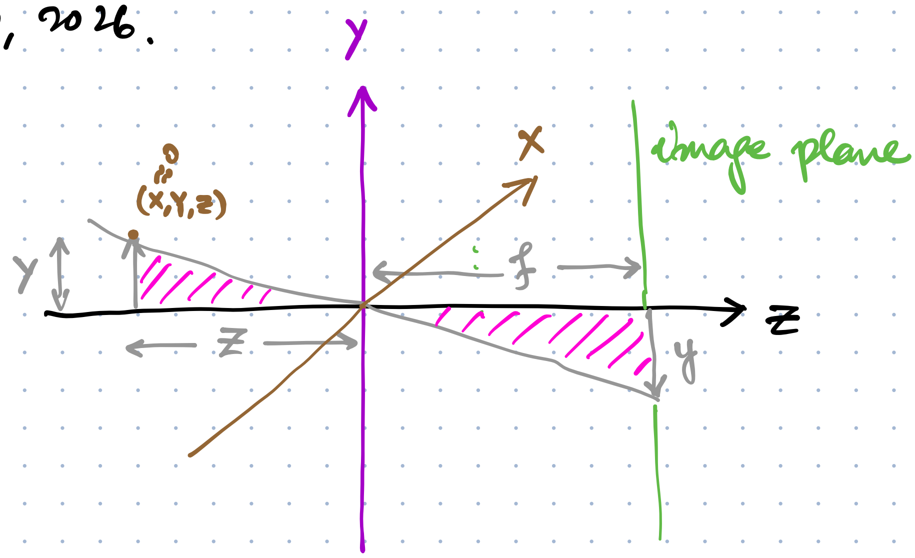
Sep 10, 2026.



f: focal length

Z: distance of the object from the camera

Y: height of the object

y: " " image of the object.

Using similar triangles:

$$\frac{Y}{Z} = \frac{y}{f}$$

$$\Rightarrow \boxed{y = f\,\frac{Y}{Z}} \longleftarrow \text{perspective projection.}$$

in 3D:

$$\boxed{x = f\,\frac{X}{Z}}$$

$\rightsquigarrow$ world point $(X,Y,Z) \in \mathbb{R}^3$

image point $(x,y) \in \mathbb{R}^2$

Homogeneous coordinates.

$$(X, Y, Z) \longrightarrow (\lambda X, \lambda Y, \lambda Y, \lambda)$$

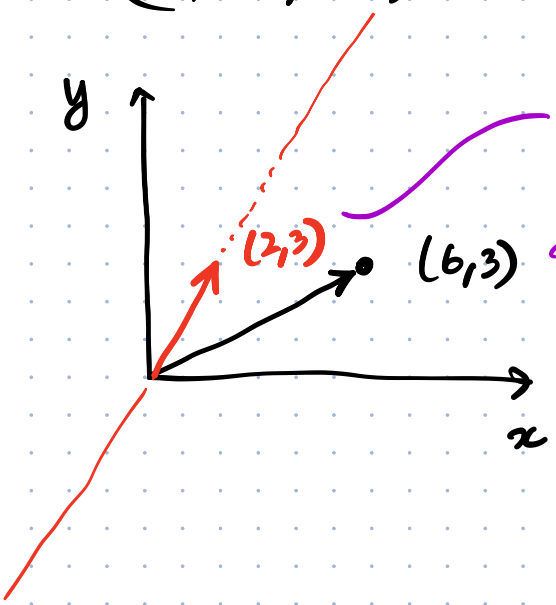
$$2, 3, 7 \longrightarrow (2,3,7,1) \text{ or } (4,6,14,2)$$

Q. convert $(7, 39, 42, \underline{\underline{3}})$ homogeneous point to a cartesian point.

A. $\left(7/3,\ 39/3,\ 42/3\right)$ position

Q. convert $(7, 39, 42, 0)$ homogeneous point to a cartesian point.

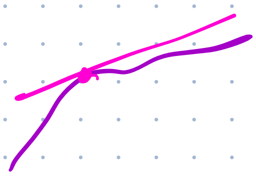
A. $(7, 39, 42)$ direction



$(2,3,0)$ homogeneous

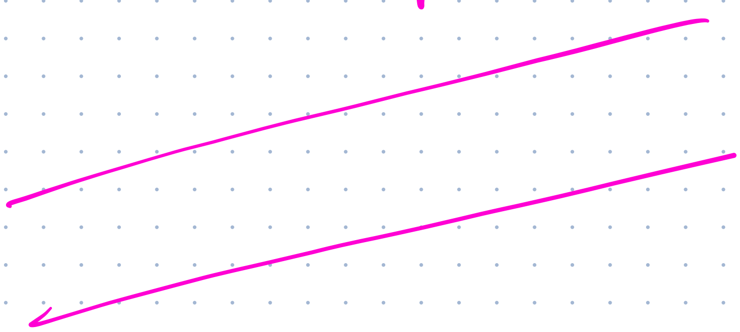
$(6,3,1)$ or $(24,12,4)$ homogeneous

$y = mx + c$



line in 2D: $ax + by + c = \phi$

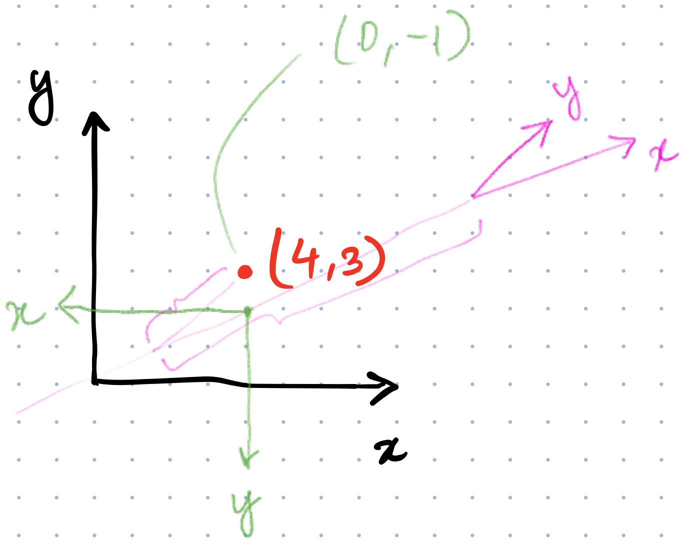
$$\underbrace{(a, b, c)}_{\text{line}} \cdot \underbrace{(x, y, 1)}_{\text{pt.}} = 0$$



$$\begin{bmatrix} f & 0 & 0 & 0 \\ 0 & f & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \\ 1 \end{bmatrix} = \begin{bmatrix} fX \\ fY \\ Z \end{bmatrix} \xrightarrow[\text{Cartesian}]{} \begin{bmatrix} \frac{fX}{Z} \\ \frac{fy}{Z} \end{bmatrix}$$

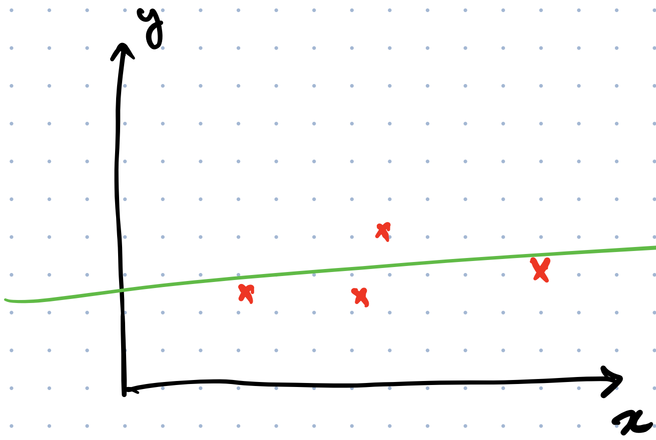
Take home: Affine Transformation.

$$y = Ax$$



$$\begin{bmatrix} wx \\ wy \\ w \end{bmatrix} = \underbrace{\begin{bmatrix} f & 0 & p_x \\ 0 & f & p_y \\ 0 & 0 & 1 \end{bmatrix}}_{\text{intrinsic matrix}} \underbrace{\left[\begin{array}{c|c} \underset{\in \mathbb{R}^{3\times 3}}{R} & \underset{\in \mathbb{R}^{3\times 1}}{-R\tilde{C}} \end{array} \right]}_{\text{extrinsic matrix}} \begin{bmatrix} X \\ Y \\ Z \\ 1 \end{bmatrix}$$

$$\vec{x} = \underbrace{P}_{\text{projection matrix}}\begin{bmatrix} X \\ Y \\ Z \\ 1 \end{bmatrix}$$



$A\vec{x} = \vec{0}$

$ax+by+c=0$

$y=mx+c$

$A\vec{x} = \vec{b}$

$\vec{x} = A^{-1}\vec{b}$