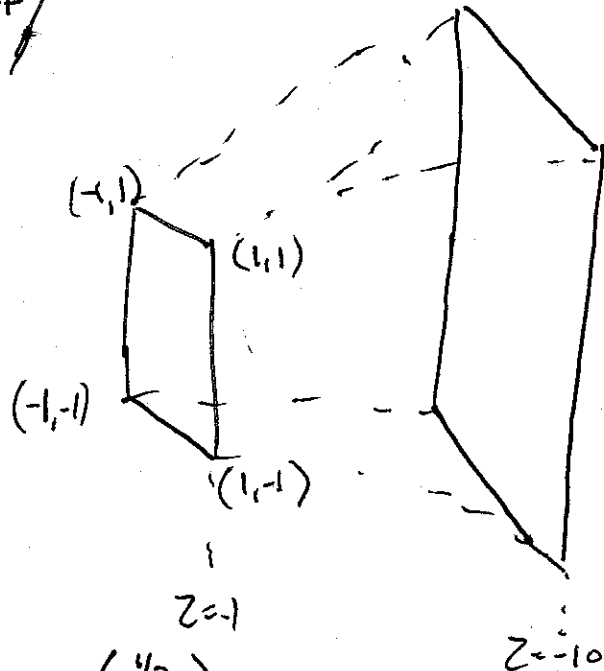


$$1) \begin{pmatrix} f & 0 & 0 & 0 \\ \text{aspect} & 0 & 0 & 0 \\ 0 & f & 0 & 0 \\ 0 & 0 & \frac{f+n}{n-f} & \frac{2fn}{n-f} \\ 0 & 0 & -1 & 0 \end{pmatrix}$$

2pts for something about the frustum
↓

2pts →

$$\begin{pmatrix} 1 & & & \\ & 1 & & \\ & & \frac{-101}{99} & \frac{-200}{99} \\ & & & -1 \end{pmatrix}$$



$$MP = M \begin{pmatrix} 1 \\ 0 \\ -3 \\ 1 \end{pmatrix} = \begin{pmatrix} 1 \\ 0 \\ \frac{303}{99} + \frac{-200}{99} \\ 3 \end{pmatrix} = \begin{pmatrix} 1 \\ 0 \\ \frac{103}{99} \\ 3 \end{pmatrix} \leftarrow 3pts$$

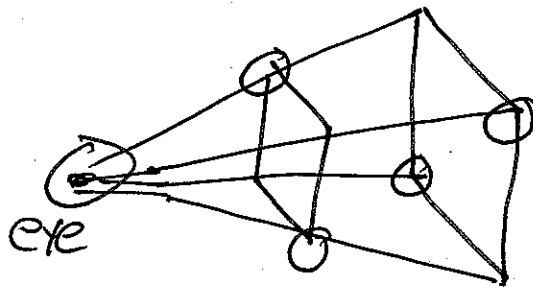
$$MQ = M \begin{pmatrix} 2 \\ 3 \\ 2 \\ 1 \end{pmatrix} = \begin{pmatrix} 2 \\ 3 \\ \frac{-202}{99} - \frac{200}{99} \\ -2 \end{pmatrix} = \begin{pmatrix} -1 \\ -3/2 \\ \frac{201}{99} \\ -2 \end{pmatrix} \leftarrow 3pts$$

$$MP = \begin{pmatrix} .3333 \\ 0 \\ .3468 \end{pmatrix}$$

$$MQ = \begin{pmatrix} -1 \\ -1.5 \\ 2.0303 \end{pmatrix}$$

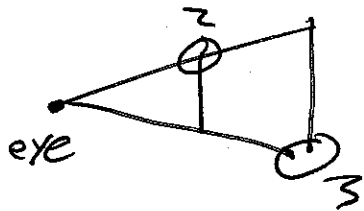
2a)

3D



5 pts needed

2D



3 pts needed \leftarrow 2 pts

2b)

$$\begin{bmatrix} X' \\ Z' \\ W' \end{bmatrix} = \begin{bmatrix} A & B & \emptyset \\ \emptyset & C & D \\ \emptyset & -1 & \emptyset \end{bmatrix} \begin{bmatrix} X \\ Z \\ W \end{bmatrix} \Rightarrow \begin{aligned} X' &= AX + ZB \\ Z' &= CZ + D \\ W' &= -Z \end{aligned}$$

$$\frac{X'}{W'} = \frac{-AX}{-Z} - B$$

$$\frac{Z'}{W'} = \frac{D}{-Z} - C$$

$\begin{pmatrix} 1 \\ -3 \end{pmatrix}$ maps to $\begin{pmatrix} 1 \\ -1 \end{pmatrix}$ and $\begin{pmatrix} -20 \\ -30 \end{pmatrix}$ maps to $\begin{pmatrix} -1 \\ +1 \end{pmatrix}$

$$\frac{X'}{W'} = 1 = \frac{-AX}{-Z} - B = \frac{-A}{-3} - B$$

$$1 = \frac{A}{3} - B$$

$$\frac{X'}{W'} = -1 = \frac{-AX}{-Z} - B = \frac{-A(-20)}{-30} - B$$

$$-1 = \frac{-2}{3}A - B$$

$$B = \frac{A}{3} - 1, \quad -1 = \frac{-2}{3}A - \frac{A}{3} + 1$$

$$A = 2 \quad B = -1/3$$

\uparrow 2 pts $\quad \uparrow$ 2 pts

$$-1 = \frac{D}{-Z} - C = \frac{D}{3} - C$$

$$+1 = \frac{D}{-Z} - C = \frac{D}{30} - C$$

~~Handwritten scribbles~~

$$C = \frac{D}{3} + 1 \Rightarrow 1 = \frac{D}{30} - \frac{D}{3} - 1$$

$$Z = \frac{-9}{30}D$$

$$D = \frac{-20}{3}$$

$$C = 11/9$$

\uparrow 2 pts

\uparrow 2 pts

10 pts for derivation

$D = -6.66667$
$C = 1.2222$
$B = -.33333$
$A = 2$

* Signs ignored because of ambiguity

3a)

$$(y_0 - y_1)x + (x_1 - x_0)y + x_0y_1 - x_1y_0 = 0$$

4pts for work

$$L_1 = -10 + 30y - 100 = 0 \quad \leftarrow 2pts$$

$$L_2 = -30 - 20 + 1900 = 0 \quad \leftarrow 2pts$$

$$L_3 = 40 - 10 - 700 = 0 \quad \leftarrow 2pts$$

* signs important!

3b)

$$P_1 = (20, 10, 0)$$

$$P_2 = (50, 20, 1)$$

$$P_3 = (30, 50, 2)$$

* 5 pts given for alternate interpretation than the question asked for

$$\text{Normal} = (P_2 - P_1) \times (P_3 - P_1) = \frac{(-20, -50, 1100)}{\| \text{normal} \|}$$

$$Ax + By + Cz + D = 0$$

$$\frac{-20x - 50y + 1100z + D = 0}{\| \text{normal} \|}$$

2pts for work

$$\frac{-20(20) - 50(10) + 1100(\emptyset) + D = 0}{\| \text{normal} \|}$$

$$\| \text{normal} \|$$

$$D = \frac{900}{\| \text{normal} \|}$$

$$\frac{-20x - 50y + 1100z + 900 = 0}{\| \text{normal} \|}$$

8pts for plane equation

$$z = \frac{+2x + 5y - 90}{110}$$

attribute "c"
or $c = .01818x + 0.04545y + .81818$