Paper : 3

1. Let A = $\begin{bmatrix} \cos a & -\sin a \\ \sin a & \cos a \end{bmatrix}$, (a ∈ R) such that $A^{32} = \begin{bmatrix} 0 & -1 \\ 1 & 0 \end{bmatrix}$. Then a value of a is :
(a) $\frac{\pi}{32}$
(b) 0
(c) $\frac{\pi}{64}$
(d) $\frac{\pi}{16}$

2. If A is a non-singular square matrix of order 3 such that $A^2 = 3A$, then value of |A| is
(a) – 3
(b) 3
(c) 9
(d) 27

3. Solution of the differential equation tany sec2x dx + tanx sec2ydy = 0 is :
(a) tanx + tany = k
(b) tanx – tany = k
(c) (tanx/tany)k
(d) tanx . tany = k

4. The function f(x) defined by $f(x) = \begin{cases} \frac{\sin^2 ax}{x^2}, & x \neq 0 \\ 1, & x = 0 \end{cases}$ is continuous at $x = 0$. The value(s) of a is/are
(a) 0
(b) ±1
(c) - 3
(d) ±2

5. If $\vec{a} = 2\hat{\imath} + 2\hat{\jmath} + 3\hat{k}, \vec{b} = -\hat{\imath} + 2\hat{\jmath} + \hat{k}$ and $\vec{c} = 3\hat{\imath} + \hat{\jmath}$ are such that $\vec{a} + \lambda\vec{b}$ is perpendicular to $\vec{c}$ then find the value of λ.
(a) 5
(b) 6
(c) 8
(d)10

6. If p and q are order and degree of differential equation $y^2\left(\frac{d^2y}{dx^2}\right)^2 + 3x\left(\frac{dy}{dx}\right)^{\frac{1}{3}} + x^2y^2 = \sin x$, then
(a) $p > q$
(b) $\frac{p}{q} = \frac{1}{2}$
(c) $p = q$
(d) $p < q$

7. The corner points of the feasible region determined by the system of linear constraints are (0,10), (5,5), (15,15), (0,20). Let z=px+qy where p,q>0. Condition on p and q so that the maximum of z occurs at both the points (15,15) and (0,20) is _________.
(a) q = 2p
(b) p = 2q
(c) p = q
(d) q = 3p

8. The two lines x = ay + b, z = cy + d; and x = a′y + b, z = c′y + d′ are perpendicular to each other, if
(a) $\frac{a}{a'} + \frac{c}{c'} = 1$

(b) $\frac{a}{a'} + \frac{c}{c'} = -1$
(c) $aa' + cc' = 1$
(d) $aa' + cc' = -1$

9. $\int x^2 e^{x^3} dx$ equals
(a) $\frac{1}{3} e^{x^3} + c$
(b) $\frac{1}{3} e^{x^4} + c$
(c) $\frac{1}{2} e^{x^3} + c$
(d) $\frac{1}{2} e^{x^2} + c$

10. Let $A = \begin{pmatrix} 1 & 2 \\ 3 & 4 \end{pmatrix}$ and $B = \begin{pmatrix} a & 0 \\ 0 & b \end{pmatrix}$, $a, b \in N$, then
(a) There cannot exist any B such that AB = BA
(b) There exist more then one but finite number of B's such that AB = BA
(c) There exists exactly one B such that AB = BA
(d) There exist infinitely many B's such that AB = BA

11. If θ is the angle between two vectors $\vec{a}$ and $\vec{b}$, then $\vec{a}.\vec{b} \geq 0$ only when
(a) $0 < \theta < \frac{\pi}{2}$
(b) $0 \leq \theta \leq \frac{\pi}{2}$
(c) $0 < \theta < n$
(d) $0 \leq \theta \leq n$

12. The solution set of the inequality $3x + 5y < 4$ is :
(a) an open half-plane not containing the origin.
(b) an open half-plane containing the origin.
(c) the whole XY-plane not containing the line 3x + 5y = 4.
(d) a closed half plane containing the origin.

13. If $\begin{vmatrix} 2 & 3 & 2 \\ x & x & x \\ 4 & 9 & 1 \end{vmatrix} + 3 = 0$, then find the value of x.
(a) 2
(b) 0
(c) - 1
(d) -3

14. An insurance company insured 3000 cyclists, 6000 scooter drivers and 9000 car drivers. The probability of an accident involving a cyclist, a scooter driver and a car driver are 0.3, 0.05 and 0.02 respectively. One of the insured persons meets with an accident. What is the probability that he is a cyclist?
(a) $\frac{15}{23}$
(b) $\frac{17}{23}$
(c) $\frac{13}{23}$
(d) $\frac{11}{23}$

15. The degree of the differential equation $\left(\frac{d^2y}{dx^2}\right)^2 - \left(\frac{dy}{dx}\right) = y^3$ is
(a) 1
(b) 2
(c) 3

(d) 6

16. Let $\vec{a}=\hat{i}+\hat{j}+\sqrt{2}\hat{k}, \vec{b}=b_1\hat{i}+b_2\hat{j}+\sqrt{2}\hat{k}$ and $\vec{c}=5\hat{i}+\hat{j}+\sqrt{2}\hat{k}$ be three vectors such that the projection vector of $\vec{b}$ on $\vec{a}$ is $\vec{a}$. If $\vec{a}+\vec{b}$ is perpendicular to $\vec{c}$, then $|\vec{b}|$ is equal to:
(a) 6
(b) 4
(c) $\sqrt{22}$
(d) $\sqrt{32}$

17. The value of k for which function $f(x)=\begin{cases}\frac{kx}{|x|}, & \text{if } x<0\\ 3, & \text{if } x\geq 0\end{cases}$ is continuous at $x=0$ is :
(a) -3
(b) -2
(c)-5
(d) 0

18. If A and B are any two events such that $P(A)+P(B)-P(A \text{ and } B)=P(A)$, then
(a) $P(B \mid A)=1$
(b) $P(A \mid B)=1$
(c) $P(B \mid A)=0$
(d) $P(A \mid B)=0$

ASSERTION-REASON BASED QUESTIONS
In the following questions, a statement of Assertion (A) is followed by a statement of Reason (R).
Choose the correct answer out of the following choices.
(a) Both (A) and (R) are true and (R) is the correct explanation of (A).
(b) Both (A) and (R) are true but (R) is not the correct explanation of (A).
(c) (A) is true but (R) is false.
(d) (A) is false but (R) is true.

19. Assertion (A) : If a line makes angles α, β, γ with positive direction of the coordinate axes, then $\sin^2\alpha+\sin^2\beta+\sin^2\gamma=2$.
Reason (R) : The sum of squares of the direction cosines of a line is 1 .

20. Assertion (A) : $\int_2^8 \frac{\sqrt{10-x}}{\sqrt{x}+\sqrt{10-x}}dx=3$
Reason (R): $\int_a^b f(x)dx=\int_a^b f(a+b-x)dx$

Section –B

[This section comprises of very short answer type questions (VSA) of 2 marks each]

21. (a) If $\frac{d}{dx}[F(x)]=\frac{\sec^4 x}{\operatorname{cosec}^4 x}$ and $F\left(\frac{\pi}{4}\right)=\frac{\pi}{4}$, then find F(x).

OR

21 (b) Find: $\int \frac{\log x}{(x+1)^2}dx$.

22. (a) If $f(x)=\begin{cases}x^2, & \text{if } x\geq 1\\ x, & \text{if } x<1\end{cases}$, then show that f is not differentiable at $x=1$.

23. If points $(2,-3), (\lambda,-2)$ and $(0,5)$ are collinear, then find λ

OR

23 Evaluate: $\int \frac{dx}{x(x^3+8)}$

24. Find $\vec{a} \cdot (\vec{b} \times \vec{c})$, if $\vec{a} = 2\hat{i} + \hat{j} + 3\hat{k}, \vec{b} = -\hat{i} + 2\hat{j} + \hat{k}, \vec{c} = 3\hat{i} + \hat{j} + 2\hat{k}$

25. A pair of dice is thrown and the sum of the numbers appearing on the dice is observed to be 7 . Find the probability that the number 5 has appeared on atleast one die.

Section – C

[This section comprises of short answer type questions (SA) of 3 marks each]

26. Integrate the rational functions.

$\int \frac{1}{x(x^4 - 1)} dx.$

27. Suppose a girl throws a die. If she gets a 5 or 6, she tosses a coin three times and notes the number of heads. If she gets 1, 2, 3 or 4 she tosses a coin once and notes whether a head or tail is obtained. If she obtained exactly one head, what is the probability that she threw 1, 2,3 or 4 with the die.

28. Solve : $\int_0^{100\pi} \sqrt{1 - \cos 2x}\, dx$

OR

28. If the $\int \frac{5\tan x}{\tan x - 2} dx = x + a \ln|\sin x - d\cos x| + k$, then a is equal to

29. Solve the differential equation : $(1 + x^2)\frac{dy}{dx} + 2xy - 4x^2 = 0$, subject to the initial condition $y(0) = 0$.

OR

29. Solve the following differential equation: $\sqrt{1 + x^2 + y^2 + x^2y^2} + xy\frac{dy}{dx} = 0$

30. Solve graphically the following linear programming problem :

Maximise $z = 6x + 3y$,

subject to the constraints

$4x + y \geq 80$

$3x + 2y \leq 150$

$x + 5y \geq 115$

$x \geq 0, y \geq 0$

OR

30. Solve the following linear programming problem by graphical method:

Maximize Z=3x+2y

subject to the in constraints

$x+2y \leq 10, 3x+y \leq 15, x, y \geq 0$

31. If $y = (\sec^{-1} x)^2$, $x > 0$, show that $x^2 (x^2 - 1)\frac{d^2y}{dx^2} + (2x^3 - x)\frac{dy}{dx} - 2 = 0$

Section –D

[This section comprises of long answer type questions (LA) of 5 marks each]

32. Sketch the graph of □ = |□ + 3| and evaluate the area under the curve □ = |□ + 3| above □-axis and between □ = − 6 □□ □ = 0

33. In answering a question on a multiple choice test a student either knows the answer or guesses. Let 3/4 be the probability that he knows the answer and 1/4 be the probability that he guesses. Assuming that a student who guesses at the answer will be correct with probability 1/4 What is the probability that a student knows the answer

given that the answered it correctly?

OR

33. If N denotes the set of all natural numbers and R is the relation on $N \times N$ defined by $(a, b)R(c, d)$, if $ad(b + c) = bc(a + d)$. Show that R is an equivalence relation.

34. If $A = \begin{bmatrix} 1 & 1 & 1 \\ 1 & 0 & 2 \\ 3 & 1 & 1 \end{bmatrix}$ find A^{-1}. Hence, solve the system of equations

$x + y + z = 6$,
$x + 2z = 7$,
$3x + y + z = 12$.

35. Find the coordinates of the foot of the perpendicular Q drawn from P(3, 2, 1) to the plane $2x - y + z + 1 = 0$. Also, find the distance PQ and the image of the point P treating this plane as a mirror.

OR

35. Find the vector equation of the line passing through (2, 3, 2) and parallel to the line $\vec{r} = (-2\hat{i}+3\hat{j}) + \mu\,(2\hat{i}-3\hat{j} + 6\hat{k})$ Also, find the distance between these two lines.

Section –E

[This section comprises of 3 case- study/passage based questions of 4 marks each with sub parts. The first two case study questions have three sub parts (i), (ii), (iii) of marks 1,1,2 respectively. The third case study question has two sub parts of 2 marks each.)

CASE STUDY 1 :

Solar Panels have to be installed carefully so that the tilt of the roof, and the direction to the sun, produce the largest possible electrical power in the solar panels.

A surveyor uses his instrument to determine the coordinates of the four corners of a roof where solar panels are to be mounted. In the picture , suppose the points are labelled counter clockwise from the roof corner nearest to the camera in units of meters P_1 (6,8,4) , P_2 (21,8,4), P_3 (21,16,10) and P_4 (6,16,10)

(i). What are the components to the two edge vectors defined by $\vec{A}$ = PV of P_2 − PV of P_1 and $\vec{B}$ = PV of P_4 − PV of P_1 ? (where PV stands for position vector)

(ii). Write the vector in standard notation with $\hat{i}, \hat{j}$ and $\hat{k}$ (where $\hat{i}, \hat{j}$ and $\hat{k}$ are the unit vectors along the three axes).

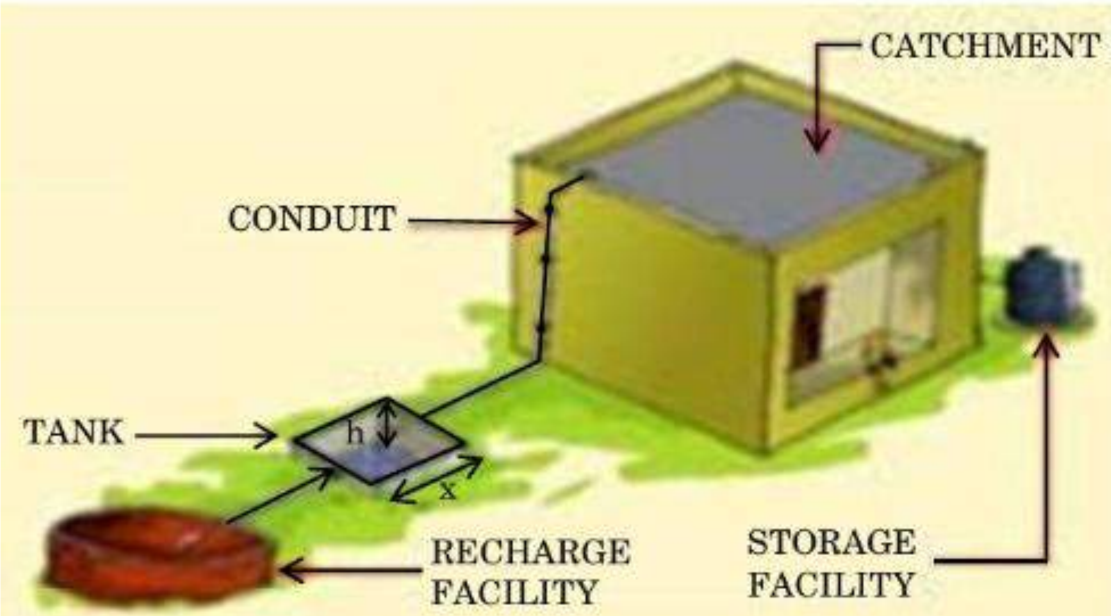
(iii)(a). What are the magnitudes of the vectors $\vec{A}$ and $\vec{B}$ and in what units?

OR

(iii)(b)What are the components to the vector $\vec{N}$, perpendicular to $\vec{A}$ and $\vec{B}$ and the surface of the roof?

Case Study – 2

37. In order to set up a rain water harvesting system, a tank to collect rain water is to be dug. The tank should have a square base and a capacity of $250m^3$. The cost of land is ₹ 5,000 per square metre and cost of digging increases with depth and for the whole tank, it is ₹ $40{,}000h^2$, where h is the depth of the tank in metres. x is the side of the square base of the tank in metres.
ELEMENTS OF A TYPICAL RAIN WATER HARVESTING SYSTEM



Based on the above information, answer the following questions :

(i) Find the total cost C of digging the tank in terms of x.

(ii) Find $\frac{dC}{dx}$.

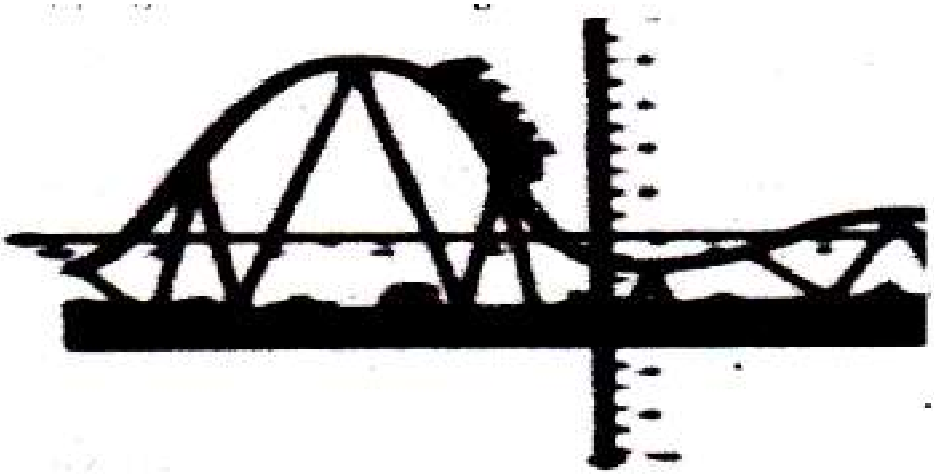
(iii) (a) Find the value of x for which cost C is minimum.

OR

(iii)(b) Check whether the cost function C(x) expressed in terms of x is increasing or not, where $x > 0$.

Case Study 3

38. The equation of the path traced by a roller-coaster is given by the polynomial $f(x) = a(x + 9)(x + 1)(x - 3)$. If the roller-coaster crosses y-axis at a point $(0, -1)$, answer the following :



(a) Find the value of ' a '.

(b) Find $f''(x)$ at $x = 1$.

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