CHAPTER 7

THE PLANE

TOPICS:

1. Equations of a plane
2. Normal form
3.perpendicula distance from a point to a plane.
3 .Intercept form
4. Angle between two planes
5. Distance between two parallel planes.

PLANES

Definition:

A surface in space is said to be a plane surface or a plane if all the points of the straight line joining any two points of the surface lie on the surface.

THEOREM

The equation of the plane passing through a point (x_1, y_1, z_1) and perpendicular to a line whose direction ratios are a, b, c is $a(x-x_1)+b(y-y_1)+c(z-z_1)=0$

THEOREM

The equation of the plane passing through a point (x_1, y_1, z_1) is $a(x-x_1)+b(y-y_1)+c(z-z_1)=0$ where a,b,c are constants.

THEOREM

The equation of the plane containing three points (x_1, y_1, z_1), (x_2, y_2, z_2), (x_3, y_3, z_3) is

$$\begin{vmatrix} x-x_1 & y-y_1 & z-z_1 \\ x_2-x_1 & y_2-y_1 & z_2-z_1 \\ x_3-x_1 & y_3-y_1 & z_3-z_1 \end{vmatrix} = 0$$

NORMAL FORM OF A PLANE

THEOREM

The equation of the plane which is at a distance of p from the origin and whose normal has the direction cosines (l, m, n) is lx + my + nz = p (or) $x\cos\alpha + y\cos\beta + z\cos\gamma = p$.

NOTE. Equation of the plane through the origin is $lx+my+nz=0$

Note: The equation of the plane ax +by+cz+d=0 in the normal form is

$$\frac{a}{\sqrt{\sum a^2}}x+\frac{b}{\sqrt{\sum a^2}}y+\frac{c}{\sqrt{\sum a^2}}z=\frac{-d}{\sqrt{\sum a^2}} \quad if\ d \le 0,$$

$$\frac{-a}{\sqrt{\sum a^2}}x+\frac{-b}{\sqrt{\sum a^2}}y+\frac{-c}{\sqrt{\sum a^2}}z=\frac{+d}{\sqrt{\sum a^2}} \quad if\ d > 0$$ where $\sum a^2 = a^2+b^2+c^2$.

PERPENDICULAR DISTANCE FROM A POINT TO A PLALNE

The perpendicular distance from the origin to the plane ax + by + cz + d = 0 is

$$\frac{|d|}{\sqrt{a^2+b^2+c^2}}$$

THEOREM

The perpendicular distance from P(x_1, y_1, z_1) to the plane ax + by + cz + d = 0 is

$$\frac{|ax_1+by_1+cz_1+d|}{\sqrt{a^2+b^2+c^2}}$$

THEOREM

Intercept form of the plane

The equation of the plane having a,b,c as x,y,z- intercepts respectively is

$$\frac{x}{a}+\frac{y}{b}+\frac{z}{c}=1$$

THEOREM

The intercepts of the plane ax + by + cz + d = 0 are respectively $\frac{-d}{a},\frac{-d}{b},\frac{-d}{c}$

ANGLE BETWEEN TWO PLANES

Definition: The angle between the normals to two planes is called the angle between the planes.

THEOREM

If θ is the angle between the planes $a_1x+b_1y+c_1z+d_1=0$, $a_2x+b_2y+c_2z+d_2=0$

then $$\cos\theta=\frac{a_1a_2+b_1b_1+c_1c_2}{\sqrt{a_1^2+b_1^2+c_1^2}\sqrt{a_2^2+b_2^2+c_2^2}}$$

Note

1. if θ is acute then $$\cos\theta=\left|\frac{a_1a_2+b_1b_1+c_1c_2}{\sqrt{a_1^2+b_1^2+c_1^2}\sqrt{a_2^2+b_2^2+c_2^2}}\right|$$

2. The planes $a_1x+b_1y+c_1z+d_1=0$, $a_2x+b_2y+c_2z+d_2=0$ are

   (i) parallel iff $\frac{a_1}{a_2}=\frac{b_1}{b_2}=\frac{c_1}{c_2}$

(ii) Perpendicular iff . $a_1a_2 + b_1b_2 + c_1c_2 = 0$

3. The given planes are perpendicular

$$\Leftrightarrow \theta = 90^0 \Leftrightarrow \cos\theta = 0 \Rightarrow a_1a_2 + b_1b_2 + c_1c_2 = 0$$

THEOREM

The equation of the plane parallel to the plane ax + by + cz + d = 0 is

ax + by + cz + k = 0 where k is a constant.

THEOREM

The distance between the parallel planes $\boldsymbol{ax + by + cz + d_1 = 0, ax + by + cz + d_2 = 0}$ is $\dfrac{|\boldsymbol{d_1 - d_2}|}{\sqrt{\boldsymbol{a^2 + b^2 + c^2}}}$.

EXERCISE 7

I.

1. **Find the equation of the plane if the foot of the perpendicular from origin to the plane is (1, 3, –5).**

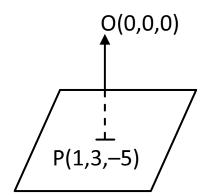
Sol. Given point P =(1, 3, –5).

$\overrightarrow{op}$ is the normal to the plane

D. Rs of $\overrightarrow{op}$ are 1, 3, –5.

The plane passes through P(1, 3, –5) equation of the plane is

$\boldsymbol{a(x-x_1)+b(y-y_1)+c(z-z_1)=0}$



1(x – 1) + 3(y – 3) – 5(z + 5) = 0

x – 1 + 3y – 9 – 5z – 25 = 0

x + 3y – 5z – 35 = 0

2. **Reduce the equation x + 2y – 3z – 6 = 0 of the plane to the normal form.**

Sol. Equation of the plane is x + 2y – 3z – 6 = 0 i.e. x + 2y – 3z = 6

Dividing with $\sqrt{1^2+2^2+(-3)^2}=\sqrt{1+4+9}=\sqrt{14}$,we get

$\left(\frac{1}{\sqrt{14}}\right)x+\left(\frac{2}{\sqrt{14}}\right)y+\left(\frac{-3}{\sqrt{14}}\right)z=\frac{6}{\sqrt{14}}$. Which is the normal form of the plane.

3. **Find the equation of the plane. Whose intercepts on X, Y, Z-axis are 1, 2, 4 respectively**.

Sol. Given X,Y,Z intercepts are a = 1, b = 2, c = 4

Equation of the plane in the intercept form is $\frac{x}{a}+\frac{y}{b}+\frac{z}{c}=1$

The equation of the plane in the intercept form is

$\frac{x}{1}+\frac{y}{2}+\frac{z}{4}=1 \Rightarrow$ 4x + 2y + z = 4.

4. **Find the intercepts of the plane 4x + 3y – 2z + 2 = 0 on the coordinate axes.**

Sol. Equation of the plane is 4x + 3y – 2z + 2 = 0

$-4x-3y+2z=2 \Rightarrow -\frac{4x}{2}-\frac{3y}{z}+\frac{2z}{2}=1 \Rightarrow \frac{x}{\left(-\frac{1}{2}\right)}+\frac{y}{\left(-\frac{2}{3}\right)}+\frac{z}{1}=1$

x-intercept = –1/2, y-intercept = –2/3, z-intercept = 1.

5. Find the d.c.'s of the normal to the plane x + 2y + 2z – 4 = 0.

Sol. Equation of the plane is $x + 2y + 2z - 4 = 0$

d.r.'s of the normal are (1, 2, 2)

Dividing with $\sqrt{1+4+4} = 3$

d.c.'s of the normal to the plane are $\left(\frac{1}{3}, \frac{2}{3}, \frac{2}{3}\right)$.

6. Find the equation of the plane passing through the point (–2, 1, 3) and having (3, –5, 4) as d.r.'s of its normal.

Sol. d.r.'s of the normal are (3, –5, 4) and the plane passes through (–2, 1, 3).

Equation of the plane is $\boldsymbol{a(x - x_1) + b(y - y_1) + c(z - z_1) = 0}$

$3(x + 2) - 5(y - 1) + 4(z - 3) = 0$

$3x + 6 - 5y + 5 + 4z - 12 = 0$

$3x - 5y + 4z - 1 = 0$.

7. Write the equation of the plane 4x – 4y + 2z + 5 = 0 in the intercept form.

Sol. Equation of the plane is : $4x - 4y + 2z + 5 = 0$

$-4x + 4y - 2z = 5$

$-\frac{4x}{5} + \frac{4y}{5} - \frac{2z}{5} = 1$

Intercept form is $\frac{x}{\left(-\frac{5}{4}\right)} + \frac{y}{\left(\frac{5}{4}\right)} + \frac{z}{\left(-\frac{5}{2}\right)} = 1$

x-intercept = $-\frac{5}{4}$, y-intercept = $\frac{5}{4}$ z-intercept = $-\frac{5}{2}$

8. Find the angle between the planes x + 2y + 2z – 5 = 0 and 3x + 3y + 2z – 8 = 0.

Sol. Equation of the plane are $x + 2y + 2z - 5 = 0$

$3x + 3y + 2z - 8 = 0$

Let θ be the angle between the planes, then

$$\cos\theta = \frac{|a_1a_2 + b_1b_2 + c_1c_2|}{\sqrt{a_1^2 + b_1^2 + c_1^2}\sqrt{a_2^2 + b_2^2 + c_2^2}} = \frac{|1-3+2-3+2-2|}{\sqrt{1+4+4}\sqrt{9+9+4}} = \frac{13}{3\sqrt{22}}$$

$$\theta = \cos^{-1}\left(\frac{13}{3\sqrt{22}}\right)$$

II.

1. Find the equation of the plane passing through the point (1, 1, 1) and parallel to the plane x + 2y + 3z – 7 = 0.

Sol. Equation of the given plane is x + 2y + 3z – 7 = 0

Equation of the plane parallel to this plane is x + 2y + 3z = k

This plane passing through the point P(1, 1, 1)

$\Rightarrow$ 1 + 2 + 3 = k $\Rightarrow$ k = –6

Equation of the required plane is x + 2y + 3z = 6

2. Find the equation of the plane passing through (2, 3, 4) and perpendicular to X-axis.

Sol. Since the plane is perpendicular to x-axis ,

$\therefore$ x-axis is the normal to the plane

d.r.'s of x-axis are 1, 0, 0

$\therefore$ Equation of the required plane is $a(x-x_1)+b(y-y_1)+c(z-z_1)=0$

$\Rightarrow$ 1(x-2) + 0 +0 =0 $\Rightarrow$ x-2 = 0

3. Show that 2x + 3y + 7 = 0 represents a plane perpendicular to XY-plane.

Sol. Equation of the given plane is 2x + 3y + 7 = 0

D,rs if normal to the plane are 2,3,0

Equation of xy-plane is : z = 0

d.rs of normal to the planes are 0,0,1

now $a_1a_2 + b_1b_2 + c_1c_2 = 2 \Rightarrow 2\cdot 0 + 3\cdot 0 + 0\cdot 1 = 0$

The plane 2x + 3y + 7 = 0 is perpendicular to xy-plane.

4. Find the constant k so that the planes x – 2y + kz = 0 and 2x + 5y – z = 0 are at right angles. Find the equation of the plane through (1, –1, –1) and perpendicular to these planes.

Sol. Equations of the given planes are

x – 2y + kz = 0 and 2x + 5y – z = 0

since these planes are perpendicular , therefore

$1 \cdot 2 - 2 \cdot 5 + k(-1) = 0$

$2 - 10 = k \Rightarrow k = -8$

Equations of the planes are

$x - 2y - 8z = 0$ … (i)

$2x + 5y - z = 0$ … (ii)

Let a,b,c be the drs of normal to the required plane.

This plane is perpendicular to the planes (i) and (ii).

$a - 2b - 8c = 0$

$2a + 5b - c = 0$

$$\begin{array}{cccccccc} & & a & & b & & c & \\ -2 & \times & -8 & \times & 1 & \times & -2 \\ 5 & & -1 & & 2 & & 5 \end{array}$$

$$\frac{a}{2+40} = \frac{b}{-16+1} = \frac{c}{5+4} \Rightarrow \frac{a}{42} = \frac{b}{-15} = \frac{c}{9}$$

The required plane passing through (1, –1, –1)

$\therefore$ Equation of the plane can be taken as

$a(x - 1) + b(y + 1) + c(z + 1) = 0$ …(iii)

$42(x - 1) - 15(y + 1) + 9(z + 1) = 0$

$42x - 42 - 15t - 15 + 9z + 9 = 0$

$42x - 15y + 9z - 48 = 0.$

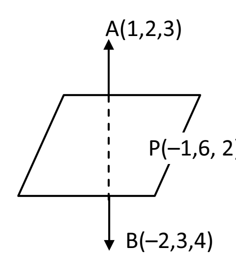
5. Find the equation of the plane through (–1, 6, 2) and perpendicular to the join of (1, 2, 3) and (–2, 3, 4).

Sol. Given points are

A(1, 2, 3) and B(–2, 3, 4).

d.r.'s of AB are 1 + 2, 2 – 3, 3 – 4

i.e. 3, –1, –1



Since the plane is perpendicular to the line joining A(1, 2, 3) and B(–2, 3, 4), AB is normal to the plane and the plane passes through the point P(–1, 6, 2).

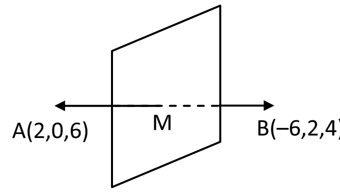
Equation of the required plane is :

$3(x + 1) – 1(y – 6) – 1(z – 2) = 0$

$3x + 3 – y + 6 – z + 2 = 0$

$3x – y – z + 11 = 0$

6, Find the equation of the plane bisecting the line segment joining (2, 0, 6) and (–6, 2, 4) and perpendicular to it.



Sol. A(2, 0, 1), B(–6, 2, 4) are the given points

Let 'M' be the mid point of AB.

Coordinates of M are :

$$\left(\frac{2-6}{2},\frac{0+2}{2},\frac{6+4}{2}\right)=(-2,1,5)$$

Since the plane is perpendicular to AB, d.r.'s of the normal to the plane are

$2 + 6, 0 – 2, 6 – 4$ i.e., $8, –2, 2$

Equation of the required plane is :

$8(x + 2) – 2(y – 1) + 2(z – 5) = 0$

$\Rightarrow 8x + 16 – 2y + 2 + 2z – 10 = 0$

$\Rightarrow 8x – 2y + 2z + 8 = 0.$

$\Rightarrow 48x – y + z + 4 = 0$

7. Find the equation of the plane passing through (0, 0, –4) and perpendicular to the line joining the point (1, –2, 2) and (–3, 1, –2).

Sol. Ans; $4x – 3y + 4z + 16 = 0.$

8. Find the equation of the plane through (4, 4, 0) and perpendicular to the planes 2x + y + 2z + 3 = 0 and 3x + 3y + 2z – 8 = 0.

Sol. Equation of the plane passing through P(4,4,0) is :

$a(x – 4) + b(y – 4) + c(z – 0) = 0$ …(i)

This plane is perpendicular to

$2x + y + 2z – 3 = 0$

$3x + 3y + 2z – 8 = 0$

$\therefore 2a + b + 2c = 0$ …(ii)

$3a + 3b + 2c = 0$ …(iii)

$$\begin{array}{cccccccc} & a & & b & & c & & \\ 1 & \times & 2 & \times & 2 & \times & 1 \\ 3 & & 2 & & 3 & & 3 \end{array}$$

$$\frac{a}{2-6} = \frac{b}{6-4} = \frac{c}{6-3} \Rightarrow \frac{a}{-4} = \frac{b}{2} = \frac{c}{3}$$

Substituting in (i), equation of the required plane is :

$-4(x - 4) + 2(y - 4) + 3(z - 0) = 0$

$\Rightarrow -4x + 16 + 2y - 8 + 3z = 0$

$\Rightarrow -4x + 2y + 3z + 8 = 0.$

$\Rightarrow 4x - 2y - 3z - 8 = 0$

III.

1. **Find the equation of the plane through the points (2, 2, –1), (3, 4, 2), (7, 0, 6).**

Sol. A(2, 2, –1), B(3, 4, 2), C(7, 0, 6) are the given points.

Let a, b, c be the d. rs of normal to the plane.

Equation of the plane passing through A(2, 2, –1) is $a(x - 2) + b(y - 2) + c(z + 1) = 0$ …(i)

This plane is passsing through B(3, 4, 2) and C(7, 0, 6).

$a(3 - 2) + b(4 - 2) + c(2 + 1) = 0 \Rightarrow a + 2b + 3c = 0$ …(ii)

$a(7 - 2) + b(0 - 2) + c(6 + 1) = 0 \Rightarrow 5a - 2b + 7c = 0$ …(iii)

From (ii) and (iii) :

$$\begin{array}{cccccccc} & a & & b & & c & & \\ 2 & \times & 3 & \times & 1 & \times & 2 \\ -2 & & 7 & & 5 & & -2 \end{array}$$

$$\frac{a}{14+6} = \frac{b}{15-7} = \frac{c}{-2-10}$$

$$\frac{a}{20} = \frac{b}{8} = \frac{c}{-12} \Rightarrow \frac{a}{5} = \frac{b}{2} = \frac{c}{-3}$$

Substituting in (i) equation of the required plane is

$5(x - 2) + 2(y - 2) - 3(z + 1) = 0 \Rightarrow 5x - 10 + 2y - 4 - 3z - 3 = 0$

$\Rightarrow 5x + 2y - 3z - 17 = 0$

2. **Show that the points (0, –1, 0), (2, 1, –1), (1, 1, 1), (3, 3, 0) are coplanar.**

Sol. Given points are A(0,-1,0) B(2,1,-1) c(1,1,1) and D(3,3,0)

The equation of the plane containing three points (x_1, y_1, z_1), (x_2, y_2, z_2), (x_3, y_3, z_3)

is $\begin{vmatrix} x-x_1 & y-y_1 & z-z_1 \\ x_2-x_1 & y_2-y_1 & z_2-z_1 \\ x_3-x_1 & y_3-y_1 & z_3-z_1 \end{vmatrix} = 0$

The equation of the plane through A,B,C is

$$\begin{vmatrix} x-0 & y+1 & z-0 \\ 2-0 & 1+1 & -1-0 \\ 1-0 & 1+1 & 1-0 \end{vmatrix} = 0$$

$$\begin{vmatrix} x & y+1 & z \\ 2 & 2 & -1 \\ 1 & 2 & 1 \end{vmatrix} = 0$$

$$\Rightarrow x(2+2)-(y+1)(2+1)+z(4-2)=0$$

$$\Rightarrow 4x-3y+2z-3=0$$

Substituting D(3,3,0), 4.3 – 3.3 + 2.0 -3 =0 $\Rightarrow$ 12-9-3 =0 $\Rightarrow$ 0=0.

Therefore D is a point of the plane ABC.

Hence given points are coplanar.

3. **Find the equation of the plane through (6, –4, 3), (0, 4, –3) and cutting of intercepts whose sum is zero.**

Sol. Suppose a, b, c are the intercepts of the plane.

Equation of the plane is $\frac{x}{a}+\frac{y}{b}+\frac{z}{c}=1$

Given a + b + c = 0 $\Rightarrow$ c = –(a + b)

The plane is passing through P(6, –4, 3), Q(0, 4, –3)

$$\Rightarrow \frac{6}{a}-\frac{4}{b}+\frac{3}{c}=1 \text{ and } \frac{4}{b}-\frac{3}{c}=1$$

Adding these two $\frac{6}{a}=2 \Rightarrow a=\frac{6}{2}=3$

$$\frac{4}{b}-\frac{3}{c}=1 \Rightarrow 4c-3b=bc \Rightarrow$$

$$c = -a - b = -3 - b \Rightarrow 4(-3-b) - 3b = b(-3-b)$$
$$\Rightarrow -12 - 4b - 3b = -3b - b^2 \Rightarrow b^2 - 4b - 12 = 0$$
$$\Rightarrow (b-6)(b+2) = 0 \Rightarrow b = 6, -2$$

Case I :

$b = 6 \Rightarrow$ $c = -3 - b = -3 - 6 = -9$

Equation of the plane is : $\frac{x}{3} + \frac{y}{6} - \frac{z}{9} = 1$

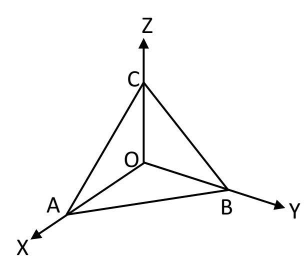
$$6x + 3y - 2z = 18$$

Case II :

$b = -2$ $\Rightarrow c = -3 - b = -3 + 2 = -1$

Equation of the plane is : $\frac{x}{3} + \frac{y}{-2} + \frac{z}{-1} = 1$

4. A plane meets the coordinate axes in A, B, C. If the centroid of ΔABC is (a, b, c). Show that the equation of the plane is $\frac{x}{a} + \frac{y}{b} + \frac{z}{c} = 3$.



Sol. let α, β, γ be the intercepts of the plane ABC.

Equation of the plane is $\frac{x}{\alpha} + \frac{y}{\beta} + \frac{z}{\beta} = 1$ …(i)

Coordinates of A are $(\alpha, 0, 0)$, B are $(0, \beta, 0)$ and C are $(0, 0, \gamma)$.

Centroid of ΔABC is G= $\left(\frac{\alpha}{3}, \frac{\beta}{3}, \frac{\gamma}{3}\right) = (a, b, c)$

$$\frac{\alpha}{3} = a, \frac{\beta}{3} = b, \frac{\gamma}{3} = c \quad \Rightarrow \quad \alpha = 3a, \beta = 3b, \gamma = 3c$$

Substituting in (i), equation of the plane ABC is : $\frac{x}{3a} + \frac{y}{3b} + \frac{z}{3c} = 1 \Rightarrow \frac{x}{a} + \frac{y}{b} + \frac{z}{c} = 3$.

5. Show that the plane through (1, 1, 1), (1, –1, 1) and (–7, –3, –5) is parallel to y-axis.

Sol. Equation of the plane through (1, 1, 1), (1, –1, 1) and (–7, –3, –5) is

$$\begin{vmatrix} x-x_1 & y-y_1 & z-z_1 \\ x_2-x_1 & y_2-y_1 & z_2-z_1 \\ x_3-x_1 & y_3-y_1 & z_3-z_1 \end{vmatrix} = 0 \Rightarrow \begin{vmatrix} x-1 & y-1 & z-1 \\ 0 & -2 & 0 \\ -8 & -4 & -6 \end{vmatrix} = 0 \Rightarrow 3x-4z+1=0$$

D.rs of normal to the plane aer 3, 0, -4

d.rs of y axis are 0,1,0 $\Rightarrow a_1a_2+b_1b_2+c_1c_2 = 3.0+0.1-4.0=0$

Normal to the plane is perpendicular to the y-axis. hence plnae is parallel to Y-axis.

6. Show that the equations ax + by + r = 0, by + cz + p = 0, cz + ax + q = 0 represent planes perpendicular to XY, YZ, ZX planes respectively.

Sol. Given plane is : ax + by + c = 0

d.r.'s of the normal are (a, b, 0)

Equation of XY-plane is z = 0

d.r.'s of the normal are (0, 0, 1)

$\Rightarrow a_1a_2+b_1b_2+c_1c_2 = a\cdot b+b\cdot 0+0\cdot 1=0$

$\therefore$ ax + by + r = 0 is perpendicular to xy-plane. Similarly we can show that by + cz + p = 0 is perpendicular to yz-plane and cz + ax + q = 0 is perpendicular to zx-plane.

7. Find the equation of the plane passing through (2, 0, 1) and (3, –3, 4) and perpendicular to x – 2y + z = 6.

Sol. Equation of the plane passing through (2, 0, 1) is

a(x – 2) + by + c(z – 1) = 0 …(i) where a,b,c are d.rs of normal to the plane.

This plane passes through B(3, –3, 4)

$\Rightarrow$ a – 3b + 3c = 0 … (ii)

The plane (i) is perpendicular to x – 2y + z = 6

$\Rightarrow$ a – 2b + c = 0 … (iii)

Solving (ii) and (iii)

$$\begin{array}{cccc} & a & b & c \\ -3 & 3 & 1 & -3 \\ -2 & 1 & 1 & -2 \end{array}$$

$$\frac{a}{-3+6} = \frac{b}{3-1} = \frac{c}{-2+3}$$

$$\frac{a}{3} = \frac{b}{2} = \frac{c}{1}$$

Substituting in (i), equation of the required plane is :

$3(x - 2) + 2y + 1(z - 1) = 0$

$3x - 6 + 2y + z - 1 = 0$

$3x + 2y + z - 7 = 0.$

Problems for practice

1. **Find the equation of the plane if the foot of the perpendicular from origin to the plane is (2, 3, –5).**

Ans : $2x + 3y - 5z - 38 = 0.$

2. **Find the equation to the plane through the points (0, –1, –1), (4, 5, 1) and (3, 9, 4).**

Ans. $5x - 7y + 11z + 4 = 0$

3. **Find the equation to the plane parallel to the ZX plane and passing through (0, 4, 4).**

Ans. $y = 4$

4. **Find the equation of the plane through the point (α, β, γ) and parallel to the plane $ax + by + cz = 0$.**

Sol. Equation of the given plane is $ax + by + cz = 0$

Equation of the parallel plane is $ax+by+cz = k$

This plane passes through $P(\alpha, \beta, \gamma) \Rightarrow a\alpha + b\beta + c\gamma = K$

$\therefore$ Equation of the required plane is :

$ax + by + cz = a\alpha + b\beta + c\gamma$

i.e. $a(x - \alpha) + b(y - \beta) + c(z - \gamma) = 0.$

5. Find the angle between the plane $2x - y + z = 6$ and $x + y + 2z = 7$.

Ans. $\theta = \pi/3$

6. Find the equation of the plane passing through (2, 0, 1) and (3, –3, 4) and perpendicular to
$x - 2y + z = 6$.

Ans. $3x + 2y + z - 7 = 0$