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Part III — MATHEMATICS

(English Version)

Time Allowed : 3 Hours]

[Maximum Marks : 200

SECTION - A

N. B. : i) All questions are compulsory.

ii) Each question carries one mark.

iii) Choose the most suitable answer from the given four alternatives.

 $40 \times 1 = 40$

1. The area of the parallelogram having a diagonal vector $3\vec{i} + \vec{j} - \vec{k}$ and a side vector $\vec{i} - 3\vec{j} + 4\vec{k}$ is

a) $10\sqrt{3}$

b) $6\sqrt{30}$

c) $\frac{3}{2}\sqrt{30}$

d) $3\sqrt{30}$.

2. If $\vec{a}, \vec{b}, \vec{c}$ are a right handed triad of mutually perpendicular vectors of magnitude a, b, c then the value of $\left[\vec{a} \vec{b} \vec{c} \right]$ is

a) $a^2 b^2 c^2$

b) 0

c) $\frac{abc}{2}$

d) abc .

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3. $\vec{r} = s\vec{i} + t\vec{j}$ is the equation of

- a) a straight line joining the points \vec{i} and \vec{j}
- b) xy plane
- c) yz plane
- d) zx plane.

4. The angle between the vectors $\vec{i} - \vec{j}$ and $\vec{j} - \vec{k}$ is

- a) $\frac{\pi}{3}$
- b) $-\frac{2\pi}{3}$
- c) $-\frac{\pi}{3}$
- d) $\frac{2\pi}{3}$

5. The length of the perpendicular from the origin to the plane

$$\vec{r} \cdot (3\vec{i} + 4\vec{j} + 12\vec{k}) = 26 \text{ is}$$

- a) 2
- b) $\frac{1}{2}$
- c) 26
- d) $\frac{26}{169}$

6. The angle between the two tangents drawn from the point $(-4, 4)$ to

$$y^2 = 16x \text{ is}$$

- a) 45°
- b) 30°
- c) 60°
- d) 90°

7. The radius of the director circle of the conic $9x^2 + 16y^2 = 144$ is

- a) $\sqrt{7}$
- b) 4
- c) 3
- d) 5.

8. If the normal to the rectangular hyperbola $xy = c^2$ at t_1 meets the curve again at t_2 then $t_1^3 t_2 =$
- a) 1
b) 0
c) -1
d) -2.
9. The slope of the tangent to the curve $y = 3x^2 + 3 \sin x$ at $x = 0$ is
- a) 3
b) 2
c) 1
d) -1.
10. For what values of x the rate of increase of $x^3 - 2x^2 + 3x + 8$ is twice the rate of increase of x ?
- a) $\left(-\frac{1}{3}, -3\right)$
b) $\left(\frac{1}{3}, 3\right)$
c) $\left(-\frac{1}{3}, 3\right)$
d) $\left(\frac{1}{3}, 1\right)$.
11. The volume generated when the region bounded by $y = x$, $y = 1$, $x = 0$ is rotated about y -axis is
- a) $\frac{\pi}{4}$
b) $\frac{\pi}{2}$
c) $\frac{\pi}{3}$
d) $\frac{2\pi}{3}$.

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12. The length of arc of the curve $x^{\frac{2}{3}} + y^{\frac{2}{3}} = 4$ is

- | | |
|-------|--------|
| a) 48 | b) 24 |
| c) 12 | d) 96. |

13. $\int_0^{\infty} x^5 e^{-4x} dx =$

- | | |
|--------------------|--------------------|
| a) $\frac{6}{4^6}$ | b) $\frac{6}{4^5}$ |
| c) $\frac{5}{4^6}$ | d) $\frac{5}{4^5}$ |

14. The order and degree of $\left(\frac{dx}{dy}\right)^2 + 5y^{\frac{1}{3}} = x$ are

- | | |
|---------|----------|
| a) 2, 1 | b) 1, 2 |
| c) 1, 6 | d) 1, 3. |

15. The integrating factor of $\frac{dy}{dx} - y \tan x = \cos x$ is

- | |
|-----------------|
| a) $\sec x$ |
| b) $\cos x$ |
| c) $e^{\tan x}$ |
| d) $\cot x$. |

16. In the group (G, \cdot) , $G = \{1, -1, i, -i\}$, order of -1 is

- | | |
|---------|----------|
| a) -1 | b) 1 |
| c) 2 | d) 0 . |

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17. If $f(x) = \begin{cases} kx^2, & 0 < x < 3 \\ 0, & \text{elsewhere} \end{cases}$

is a probability density function, then the value of k is

a) $\frac{1}{3}$

b) $\frac{1}{6}$

c) $\frac{1}{9}$

d) $\frac{1}{12}$

18. $\text{Var}(4X + 3)$ is

a) 7

b) $16 \text{Var}(X)$

c) 19

d) 0.

19. If a random variable X follows Poisson distribution such that $E(X^2) = 30$,

then the variance of the distribution is

a) 6

b) 5

c) 30

d) 25.

20. Which of the following is / are correct regarding normal distribution curve ?

I. Symmetrical about the line $X = \mu$ (mean)

II. Unimodal

III. Mean = Median = Mode

IV. Point of inflexion is at $X = \mu \pm \sigma$.

a) I, II only

b) II, IV only

c) I, II, III only

d) all of these.

21. If A is a scalar matrix with scalar $k \neq 0$ of order 3, then A^{-1} is

a) $\frac{1}{k^2} I$

b) $\frac{1}{k^3} I$

c) $\frac{1}{k} I$

d) kI .

22. If $ae^x + be^y = c$, $pe^x + qe^y = d$ and $\Delta_1 = \begin{vmatrix} a & b \\ p & q \end{vmatrix}$, $\Delta_2 = \begin{vmatrix} c & b \\ d & q \end{vmatrix}$,

$\Delta_3 = \begin{vmatrix} a & c \\ p & d \end{vmatrix}$, then the value of (x, y) is

a) $\left(\frac{\Delta_2}{\Delta_1}, \frac{\Delta_3}{\Delta_1} \right)$

b) $\left(\log \frac{\Delta_2}{\Delta_1}, \log \frac{\Delta_3}{\Delta_1} \right)$

c) $\left(\log \frac{\Delta_1}{\Delta_3}, \log \frac{\Delta_1}{\Delta_2} \right)$

d) $\left(\log \frac{\Delta_1}{\Delta_2}, \log \frac{\Delta_1}{\Delta_3} \right)$.

23. If the rank of $\begin{bmatrix} \lambda & -1 & 0 \\ 0 & \lambda & -1 \\ -1 & 0 & \lambda \end{bmatrix}$ is 2, then λ is

a) 1

b) 2

c) 3

d) any real number.

24. Every homogeneous system (linear)

- a) is always consistent
- b) has only trivial solution
- c) has infinitely many solutions
- d) need not be consistent.

25. If $\vec{u} = \vec{a} \times (\vec{b} \times \vec{c}) + \vec{b} \times (\vec{c} \times \vec{a}) + \vec{c} \times (\vec{a} \times \vec{b})$, then

- a) \vec{u} is a unit vector
- b) $\vec{u} = \vec{0}$
- c) $\vec{u} \neq \vec{0}$
- d) $\vec{u} = \vec{a} + \vec{b} + \vec{c}$.

26. The modulus and amplitude of $(e^{3 - \frac{i\pi}{4}})^3$ are

- a) $e^9, \frac{\pi}{2}$
- b) $e^9, -\frac{\pi}{2}$
- c) $e^6, -\frac{3\pi}{4}$
- d) $e^9, -\frac{3\pi}{4}$.

27. If $a = 3 + i, z = 2 - 3i$ then the points on the Argand diagram representing $az, 3az$ and $-az$ are

- a) vertices of a right angled triangle
- b) vertices of an equilateral triangle
- c) vertices of an isosceles triangle
- d) collinear.

28. If $Z_n = \cos \frac{n\pi}{3} + i \sin \frac{n\pi}{3}$, then $Z_1 \cdot Z_2 \dots Z_6$ is

- a) 1 b) -1
c) i d) $-i$

29. If $|Z - Z_1| = |Z - Z_2|$ then the locus of Z is

- a) a circle with centre at the origin
b) a circle with centre at Z_1
c) a straight line passing through the origin
d) a perpendicular bisector of the line joining Z_1 and Z_2 .

30. $16x^2 - 3y^2 - 32x - 12y - 44 = 0$ represents

- a) an ellipse
b) a circle
c) a parabola
d) a hyperbola.

31. If $f(a) = 2$, $f'(a) = 1$, $g(a) = -1$, $g'(a) = 2$, then the value of

$\lim_{x \rightarrow a} \frac{g(x)f(a) - g(a)f(x)}{x - a}$ is

- a) 5 b) -5
c) 3 d) -3.

32. $x = x_0$ is a root of even order for the equation $f'(x) = 0$ then $x = x_0$ is a/an

- a) maximum point
- b) minimum point
- c) inflexion point
- d) critical point.

33. If $u = y \sin x$ then $\frac{\partial^2 u}{\partial x \partial y}$ is

- a) $\cos x$
- b) $\cos y$
- c) $\sin x$
- d) 0.

34. An asymptote to the curve $y^2(a + 2x) = x^2(3a - x)$ is

- a) $x = 3a$
- b) $x = -\frac{a}{2}$
- c) $x = \frac{a}{2}$
- d) $x = 0$.

35. The value of $\int_0^{\pi} \sin^2 x \cos^3 x \, dx$ is

- a) π
- b) $\frac{\pi}{2}$
- c) $\frac{\pi}{4}$
- d) 0.

36. The particular integral of $(D^2 - 4D + 4)y = e^{2x}$ is

a) $\frac{x^2}{2} e^{2x}$

b) xe^{2x}

c) xe^{-2x}

d) $\frac{x}{2} e^{-2x}$

37. In finding the differential equation corresponding to $y = e^{mx}$ where m is the arbitrary constant, m is

a) $\frac{y}{y'}$

b) $\frac{y'}{y}$

c) y'

d) y

38. The number of rows in the truth table of $\sim [p \wedge (\sim q)]$ is

a) 2

b) 4

c) 6

d) 8

39. Which of the following is not a binary operation on R ?

a) $a * b = ab$

b) $a * b = a - b$

c) $a * b = \sqrt{ab}$

d) $a * b = \sqrt{a^2 + b^2}$

40. The order of $[7]$ in $(Z_9, +_9)$ is

a) 9

b) 6

c) 3

d) 1

SECTION - B

- N. B. : i) Answer any *ten* questions.
- ii) Question No. **55** is compulsory and choose any *nine* questions from the remaining.
- iii) Each question carries *six* marks. 10 × 6 = 60

41. Solve by matrix inversion method :

$$x + y = 3, \quad 2x + 3y = 8.$$

42. Find the rank of
$$\begin{bmatrix} 3 & 1 & 2 & 0 \\ 1 & 0 & -1 & 0 \\ 2 & 1 & 3 & 0 \end{bmatrix}.$$

43. Prove that $\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$ by vector method.

44. a) The work done by the force $\vec{F} = a\vec{i} + \vec{j} + \vec{k}$ in moving the point of application from (1, 1, 1) to (2, 2, 2) along a straight line is given to be 5 units. Find the value of a .

b) If $\vec{x} \cdot \vec{a} = 0$, $\vec{x} \cdot \vec{b} = 0$, $\vec{x} \cdot \vec{c} = 0$ and $\vec{x} \neq \vec{0}$, show that \vec{a} , \vec{b} , \vec{c} are coplanar.

45. For any two complex numbers Z_1 and Z_2 , prove that

a) $|Z_1 \cdot Z_2| = |Z_1| |Z_2|$

b) $\arg(Z_1 \cdot Z_2) = \arg Z_1 + \arg Z_2$.

46. If $n \in \mathbb{N}$, prove that $(1 + i\sqrt{3})^n + (1 - i\sqrt{3})^n = 2^{n+1} \cos \frac{n\pi}{3}$.

47. Find the equation of the hyperbola whose directrix is $2x + y - 1 = 0$, focus (1, 2) and eccentricity $\sqrt{3}$.

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48. Prove that the curves $2x^2 + 4y^2 = 1$ and $6x^2 - 12y^2 = 1$, cut each other at right angles.

49. Find the volume of the solid that results when the region enclosed by the curve $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$ is revolved about major axis ($a > b > 0$).

50. a) Form the differential equation for the equation $y = e^{2x} (A + Bx)$.

b) Solve : $(D^2 + D + 1) y = 0$.

51. Use the truth table to establish that the following statement is tautology or contradiction :

$$(p \wedge (\sim p)) \wedge ((\sim q) \wedge p).$$

52. Find the order of all the elements of the group $(Z_6, +_6)$.

53. The probability distribution of a random variable X is given below :

$X :$	0	1	2	3
$P(X = x) :$	0.1	0.3	0.5	0.1

If $Y = X^2 + 2X$, find the mean and variance of Y .

54. Let X be a binomially distributed variable with mean 2 and standard deviation $\frac{2}{\sqrt{3}}$. Find the corresponding probability function.

55. a) Find the equation of the tangent and normal to the curve $y = x^3$ at the point $(1, 1)$.

OR

b) If $u = \log(\tan x + \tan y + \tan z)$, prove that $\sum \sin 2x \frac{\partial u}{\partial x} = 2$.

SECTION - C

N. B. : i) Answer any *ten* questions.

ii) Question No. **70** is compulsory and choose any *nine* questions from the remaining.

iii) Each question carries *ten* marks. 10 × 10 = 100

56. Solve by Cramer's rule :

$$\frac{1}{x} + \frac{2}{y} - \frac{1}{z} = 1, \quad \frac{2}{x} + \frac{4}{y} + \frac{1}{z} = 5, \quad \frac{3}{x} - \frac{2}{y} - \frac{2}{z} = 0.$$

57. Prove by vector method that altitudes of a triangle are concurrent.

58. Find the vector and cartesian equation of the plane passing through the points $(1, 2, 3)$, $(2, 3, 1)$ and perpendicular to the plane $3x - 2y + 4z - 5 = 0$.

59. Solve : $x^4 - x^3 + x^2 - x + 1 = 0$.

60. Find the axis, vertex, focus, directrix, equation of the latus rectum and the length of the latus rectum of the parabola $y^2 - 8x + 6y + 9 = 0$.

61. Find the equation of the hyperbola if its asymptotes are parallel to

$x + 2y - 12 = 0$ and $x - 2y + 8 = 0$. $(2, 4)$ is the centre of the hyperbola and

it passes through the point $(2, 0)$.

62. A water tank has the shape of an inverted circular cone with base radius 2 metres and height 4 metres. If water is being pumped into the tank at a rate of $2 \text{ m}^3/\text{min}$, find the rate at which the water level is rising when the water is 3 m deep.

63. Obtain the Maclaurin's series expansion for $\tan x$, $-\frac{\pi}{2} < x < \frac{\pi}{2}$.

64. Trace the curve $y = x^3$.

65. Find the common area enclosed by the parabolas $y^2 = x$ and $x^2 = y$.

66. Find the length of the curve $\left(\frac{x}{a}\right)^{\frac{2}{3}} + \left(\frac{y}{a}\right)^{\frac{2}{3}} = 1$.

67. The sum of Rs. 1,000 is compounded continuously, the nominal rate of interest being 4% per annum. In how many years will the amount be twice the original principal?

$$[\log_e 2 = 0.6931].$$

68. Let G be the set of all rational numbers except 1 and $*$ be defined on G by $a * b = a + b - ab$ for all $a, b \in G$. Show that $(G, *)$ is an infinite Abelian group.

69. If X is normally distributed with mean 6 and standard deviation 5, find

i) $P(0 \leq X \leq 8)$

ii) $P(|X - 6| < 10)$.

[Given that $P(0 < z < 1.2) = 0.3849$, $P(0 < z < 0.4) = 0.1554$,

$P(0 < z < 1) = 0.3413$, $P(0 < z < 2) = 0.4772$].

70. a) A satellite is travelling around the earth in an elliptical orbit having the earth at a focus and of eccentricity $\frac{1}{2}$. The shortest distance that the satellite gets to the earth is 400 kms. Find the longest distance that the satellite gets from the earth.

OR

b) Solve : $(D^2 - 6D + 9)y = x + e^{2x}$.
