1) $x_0 = 120,\ y_0 = 23$

$x_1 = 423,\ y_1 = 428$

$$m = \frac{y_1 - y_0}{x_1 - x_0} = \frac{428 - 23}{423 - 120} \Rightarrow 1.33$$

$\therefore m > 1$ and $y_1 > y_0$

~~$y = y+1$~~ $\therefore$ y will be increase; $y+1$

Total pixel $= \max(|\Delta x|, |\Delta y|) + 1$

$\Rightarrow \max(303, 405) + 1$

$\Rightarrow 405 + 1 \Rightarrow 406$ pixel

$\therefore$ Total pixel $\Rightarrow 406$

Num of times y will be increase

$= 405$ times

Ans

2)

$$\frac{x}{7} - \frac{y}{12} = 5$$

For starting point,

$y_0 = 12 \quad \therefore x_0 \Rightarrow \frac{x}{7} - \frac{42}{12} = 5$

$\Rightarrow \frac{x}{7} = 6$

$\Rightarrow x_0 = 42$

$\therefore (x_0, y_0) = (42, 12)$

For ending point,

$y_1 = 0 \Rightarrow x_1 = 35$

$\therefore (x_1, y_1) = (35, 0)$

Now,

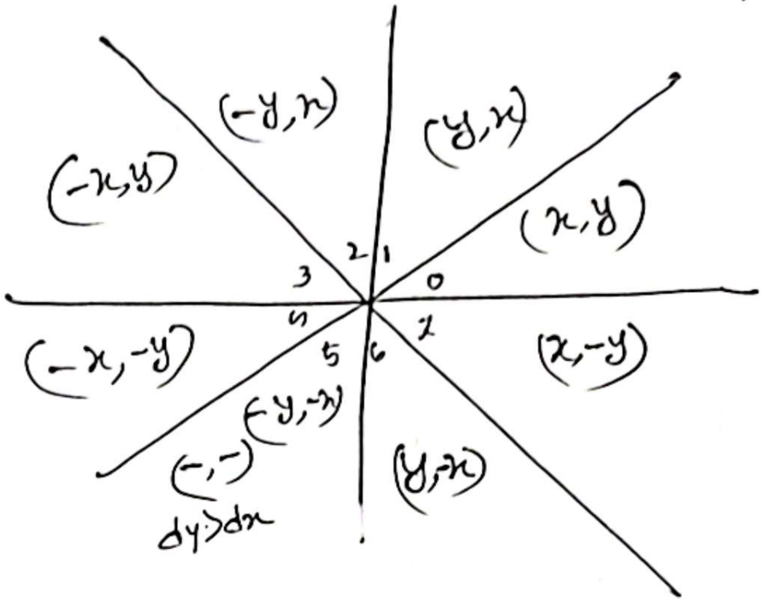
$dx \Rightarrow (35-42) \Rightarrow -7$

$dy \Rightarrow (0-12) \Rightarrow -12$

$\therefore dx < 0$ and $dy < 0$ | $|dy| > |dx|$

$\therefore$ Co-ordinates are now in Zone 5

Zone 5	Zone 0
$(-y,-x)$	(x,y)
$(42,12)$	$(-12,-42)$
$(35,0)$	$(0,-35)$



$d_{init} \Rightarrow 2dy - dx$

$\Rightarrow 14 - 12$

$\Rightarrow 2$

$dx = 0 - (-12)$

$\Rightarrow 12$

$dy = -35 + 42$

$\Rightarrow 7$

$d_{NE} \Rightarrow 2dy - 2dx$

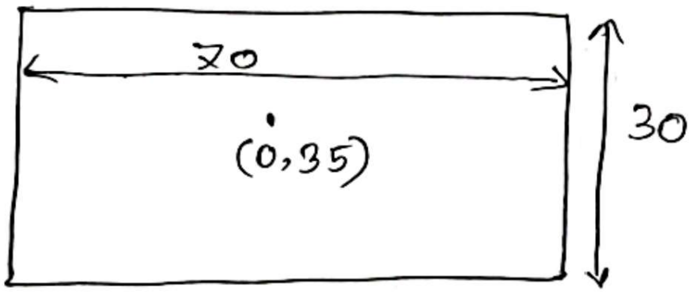
$\Rightarrow 14 - 24$

$\Rightarrow -10$

$d_E \Rightarrow d\,2dy \Rightarrow 14$

x'	y'	d_{init}	NF/F	pixel (x, y)	Zone 5 pixel $(-y, -x)$
-12	-42	2	NF	(-12, -42)	(42, 12)
-11	-41	-8	F	(-11, -41)	(41, 11)
-10	-41	6	NF	(-10, -41)	(41, 10)
-9	-40	-4	F	(-9, -40)	(40, 9)
-8	-40	10	NF	(-8, -40)	(40, 8)
-7	-39	0	F	(-7, -39)	(39, 7)
-6	-39	14	NF	(-6, -39)	(39, 6)

(3)



$\therefore x_{min} \Rightarrow -35$

$x_{max} \Rightarrow 35$

$y_{min} \Rightarrow 35-15 \Rightarrow 20$

$y_{max} \Rightarrow 35+15 \Rightarrow 50$

$x_0 = -45, \; y_0 = 65$

$x_1 = 25, \; y_1 = -10$

For, (x_0, y_0)

$x_0 < x_{min}$

$y_0 > y_{max}$

a	b	r	l
1	0	0	1

For (x_1, y_1)

$x_{min} < x_1 < x_{max}$

~~$y_1 > y_{min}$~~

$y_1 < y_{min}$

a	b	r	l
0	1	0	0

Now,

$$
\begin{array}{r}
1\,0\,0\,1 \\
\text{(AND)}\ 0\,1\,0\,0 \\
\hline
0\,0\,0\,0
\end{array}
$$

$\therefore$ Partially inside

Now, For left intersection (x_0, y_0)

$x = x_{min}$

$y = y_0 + m(x_{min} - x_0)$

$\therefore$ $x_0 = -35$

$y_0 = 65 + \left(\frac{-15}{14}\right) \times (-35 + 45)$

$\Rightarrow 54.286$

Now, $x_{min} \leq x_0 < x_{max}$

$y_0 > y_{max}$

Updated opcode

a	b	r	l
1	0	0	0

Now for above intesection

$y = y_{max}$

$x = x_0 + \frac{1}{m}(y_{max} - y_0)$

$y_0 = 50$

$x_0 = -35 + \frac{25+35}{-10-54.286} \times (50 - 54.286)$

$\Rightarrow -30.99$

$\therefore (x_0, y_0) = (-30.99, 50)$

Outcode 1 = 0000.

Now, Outcode 2 = 0100 $\therefore$ bottom intersection

$(x_0, y_0) = (-30.99, 50)$

$(x_1, y_1) = (23, -10)$

$m = \cancel{\frac{23+30.99}{}}$

$m = \frac{-10-50}{23+30.99}$

$\Rightarrow -1.11$

$y_1 = y_{min} \Rightarrow 20$

$x_1 = x_q + \frac{1}{m}(y_{min} - y_q)$

$x_1 = 23 + \frac{1}{-1.11}(20+10)$

$\Rightarrow -4.02$

$\therefore (x_1, y_1) = (-4.02, 20)$

$\therefore$ Outcode 2

0000

Final clipped point $(-30.99, 50) \rightarrow (-4.02, 20)$

Cyrus beck

$x_{min} \Rightarrow -35$ | $y_{min} \Rightarrow 20$ | $(x_0, y_0) = (-45, 65)$

$x_{max} \Rightarrow 35$ | $y_{max} \Rightarrow 50$ | $(x_1, y_1) = (23, -10)$

$D = P_1 - P_0$

$\Rightarrow ((x_1 - x_0), (y_1 - y_0))$

$\Rightarrow (68, -75)$

$$t_{left} = \frac{-(x_0 - x_{min})}{x_1 - x_0} = \frac{-(-45+35)}{68} \Rightarrow 0.147$$

$$t_{right} = \frac{-(x_0 - x_{max})}{x_1 - x_0} = \frac{-(-45-35)}{68} = 1.177$$

$$t_{above} = \frac{-(y_0 - y_{max})}{y_1 - y_0} = \frac{-(65-50)}{-75} = 0.2$$

$$t_{below} = \frac{-(y_0 - y_{min})}{y_1 - y_0} = \frac{-(65-20)}{-75} = 0.6$$

Dir	N	N.D	PE/PL	t	max(0,t) $t_E \to 0$	min(1,t) $t_L \to 1$
Left	(-1,0)	-68	PE	0.147	0.145	1
Right	(1,0)	68	PL	1.177	0.145	1
Above	(0,1)	-75	PE	0.2	0.2	1
Below	(0,-1)	75	PL	0.6	0.2	0.6

$t_E < t_L$ ∴ Partially inside

∴ $t = 0.6$

$P_0 = P_0 + t(P_1 - P_0)$

$\Rightarrow (-45, 65) + 0.6 \times (68, -75)$

$\Rightarrow (-45, 65) + (40.8, -45)$

$\Rightarrow (-4.2, 20)$

$t = 0.2$

$P_1 = P_0 + t(P_1 - P_0)$

$= (-45, 65) + \cancel{(40.8, -45)}\ (13.6, -15)$

$\Rightarrow (-31.4, 50)$

Yes cynus beck and cohensutherland gives the same output.

9)

1 $$\begin{bmatrix} \cos 90 & -\sin 90 & 0 \\ \sin 90 & \cos 90 & 0 \\ 0 & 0 & 1 \end{bmatrix} \propto \begin{bmatrix} 1 & 0 & -2 \\ 0 & 1 & 3 \\ 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} 3 & 5 & 4 \\ 2 & 1 & 3 \\ 1 & 1 & 1 \end{bmatrix}$$

$$\Rightarrow \begin{bmatrix} 0 & -1 & -3 \\ 1 & 0 & -2 \\ 0 & 0 & 1 \end{bmatrix} \propto \begin{bmatrix} 3 & 5 & 4 \\ 2 & 1 & 3 \\ 1 & 1 & 1 \end{bmatrix}$$

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

$A = (-5, 1)$

$B = (-4, 3)$

$C = (-6, 2)$

(b) Translation (-1,1) $\quad$ Reflection (x-axis) $\quad$ Rotate (90°) $\quad$ Translation (-2,3)

$$\begin{bmatrix} 1 & 0 & -1 \\ 0 & 1 & 1 \\ 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} 1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} \cos 90 & -\sin 90 & 0 \\ \sin 90 & \cos 90 & 0 \\ 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} 1 & 0 & -2 \\ 0 & 1 & 3 \\ 0 & 0 & 1 \end{bmatrix}$$

$\downarrow$ Scaling $\quad$ Translation (1,-1)

$$\times \begin{bmatrix} 2 & 0 & 0 \\ 0 & 2 & 0 \\ 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} 1 & 0 & 1 \\ 0 & 1 & -1 \\ 0 & 0 & 1 \end{bmatrix} = M$$

(c) After translation = Angle, distance preserve

Rotation $\Rightarrow$ Angle, distance "

Reflection $\Rightarrow$ Parallel line

Scaling $\Rightarrow$ Angle and Parallel line preserve.

$$
\begin{bmatrix} 1 & 0 & 0 & -2 \\ 0 & 1 & 0 & -10 \\ 0 & 0 & 1 & -12 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times
\begin{bmatrix} 3 & 0 & 0 & 0 \\ 0 & 3 & 0 & 0 \\ 0 & 0 & 3 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times
\begin{bmatrix} 1 & 0 & 0 & 423 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times
\begin{bmatrix} 1 & 0 & 0 & 0 \\ 2 & 1 & 0 & 0 \\ 4 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times
\begin{bmatrix} 1 & 0 & 0 & -423 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}
$$

$$
\times \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos 30 & -\sin 30 & 0 \\ 0 & \sin 30 & \cos 30 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times
\begin{bmatrix} 1 & 0 & 0 & 2 \\ 0 & 1 & 0 & 10 \\ 0 & 0 & 1 & 12 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times
\begin{bmatrix} 1 & 0 & 0 & -4 \\ 0 & 1 & 0 & -2 \\ 0 & 0 & 1 & -3 \\ 0 & 0 & 0 & 1 \end{bmatrix} = M
$$

$$
M = \text{translation}(-4,-2,-3) \times \text{translation}(2,10,12) \times \text{rotation}(30°) \times \text{translation}(-2,-10,-12) \times \text{Scaling}(3,3,3) \times \text{translation}(423) \times \text{Shearing}(2,4) \times \text{translation}(-423)
$$

$$\overbrace{\begin{bmatrix} \frac{1}{3} & 0 & 0 & 0 \\ 0 & \frac{1}{3} & 0 & 0 \\ 0 & 0 & \frac{1}{3} & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}}^{\text{Scaling}} \times \overbrace{\begin{bmatrix} 1 & 0 & 0 & 2 \\ 0 & 1 & 0 & 12 \\ 0 & 0 & 1 & 10 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos(-30) & -\sin(-30) & 0 \\ 0 & \sin(-30) & \cos(-30) & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} 1 & 0 & 0 & -2 \\ 0 & 1 & 0 & -12 \\ 0 & 0 & 1 & -10 \\ 0 & 0 & 0 & 1 \end{bmatrix}}^{\text{rotation}} \times \overbrace{\begin{bmatrix} 1 & 0 & 0 & 4 \\ 0 & 1 & 0 & 2 \\ 0 & 0 & 1 & 3 \\ 0 & 0 & 0 & 1 \end{bmatrix}}^{\text{translation}} \times P'$$

$$\times \underbrace{\begin{bmatrix} 1 & 0 & 0 & -423 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} 1 & 0 & 0 & 0 \\ -2 & 1 & 0 & 0 \\ -4 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} 1 & 0 & 0 & 423 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}}_{\text{Shearing}} = P$$

6)
a)

$$x' = 5x - 11$$
$$y' = 10y + 22 \Rightarrow \begin{bmatrix} 5 & 0 & 0 & -11 \\ 0 & 10 & 0 & 22 \\ 0 & 0 & 1 & 33 \\ 0 & 0 & 0 & 1 \end{bmatrix} \Rightarrow P'$$
$$z' = 33 + z$$

$$P' = \text{Translation}(-11, 22, 33) \times \text{Scaling}(x, y) \times P$$

The 2nd transformation was Scaling

(b)

$$P'' = \cancel{\text{Translation}(11,-22,-33)}$$

$$\text{Translation}(11,-22,-33) \times P'$$

$$= \begin{bmatrix} 1 & 0 & 0 & 11 \\ 0 & 1 & 0 & -22 \\ 0 & 0 & 1 & -33 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} 5 & 0 & 0 & -11 \\ 0 & 10 & 0 & 22 \\ 0 & 0 & 1 & 33 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\Rightarrow \begin{bmatrix} 5 & 0 & 0 & 0 \\ 0 & 10 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Ans

(e)

$$M' = \underbrace{\begin{bmatrix} 5 & 0 & 0 & -11 \\ 0 & 10 & 0 & 22 \\ 0 & 0 & 1 & 33 \\ 0 & 0 & 0 & 1 \end{bmatrix}}_{M} \times \underbrace{\begin{bmatrix} 4 \\ 2 \\ 3 \\ 1 \end{bmatrix}}_{P}$$

$$\Rightarrow \begin{bmatrix} 9 \\ 42 \\ 36 \\ 1 \end{bmatrix}$$

$$(x, y, z) = (9, 42, 36)$$

Ans

$$\begin{bmatrix} S_x & 0 & 0 & 0 \\ 0 & S_y & 0 & 0 \\ 0 & 0 & S_z & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} 1 & 0 & 0 & -2 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & -3 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} 1 & 0 & 0 & 2 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 3 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos 90 & -\sin 90 & 0 \\ 0 & \sin 90 & \cos 90 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} 1 & 0 & 0 & -2 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & -3 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} 2 \\ -2 \\ 1 \\ 1 \end{bmatrix}$$

$$\times \begin{bmatrix} 1 & 0 & 0 & 2 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 3 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} 1 & 0 & 0 & 10 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 15 \\ 0 & 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} 12 \\ 5 \\ 13 \\ 1 \end{bmatrix}$$

$$\begin{bmatrix} 1 & 0 & 0 & \cancel{12} \end{bmatrix}$$

$$\begin{bmatrix}12\\5\\13\\1\end{bmatrix} = \begin{bmatrix}1&0&0&12\\0&1&0&0\\0&0&1&18\\0&0&0&1\end{bmatrix} \times \begin{bmatrix}S_x&0&0&0\\0&S_y&0&0\\0&0&S_z&0\\0&0&0&1\end{bmatrix} \times \begin{bmatrix}1&0&0&0\\0&0&-1&0\\0&1&0&0\\0&0&0&1\end{bmatrix} \times \begin{bmatrix}1&0&0&-2\\0&1&0&0\\0&0&1&-3\\0&0&0&1\end{bmatrix} \times \begin{bmatrix}2\\-2\\1\\1\end{bmatrix}$$

$$\Rightarrow \begin{bmatrix}S_x&0&0&12\\0&S_y&0&0\\0&0&S_z&0\\0&0&0&1\end{bmatrix} \times \begin{bmatrix}1&0&0&0\\0&0&-1&0\\0&1&0&0\\0&0&0&1\end{bmatrix} \times \begin{bmatrix}1&0&0&-2\\0&1&0&0\\0&0&1&-3\\0&0&0&1\end{bmatrix} \times \begin{bmatrix}2\\-2\\1\\1\end{bmatrix}$$

$$\Rightarrow \begin{bmatrix}S_x&0&0&12\\0&0&-S_y&0\\0&S_z&0&0\\0&0&0&1\end{bmatrix} \times \begin{bmatrix}1&0&0&-2\\0&1&0&0\\0&0&1&-3\\0&0&0&1\end{bmatrix} \times \begin{bmatrix}2\\-2\\1\\1\end{bmatrix}$$

$$\Rightarrow \begin{bmatrix}S_x&0&0&-2S_x+12\\0&0&-S_y&-3S_y\\0&S_z&0&0\\0&0&0&1\end{bmatrix} \times \begin{bmatrix}2\\-2\\1\\1\end{bmatrix}$$

$$\begin{bmatrix} 12 \\ 5 \\ 13 \\ 1 \end{bmatrix} = \begin{bmatrix} 2S_x - 2S_x + 12 \\ -S_y - 3S_y \\ \cancel{-S_z} - 2S_z \\ 1 \end{bmatrix} \Rightarrow \begin{bmatrix} 12 \\ -4S_y \\ -2S_z \\ 1 \end{bmatrix}$$

$$S_x - S_x = 1$$

$$S_y = \frac{5}{-4}$$

$$S_z = \frac{13}{-2}$$