EXERCISE 4.4

Q.1 Find the point of intersection of the lines

(i) $x-2y+1=0$ **and** $2x-y+2=0$

Solution:

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

$2x-y+2=0$

$2x=y-2$

$x=\frac{y-2}{2}$ ...(ii)

Comparing (i) and (ii)

$2y-1=\frac{y-2}{2}$

$4y-2=y-2$

$3y=0$

$y=0$

Put $y=0$ in (i)

$x=2(0)-1$

$x=-1$

So point of intersection is $(-1,0)$

(ii) $3x+y+12=0$ **and** $x+2y-1=0$

Solution:

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

$3x+y+12=0$

$3x=-y-12$

$x=\frac{-y-12}{3}$ ...(ii)

Comparing (i) and (ii)

$\frac{-y-12}{3}=-2y+1$

$-y-12=-6y+3$

$5y=15$

$y=3$

Put $y=3$ in (i)

$x=-2(3)+1$

$x=-6+1$

$x=-5$

So point of intersection is $(-5,3)$.

(iii) $x+4y-12=0$ **and** $x-3y+3=0$

Solution:

$x+4y-12=0 \Rightarrow x=-4y+12$ ...(i)

$x-3y+3=0$

$x=3y-3$ ...(ii)

Comparing (i) and (ii)

$-4y+12=3y-3$

$7y=15$

$y=\frac{15}{7}$

Put $y=\frac{15}{7}$ in (ii)

$x=3\left(\frac{15}{7}\right)-3$

$x=\frac{45-21}{7}=\frac{24}{7}$

So point of intersection is $\left(\frac{24}{7},\frac{15}{7}\right)$

Q.2 Find an equation of the line through

(i) The point $(2,-9)$ **and the intersection of the lines** $2x+5y-8=0$ **and** $3x-4y-6=0$

Solution:

$2x+5y-8=0$

$2x=-5y+8$

$x=\frac{-5y+8}{2}$ ...(i)

$3x-4y-6=0$

$3x=4y+6$

$x=\frac{4y+6}{3}$ ...(ii)

Comparing (i) and (ii)

$\frac{-5y+8}{2}=\frac{4y+6}{3}$

$-15y+24=8y+12$

$23y=12$

$y=\frac{12}{23}$

Put $y=\frac{12}{23}$ in (ii)

$x=\frac{4\left(\frac{12}{23}\right)+6}{3}$

$x=\frac{\frac{48+138}{23}}{3}$

$x=\frac{186}{3\times 23}$

$x=\frac{62}{23}$

So point of intersection is $\left(\frac{62}{23},\frac{12}{23}\right)$

So equation of line through $(2,-9)$ and $\left(\frac{62}{23},\frac{12}{23}\right)$ is given by

$y-y_1=\frac{y_2-y_1}{x_2-x_1}(x-x_1)$

$y-(-9)=\frac{\frac{12}{23}-(-9)}{\frac{62}{23}-2}(x-2)$

$y-(-9)=\frac{219}{16}(x-2)$

$16y+144=219x-438$

$\boxed{219x-16y-582=0}$

(ii) The intersection of the lines $x-y-4=0$ **and** $7x+y+20=0$

(a) Parallel to the line $6x+y-14=0$

Solution:

$x-y-4=0\Rightarrow y=x-4$ ...(i)

$7x+y+20=0\Rightarrow y=-7x-20$ ...(ii)

Comparing (i) and (ii)

$x-4=-7x-20$

$8x=-16$

$x=-2$

Put $x=-2$ in (i)

$y=-2-4$

$y=-6$

So point of intersection is $(-2,-6)$

Given line is $6x+y-14=0$

Slope of given line $=m_1=\frac{-a}{b}=\frac{-6}{1}=-6$

As slope of parallel lines are equal so slope of required line $=m=-6$

Using point slope form

$y-y_1=m(x-x_1)$

$y-(-6)=-6(x-(-2))$

$y+6=-6(x+2)$

$y+6=-6x-12$

$\boxed{6x+y+18=0}$

(b) Perpendicular to the line $6x+y-14=0$

Solution:

Slope of given line $=m_1=-6$

Slope of required line = $m=-\frac{1}{m_1}=\frac{1}{6}$

Using point slope form

$y-y_1=m(x-x_1)$

$y-(-6)=\frac{1}{6}(x-(-2))$

$6y+36=x+2$

$\boxed{x-6y-34=0}$

(iii) The intersection of the lines $x+2y+3=0$; $3x+4y+7=0$ **and making equal intercepts on the axes**

Solution:

$x+2y+3=0\Rightarrow x=-2y-3$ ...(i)

$3x+4y+7=0$

$3x=-4y-7$

$x=\frac{-4y-7}{3}$ ...(ii)

Comparing (i) and (ii)

$\frac{-4y-7}{3}=-2y-3$

$-4y-7=-6y-9$

$2y=-2$

$y=-1$

Put $y=-1$ in (i)

$x=-2(-1)-3$

$x=2-3$

$x=-1$

So the point of intersection is $(-1,-1)$

Equation of line in two intercepts form

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

As line is making equal intercepts i.e. $a=b$, so

$\frac{x}{a}+\frac{y}{a}=1$

$x+y=a$ ...(iii)

As the line passes through $(-1,-1)$ so

$-1+(-1)=a$

$a=-2$

So, (iii) becomes

$x+y=-2$

$\boxed{x+y+2=0}$

Q.3 Find an equation of the line through the intersection of $16x-10y-33=0$ and $12x+14y+29=0$ and the intersection of $x-y+4=0$ and $x-7y+2=0$.

Solution:

Here

$16x-10y-33=0$ (i)

$12x+14y+29=0$ (ii)

From (i)

$16x=10y+33$

$x=\frac{10y+33}{16}$ (iii)

From (ii)

$12x=-14y-29$

$x=\frac{-14y-29}{12}$ (iv)

Comparing (iii) and (iv)

$\frac{10y+33}{16}=\frac{-14y-29}{12}$

$120y+396=-224y-464$

$120y+224y=-464-396$

$344y=-860$

$y=\frac{-860}{344}$

$y=\frac{-5}{2}$

Put $y=\frac{-5}{2}$ in (iii)

$x=\frac{10\left(\frac{-5}{2}\right)+33}{16}$

$=\frac{-25+33}{16}$

$=\frac{8}{16}$

$=\frac{1}{2}$

So point of intersection is $\left(\frac{1}{2},\frac{-5}{2}\right)$

Also

$x-y+4=0$ (v)

$x-7y+2=0$ (vi)

From (v)

$x=y-4$ (vii)

Put this in (vi)

$-6y-2=0$

$y-4-7y+2=0$

$y=\frac{-2}{6}=\frac{-1}{3}$

Put $y=\frac{-1}{3}$ in (vii)

$x=\frac{-1}{3}-\frac{4}{1}=\frac{-1-12}{3}$

$x=\frac{-13}{3}$

So point of intersection is $\left(\frac{-13}{3},\frac{-1}{3}\right)$

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$$\text{Slope of line} = m = \frac{\frac{-1}{3}-\left(\frac{-5}{2}\right)}{\frac{-13}{3}-\frac{1}{2}}$$

$$= \frac{\frac{-2+15}{6}}{\frac{-26-3}{6}} = \frac{-13}{29}$$

Using point $\left(\frac{1}{2},\frac{-5}{2}\right)$ and

Slope $= \frac{-13}{29}$, equation of the line is

$$y-y_1 = m(x-x_1)$$

$$y-\left(\frac{-5}{2}\right) = \frac{-13}{29}\left(x-\frac{1}{2}\right)$$

$$\frac{2y+5}{2} = \frac{-13}{29}\left(\frac{2x-1}{2}\right)$$

$$29(2y+5) = -13(2x-1)$$

$$58y+145 = -26x+13$$

$$26x-13+58y+145=0$$

$$26x+58y+132=0$$

Divide by 2

$$13x+29y+66=0$$

Q.4 Find the condition that the lines $y=m_1x+c_1; y=m_2x+c_2$ and $y=m_3x+c_3$ are concurrent.

Solution:

We can write

$$m_1x-y+c_1=0$$

$$m_2x-y+c_2=0$$

$$m_3x-y+c_3=0$$

Applying condition of concurrency

$$\begin{vmatrix} m_1 & -1 & c_1 \\ m_2 & -1 & c_2 \\ m_3 & -1 & c_3 \end{vmatrix} = 0$$

By R_2-R_1, R_3-R_1

$$\begin{vmatrix} m_1 & -1 & c_1 \\ m_2-m_1 & 0 & c_2-c_1 \\ m_3-m_1 & 0 & c_3-c_1 \end{vmatrix} = 0$$

Expanding by C_2

$$-(-1)\begin{vmatrix} m_2-m_1 & c_2-c_1 \\ m_3-m_1 & c_3-c_1 \end{vmatrix} + 0 - 0 = 0$$

$$(m_2-m_1)(c_3-c_1)-(m_3-m_1)(c_2-c_1)=0$$

$$\boxed{(m_2-m_1)(c_3-c_1)=(m_3-m_1)(c_2-c_1)}$$

Q.5 Determine the value of *p* such that the lines $2x-3y-1=0$, $3x-y-5=0$ and $3x+py+8=0$ meet at a point.

Solution:

$$2x-3y-1=0$$

$$3x-y-5=0$$

$$3x+py+8=0$$

As lines meet at a point so

$$\begin{vmatrix} 2 & -3 & -1 \\ 3 & -1 & -5 \\ 3 & p & 8 \end{vmatrix} = 0$$

Expanding by R_1

$$2\begin{vmatrix} -1 & -5 \\ p & 8 \end{vmatrix} - (-3)\begin{vmatrix} 3 & -5 \\ 3 & 8 \end{vmatrix} + (-1)\begin{vmatrix} 3 & -1 \\ 3 & p \end{vmatrix} = 0$$

$$2(-8+5p)+3(24+15)-1(3p+3)=0$$

$$-16+10p+117-3p-3=0$$

$$7p+98=0$$

$$7p=-98$$

$$\boxed{p=-14}$$

Q.6 Show that the lines $4x-3y-8=0$, $3x-4y-6=0$ and $x-y-2=0$ are concurrent and the third line bisects the angle formed by the first two lines.

Solution:

Let

$$\ell_1 : 4x-3y-8=0$$

$$\ell_2 : 3x-4y-6=0$$

$$\ell_3 : x-y-2=0$$

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Consider

$$\begin{vmatrix} 4 & -3 & -8 \\ 3 & -4 & -6 \\ 1 & -1 & -2 \end{vmatrix}$$

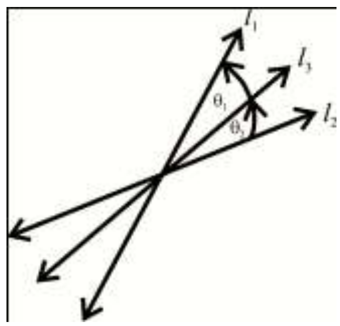
Expanding by R_1

$$= 4\begin{vmatrix} -4 & -6 \\ -1 & -2 \end{vmatrix} - (-3)\begin{vmatrix} 3 & -6 \\ 1 & -2 \end{vmatrix} + (-8)\begin{vmatrix} 3 & -4 \\ 1 & -1 \end{vmatrix}$$

$$= 4(8-6) + 3(-6+6) - 8(-3+4)$$

$$= 8+0-8 = 0$$

As determinant is zero so lines are concurrent.



Slope of $l_1 = m_1 = \frac{-a}{b} = -\left(\frac{4}{-3}\right) = \frac{4}{3}$

Slope of $l_2 = m_2 = \frac{-a}{b} = -\frac{3}{(-4)} = \frac{3}{4}$

Slope of $l_3 = m_3 = \frac{-a}{b} = -\left(\frac{1}{-1}\right) = 1$

Let the angle from l_3 and l_1 be θ_1, then

$$\tan\theta_1 = \frac{m_1 - m_3}{1 + m_1 m_3}$$

$$= \frac{\frac{4}{3} - 1}{1 + \left(\frac{4}{3}\right)(1)} = \frac{\frac{4-3}{3}}{\frac{3+4}{3}}$$

$$\tan\theta_1 = \frac{1}{7}$$

$$\theta_1 = \tan^{-1}\left(\frac{1}{7}\right) \text{ ... (i)}$$

Let the angle from l_2 and l_3 be θ_2, then

$$\tan\theta_2 = \frac{m_3 - m_2}{1 + m_3 m_2} = \frac{1 - \frac{3}{4}}{1 + (1)\left(\frac{3}{4}\right)}$$

$$= \frac{\frac{4-3}{4}}{\frac{4+3}{4}} = \frac{1}{7}$$

$$\theta_2 = \tan^{-1}\left(\frac{1}{7}\right) \text{ ...(ii)}$$

Comparing (i) and (ii)

$$\theta_1 = \theta_2$$

As $\theta_1 = \theta_2$ so third line bisects the angle formed by first two lines.

Q.7 The vertices of a triangle are $A(-2,3), B(-4,1)$ and $C(3,5)$.

Find coordinates of the

(i) Centroid

(ii) Orthocentre

(iii) Circumcentre of the triangle

Are these three points collinear?

Solution:

(i) If $A(x_1, y_1), B(x_2, y_2)$ and $C(x_3, y_3)$ are vertices of triangle, then

Centroid $= C\left(\frac{x_1+x_2+x_3}{3}, \frac{y_1+y_2+y_3}{3}\right)$

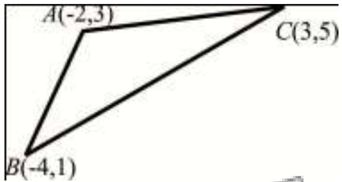
$$= C\left(\frac{-2+(-4)+3}{3}, \frac{3+1+5}{3}\right)$$

$$= C\left(\frac{-3}{3}, \frac{9}{3}\right)$$

$$= C(-1,3)$$

(ii) Orthocentre

Orthocenter is the point of intersection of altitudes.



Slope of side $\overline{AB} = m_1 = \frac{y_2 - y_1}{x_2 - x_1}$

$= \frac{3-1}{-2+4}$

$m_1 = \frac{2}{2} = 1$

Slope of line perpendicular to side $\overline{AB}$

$= m_2 = \frac{-1}{m_1} = -1$

Using point $C(3,5)$ and slope $= -1$, the equation of altitude on $\overline{AB}$ from '*C*' is

$y - y_1 = m(x - x_1)$

$y - 5 = -1(x - 3)$

$y - 5 = -x + 3$

$x + y - 8 = 0$ ...(i)

Slope of side $\overline{BC} = m_3 = \frac{y_2 - y_1}{x_2 - x_1}$

$= \frac{5-1}{3-(-4)} = \frac{4}{7}$

Slope of side perpendicular to

$\overline{BC} = m_4 = -\frac{1}{m_3} = -\frac{1}{\left(\frac{4}{7}\right)} = -\frac{7}{4}$

Using point $A(-2,3)$ and slope $= \frac{-7}{4}$, the equation of altitude on $\overline{BC}$ from *A* is

$y - y_1 = m(x - x_1)$

$y - 3 = \frac{-7}{4}(x - (-2))$

$4y - 12 = -7x - 14$

$7x + 4y + 2 = 0$ ...(ii)

As orthocentre is point of intersection of (i) and (ii) so

From (i)

$y = 8 - x$ ...(iii)

Put $y = 8 - x$ in (ii)

$7x + 4(8 - x) + 2 = 0$

$7x + 32 - 4x + 2 = 0$

$3x + 34 = 0$

$x = \frac{-34}{3}$

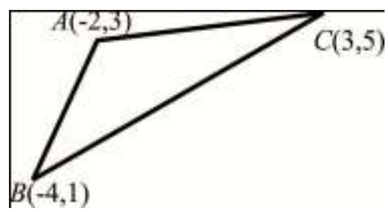
Put $x = \frac{-34}{3}$ in (iii)

$y = 8 - \left(\frac{-34}{3}\right) = \frac{24+34}{3}$

$y = \frac{58}{3}$

So orthocentre is $\left(\frac{-34}{3}, \frac{58}{3}\right)$

(iii) Circumcentre of the triangle



Circumcentre is the point of intersection of right bisectors of a triangle.

Mid-point of $\overline{AB} = \left(\frac{-2+(-4)}{2}, \frac{3+1}{2}\right)$

$= (-3, 2)$

Slope of side $\overline{AB} = \frac{y_2 - y_1}{x_2 - x_1}$

$= \frac{1-3}{-4+2} = \frac{-2}{-2} = 1$

Slope of line perpendicular to

$\overline{AB} = \frac{-1}{1} = -1$

Using point $(-3, 2)$ and slope $= -1$, the equation of right bisector of $\overline{AB}$ is

$y - y_1 = m(x - x_1)$

$y-2=-1\left(x-(-3)\right)$

$y-2=-x-3$

$x+y+1=0$ ...(i)

Mid point of side $\overline{BC}=\left(\frac{-4+3}{2},\frac{1+5}{2}\right)$

$=\left(\frac{-1}{2},3\right)$

Slope of side $\overline{BC}=\frac{y_2-y_1}{x_2-x_1}$

$=\frac{5-1}{3-(-4)}=\frac{4}{7}$

Slope of line perpendicular to

$\overline{BC}=\frac{-1}{\frac{4}{7}}=\frac{-7}{4}$

Using point $\left(\frac{-1}{2},3\right)$ and slope $=\frac{-7}{4}$,

the equation of right bisector of $\overline{BC}$ is

$y-y_1=m(x-x_1)$

$y-3=\frac{-7}{4}\left(x-\left(\frac{-1}{2}\right)\right)$

$4y-12=-7\left(\frac{2x+1}{2}\right)$

$8y-24=-14x-7$

$14x+8y-17=0$ ...(ii)

As circumcentre is point of intersection of (i) and (ii), so

From (i)

$y=-x-1$ ...(iii)

Put $y=-x-1$ in (ii)

$14x+8(-x-1)-17=0$

$14x-8x-8-17=0$

$6x-25=0$

$x=\frac{25}{6}$

Put $x=\frac{25}{6}$ in (iii)

$y=-\left(\frac{25}{6}\right)-1$

$y=\frac{-25-6}{6}=\frac{-31}{6}$

So circumcentre is $\left(\frac{25}{6},\frac{-31}{6}\right)$.

To check whether centroid $(-1,3)$, orthocenter $\left(\frac{-34}{3},\frac{58}{3}\right)$ and circumcentre $\left(\frac{25}{6},\frac{-31}{6}\right)$ are collinear, consider

$$\begin{vmatrix} -1 & 3 & 1 \\ \frac{-34}{3} & \frac{58}{3} & 1 \\ \frac{25}{6} & \frac{-31}{6} & 1 \end{vmatrix}$$

Expanding by R_1

$$=-1\begin{vmatrix} \frac{58}{3} & 1 \\ \frac{-31}{6} & 1 \end{vmatrix}-3\begin{vmatrix} \frac{-34}{3} & 1 \\ \frac{25}{6} & 1 \end{vmatrix}+1\begin{vmatrix} \frac{-34}{3} & \frac{58}{3} \\ \frac{25}{6} & \frac{-31}{6} \end{vmatrix}$$

$$=-1\left(\frac{58}{3}+\frac{31}{6}\right)-3\left(\frac{-34}{3}-\frac{25}{6}\right)+1\left(\frac{1054}{18}-\frac{1450}{18}\right)$$

$$=-\left(\frac{116+31}{6}\right)+3\left(\frac{68+25}{6}\right)+\left(\frac{1054-1450}{18}\right)$$

$$=-\frac{147}{6}+\frac{279}{6}-\frac{396}{18}$$

$$=\frac{-441+837-396}{18}$$

$$=\frac{-837+837}{18}=\frac{0}{18}=0$$

As determinant is zero so these points are collinear.

Q.8 Check whether the lines $4x-3y-8=0$; $3x-4y-6=0$; $x-y-2=0$ are concurrent. If so, find the point where they meet.

Solution:

$4x-3y-8=0$ ...(i)

$3x-4y-6=0$ ...(ii)

$x-y-2=0$ ...(iii)

Applying condition of concurrency

$$\begin{vmatrix} 4 & -3 & -8 \\ 3 & -4 & -6 \\ 1 & -1 & -2 \end{vmatrix}$$

Expanding by R_1

$$=4\begin{vmatrix} -4 & -6 \\ -1 & -2 \end{vmatrix}-(-3)\begin{vmatrix} 3 & -6 \\ 1 & -2 \end{vmatrix}+(-8)\begin{vmatrix} 3 & -4 \\ 1 & -1 \end{vmatrix}$$

$=4(8-6)+3(-6+6)-8(-3+4)$

$=8+0-8$

$=0$

As determinant is zero so given lines are concurrent.

From (iii)

$y=x-2$ ...(iv)

Put $y=x-2$ in (ii)

$3x-4(x-2)-6=0$

$3x-4x+8-6=0$

$-x+2=0$

$x=2$

Put $x=2$ in (iv)

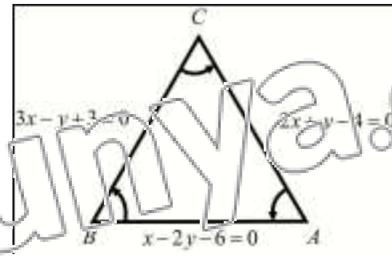
$y=2-2$

$y=0$

So lines meet at $(2,0)$

Q.9 Find the coordinates of the vertices of the triangle formed by the lines $x-2y-6=0$; $3x-y+3=0$; $2x+y-4=0$ Also find measures of the angles of the triangle.

Solution:



$l_1: x-2y-6=0$ ...(i)

$l_2: 3x-y+3=0$ ...(ii)

$l_3: 2x+y-4=0$ ...(iii)

Solving (i) and (ii)

From (i)

$x=2y+6$ ...(iv)

Put $x=2y+6$ in (ii)

$3(2y+6)-y+3=0$

$6y+18-y+3=0$

$5y+21=0$

$y=\frac{-21}{5}$

Put $y=\frac{-21}{5}$ in (iv)

$x=2\left(\frac{-21}{5}\right)+6$

$x=\frac{-42+30}{5}$

$x=\frac{-12}{5}$

So $B\left(\frac{-12}{5},\frac{-21}{5}\right)$ is the point of intersection of ℓ_1 and ℓ_2

Solving (i) and (iii)

From (i)

$x=2y+6$ ...(iv)

Put $x=2y+6$ in (iii)

$2(2y+6)+y-4=0$

$4y+12+y-4=0$

$5y+8=0$

$y=\frac{-8}{5}$

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Put $y=\frac{-8}{5}$ in (iv)

$$x=2\left(\frac{-8}{5}\right)+6$$

$$x=\frac{-16+30}{5}$$

$$x=\frac{14}{5}$$

So $A\left(\frac{14}{5},\frac{-8}{5}\right)$ is the point of intersection of ℓ_1 and ℓ_3

Solving (ii) and (iii)

From (ii)

$y=3x+3$ ...(v)

Put $y=3x+3$ in (iii)

$$2x+3x+3-4=0$$

$$5x-1=0$$

$$x=\frac{1}{5}$$

Put $x=\frac{1}{5}$ in (v)

$$y=3\left(\frac{1}{5}\right)+3$$

$$y=\frac{3+15}{5}=\frac{18}{5}$$

So $C\left(\frac{1}{5},\frac{18}{5}\right)$ is the point of intersection of ℓ_2 and ℓ_3

Slope of $\overline{AB}=m_1=\frac{-a}{b}=\frac{-1}{-2}=\frac{1}{2}$

Slope of $\overline{BC}=m_2=\frac{-a}{b}=\frac{-3}{-1}=3$

Slope of $\overline{AC}=m_3=\frac{-a}{b}=\frac{-2}{1}=-2$

$$\tan(m\angle A)=\frac{m_1-m_3}{1+m_1m_3}$$

$$=\frac{\frac{1}{2}-(-2)}{1+(-2)\left(\frac{1}{2}\right)}$$

$$\tan(m\angle A)=\frac{\frac{4+1}{2}}{0}$$

$$\tan(m\angle A)=\infty$$

$$m\angle A=90^\circ$$

$$\tan(m\angle B)=\frac{m_2-m_1}{1+m_1m_2}=\frac{3-\frac{1}{2}}{1+\left(\frac{1}{2}\right)(3)}$$

$$\tan(m\angle B)=\frac{\frac{6-1}{2}}{\frac{2+3}{2}}=\frac{5}{5}=1$$

$$m\angle B=\tan^{-1}(1)$$

$$m\angle B=45^\circ$$

Also

$$m\angle C=180^\circ-(m\angle A+m\angle B)$$

$$m\angle C=180^\circ-(90^\circ+45^\circ)$$

$$m\angle C=45^\circ$$

Q.10 Find the angle measured from the line l_1 to the line l_2 where

(i) ℓ_1 **: Joining (2,7) and (7,10)**

ℓ_2 **: Joining (1,1) and (−5,3)**

Also find the acute angle in each case.

Solution:

Slope of the line $\ell_1=m_1=\frac{10-7}{7-2}=\frac{3}{5}$

Slope of the line $\ell_2=m_2=\frac{3-1}{-5-1}=\frac{-1}{3}$

If θ is the angle from line l_1 to l_2 then

$$\tan\theta=\frac{m_2-m_1}{1+m_1m_2}$$

$$=\frac{\frac{-1}{3}-\frac{3}{5}}{1+\left(\frac{-1}{3}\right)\left(\frac{3}{5}\right)}$$

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$$= \frac{\frac{-5-9}{15}}{\frac{15-3}{15}} = \frac{-14}{12}$$

$$\theta = \tan^{-1}\left(\frac{-7}{6}\right)$$

$$= 180^\circ - \tan^{-1}\left(\frac{7}{6}\right)$$

$$= 180^\circ - 49.4^\circ$$

$$\theta = 130.6^\circ$$

Acute angle $= 180^\circ - 130.6^\circ = 49.4^\circ$

(ii) ℓ_1 **: Joining** $(3,-1)$ **and** $(5,7)$

ℓ_2 **: Joining** $(2,4)$ **and** $(-8,2)$

Solution:

Slope of line $\ell_1 = m_1 = \frac{7-(-1)}{5-3} = 4$

Slope of line $\ell_2 = m_2 = \frac{2-4}{-8-2} = \frac{1}{5}$

If θ is the angle from line l_1 to l_2, then

$$\tan\theta = \frac{m_2 - m_1}{1 + m_1 m_2}$$

$$= \frac{\frac{1}{5} - 4}{1 + \left(\frac{1}{5}\right)(4)}$$

$$= \frac{\frac{1-20}{5}}{\frac{5+4}{5}} = \frac{-19}{9}$$

$$\theta = \tan^{-1}\left(\frac{-19}{9}\right)$$

$$\theta = 180^\circ - \tan^{-1}\left(\frac{19}{9}\right)$$

$$\theta = 180^\circ - 64.65^\circ$$

$$\theta = 115.35^\circ$$

Acute angle $= 180^\circ - 115.35^\circ$

$= 64.65^\circ$

(iii) ℓ_1 **: Joining** $(1,-7)$ **and** $(6,-4)$

ℓ_2 **: Joining** $(-1,2)$ **and** $(-6,-1)$

Solution:

Slope of line $\ell_1 = m_1 = \frac{-4+7}{6-1} = \frac{3}{5}$

Slope of line $\ell_2 = m_2 = \frac{-1-2}{-6+1} = \frac{3}{5}$

If θ is the angle from line l_1 to l_2, then

$$\tan\theta = \frac{m_2 - m_1}{1 + m_2 m_1}$$

$$= \frac{\frac{3}{5} - \frac{3}{5}}{1 + \left(\frac{3}{5}\right)\left(\frac{3}{5}\right)}$$

$$\tan\theta = 0$$

$$\theta = 0$$

(iv) ℓ_1 **: Joining** $(-9,-1)$ **and** $(3,-5)$

ℓ_2 **: Joining** $(2,7)$ **and** $(-6,-7)$

Solution:

Slope of line $\ell_1 = m_1 = \frac{-5+1}{3+9} = \frac{-1}{3}$

Slope of line $\ell_2 = m_2 = \frac{-7-7}{-6-2} = \frac{7}{4}$

If θ is the angle from line l_1 to l_2 then

$$\tan\theta = \frac{m_2 - m_1}{1 + m_2 m_1}$$

$$= \frac{\frac{7}{4} - \left(-\frac{1}{3}\right)}{1 + \left(\frac{7}{4}\right)\left(-\frac{1}{3}\right)}$$

$$= \frac{\frac{21+4}{12}}{\frac{12-7}{12}} = \frac{25}{5}$$

$$\tan\theta = 5$$

$$\theta = \tan^{-1}(5)$$

$$\theta = 78.69^\circ$$

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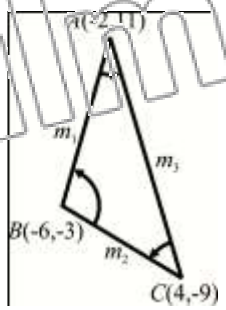
Q.11 Find the interior angles of the triangle whose vertices are

(i) $A(-2,11), B(-6,-3), (4,-9)$

Solution:

$A(-2,11), B(-6,-3), (4,-9)$



Slope of $\overline{AB} = m_1 = \frac{11-(-3)}{-2-(-6)} = \frac{7}{2}$

Slope of $\overline{BC} = m_2 = \frac{-9-(-3)}{4-(-6)} = \frac{-3}{5}$

Slope of $\overline{AC} = m_3 = \frac{-9-11}{4-(-2)} = \frac{-10}{3}$

$$\tan(m\angle B) = \frac{m_1 - m_2}{1+m_1m_2}$$

$$= \frac{\frac{7}{2} - \left(\frac{-3}{5}\right)}{1+\left(\frac{7}{2}\right)\left(\frac{-3}{5}\right)}$$

$$= \frac{\frac{35+6}{10}}{\frac{10-21}{10}}$$

$$= \frac{41}{-11}$$

$$m\angle B = \tan^{-1}\left(\frac{41}{-11}\right)$$

$$= 180^\circ - \tan^{-1}\left(\frac{41}{11}\right)$$

$$= 180^\circ - 74.98^\circ$$

$$m\angle B = 105.02^\circ$$

$$\tan(m\angle A) = \frac{m_3 - m_1}{1+m_3m_1}$$

$$= \frac{\frac{-10}{3} - \frac{7}{2}}{1+\left(\frac{-10}{3}\right)\left(\frac{7}{2}\right)}$$

$$= \frac{\frac{-20-21}{6}}{\frac{6-70}{6}}$$

$$= \frac{-41}{-64} = \frac{41}{64}$$

$$m\angle A = \tan^{-1}\left(\frac{41}{64}\right) = 32.64^\circ$$

Also

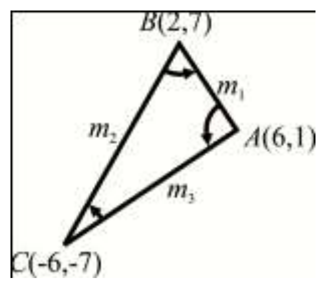
$$m\angle C = 180^\circ - m\angle A - m\angle B$$

$$= 180^\circ - 32.64^\circ - 105.02^\circ$$

$$= 42.34^\circ$$

(ii) $A(6,1), B(2,7), C(-6,-7)$

Solution:



Slope of $\overline{AB} = m_1 = \frac{7-1}{2-6} = \frac{6}{-4} = \frac{-3}{2}$

Slope of $\overline{BC} = m_2 = \frac{-7-7}{-6-2} = \frac{7}{4}$

Slope of $\overline{AC} = m_3 = \frac{-7-1}{-6-6} = \frac{2}{3}$

$$\tan(m\angle B) = \frac{m_1 - m_2}{1+m_1m_2}$$

$$= \frac{\frac{-3}{2} - \frac{7}{4}}{1+\left(\frac{-3}{2}\right)\left(\frac{7}{4}\right)}$$

$$= \frac{\frac{-6-7}{4}}{\frac{8-21}{16}}$$

$$= \frac{-13}{4} \times \frac{8}{-13} = 2$$

$$m\angle B = \tan^{-1}(2)$$

$$= 63.43^\circ$$

$$\tan(m\angle C) = \frac{m_2 - m_3}{1 + m_2 m_3}$$

$$= \frac{\frac{7}{4} - \frac{2}{3}}{1 + \left(\frac{7}{4}\right)\left(\frac{2}{3}\right)}$$

$$= \frac{\frac{21-8}{12}}{\frac{12+14}{12}} = \frac{13}{26} = \frac{1}{2}$$

$$m\angle C = \tan^{-1}\left(\frac{1}{2}\right)$$

$$= 26.57^\circ$$

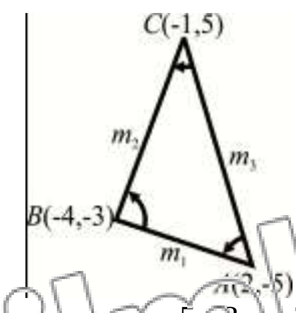
$$m\angle A = 180^\circ - m\angle B - m\angle C$$

$$= 180^\circ - 63.43^\circ - 26.57^\circ$$

$$= 90^\circ$$

(iii) $A(2,-5), B(-4,-3), C(-1,5)$

Solution:



Slope of $\overline{AB} = m_1 = \frac{-5+3}{2+4} = \frac{-2}{6} = \frac{-1}{3}$

Slope of $\overline{BC} = m_2 = \frac{5+3}{-1+4} = \frac{8}{3}$

Slope of $\overline{AC} = m_3 = \frac{5+5}{-1-2} = \frac{-10}{3}$

$$\tan(m\angle B) = \frac{m_2 - m_1}{1 + m_1 m_2}$$

$$= \frac{\frac{8}{3} - \left(\frac{-1}{3}\right)}{1 + \left(\frac{8}{3}\right)\left(\frac{-1}{3}\right)}$$

$$= \frac{\frac{8+1}{3}}{\frac{9-8}{9}} = \frac{9}{3} \times \frac{9}{1} = 27$$

$$m\angle B = \tan^{-1}(27)$$

$$= 87.88^\circ$$

$$\tan(m\angle C) = \frac{m_3 - m_2}{1 + m_3 m_2}$$

$$= \frac{\frac{-10}{3} - \frac{8}{3}}{1 + \left(\frac{-10}{3}\right)\left(\frac{8}{3}\right)}$$

$$= \frac{\frac{-10-8}{3}}{\frac{9-80}{9}}$$

$$= \frac{-18}{3} \times \frac{9}{-71} = \frac{54}{71}$$

$$m\angle C = \tan^{-1}\left(\frac{54}{71}\right)$$

$$= 37.25^\circ$$

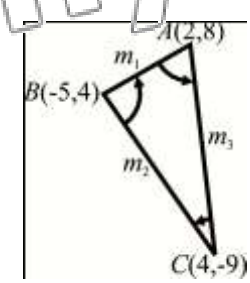
$$m\angle A = 180^\circ - m\angle B - m\angle C$$

$$= 180^\circ - 87.88^\circ - 37.25^\circ$$

$$= 54.87^\circ$$

(iv) $A(2,8), B(-5,4), C(4,-9)$

Solution:



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Slope of side $\overline{AB} = m_1 = \frac{8-4}{2+5} = \frac{4}{7}$

Slope of side $\overline{BC} = m_2 = \frac{4+9}{-5-4} = -\frac{13}{9}$

Slope of side $\overline{AC} = m_3 = \frac{8-(-9)}{2-4} = -\frac{17}{2}$

$$\tan(m\angle B) = \frac{m_1 - m_2}{1+m_1m_2}$$

$$= \frac{\frac{4}{7}-\left(\frac{-13}{9}\right)}{1+\left(\frac{4}{7}\right)\left(\frac{-13}{9}\right)}$$

$$= \frac{\frac{36+91}{63}}{\frac{63-52}{63}} = \frac{127}{11}$$

$$m\angle B = \tan^{-1}\left(\frac{127}{11}\right)$$

$$= 85.05^\circ$$

$$\tan(m\angle C) = \frac{m_2 - m_3}{1+m_2m_3}$$

$$= \frac{\frac{-13}{9}-\left(-\frac{17}{2}\right)}{1+\left(\frac{-13}{9}\right)\left(-\frac{17}{2}\right)}$$

$$= \frac{\frac{-26+153}{18}}{\frac{18+221}{18}} = \frac{127}{239}$$

$$m\angle C = \tan^{-1}\left(\frac{127}{239}\right)$$

$$= 27.99^\circ$$

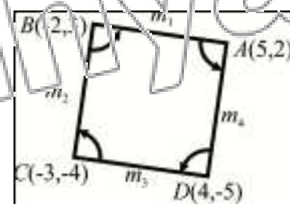
$$m\angle A = 180^\circ - m\angle B - m\angle C$$

$$= 180^\circ - 85.05^\circ - 27.99^\circ$$

$$= 66.96^\circ$$

Q.12 Find the interior angles of the quadrilateral whose vertices are $A(5,2), B(-2,3), C(-3,-4)$ **and** $D(4,-5)$.

Solution:



Slope of side $\overline{AB} = m_1 = \frac{2-3}{5-(-2)} = \frac{-1}{7}$

Slope of side $\overline{BC} = m_2 = \frac{3+4}{-2+3} = 7$

Slope of side $\overline{CD} = m_3 = \frac{-5+4}{4+3} = \frac{-1}{7}$

Slope of side $\overline{AD} = m_4 = \frac{2+5}{5-4} = 7$

$$\tan(m\angle B) = \frac{m_1 - m_2}{1+m_1m_2} = \frac{\frac{-1}{7}-7}{1+\left(\frac{-1}{7}\right)(7)}$$

$$= \frac{\frac{-1}{7}-7}{0} = \infty$$

$$m\angle B = 90^\circ$$

$$\tan(m\angle A) = \frac{m_4 - m_1}{1+m_4m_1}$$

$$= \frac{7-\left(\frac{-1}{7}\right)}{1+(7)\left(\frac{-1}{7}\right)}$$

$$= \frac{7+\frac{1}{7}}{0} = \infty$$

$$m\angle A = 90^\circ$$

As $m_1 = m_3$ and $m_2 = m_4$ so *ABCD* is parallelogram, hence its opposite angles are equal i.e.

$m\angle D = m\angle B = 90^\circ$ and

$m\angle C = m\angle A = 90^\circ$

Q.13 Show that the points $A(0,0), B(2,1), C(3,3)$ **and** $D(1,2)$

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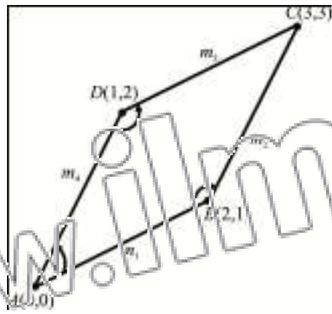
are the vertices of a rhombus. Find its interior angles.

Solution:



Slope of $\overline{AB} = m_1 = \frac{1-0}{2-0} = \frac{1}{2}$

Slope of $\overline{BC} = m_2 = \frac{3-1}{3-2} = 2$

Slope of $\overline{CD} = m_3 = \frac{3-2}{3-1} = \frac{1}{2}$

Slope of $\overline{AD} = m_4 = \frac{2-0}{1-0} = 2$

As $m_1 = m_3$ and $m_2 = m_4$ so opposite sides are parallel.

Using distance formula

$$\left|\overline{AB}\right| = \sqrt{(2-0)^2 + (1-0)^2} = \sqrt{4+1} = \sqrt{5}$$

$$\left|\overline{BC}\right| = \sqrt{(3-2)^2 + (3-1)^2} = \sqrt{1+4} = \sqrt{5}$$

$$\left|\overline{CD}\right| = \sqrt{(3-1)^2 + (3-2)^2} = \sqrt{4+1} = \sqrt{5}$$

$$\left|\overline{AD}\right| = \sqrt{(2-0)^2 + (1-0)^2} = \sqrt{5}$$

As length of all sides are equal so it is a rhombus.

$$\tan(m\angle B) = \frac{m_1 - m_2}{1 + m_1 m_2}$$

$$= \frac{\frac{1}{2} - 2}{1 + \left(\frac{1}{2}\right)(2)}$$

$$= \frac{\frac{1-4}{2}}{\frac{2+2}{2}} = \frac{-3}{4}$$

$$m\angle B = \tan^{-1}\left(\frac{-3}{4}\right)$$

$$= 180^\circ - \tan^{-1}\left(\frac{3}{4}\right)$$

$$= 180^\circ - 36.9^\circ$$

$$= 143.1^\circ$$

Since opposite angles are equal, so

$m\angle D = m\angle B = 143.1^\circ$

$m\angle A + m\angle B + m\angle C + m\angle D = 360^\circ$

$m\angle A + m\angle C + 143.1^\circ + 143.1^\circ = 360^\circ$

$m\angle A + m\angle C = 73.8^\circ$

Since opposite angles are equal, so

$m\angle A = m\angle C = 36.9^\circ$

Q.14 Find the area of the region bounded by the triangle whose sides are

$7x - y - 10 = 0$ **;** $10x + y - 41 = 0$ **;**

$3x + 2y + 3 = 0$

Solution:

$\ell_1 : 7x - y - 10 = 0 \Rightarrow y = 7x - 10$ ...(i)

$\ell_2 : 10x + y - 41 = 0$ ...(ii)

Put $y = 7x - 10$ in (ii)

$10x + 7x - 10 - 41 = 0$

$17x - 51 = 0$

$17x = 51$

$x = 3$

Put $x = 3$ in (i)

$y = 7(3) - 10$

$y = 21 - 10$

$y = 11$

Point of intersection of ℓ_1 and ℓ_2 is $(3,11)$

$\ell_3 : 3x + 2y + 3 = 0$ ...(iii)

Put $y = 7x - 10$ in (iii)

$3x + 2(7x - 10) + 3 = 0$

$3x + 14x - 20 + 3 = 0$

$17x - 17 = 0$

$x = 1$

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Put $x=1$ in (i)

$y=7(1)-10$

$y=-3$

Point of intersection of ℓ_1 and ℓ_3 is

$(1,-3)$

$\ell_2: 10x+y-41=0$ ...(ii)

$y=41-10x$ ...(iv)

Put $y=41-10x$ in (iii)

$3x+2(41-10x)+3=0$

$3x+82-20x+3=0$

$-17x+85=0$

$17x=85$

$x=5$

Put $x=5$ in...(iv)

$y=41-10(5)$

$y=41-50$

$y=-9$

Point of intersection of ℓ_2 and ℓ_3 is

$(5,-9)$

Hence three vertices of triangle are

$(3,11),(1,-3),(5,-9)$

Area of triangle is given by

$$\Delta=\frac{1}{2}\begin{vmatrix}3 & 11 & 1\\ 1 & -3 & 1\\ 5 & -9 & 1\end{vmatrix}$$

Expanding by R_1

$$=\frac{1}{2}\left[3\begin{vmatrix}-3 & 1\\ -9 & 1\end{vmatrix}-11\begin{vmatrix}1 & 1\\ 5 & 1\end{vmatrix}+1\begin{vmatrix}1 & -3\\ 5 & -9\end{vmatrix}\right]$$

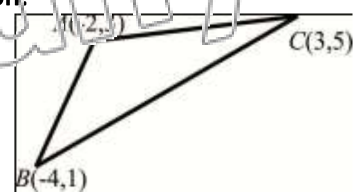
$$=\frac{1}{2}\left[3(-3+9)-11(1-5)+1(-9+15)\right]$$

$$=\frac{1}{2}[18+44+6]$$

$=\frac{1}{2}(68)=34$ square unit

Q.15 The vertices of a triangle are $A(-2,3), B(-4,1)$ and $C(3,5)$. Find the centre of the circumcircle of the triangle.

Solution:



Slope of $\overline{AB}=m_1=\frac{3-1}{-2+4}=\frac{2}{2}=1$

Slope of $\overline{BC}=m_2=\frac{5-1}{3+4}=\frac{4}{7}$

Slope of $\overline{AC}=m_3=\frac{5-3}{3+2}=\frac{2}{5}$

Slope of line perpendicular to

$\overline{AB}=m_4=\frac{-1}{m_1}=\frac{-1}{1}=-1$

Mid point of $\overline{AB}=\left(\frac{-2+(-4)}{2},\frac{3+1}{2}\right)$

$=(-3,2)$

Equation of line passing through $(-3,2)$ having slope -1 is

$y-y_1=m(x-x_1)$

$y-2=-1(x-(-3))$

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

$y-2=-x-3$

$x+y+1=0$ ...(i)

Slope of line perpendicular to

$\overline{BC}=m_5=\frac{-1}{m_2}=\frac{-1}{\left(\frac{4}{7}\right)}=-\frac{7}{4}$

Mid point of $\overline{BC}=\left(\frac{-4+3}{2},\frac{1+5}{2}\right)$

$=\left(\frac{-1}{2},3\right)$

Equation of line passing through $\left(\frac{-1}{2},3\right)$ and having slope $-\frac{7}{4}$ is

$y-y_1=m(x-x_1)$

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$$y-3=\frac{-7}{4}\left(x-\left(\frac{-1}{2}\right)\right)$$

$$4y-12=-7\left(\frac{2x+1}{2}\right)$$

$$8y-24=-14x-7$$

$14x+8y-17=0$ ...(ii)

Circumcentre is the point of the intersection of (i) and (ii)

From (i)

$y=-x-1$ ...(iii)

Put $y=-x-1$ in (ii)

$$14x+8(-x-1)-17=0$$

$$14x-8x-8-17=0$$

$$6x-25=0$$

$$x=\frac{25}{6}$$

Put $x=\frac{25}{6}$ in (iii)

$$y=\frac{-25}{6}-1=\frac{-25-6}{6}=\frac{-31}{6}$$

So circumcentre is $\left(\frac{25}{6},\frac{-31}{6}\right)$

Q.16 Express the given system of equations in matrix form. Find in each case whether the lines are concurrent.

(i) $x+3y-2=0;\ 2x-y+4=0;\ x-11y+14=0$

Solution:

$$\ell_1: x+3y-2=0$$

$$\ell_2: 2x-y+4=0$$

$$\ell_3: x-11y+14=0$$

The matrix equation of the system is

$$\begin{bmatrix}1 & 3 & -2\\ 2 & -1 & 4\\ 1 & -11 & 14\end{bmatrix}\begin{bmatrix}x\\ y\\ 1\end{bmatrix}=\begin{bmatrix}0\\ 0\\ 0\end{bmatrix}$$

Determinant of matrix of co-efficients is

$$\begin{vmatrix}1 & 3 & -2\\ 2 & -1 & 4\\ 1 & -11 & 14\end{vmatrix}$$

Expanding by R_1

$$=1\begin{vmatrix}-1 & 4\\ -11 & 14\end{vmatrix}-3\begin{vmatrix}2 & 4\\ 1 & 14\end{vmatrix}+(-2)\begin{vmatrix}2 & -1\\ 1 & -11\end{vmatrix}$$

$$=1(-14+44)-3(28-4)-2(-22+1)$$

$$=30-3(24)-2(-21)$$

$$=30-72+42$$

$$=0$$

So given lines are concurrent

(ii) $2x+3y+4=0;\ x-2y-3=0;\ 3x+y-8=0$

Solution:

$$\ell_1: 2x+3y+4=0$$

$$\ell_2: x-2y-3=0$$

$$\ell_3: 3x+y-8=0$$

The matrix equation of the system is

$$\begin{bmatrix}2 & 3 & 4\\ 1 & -2 & -3\\ 3 & 1 & -8\end{bmatrix}\begin{bmatrix}x\\ y\\ 1\end{bmatrix}=\begin{bmatrix}0\\ 0\\ 0\end{bmatrix}$$

Determinant of matrix of co-efficients is

$$\begin{vmatrix}2 & 3 & 4\\ 1 & -2 & -3\\ 3 & 1 & -8\end{vmatrix}$$

Expanding by R_1

$$=2\begin{vmatrix}-2 & -3\\ 1 & -8\end{vmatrix}-3\begin{vmatrix}1 & -3\\ 3 & -8\end{vmatrix}+4\begin{vmatrix}1 & -2\\ 3 & 1\end{vmatrix}$$

$$=2(16+3)-3(-8+9)+4(1+6)$$

$$=38-3+28$$

$$=63\neq 0$$

So, given lines are not concurrent

(iii) $3x-4y-2=0:\ x+2y-4=0;$ $3x-2y+5=0$

Solution:

$$\ell_1: 3x-4y-2=0$$

$$\ell_2: x+2y-4=0$$

$$\ell_3: 3x-2y+5=0$$

The matrix equation of the system is

$$\begin{bmatrix}3 & -4 & -2\\ 1 & 2 & -4\\ 3 & -2 & 5\end{bmatrix}\begin{bmatrix}x\\ y\\ 1\end{bmatrix}=\begin{bmatrix}0\\ 0\\ 0\end{bmatrix}$$

Determinant of matrix of co-efficients is

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$$\begin{vmatrix} 3 & -4 & -2 \\ 1 & 2 & -4 \\ 3 & -2 & 5 \end{vmatrix}$$

Expanding by R_1

$$=3\begin{vmatrix} 2 & -4 \\ -2 & 5 \end{vmatrix}-(-4)\begin{vmatrix} 1 & -4 \\ 3 & 5 \end{vmatrix}+(-2)\begin{vmatrix} 1 & 2 \\ 3 & -2 \end{vmatrix}$$

$=3(10-8)+4(5+12)-2(-2-6)$

$=6+68+16$

$=90\neq 0$

So the lines are not concurrent

Q.17 Find a system of linear equations corresponding to the given matrix form. Check whether the lines represented by the system are concurrent.

Solution:

(a) $$\begin{bmatrix} 1 & 0 & -1 \\ 2 & 0 & 1 \\ 0 & -1 & 2 \end{bmatrix}\begin{bmatrix} x \\ y \\ 1 \end{bmatrix}=\begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}$$

$$\begin{bmatrix} x+0y-1 \\ 2x+0y+1 \\ 0x-y+2 \end{bmatrix}=\begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}$$

So required system of equations is

$x-1=0$

$2x+1=0$

$-y+2=0$

Determinant of matrix of co-efficients is

$$\begin{vmatrix} 1 & 0 & -1 \\ 2 & 0 & 1 \\ 0 & -1 & 2 \end{vmatrix}$$

Expanding by R_1

$$=1\begin{vmatrix} 0 & 1 \\ -1 & 2 \end{vmatrix}-0+(-1)\begin{vmatrix} 2 & 0 \\ 0 & -1 \end{vmatrix}$$

$=1(0+1)+(-1)(-2-0)$

$=1+2=3\neq 0$

So the lines are not concurrent

(b) $$\begin{bmatrix} 1 & 1 & 2 \\ 2 & 4 & -3 \\ 3 & 6 & -5 \end{bmatrix}\begin{bmatrix} x \\ y \\ 1 \end{bmatrix}=\begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}$$

Solution:

$$\begin{bmatrix} x+y+2 \\ 2x+4y-3 \\ 3x+6y-5 \end{bmatrix}=\begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}$$

So required system of equations is

$x+y+2=0$

$2x+4y-3=0$

$3x+6y-5=0$

Determinant of matrix of co-efficients is

$$\begin{vmatrix} 1 & 1 & 2 \\ 2 & 4 & -3 \\ 3 & 6 & -5 \end{vmatrix}$$

Expanding by R_1

$$=1\begin{vmatrix} 4 & -3 \\ 6 & -5 \end{vmatrix}-1\begin{vmatrix} 2 & -3 \\ 3 & -5 \end{vmatrix}+2\begin{vmatrix} 2 & 4 \\ 3 & 6 \end{vmatrix}$$

$=1(-20+18)-1(-10+9)+2(12-12)$

$=-2+1+0=-1\neq 0$

So given lines are not concurrent

Homogeneous Equation:

An equation in two variables *x* and *y* is called a homogeneous equation of degree n, if the sum of exponents of *x* and *y* in each term is same and equal to *n*.

The equation $ax^2+2hxy+by^2=0$ is a homogenous equation of second degree which represents a pair of intersecting lines passing from origin. Measure of the angle θ between these lines is given by $\tan\theta=\dfrac{2\sqrt{h^2-ab}}{a+b}$.

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