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3 (Sem-3/CBCS) MAT HC 3

2021

(Held in 2022)

**MATHEMATICS**

(Honours)

Paper : MAT-HC-3036

**(Analytical Geometry)**

Full Marks : 80

Time : Three hours

**The figures in the margin indicate full marks for the questions.**

1. Answer the following questions :  $1 \times 10 = 10$

(i) What is the nature of the conic represented by

$$4x^2 - 4xy + y^2 - 12x + 6y + 9 = 0 ?$$

(ii) Define skew lines.

Contd.

(iii) Under what condition

$$ax^2 + 2hxy + by^2 + 2gx + 2fy + c = 0$$

may represent a pair of parallel straight lines ?

(iv) If the axes are rectangular, find the direction cosines of the normal to the plane  $x + 2y - 2z = 9$ .

(v) Write down the conditions under which the general equation of second degree  $ax^2 + by^2 + cz^2 + 2ux + 2vy + 2wz + d = 0$  represents a sphere.

(vi) If  $\frac{x}{l} = \frac{y}{m} = \frac{z}{n}$  is a generator of the cone represented by the homogeneous equation  $f(x, y, z)$ , then what is the value of  $f(l, m, n)$  ?

(vii) What is meant by diametral plane of a conicoid ?

(viii) Find the equation of the line  $\frac{x}{a} + \frac{y}{b} = 2$ ,

when the origin is transferred to the point  $(a, b)$ .

(ix) Find the point on the conic  $\frac{8}{r} = 3 - \sqrt{2} \cos \theta$  whose radius vector is 4.

(x) What is the polar equation of a circle when the pole is at the centre ?

2. Answer the following questions :  $2 \times 5 = 10$

(a) Write down the equation to the cone whose vertex is the origin and which passes through the curve of intersection of the plane  $lx + my + nz = p$  and the surface  $ax^2 + by^2 + cz^2 = 1$ .

(b) Transform the equation  $x^2 - y^2 = a^2$  by taking the perpendicular lines  $y - x = 0$  and  $y + x = 0$  as coordinate axes.



(c) If  $(at_1^2, 2at_1)$  and  $(at_2^2, 2at_2)$  are the extremities of any focal chord of the parabola  $y^2 = 4ax$ , then prove that  $t_1 t_2 = -1$ .

(d) Find the centre and foci of the hyperbola  $x^2 - y^2 = a^2$ .

(e) Find where the line  $\frac{x-1}{2} = \frac{y-2}{-3} = \frac{z+3}{4}$  meets the plane  $x+y+z=3$ .

3. Answer **any four**:  $5 \times 4 = 20$

(a) If by transformation from one set of rectangular axes to another with the same origin the expression  $ax+by$  changes to  $a'x'+b'y'$ , prove that  $a^2 + b^2 = a'^2 + b'^2$ .

(b) Prove that the equation

$$ax^2 + 2hxy + by^2 + 2gx + 2fy + c = 0$$

represents a pair of parallel straight

lines, if  $\frac{a}{h} = \frac{h}{b} = \frac{g}{f}$ .

(c) Find the condition that line

$$\frac{l}{r} = A \cos \theta + B \sin \theta$$

may touch the conic  $\frac{l}{r} = 1 - e \cos \theta$ .

(d) Find the equation to the plane which cuts  $x^2 + 4y^2 - 5z^2 = 1$  in a conic whose centre is the point  $(2, 3, 4)$ .

(e) Show that the equation to the cone whose vertex is origin and base is  $z = k$ ,  $f(x, y) = 0$  is  $f\left(\frac{kx}{z}, \frac{ky}{z}\right) = 0$ .

- (f) A variable plane is at a constant distance  $p$  from the origin and meets the axes, which are rectangular in  $A, B, C$ . Through  $A, B, C$  planes are drawn parallel to the coordinate planes, show that locus of their point of intersection is given by  $x^{-2} + y^{-2} + z^{-2} = p^{-2}$ .

4. Answer the following questions:  $10 \times 4 = 40$

- (a) Find the point of intersection of the lines represented by the equation

$$ax^2 + 2hxy + by^2 + 2gx + 2fy + c = 0.$$

- (b) Show that the equation

$$9x^2 - 24xy + 16y^2 - 18x - 101y + 19 = 0$$

represents a parabola and it can be

reduced to the standard form  $Y^2 = 3X$ .

Find the coordinates of the vertex and the focus.

- (c) Prove that the sum of the reciprocals of two perpendicular focal chords of a conic is constant.

- (d) Show that the ortho-centre of the triangle formed by the lines

$$ax^2 + 2hxy + by^2 = 0 \text{ and } lx + my = 1 \text{ is}$$

$$\text{given by } \frac{x}{l} = \frac{y}{m} = \frac{a+b}{am^2 - 2hlm + bl^2}$$

- (e) Find the condition that the plane  $lx + my + nz = p$  may touch the conicoid

$$ax^2 + by^2 + cz^2 = 1. \text{ Verify that the plane}$$

$$2x - 2y + 8z = 9 \text{ touches the ellipsoid}$$

$$x^2 + 2y^2 + 3z^2 = 9.$$

- (f) Show that the shortest distance between any two opposite edges of the tetrahedron formed by the planes  $y + z = 0, z + x = 0, x + y = 0,$

$$x + y + z = a \text{ is } \frac{2a}{\sqrt{6}} \text{ and that the three}$$

lines of shortest distance intersect at the point  $x = y = z = -a$ .



(g) Find the equation to the cylinder generated by the lines drawn through the points of the circle

$$x + y + z = 1, x^2 + y^2 + z^2 = 4 \text{ which are}$$

$$\text{parallel to the line } \frac{x}{2} = \frac{y}{-1} = \frac{z}{2}.$$

(h) A variable plane is parallel to the given

$$\text{plane } \frac{x}{a} + \frac{y}{b} + \frac{z}{c} = 0 \text{ and meets the axes}$$

in  $A, B, C$  respectively. Prove that the circle  $ABC$  lies on the cone

$$yz\left(\frac{b}{c} + \frac{c}{b}\right) + zx\left(\frac{c}{a} + \frac{a}{c}\right) + xy\left(\frac{a}{b} + \frac{b}{a}\right) = 0.$$