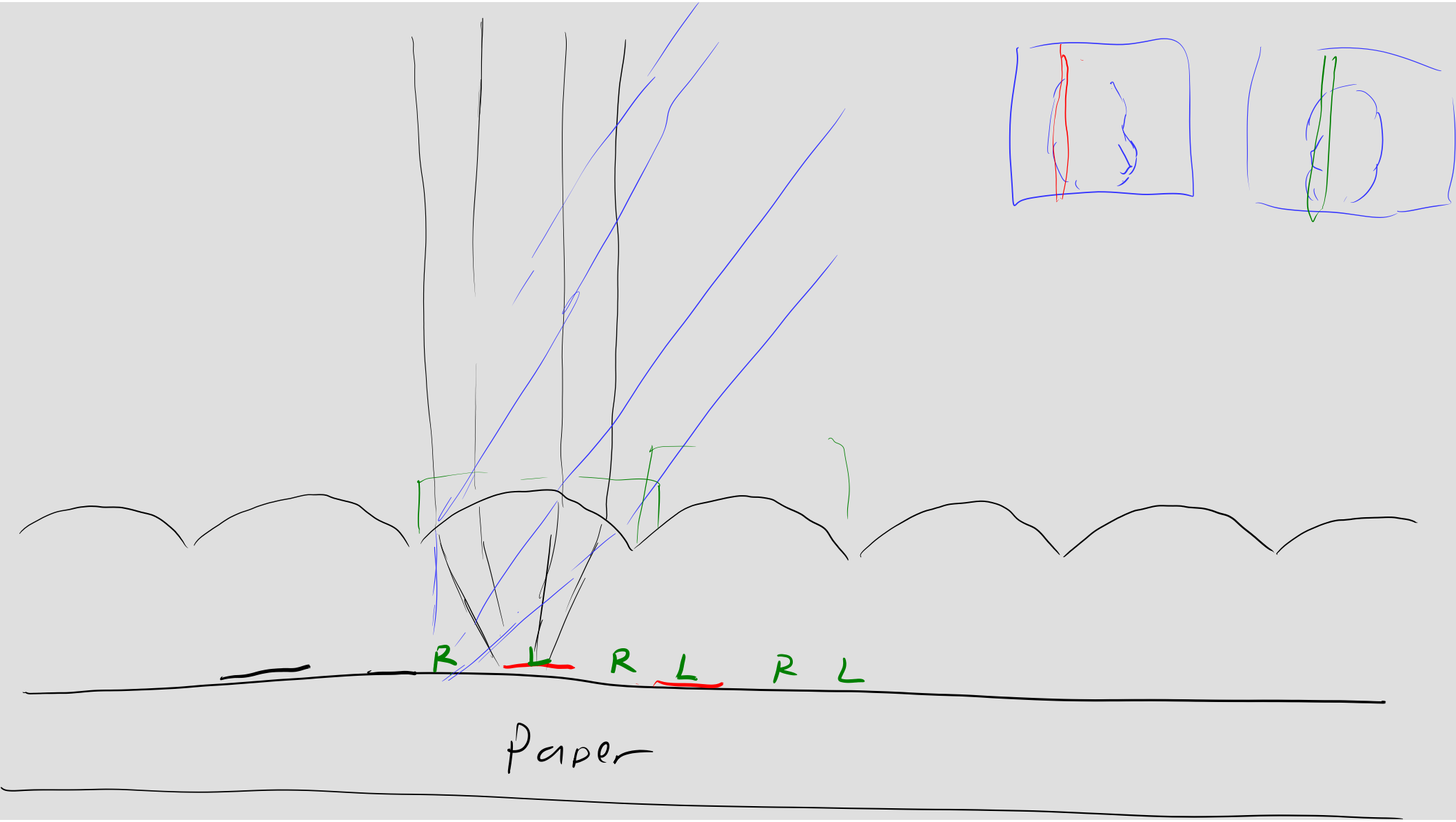

R L R L R L
Paper

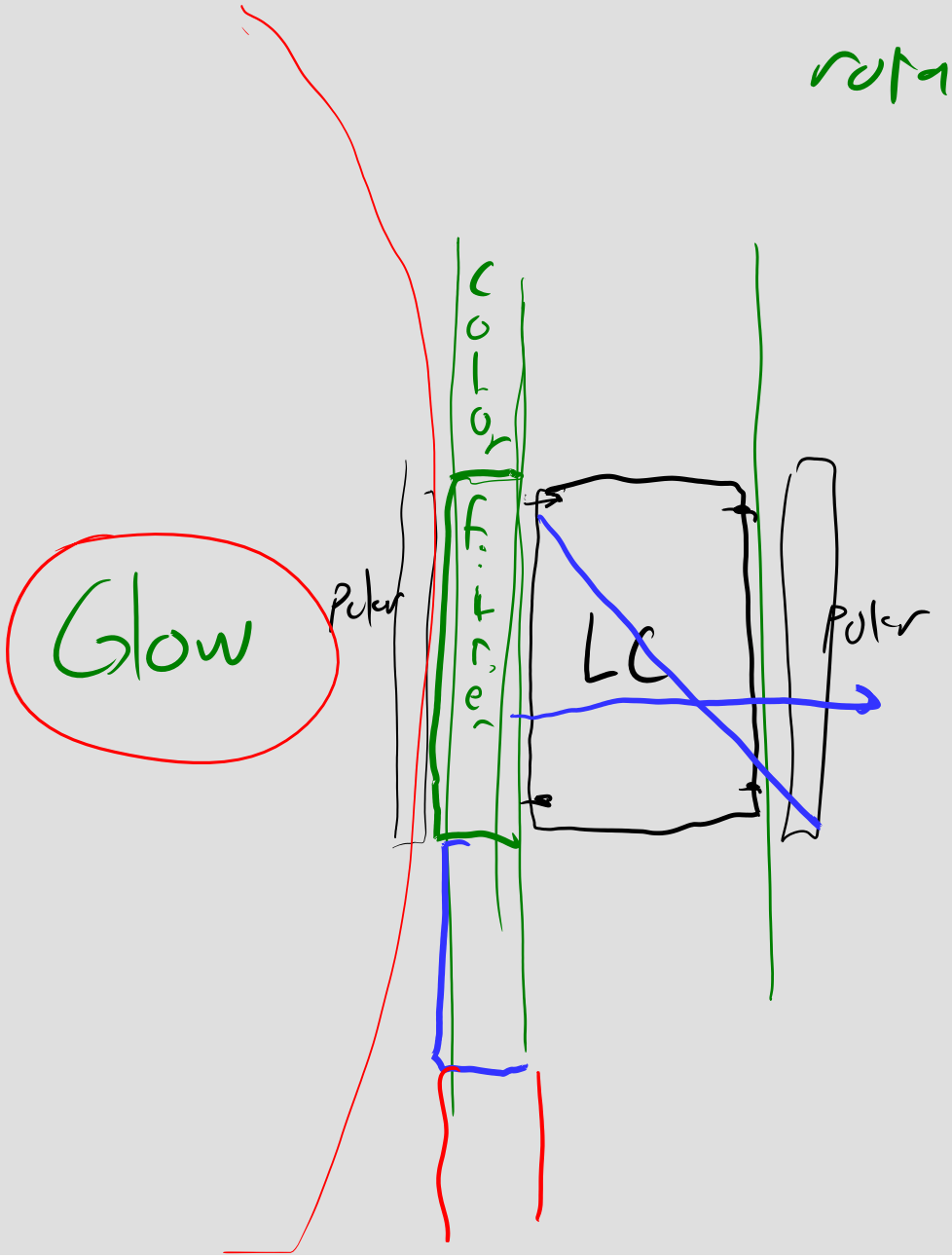
FoV of monitors

finger color screens

Liquid crystal

rotate polarization

OLED



Homogeneous Coordinates

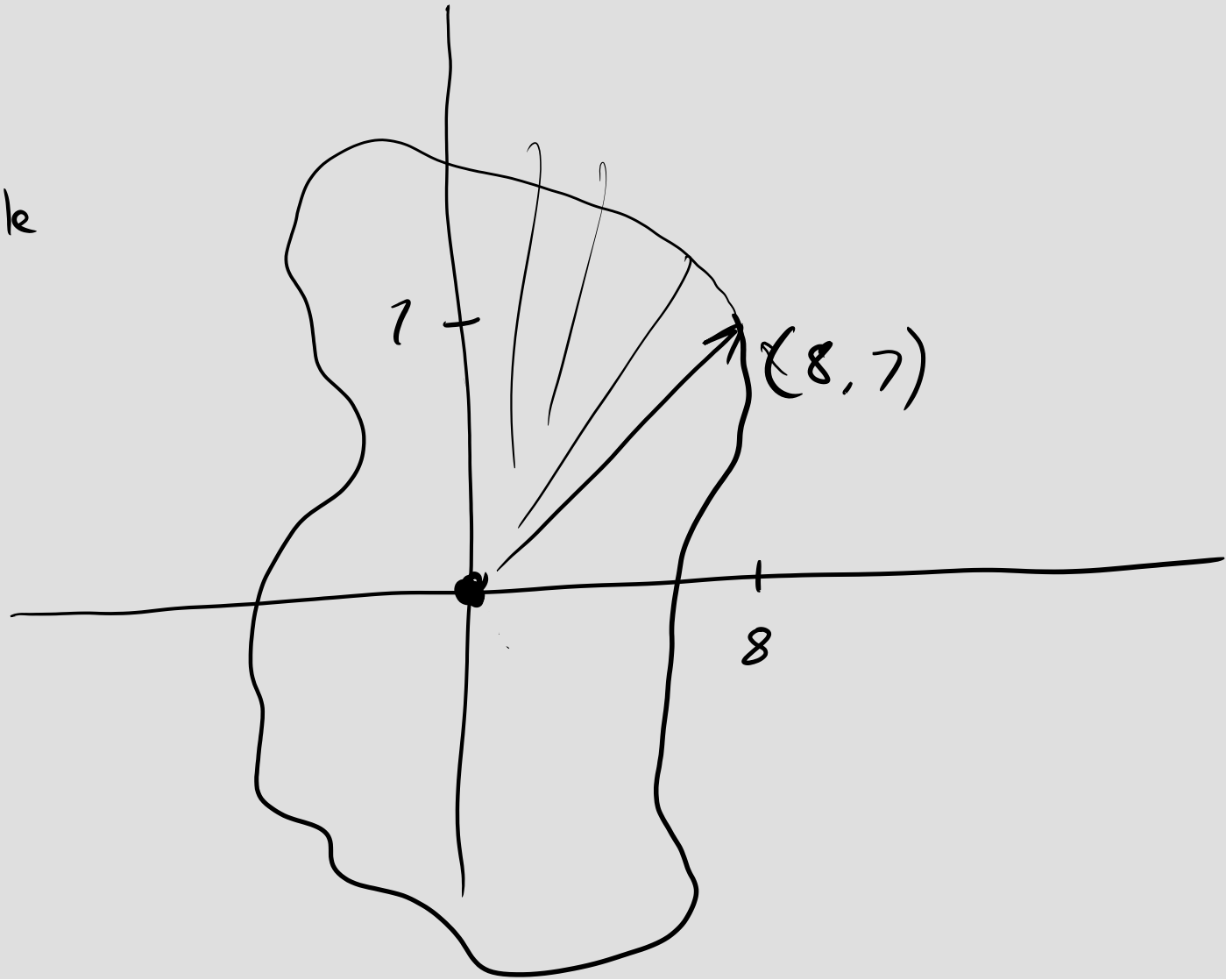
matrix

linear Transformation

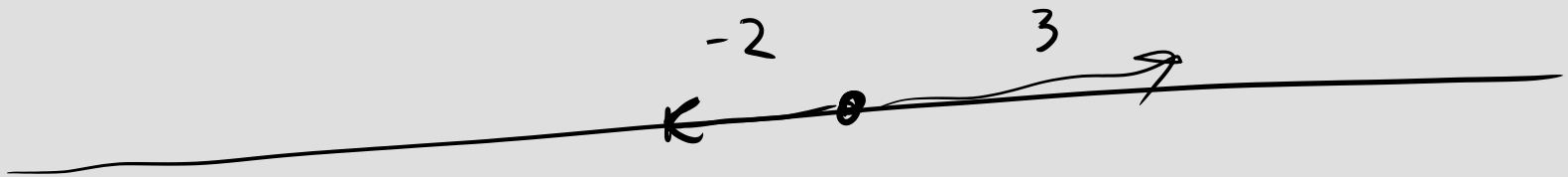
rotation

scale

reflection = − Scale

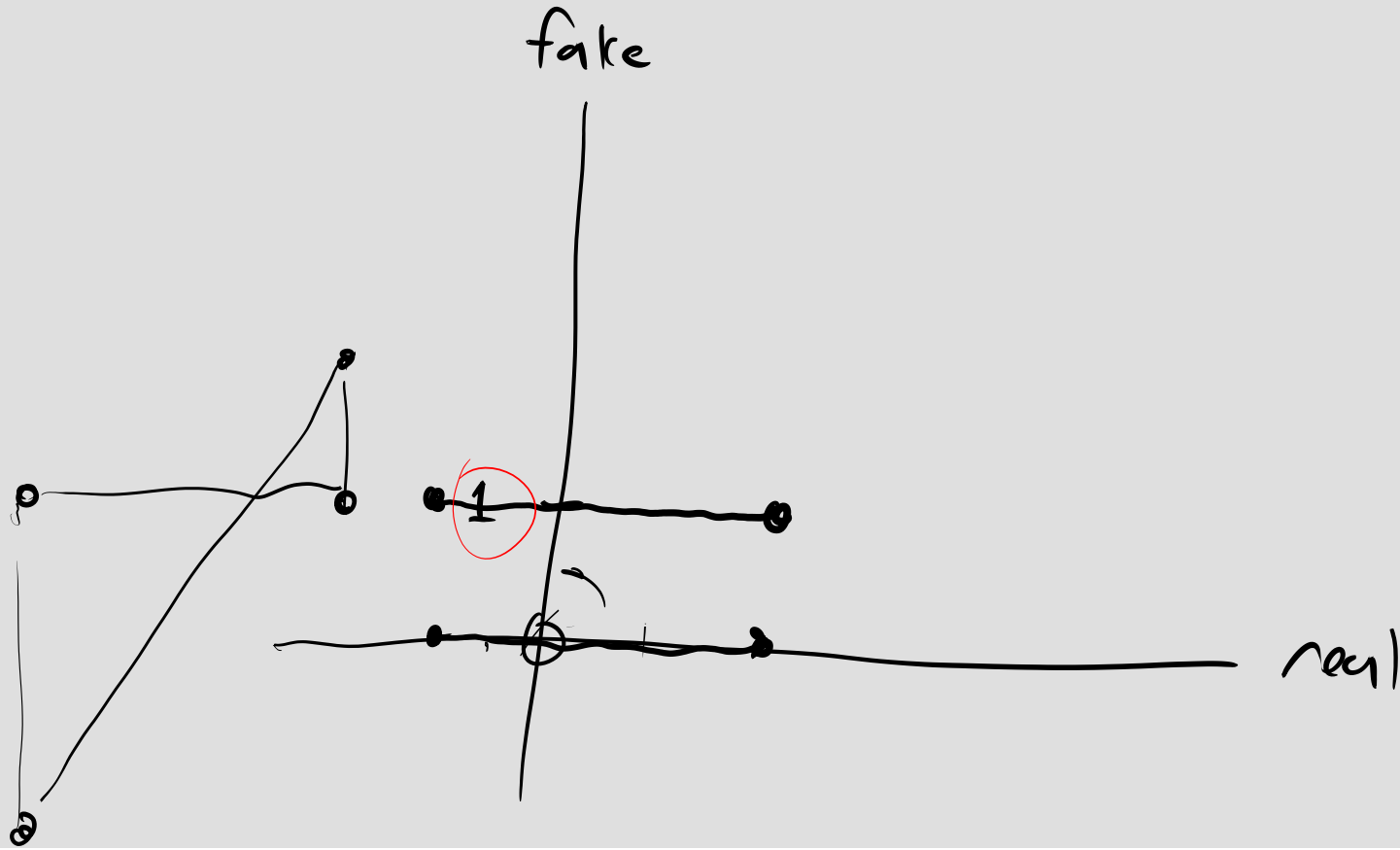


1-dim vector



affine Transform

- all linear
+ all translation



Vector → ord list of elements of field

$(x, y, z, w) \triangleq (ax, ay, az, aw)$

$\forall a \neq 0$

homogeneous

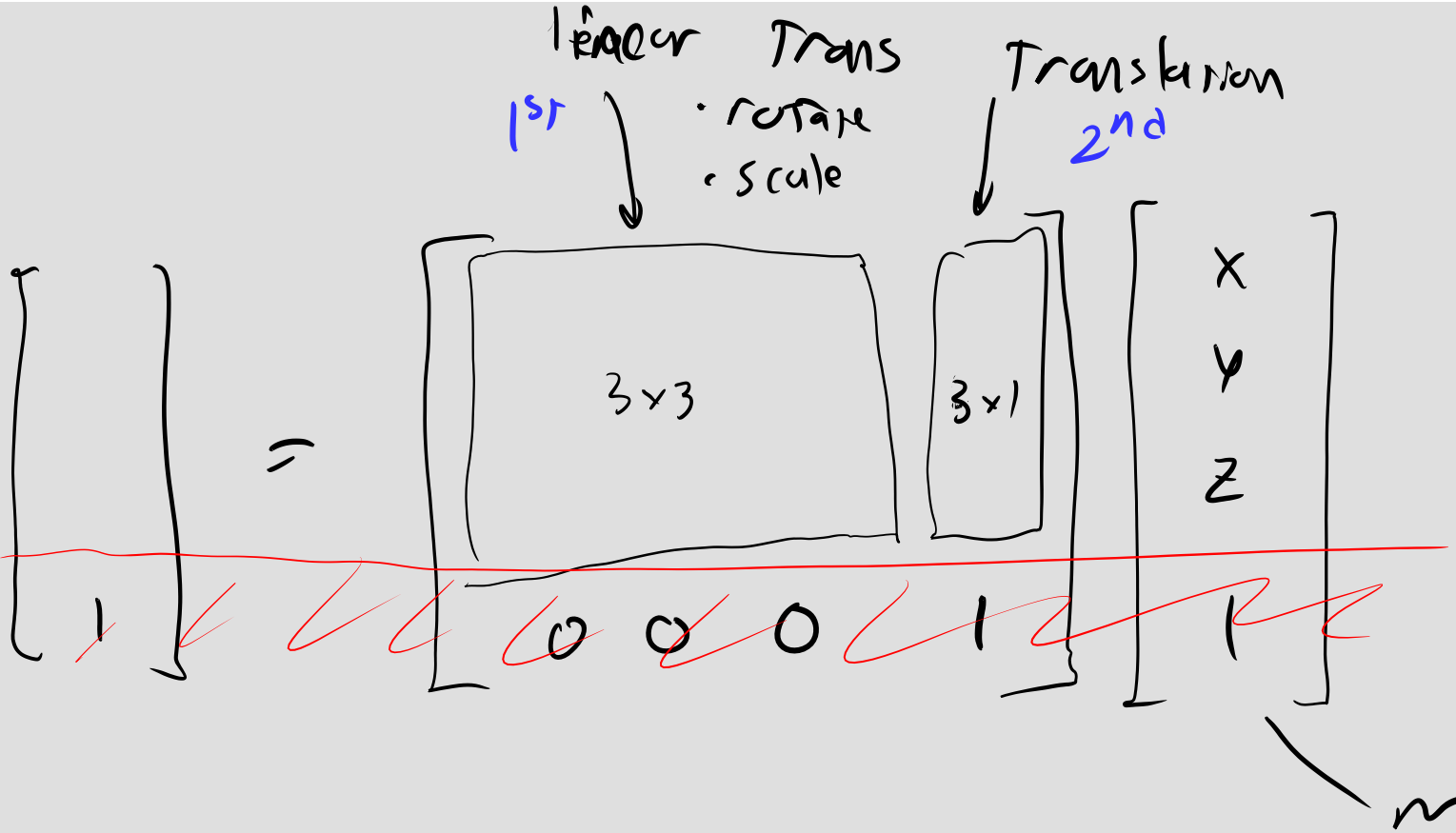
$\downarrow$

$\left(\frac{x}{w}, \frac{y}{w}, \frac{z}{w}, \frac{w}{w}\right) \quad 1$

$(2, 4) \neq (-8, -16)$

$\begin{bmatrix} v \end{bmatrix} \leftarrow \begin{bmatrix} M \end{bmatrix} \begin{bmatrix} v \end{bmatrix}$

affine

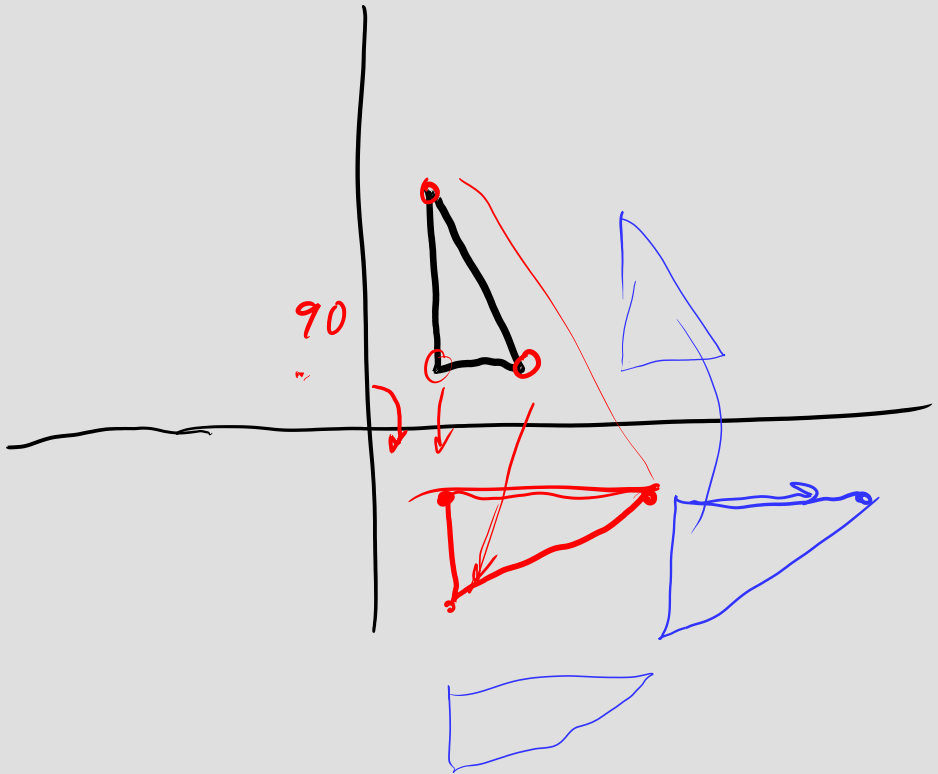


$$\vec{X}_2 = \overbrace{M_2 \quad M_1}^{M} \quad \vec{x}_1$$

$s = 0$

$t = 10$

$$\begin{bmatrix} y+s \\ -x+t \\ 1 \end{bmatrix} \leftarrow \begin{bmatrix} 0 & 1 & s \\ -1 & 0 & t \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ 1 \end{bmatrix}$$



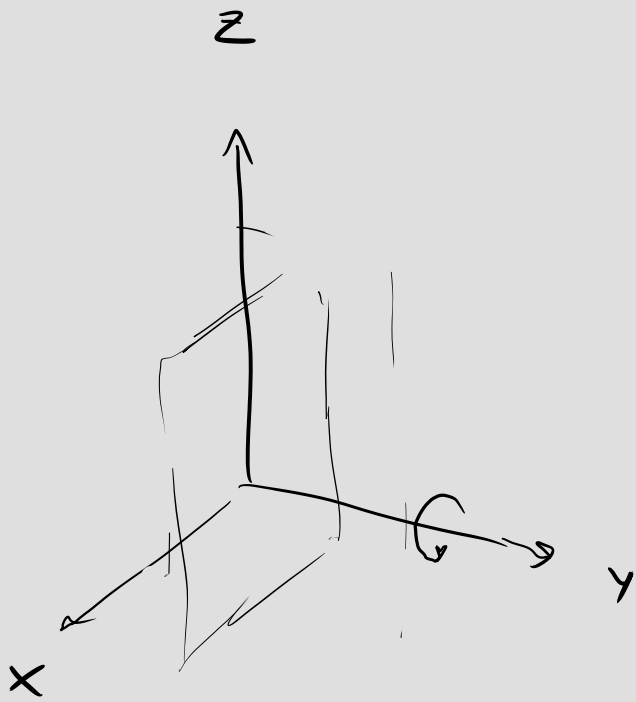
key matrix pieces

$$\begin{bmatrix} c & 0 & s & 0 \\ 0 & 1 & 0 & 0 \\ -s & 0 & c & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \rightarrow$$

$c^2 + s^2 = 1$

$c = \cos(\theta)$

rotation by θ in x-z plane



$$\begin{bmatrix} 1 & 0 & 0 & x \\ 0 & 1 & 0 & y \\ 0 & 0 & 1 & z \\ 0 & 0 & 0 & 1 \end{bmatrix} \rightarrow \text{translate}$$

$$\begin{bmatrix} s_x & 0 & 0 & 0 \\ 0 & s_y & 0 & 0 \\ 0 & 0 & s_z & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \rightarrow \text{scale}$$

$$\begin{bmatrix} 1 & a & b & 0 \\ d & 1 & c & 0 \\ e & f & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \rightarrow \text{sheer}$$

1. rot axis into x-y plane
2. rot onto +y axis
3. rot around y by Θ
4. undo 2
5. undo 1

T

R_1

R_2

R_3

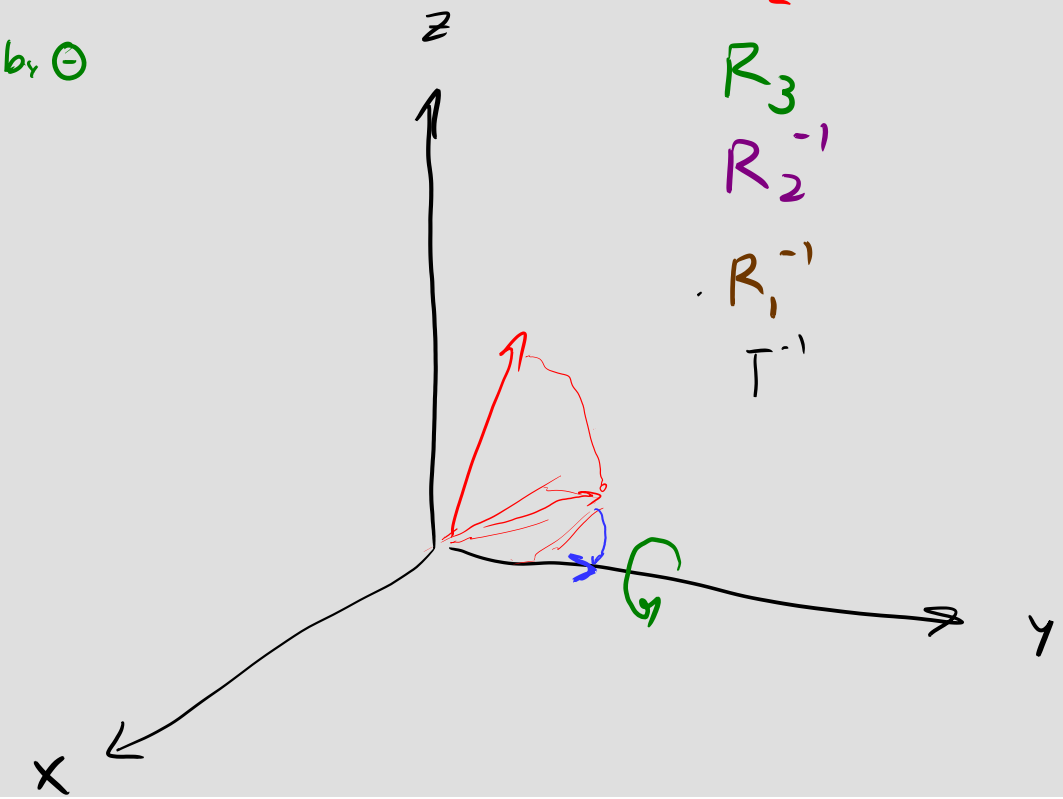
R_2^{-1}

R_1^{-1}

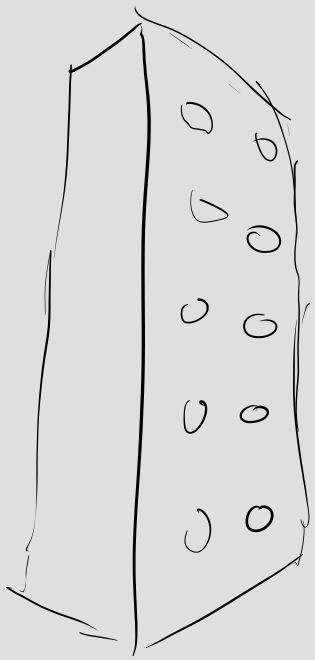
T^{-1}

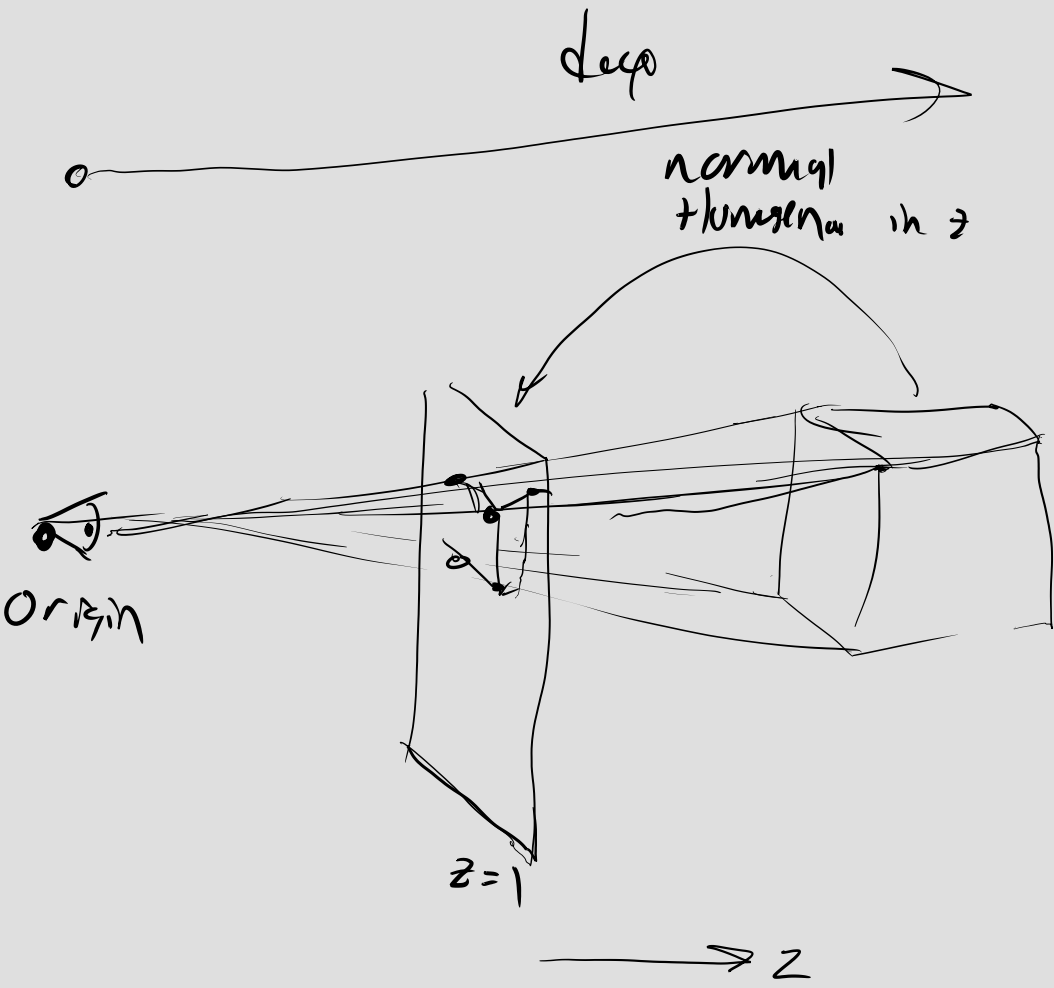
$R_1^{-1} R_2^{-1} R_3 R_2 R_1$

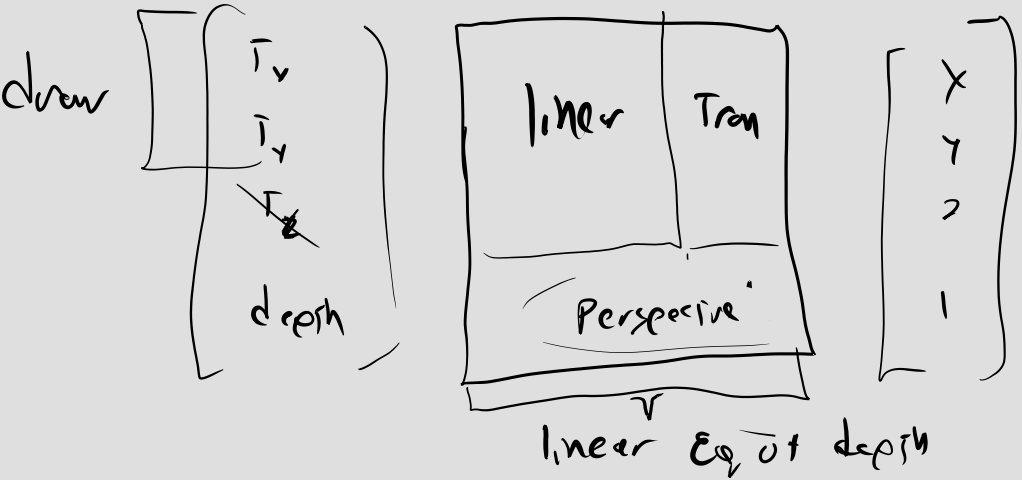
R



Perspective







Frustum