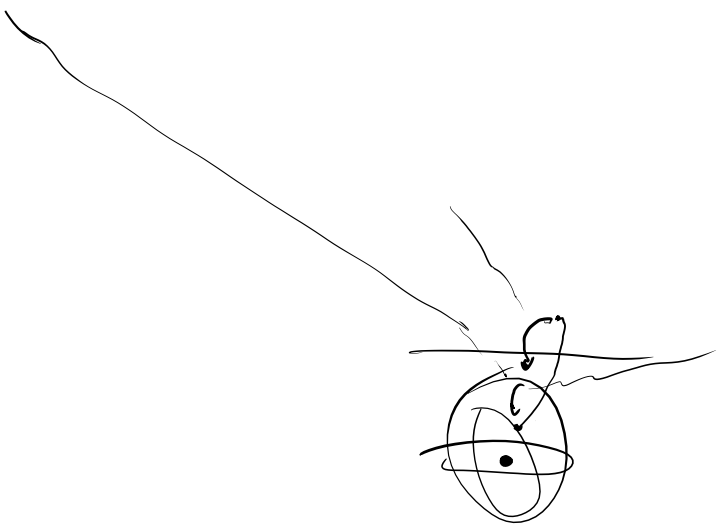
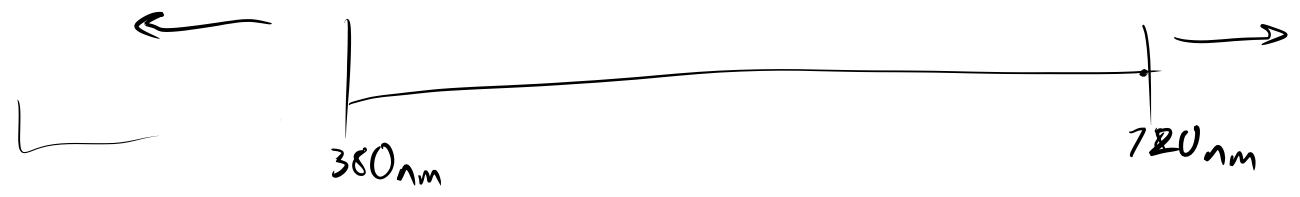


Ultraviolet
black light

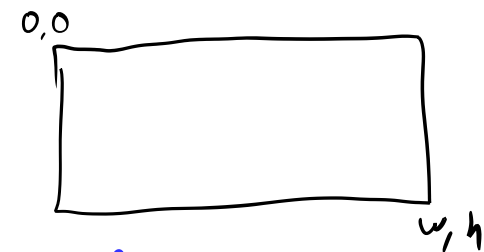
Ultraviolet

infrared



3D pipeline

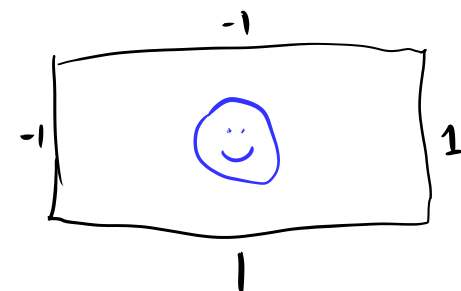
device coordinates



Normalized device coordinates

$$d_x = (n_x + 1) \frac{w}{2}$$

viewport transform

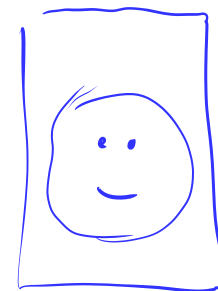


aspect ratio

Projection matrix

$$\begin{bmatrix} \frac{h}{w} & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{bmatrix}$$

$$n_x = x \frac{h}{w}$$
$$n_y = y$$



Ignore Z

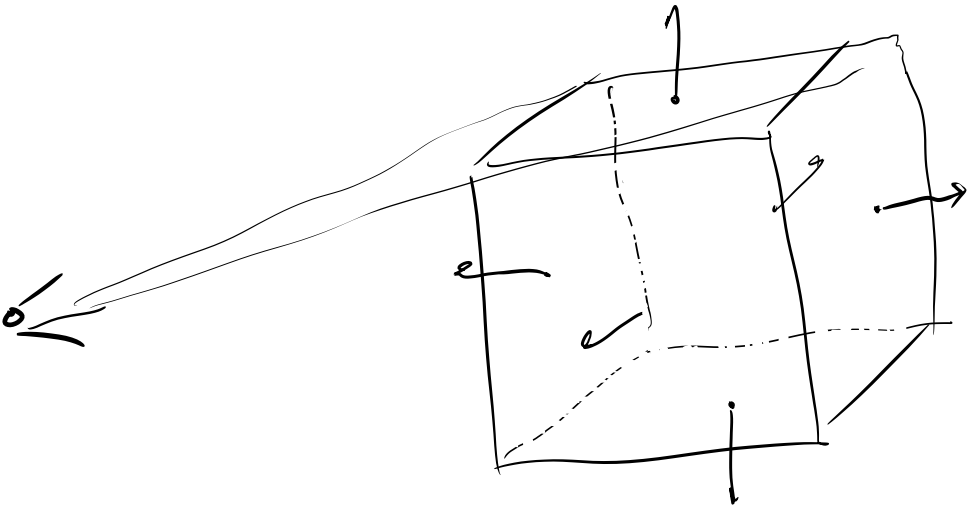
View Matrix $\left[\begin{array}{l} \text{rotate} \\ \text{scale} \\ \text{translate} \end{array} \right.$ so "forward" is on Z axis
 so "frame" is between -1 and 1 in x dy

2D raster
 P
 depth buffer

LIGHT
↓

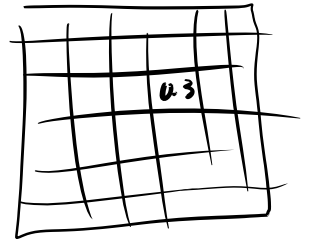
$$V_{\text{viewport}} \left[\begin{array}{c} \text{Proj} \\ \text{aspect ratio} \\ \text{perspective} \end{array} \right] \left[\begin{array}{c} \text{View} \\ \text{model view} \end{array} \right] \left[\begin{array}{c} \text{model} \end{array} \right] \vec{P}$$

back-face culling



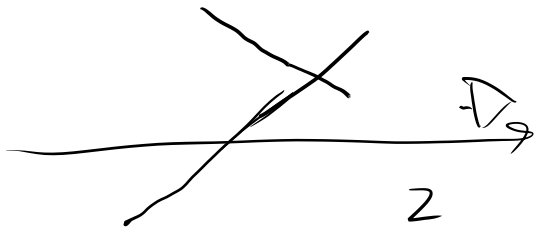
nearest Z

- depth buffer



fragment

Painter's algorithm



Orthographic

Perspective

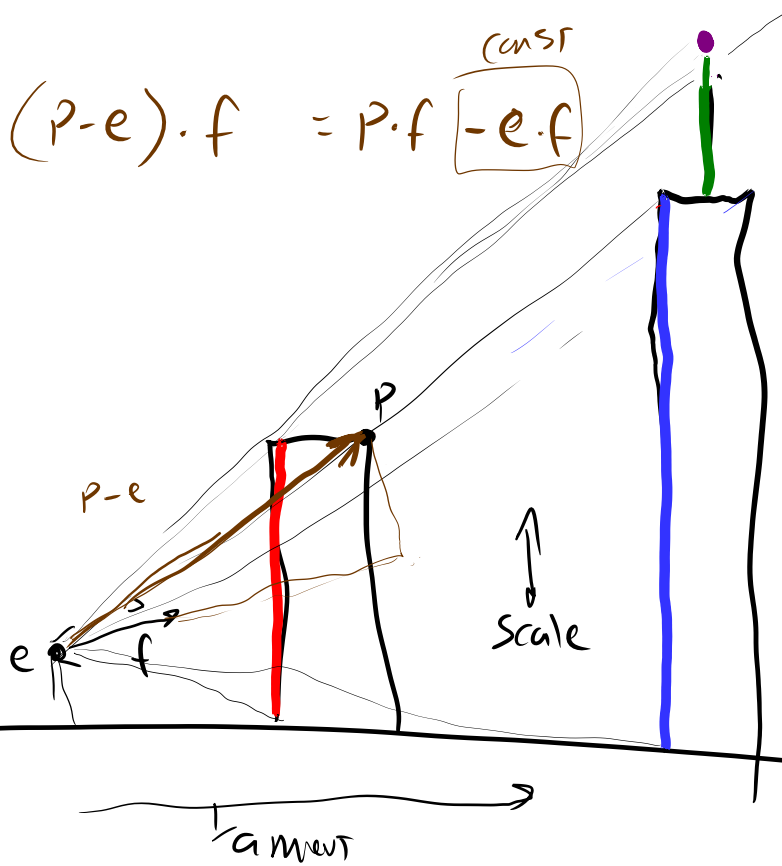
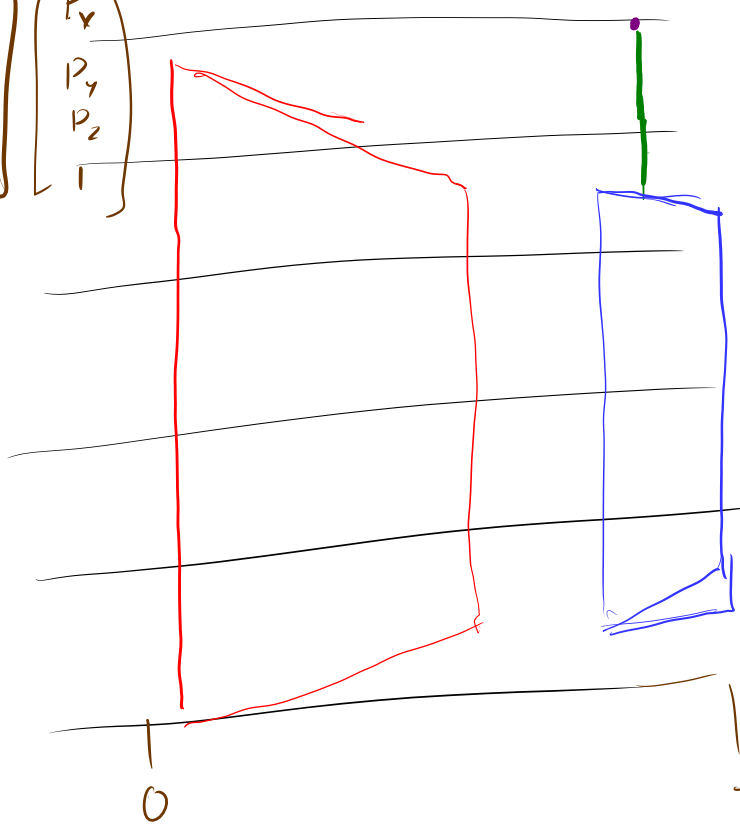
$$\frac{x}{\text{dist}}$$

$$(p-e) \cdot f = p \cdot f \quad \boxed{\text{const} \quad -e \cdot f}$$

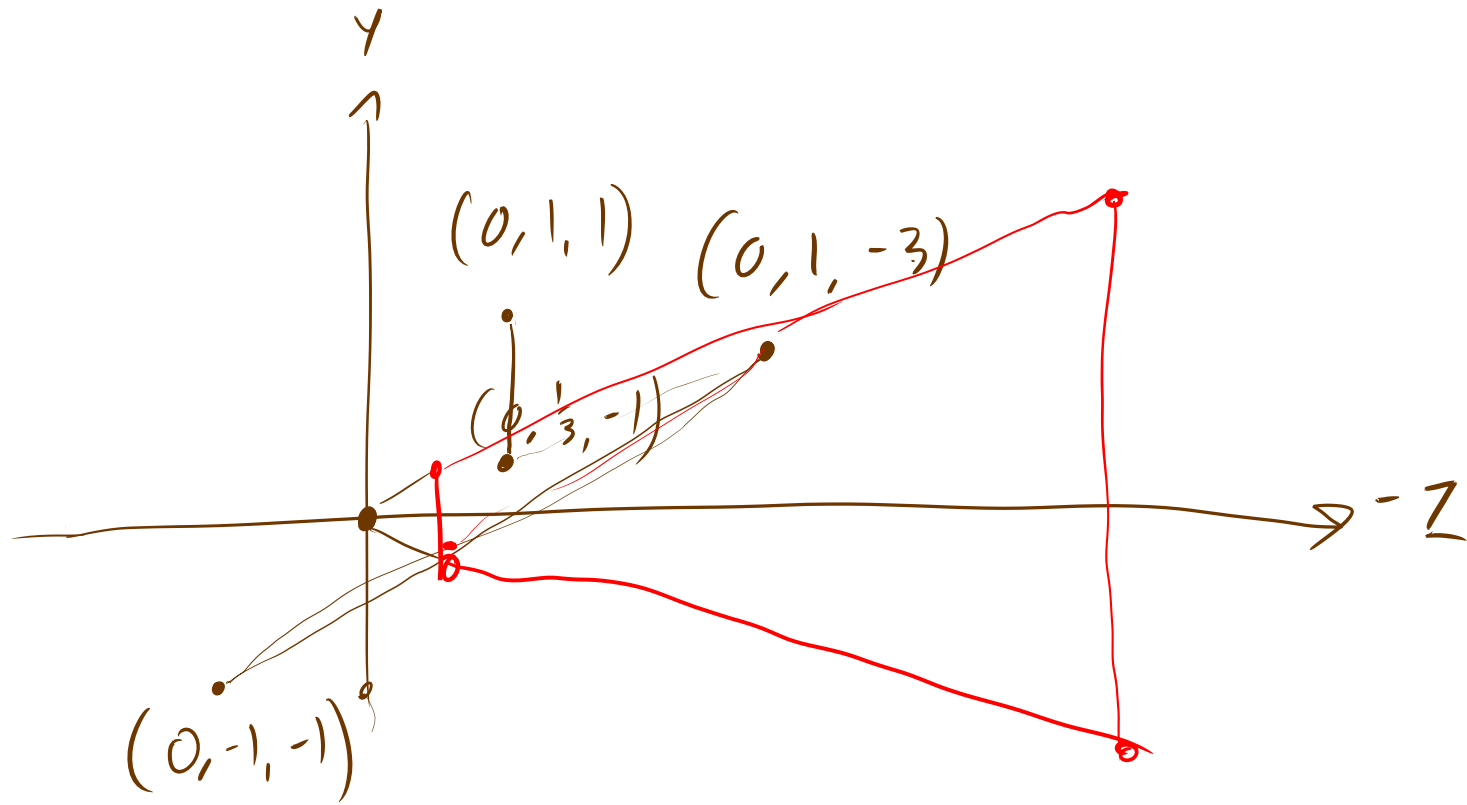
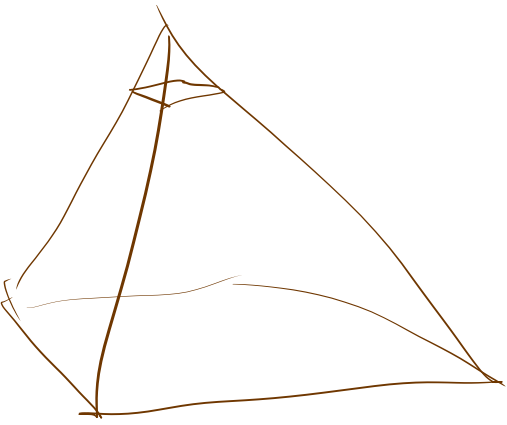
$$\begin{bmatrix} 1 & & & \\ & 1 & & \\ & & 1 & \\ f_x & f_y & f_z & -e \cdot f \end{bmatrix} \begin{pmatrix} p_y \\ p_y \\ p_z \\ 1 \end{pmatrix}$$

$$0 \quad 0 \quad -1 \quad 0$$

main
→

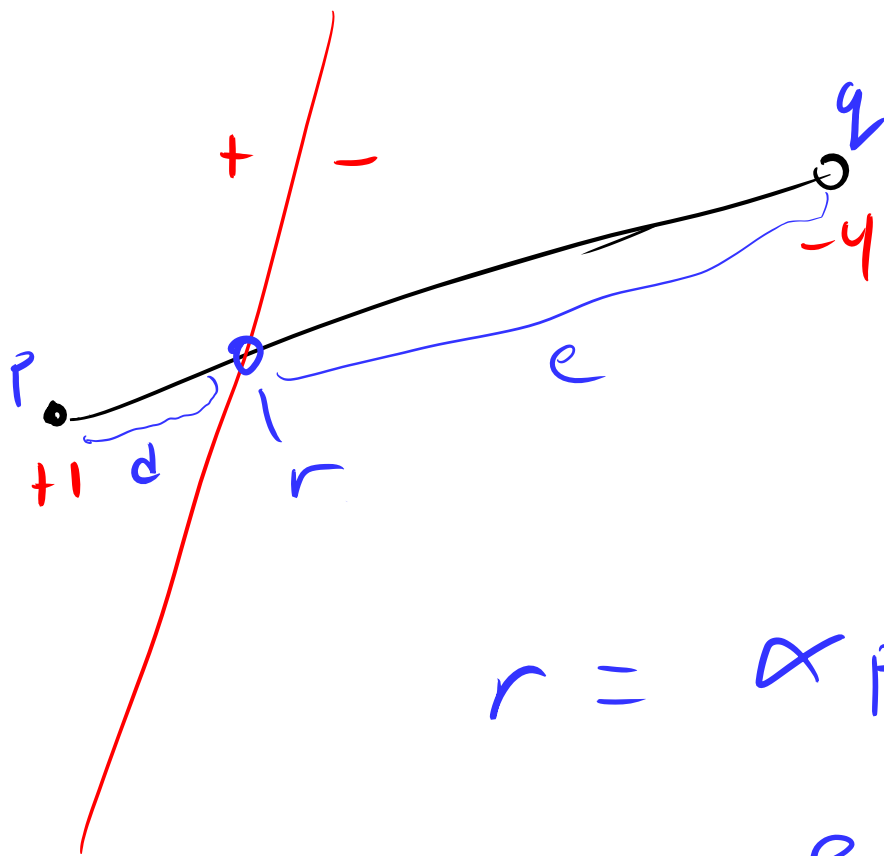
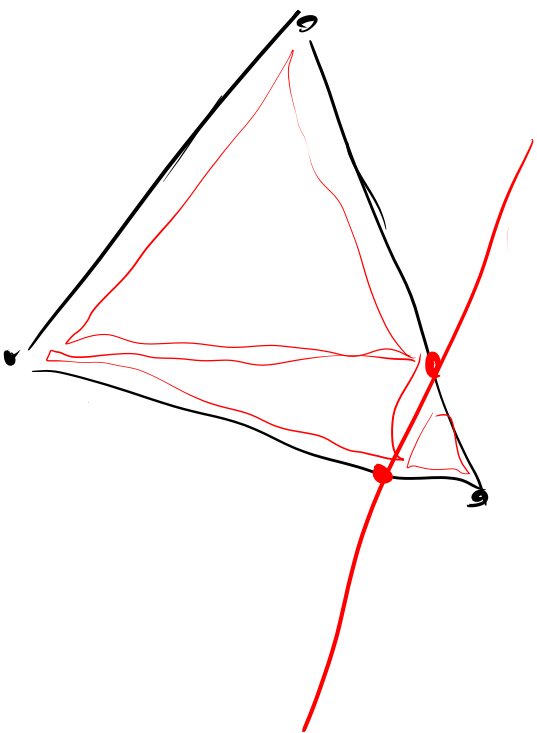


Frustum Clipping



Plane

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



$$r = \alpha p + (1 - \alpha) q$$

$$\alpha = \frac{e}{e - d}$$