such that $a_1 = 1$ and $4a_{n+1} = \sqrt{45 + 16a_n}$, $n = 1, 2, 3, \dots$. Then, which one of the following statements is TRUE?

- (A) $\{a_n\}_{n \geq 1}$ is monotonically increasing and converges to $\frac{17}{8}$
- (B) $\{a_n\}_{n \geq 1}$ is monotonically increasing and converges to $\frac{9}{4}$
- (C) $\{a_n\}_{n \geq 1}$ is bounded above by $\frac{17}{8}$
- (D) $\sum_{n=1}^{\infty} a_n$ is convergent

Q.25 Let the series S and T be defined by

$$\sum_{n=0}^{\infty} \frac{2 \cdot 5 \cdot 8 \cdots (3n+2)}{1 \cdot 5 \cdot 9 \cdots (4n+1)} \quad \text{and} \quad \sum_{n=1}^{\infty} \left(1 + \frac{1}{n}\right)^{-n^2},$$

respectively. Then, which one of the following statements is TRUE?

- (A) S is convergent and T is divergent
- (B) S is divergent and T is convergent
- (C) Both S and T are convergent
- (D) Both S and T are divergent

Q.26 The volume of the region

$$R = \{(x, y, z) \in \mathbb{R} \times \mathbb{R} \times \mathbb{R} : x^2 + y^2 \leq 4, 0 \leq z \leq 4 - y\}$$

is

- (A) $16\pi + 16$
- (B) 16π
- (C) 8π
- (D) $16\pi + 4$

Q.27 For real constants α and β , suppose that the system of linear equations

$$x + 2y + 3z = 6; \quad x + y + \alpha z = 3; \quad 2y + z = \beta,$$

has infinitely many solutions. Then, the value of $4\alpha + 3\beta$ equals

- (A) 18
- (B) 23
- (C) 28
- (D) 32

Q.28

Let x_1, x_2, x_3 and x_4 be observed values of a random sample from an $N(\theta, \sigma^2)$ distribution, where $\theta \in \mathbb{R}$ and $\sigma > 0$ are unknown parameters. Suppose that $\bar{x} = \frac{1}{4} \sum_{i=1}^4 x_i = 3.6$ and $\frac{1}{3} \sum_{i=1}^4 (x_i - \bar{x})^2 = 20.25$. For testing the null hypothesis $H_0 : \theta = 0$ against $H_1 : \theta \neq 0$, the p -value of the likelihood ratio test equals

- (A) 0.712
- (B) 0.208
- (C) 0.104
- (D) 0.052

Q.29 Let X and Y be jointly distributed random variables such that, for every fixed $\lambda > 0$, the conditional distribution of X given $Y = \lambda$ is the Poisson distribution with mean λ . If the distribution of Y is $\text{Gamma}\left(2, \frac{1}{2}\right)$, then the value of $P(X = 0) + P(X = 1)$ equals

- (A) $\frac{7}{27}$
- (B) $\frac{20}{27}$
- (C) $\frac{8}{27}$
- (D) $\frac{16}{27}$

Q.30 Among all the points on the sphere $x^2 + y^2 + z^2 = 24$, the point (α, β, γ) is closest to the point $(1, 2, -1)$. Then, the value of $\alpha + \beta + \gamma$ equals

- (A) 4
- (B) -4
- (C) 2
- (D) -2

Section B: Q.31 – Q.40 Carry TWO marks each.

Q.31 Let M be a 3×3 real matrix. If $P = M + M^T$ and $Q = M - M^T$, then which of the following statements is/are always TRUE?

- (A) $\det(P^2 Q^3) = 0$
- (B) $\text{trace}(Q + Q^2) = 0$
- (C) $X^T Q^2 X = 0$, for all $X \in \mathbb{R}^3$
- (D) $X^T P X = 2X^T M X$, for all $X \in \mathbb{R}^3$

Q.32 Let X_1, X_2, X_3 be *i.i.d.* random variables, each having the $N(0, 1)$ distribution. Then, which of the following statements is/are TRUE?

(A) $\frac{\sqrt{2} (X_1 - X_2)}{\sqrt{(X_1 + X_2)^2 + 2X_3^2}} \sim t_1$

(B) $\frac{(X_1 + X_2)^2}{(X_1 - X_2)^2 + 2X_3^2} \sim F_{1,2}$

(C) $E\left(\frac{X_1}{X_2^2 + X_3^2}\right) = 0$

(D) $P(X_1 < X_2 + X_3) = \frac{1}{3}$

Q.33 Let $x_1, x_2, \dots, x_{10}$ be the observed values of a random sample of size 10 from an $N(\theta, \sigma^2)$ distribution, where $\theta \in \mathbb{R}$ and $\sigma > 0$ are unknown parameters. If

$$\bar{x} = \frac{1}{10} \sum_{i=1}^{10} x_i = 0 \quad \text{and} \quad s = \sqrt{\frac{1}{9} \sum_{i=1}^{10} (x_i - \bar{x})^2} = 2,$$

then based on the values of $\bar{x}$ and s and using Student's t -distribution with 9 degrees of freedom, 90% confidence interval(s) for θ is/are

- (A) $(-0.8746, \infty)$
- (B) $(-0.8746, 0.8746)$
- (C) $(-1.1587, 1.1587)$
- (D) $(-\infty, 0.8746)$

Q.34 Let (X_1, X_2) be a random vector having the probability mass function

$$f(x_1, x_2) = \begin{cases} \frac{c}{x_1! x_2! (12 - x_1 - x_2)!}, & \text{if } x_1, x_2 \in \{0, 1, \dots, 12\}, x_1 + x_2 \leq 12, \\ 0, & \text{otherwise,} \end{cases}$$

where c is a real constant. Then, which of the following statements is/are TRUE?

(A) $E(X_1 + X_2) = 8$

(B) $Var(X_1 + X_2) = \frac{8}{3}$

(C) $Cov(X_1, X_2) = -\frac{5}{3}$

(D) $Var(X_1 + 2X_2) = 8$

Q.35 Let P be a 3×3 matrix having the eigenvalues 1, 1 and 2. Let $(1, -1, 2)^T$ be the only linearly independent eigenvector corresponding to the eigenvalue 1. If the adjoint of the matrix $2P$ is denoted by Q , then which of the following statements is/are TRUE?

- (A) $\text{trace}(Q) = 20$
- (B) $\det(Q) = 64$
- (C) $(2, -2, 4)^T$ is an eigenvector of the matrix Q
- (D) $Q^3 = 20Q^2 - 124Q + 256I_3$

Q.36 Let $f: \mathbb{R} \times \mathbb{R} \rightarrow \mathbb{R}$ be a function defined by

$$f(x, y) = \begin{cases} \frac{xy(x+y)}{x^2+y^2}, & \text{if } (x, y) \neq (0, 0), \\ 0, & \text{if } (x, y) = (0, 0). \end{cases}$$

Then, which of the following statements is/are TRUE?

- (A) f is continuous on $\mathbb{R} \times \mathbb{R}$
- (B) The partial derivative of f with respect to y exists at $(0, 0)$, and is 0
- (C) The partial derivative of f with respect to x is continuous on $\mathbb{R} \times \mathbb{R}$
- (D) f is NOT differentiable at $(0, 0)$

Q.37 Let X and Y be i.i.d. random variables each having the $N(0, 1)$ distribution. Let $U = \frac{X}{Y}$ and $Z = |U|$. Then, which of the following statements is/are TRUE?

- (A) U has a Cauchy distribution
- (B) $E(Z^p) < \infty$, for some $p \geq 1$
- (C) $E(e^{tZ})$ does not exist for all $t \in (-\infty, 0)$
- (D) $Z^2 \sim F_{1,1}$

Q.38 Which of the following is/are TRUE?

- (A) $\int_0^1 \int_0^1 e^{\max\{x^2, y^2\}} dx dy = e - 1$
- (B) $\int_0^1 \int_0^1 e^{\min\{x^2, y^2\}} dx dy = \int_0^1 e^{t^2} dt - (e - 1)$
- (C) $\int_0^1 \int_0^1 e^{\max\{x^2, y^2\}} dx dy = 2 \int_0^1 \int_y^1 e^{x^2} dx dy$
- (D) $\int_0^1 \int_0^1 e^{\min\{x^2, y^2\}} dx dy = 2 \int_0^1 \int_1^y e^{y^2} dx dy$

Q.39 Let X be a random variable having the probability density function

$$f(x) = \begin{cases} \frac{5}{x^6}, & \text{if } x > 1, \\ 0, & \text{otherwise.} \end{cases}$$

Then, which of the following statements is/are TRUE for the distribution of X ?

- (A) The coefficient of variation is $\frac{4}{\sqrt{15}}$
- (B) The first quartile is $\left(\frac{3}{4}\right)^{\frac{1}{5}}$
- (C) The median is $(2)^{\frac{1}{5}}$
- (D) The upper bound obtained by Chebyshev's inequality for $P\left(X \geq \frac{5}{2}\right)$ is $\frac{1}{15}$

Q.40 Based on 10 data points $(x_1, y_1), (x_2, y_2), \dots, (x_{10}, y_{10})$ on a variable (X, Y) , the simple regression lines of Y on X and X on Y are obtained as $2y - x = 8$ and $y - x = -3$, respectively. Let $\bar{x} = \frac{1}{10} \sum_{i=1}^{10} x_i$ and $\bar{y} = \frac{1}{10} \sum_{i=1}^{10} y_i$. Then, which of the following statements is/are TRUE?

(A) $\sum_{i=1}^{10} x_i = 140$

(B) $\sum_{i=1}^{10} y_i = 110$

(C) $\frac{\sum_{i=1}^{10} (x_i - \bar{x}) y_i}{\sqrt{\left(\sum_{i=1}^{10} (x_i - \bar{x})^2\right) \left(\sum_{i=1}^{10} (y_i - \bar{y})^2\right)}} = -\frac{1}{\sqrt{2}}$

(D) $\frac{\sum_{i=1}^{10} (x_i - \bar{x})^2}{\sum_{i=1}^{10} (y_i - \bar{y})^2} = 2$

Section C: Q.41 – Q.50 Carry ONE mark each.

Q.41 Let $f: \mathbb{R} \rightarrow \mathbb{R}$ be a function defined by $f(x) = x^2 - x$, $x \in \mathbb{R}$. Let $g: \mathbb{R} \rightarrow \mathbb{R}$ be a twice differentiable function such that $g(x) = 0$ has exactly three distinct roots in the open interval $(0, 1)$. Let $h(x) = f(x)g(x)$, $x \in \mathbb{R}$, and h'' be the second order derivative of the function h . If n is the number of roots of $h''(x) = 0$ in $(0, 1)$, then the minimum possible value of n equals _____

Q.42 Let $X_1, X_2, \dots$ be a sequence of *i. i. d.* random variables, each having the probability density function

$$f(x) = \begin{cases} \frac{x^2 e^{-x}}{2}, & \text{if } x \geq 0, \\ 0, & \text{otherwise.} \end{cases}$$

For some real constants β , γ and k , suppose that

$$\lim_{n \rightarrow \infty} P\left(\frac{1}{n} \sum_{i=1}^n X_i \leq x\right) = \begin{cases} 0, & \text{if } x < \beta, \\ kx, & \text{if } \beta \leq x \leq \gamma, \\ k\gamma, & \text{if } x > \gamma. \end{cases}$$

Then, the value of $2\beta + 3\gamma + 6k$ equals _____

Q.43 Let α and β be real constants such that

$$\lim_{x \rightarrow 0^+} \frac{\int_0^x \left(\frac{\alpha t^2}{1+t^4} \right) dt}{\beta x - \sin x} = 1.$$

Then, the value of $\alpha + \beta$ equals _____

Q.44 Let $X_1, X_2, \dots, X_{10}$ be a random sample from an $N(0, \sigma^2)$ distribution, where $\sigma > 0$ is an unknown parameter. For some real constant c , let $Y = \frac{c}{10} \sum_{i=1}^{10} |X_i|$ be an unbiased estimator of σ . Then, the value of c equals _____ (round off to two decimal places)

Q.45 Let X be a random variable having the probability density function

$$f(x) = \begin{cases} \frac{x}{2}, & \text{if } 0 < x < 2, \\ 0, & \text{otherwise.} \end{cases}$$

Then, $Var\left(\ln\left(\frac{2}{x}\right)\right)$ equals _____

Q.46 Let X_1, X_2, X_3 be *i. i. d.* random variables, each having the $N(2, 4)$ distribution. If

$$P(2X_1 - 3X_2 + 6X_3 > 17) = 1 - \Phi(\beta),$$

then β equals _____

Q.47 Let the probability mass function of a random variable X be given by

$$P(X = n) = \frac{k}{(n-1)n}, \quad n = 2, 3, \dots,$$

where k is a positive constant. Then, $P(X \geq 17 \mid X \geq 5)$ equals _____

Q.48 Let

$$S_n = \sum_{k=1}^n \frac{1 + k 2^k}{4^{k-1}}, \quad n = 1, 2, \dots$$

Then, $\lim_{n \rightarrow \infty} S_n$ equals _____ (round off to two decimal places)

Q.49 A box contains a certain number of balls out of which 80% are white, 15% are blue and 5% are red. All the balls of the same color are indistinguishable. Among all the white balls, $\alpha\%$ are marked defective, among all the blue balls, 6% are marked defective and among all the red balls, 9% are marked defective. A ball is chosen at random from the box. If the conditional probability that the chosen ball is white, given that it is defective, is 0.4, then α equals _____

Q.50 Let X_1, X_2 be a random sample from a distribution having a probability density function

$$f(x; \theta) = \begin{cases} \frac{1}{\theta} e^{-\frac{x}{\theta}}, & \text{if } x > 0, \\ 0, & \text{otherwise,} \end{cases}$$

where $\theta \in (0, \infty)$ is an unknown parameter. For testing the null hypothesis $H_0 : \theta = 1$ against $H_1 : \theta \neq 1$, consider a test that rejects H_0 for small observed values of the statistic $W = \frac{X_1 + X_2}{2}$. If the observed values of X_1 and X_2 are 0.25 and 0.75, respectively, then the p -value equals _____ (round off to two decimal places)

Section C: Q.51 – Q.60 Carry TWO marks each.

Q.51 Let $f : \mathbb{R} \rightarrow \mathbb{R}$ be a function defined by

$$f(x) = x^2 \sin(x - 1) + x e^{(x-1)}, \quad x \in \mathbb{R}.$$

Then,

$$\lim_{n \rightarrow \infty} n \left(f\left(1 + \frac{1}{n}\right) + f\left(1 + \frac{2}{n}\right) + \cdots + f\left(1 + \frac{10}{n}\right) - 10 \right)$$

equals _____

Q.52 Let the random vector (X_1, X_2) follow the bivariate normal distribution with

$$E(X_1) = E(X_2) = 1, \quad \text{Var}(X_2) = 4 \text{Var}(X_1) = 4 \quad \text{and} \quad \text{Cov}(X_1, X_2) = 1.$$

Then, $\text{Var}(X_1 + X_2 \mid X_1 = \frac{1}{2})$ equals _____

Q.53 If for some $\alpha \in (0, \infty)$,

$$\int_0^{\infty} 2^{-x^2} dx = \alpha \sqrt{\pi},$$

then α equals _____ (round off to two decimal places)

- Q.54 Let $x_1 = 2.1$, $x_2 = 4.2$, $x_3 = 5.8$ and $x_4 = 3.9$ be the observed values of a random sample X_1, X_2, X_3 and X_4 from a population having a probability density function

$$f(x; \theta) = \begin{cases} \frac{x}{\theta^2} e^{-\frac{x}{\theta}}, & \text{if } x > 0, \\ 0, & \text{otherwise,} \end{cases}$$

where $\theta \in (0, \infty)$ is an unknown parameter. Then, the maximum likelihood estimate of $\text{Var}(X_1)$ equals _____

- Q.55 Let $x_1 = 2$, $x_2 = 5$ and $x_3 = 4$ be the observed values of a random sample from a population having a probability mass function

$$f(x; \theta) = \begin{cases} \theta(1 - \theta)^x, & \text{if } x = 0, 1, 2, \dots, \\ 0, & \text{otherwise,} \end{cases}$$

where $\theta \in (0, 1)$ is an unknown parameter. If $\hat{\tau}$ is the uniformly minimum variance unbiased estimate of θ^2 , then $156 \hat{\tau}$ equals _____

- Q.56 Let $X_1, X_2, \dots, X_5$ be *i.i.d.* random variables, each having the $\text{Bin}\left(1, \frac{1}{2}\right)$ distribution. Let $K = X_1 + X_2 + \dots + X_5$ and

$$U = \begin{cases} 0, & \text{if } K = 0, \\ X_1 + X_2 + \dots + X_K, & \text{if } K = 1, 2, \dots, 5. \end{cases}$$

Then, $E(U)$ equals _____

- Q.57 Let $X_1 \sim \text{Gamma}(1, 4)$, $X_2 \sim \text{Gamma}(2, 2)$ and $X_3 \sim \text{Gamma}(3, 4)$ be three independent random variables. If $Y = X_1 + 2X_2 + X_3$, then $E\left(\left(\frac{Y}{4}\right)^4\right)$ equals _____

- Q.58 Let X_1, X_2 be a random sample from a $U(0, \theta)$ distribution, where $\theta > 0$ is an unknown parameter. For testing the null hypothesis $H_0 : \theta \in (0, 1] \cup [2, \infty)$ against $H_1 : \theta \in (1, 2)$, consider the critical region

$$R = \left\{ (x_1, x_2) \in \mathbb{R} \times \mathbb{R} : \frac{5}{4} < \max\{x_1, x_2\} < \frac{7}{4} \right\}.$$

Then, the size of the critical region equals _____

Q.59 Let $X_1, X_2, \dots, X_5$ be a random sample from a $Bin(1, \theta)$ distribution, where $\theta \in (0, 1)$ is an unknown parameter. For testing the null hypothesis $H_0 : \theta \leq 0.5$ against $H_1 : \theta > 0.5$, consider the two tests T_1 and T_2 defined as:

T_1 : Reject H_0 if, and only if, $\sum_{i=1}^5 X_i = 5$.

T_2 : Reject H_0 if, and only if, $\sum_{i=1}^5 X_i \geq 3$.

Let β_i be the probability of making Type-II error, at $\theta = \frac{2}{3}$, when the test T_i , $i = 1, 2$, is used. Then, the value of $\beta_1 + \beta_2$ equals _____ (round off to two decimal places)

Q.60 Let $X_1 \sim N(2, 1)$, $X_2 \sim N(-1, 4)$ and $X_3 \sim N(0, 1)$ be mutually independent random variables. Then, the probability that exactly two of these three random variables are less than 1, equals _____ (round off to two decimal places)

Answer Key

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Question No.	Question ID	Question Type	Section	Answer	Marks
1	3651212701	MCQ	A	B	1
2	3651212702	MCQ	A	C	1
3	3651212703	MCQ	A	B	1
4	3651212704	MCQ	A	C	1
5	3651212705	MCQ	A	D	1
6	3651212706	MCQ	A	D	1
7	3651212707	MCQ	A	C	1
8	3651212708	MCQ	A	C	1
9	3651212709	MCQ	A	C	1
10	3651212710	MCQ	A	B	1
11	3651212711	MCQ	A	D	2
12	3651212712	MCQ	A	B	2
13	3651212713	MCQ	A	B	2
14	3651212714	MCQ	A	D	2
15	3651212715	MCQ	A	A	2
16	3651212716	MCQ	A	B	2
17	3651212717	MCQ	A	B	2
18	3651212718	MCQ	A	C	2
19	3651212719	MCQ	A	C	2
20	3651212720	MCQ	A	B	2
21	3651212721	MCQ	A	C	2
22	3651212722	MCQ	A	D	2
23	3651212723	MCQ	A	A	2
24	3651212724	MCQ	A	B	2
25	3651212725	MCQ	A	C	2
26	3651212726	MCQ	A	B	2
27	3651212727	MCQ	A	C	2
28	3651212728	MCQ	A	B	2
29	3651212729	MCQ	A	B	2
30	3651212730	MCQ	A	A	2
31	3651212731	MSQ	B	A, D	2
32	3651212732	MSQ	B	C	2
33	3651212733	MSQ	B	A, C, D	2
34	3651212734	MSQ	B	A, B, D	2
35	3651212735	MSQ	B	A, C	2
36	3651212736	MSQ	B	A, B, D	2
37	3651212737	MSQ	B	A, D	2
38	3651212738	MSQ	B	A, C	2
39	3651212739	MSQ	B	C, D	2
40	3651212740	MSQ	B	A, B, D	2
41	3651212741	NAT	C	3 to 3	1
42	3651212742	NAT	C	17 to 17	1
43	3651212743	NAT	C	1.5 to 1.5	1
44	3651212744	NAT	C	1.24 to 1.26	1
45	3651212745	NAT	C	0.25 to 0.25	1
46	3651212746	NAT	C	0.5 to 0.5	1
47	3651212747	NAT	C	0.25 to 0.25	1
48	3651212748	NAT	C	9.32 to 9.34	1
49	3651212749	NAT	C	1.125 to 1.125	1
50	3651212750	NAT	C	0.25 to 0.27	1
51	3651212751	NAT	C	165 to 165	2
52	3651212752	NAT	C	3 to 3	2
53	3651212753	NAT	C	0.59 to 0.61	2
54	3651212754	NAT	C	8 to 8	2
55	3651212755	NAT	C	2 to 2	2
56	3651212756	NAT	C	1.5 to 1.5	2
57	3651212757	NAT	C	3024 to 3024	2
58	3651212758	NAT	C	0.375 to 0.375	2
59	3651212759	NAT	C	1.07 to 1.09	2
60	3651212760	NAT	C	0.63 to 0.65	2