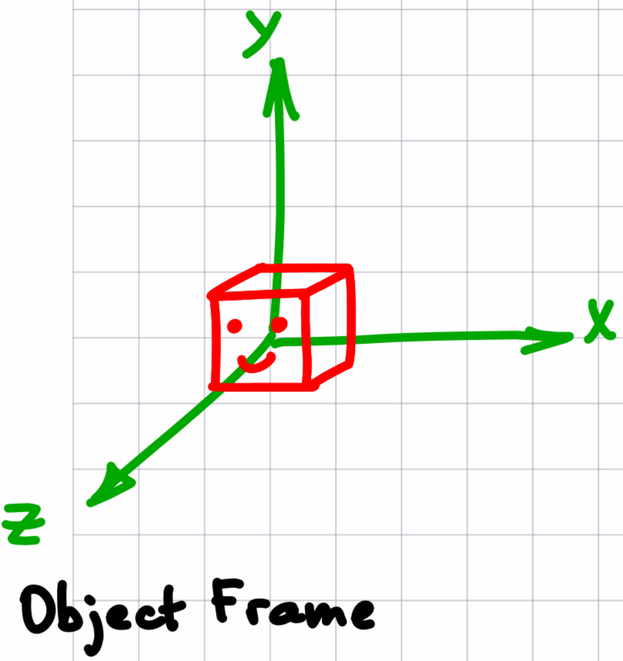
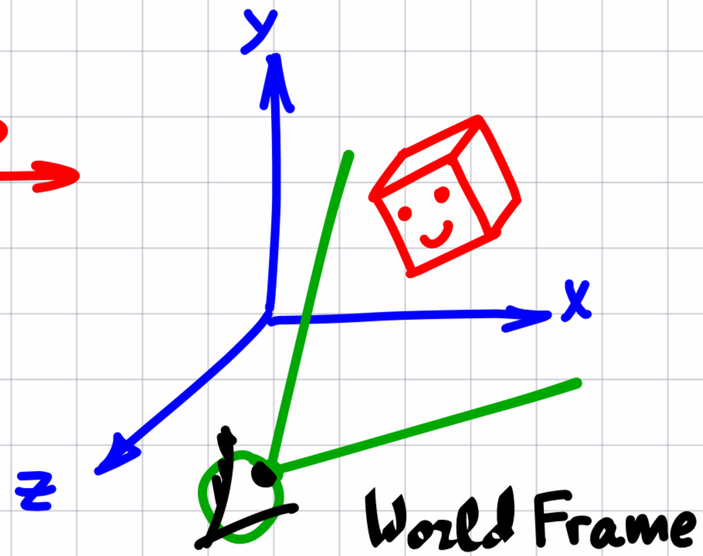
Announcements

- Project team and abstract due Oct 8, IN CLASS!
- MP2 is out, due Sep 29, 11:59pm.
- Reading: Chapter 6 and 7 of Shirley (computer graphics).
- Additional resource for geometric transformations background.
  Free online book: S. M. LaValle, "Planning Algorithms"
- Reading: Chapter 6 by Mather (light propagation)

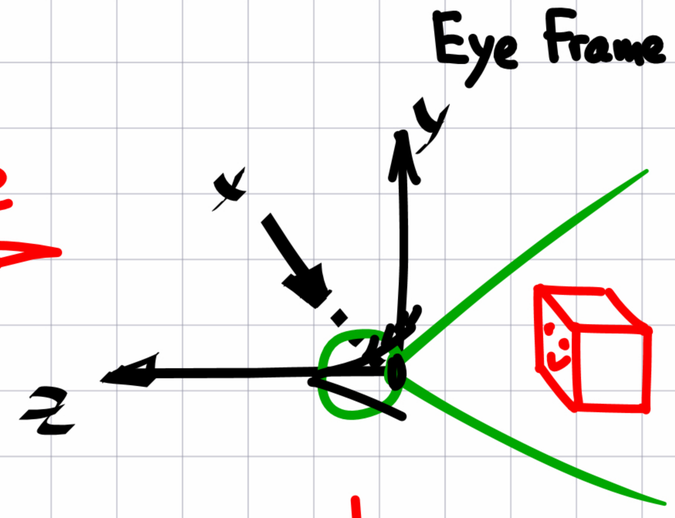
From Alternate World Generator to GPU



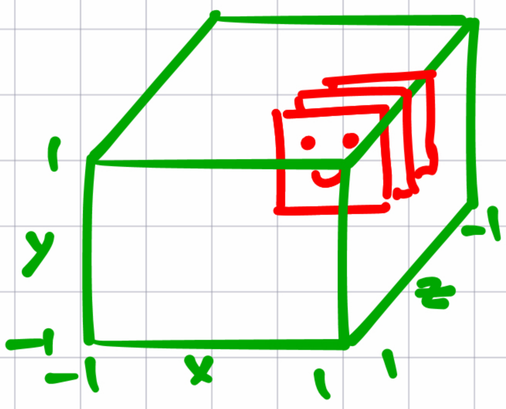
T_{rb}



T_{eye}

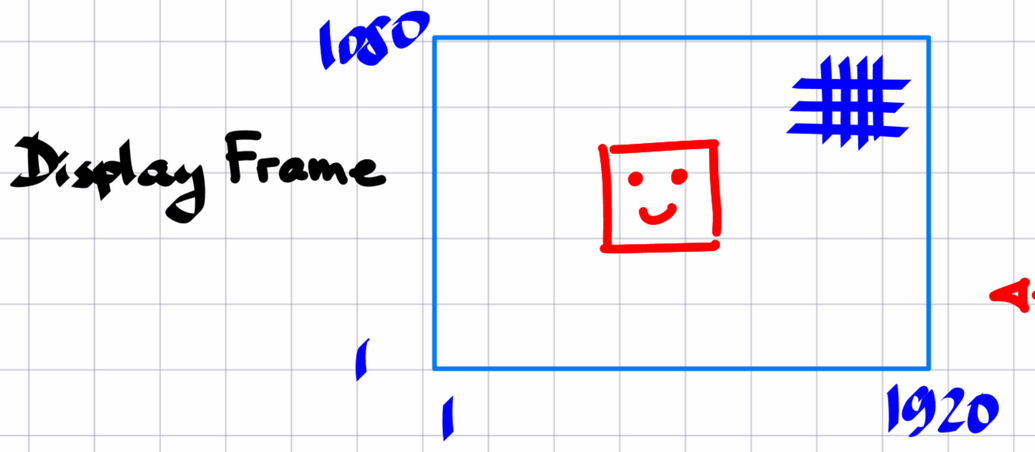


T_{can}



Canonical Frame

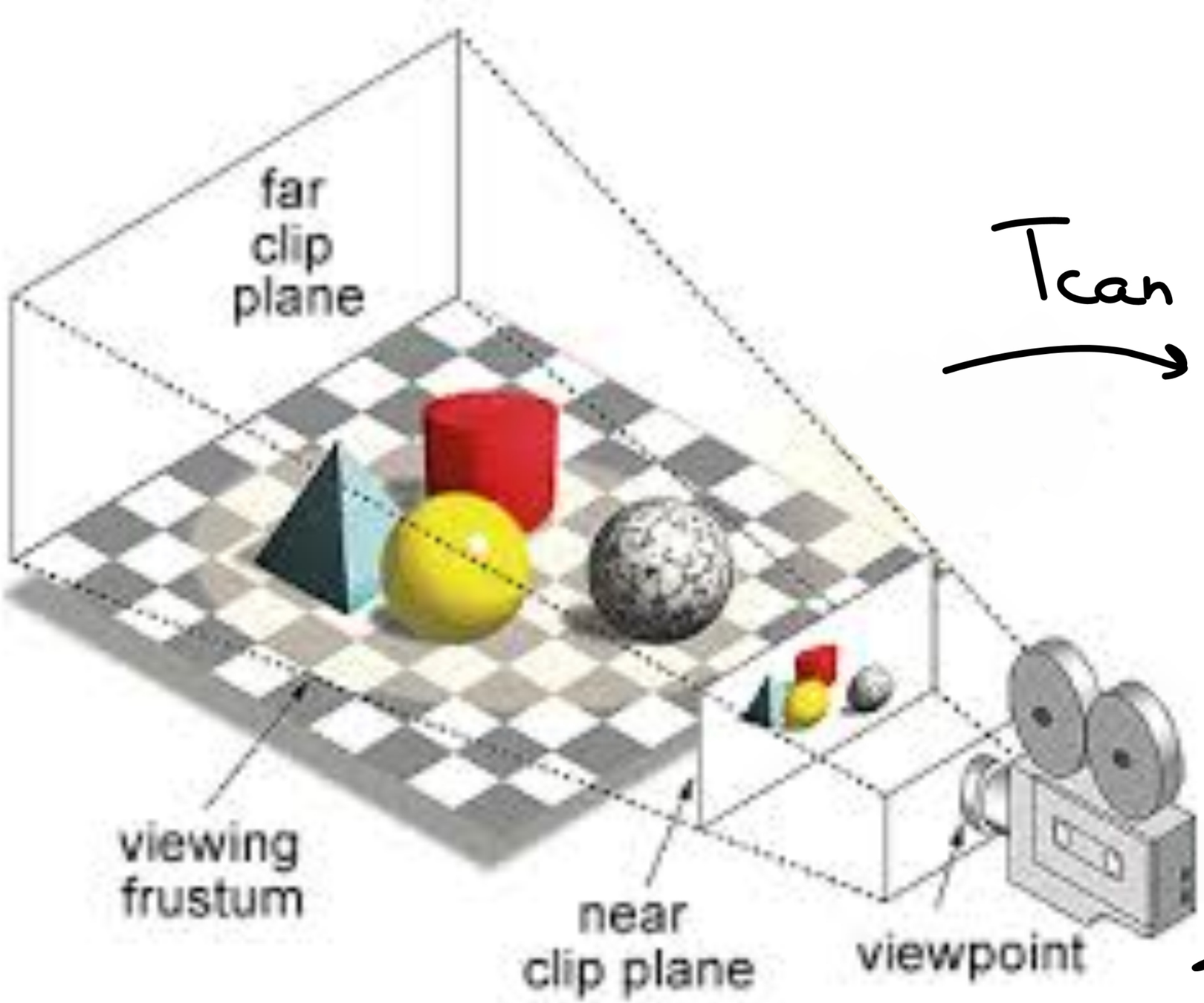
T_{vp}



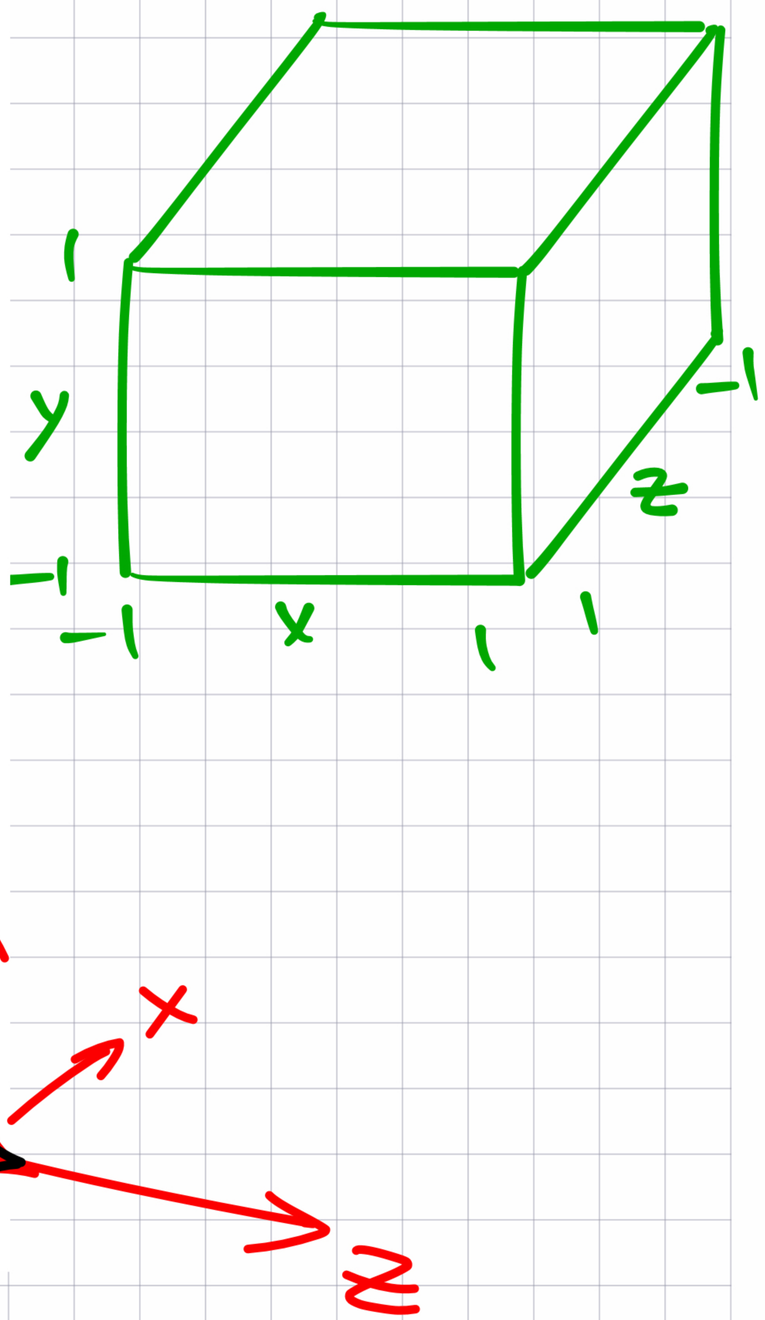
$$T = T_{vp} \cdot T_{can} \cdot T_{eye} \cdot T_{rB}$$

(T_{vp}: T_{dist}; T_{can}: T_L or T_R)

Canonical Transformation

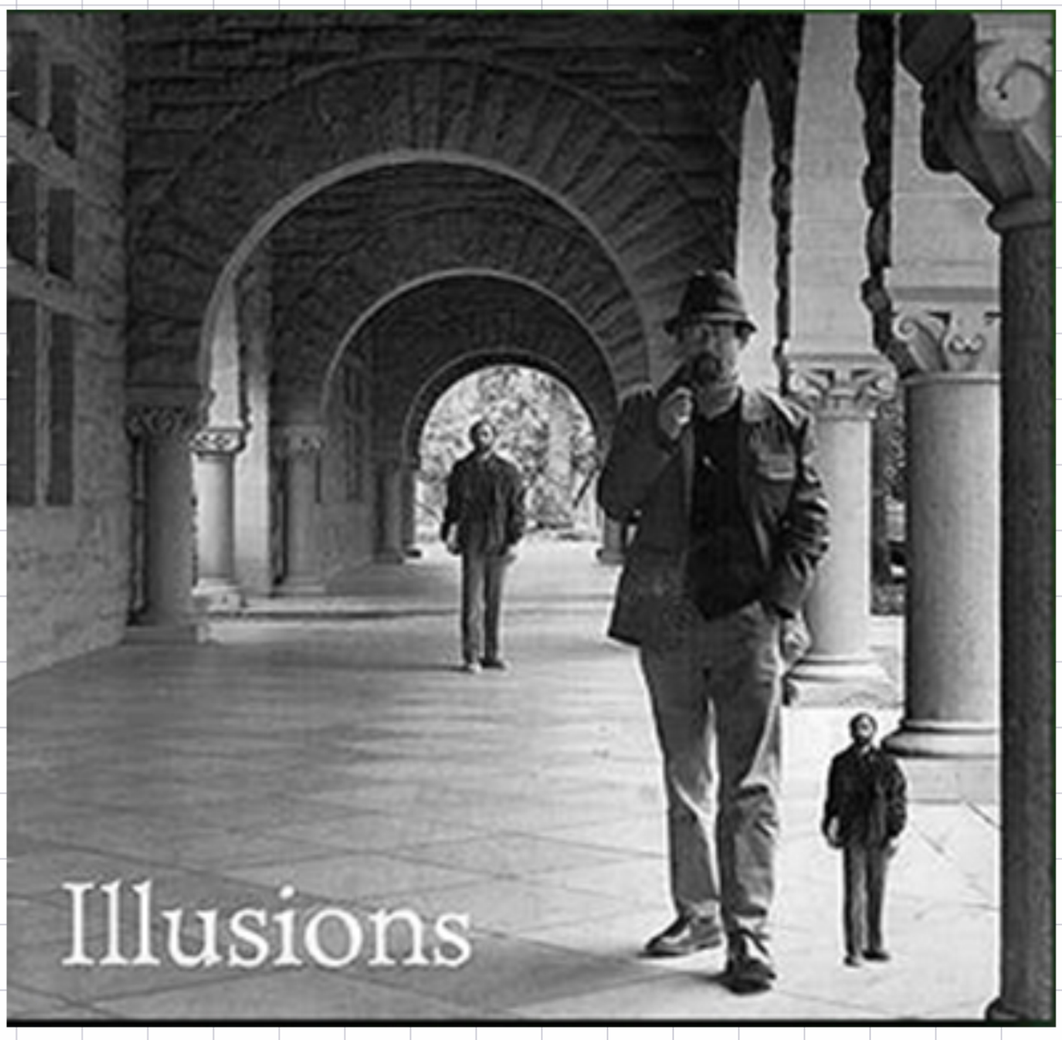


T_{can}



Canonical Transformation

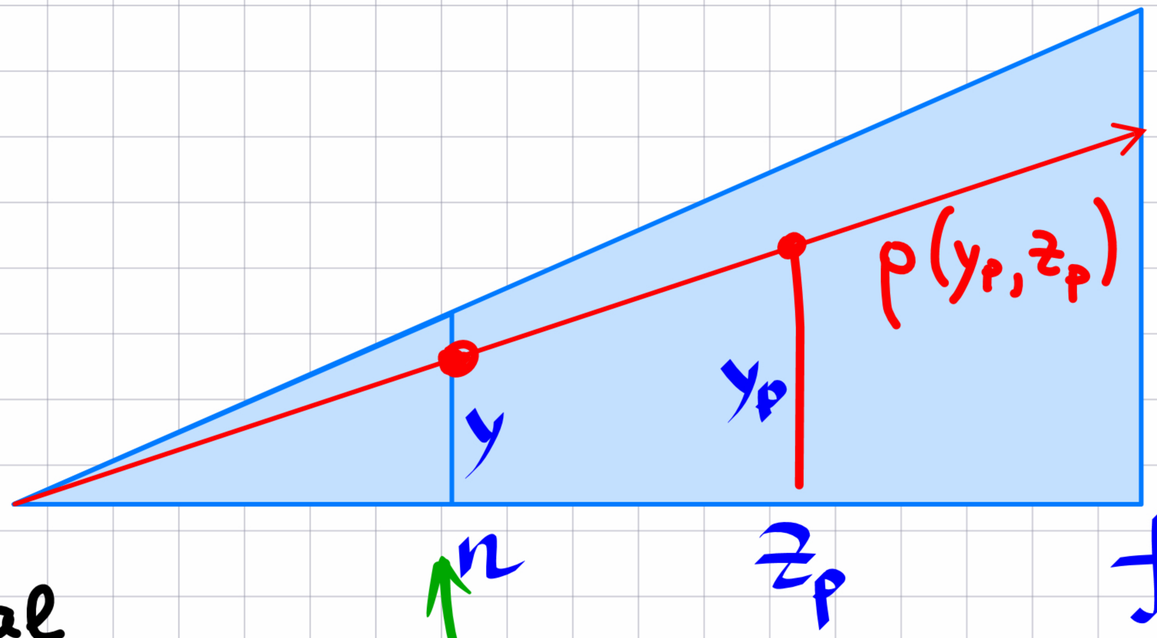
Andrea Mantegna
The Lamentation over the Dead Christ 1490



incorrect perspective

correct perspective

Canonical Transformation: 2D Analogy



Preserved ratios:

$$\frac{y_p}{z_p} = \frac{y}{n}$$

$$y = \left(\frac{n}{z_p}\right) y_p$$

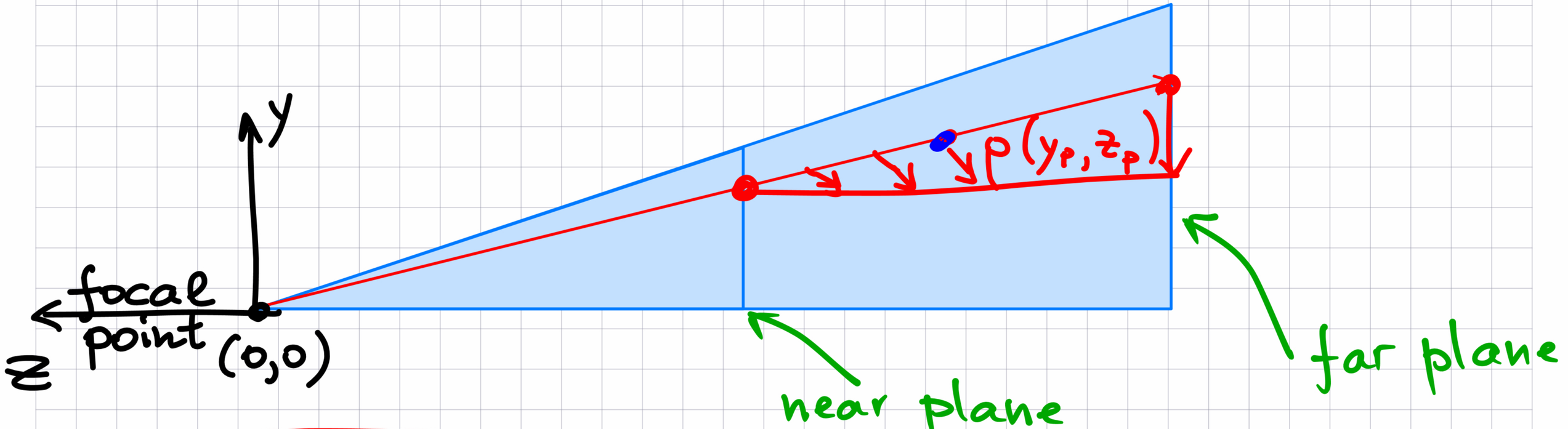
$$\begin{bmatrix} \frac{n y_p}{z_p} \\ \cdot \\ 1/z_p \\ 1 \end{bmatrix} \sim \begin{bmatrix} n y_p \\ \cdot \\ z_p \end{bmatrix} = \begin{bmatrix} n & 0 & 0 \\ \cdot & \cdot & \cdot \\ 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} y_p \\ z_p \\ 1 \end{bmatrix}$$

$\neq 1$

$$y = \frac{n y_p}{z_p}$$

$z =$ (next slide)

Canonical Transformation: 2D Analogy



if $z = n \Rightarrow z = n + f - \frac{nf}{n} = n$

$z = f \Rightarrow z = n + f - \frac{nf}{f} = f$

$z = \frac{f+n}{2} \Rightarrow z = ?$ preserves depth order

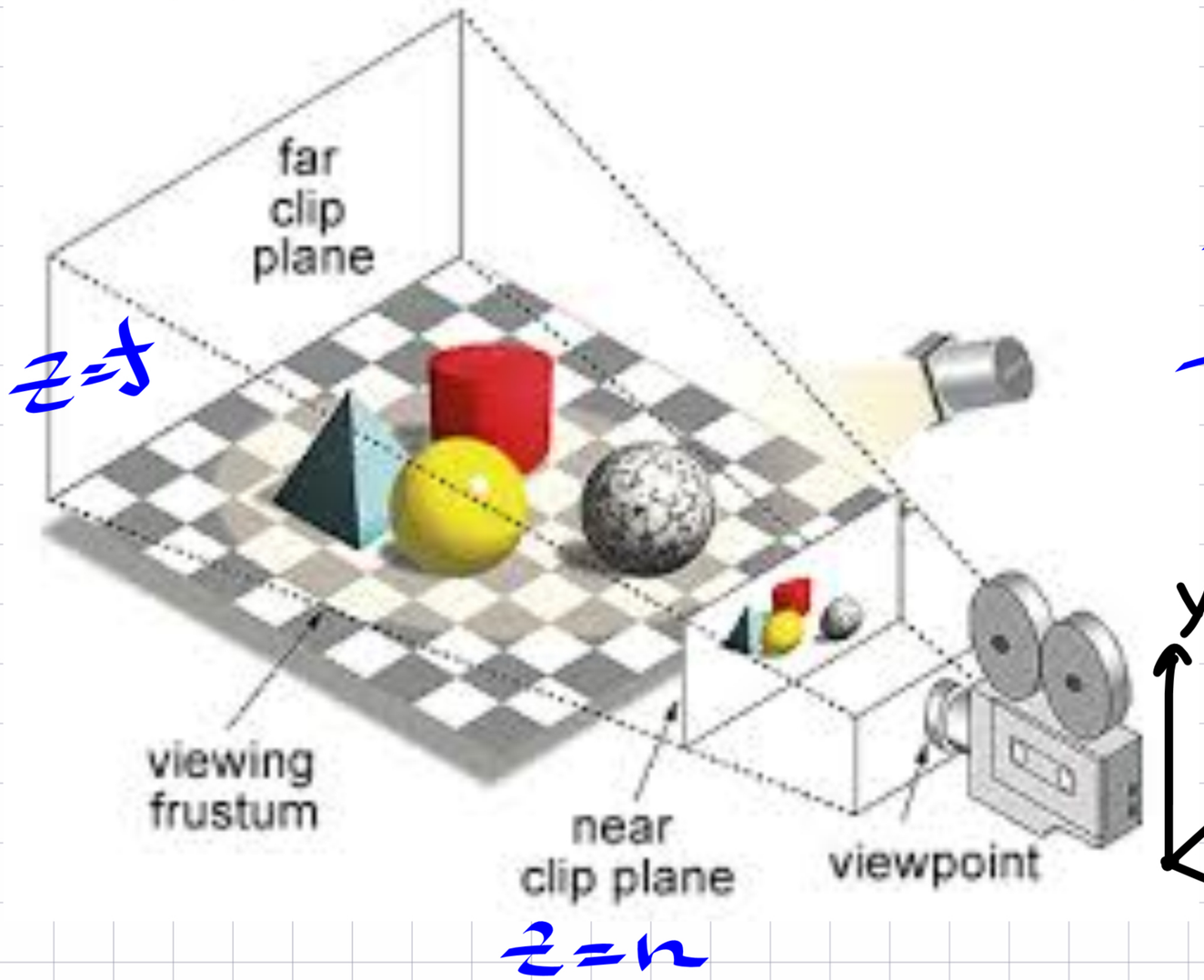
$$\begin{bmatrix} n\,y_p \\ (n+f)z_p - nf \\ z_p \end{bmatrix} = \begin{bmatrix} n & 0 & 0 \\ 0 & n+f & -nf \\ 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} y_p \\ z_p \\ 1 \end{bmatrix}$$

$$y = \frac{n y_p}{z_p}$$

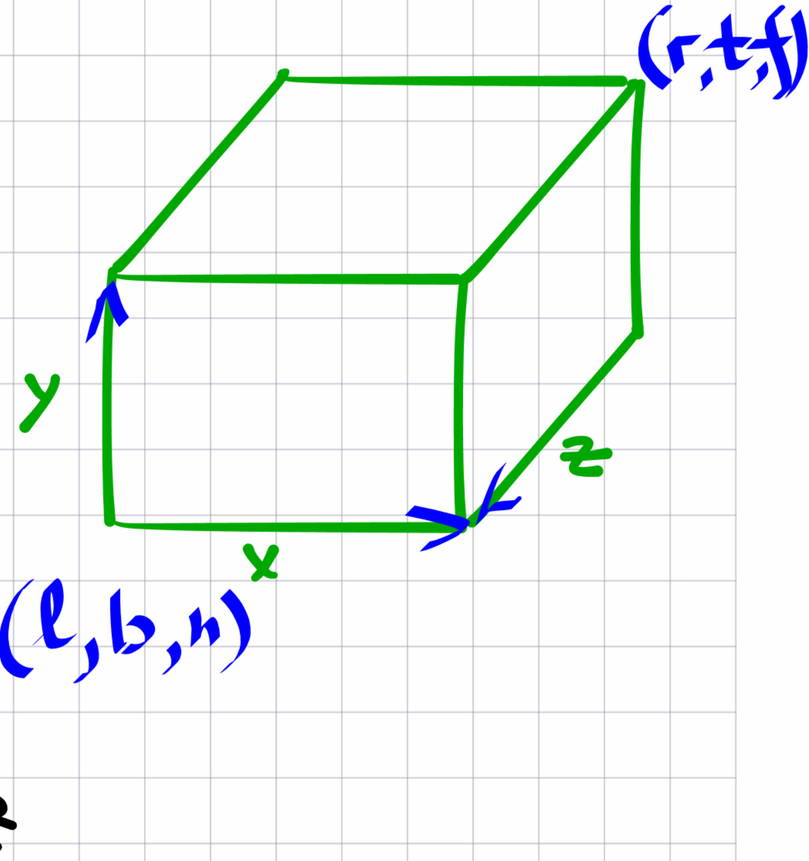
$$z = n + f - \frac{nf}{z_p}$$

↘ divide all components by z_p

Canonical Transformation

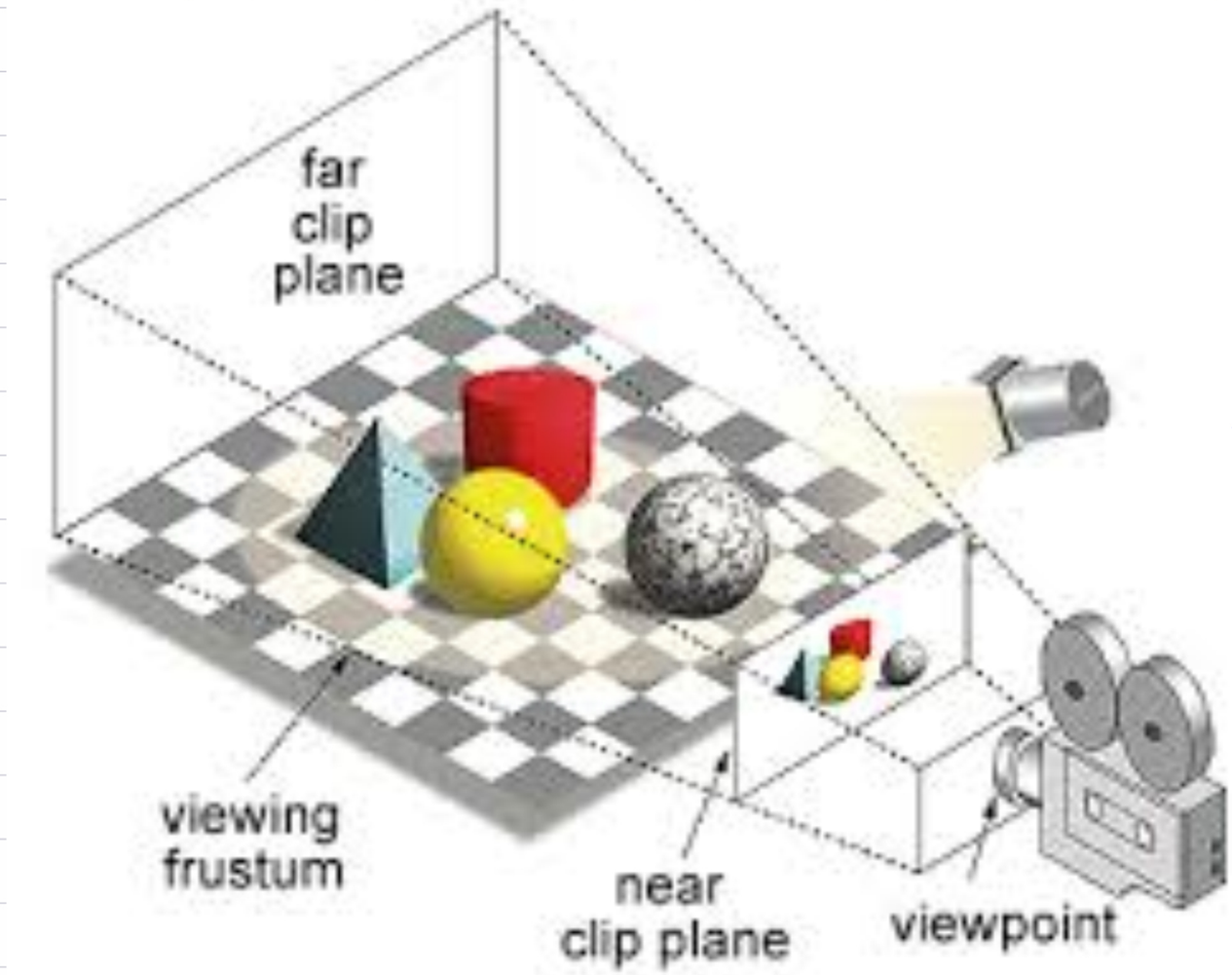


T_p



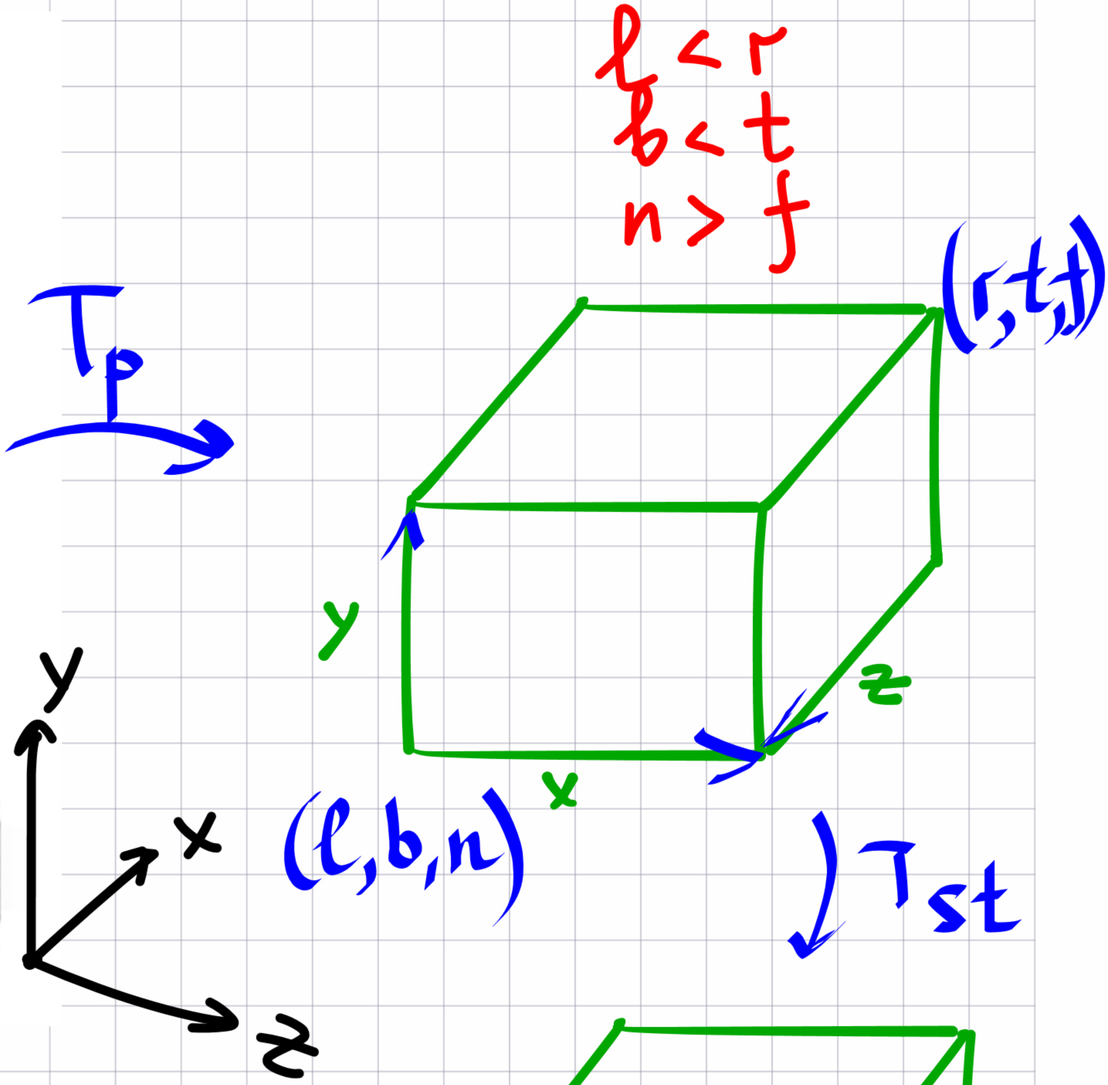
$$T_p = \begin{bmatrix} n & 0 & 0 & 0 \\ 0 & n & 0 & 0 \\ 0 & 0 & n+f & -nf \\ 0 & 0 & 1 & 0 \end{bmatrix}$$

Canonical Transformation

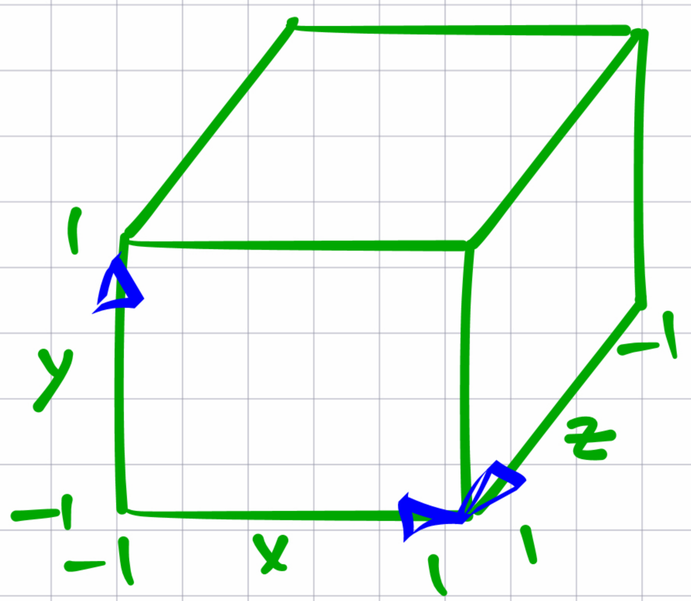


$l < r$
$b < t$
$n > f$

T_p

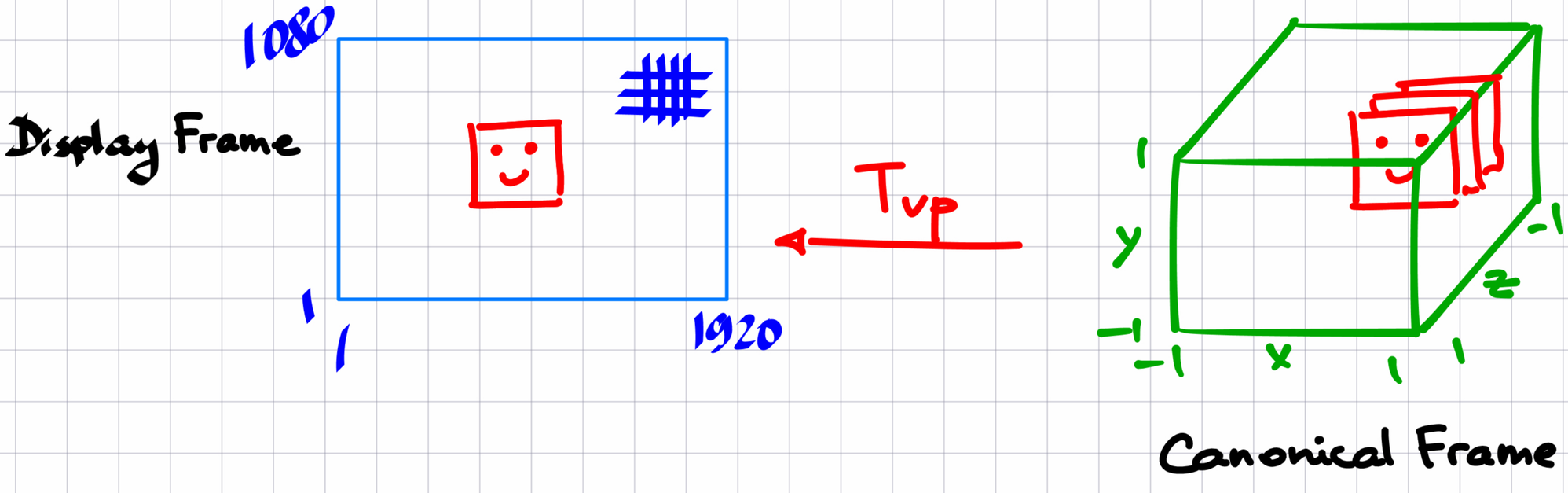


$$T_{st} = \begin{bmatrix} \frac{2}{r-l} & 0 & 0 & -\frac{r+l}{r-l} \\ 0 & \frac{2}{t-b} & 0 & -\frac{t+b}{t-b} \\ 0 & 0 & \frac{2}{n-f} & -\frac{n+f}{n-f} \\ 0 & 0 & 0 & 1 \end{bmatrix}$$



$$T_{can} = T_{st} \cdot T_p$$

Viewport Transformation



T_{vp} converts $-1..1$ range to pixel coordinates:

$n_x = \#$ horizontal pixels

$n_y = \#$ vertical pixels

$$T_{vp} = \begin{bmatrix} \frac{n_x}{2} & 0 & 0 & \frac{n_x-1}{2} \\ 0 & \frac{n_y}{2} & 0 & \frac{n_y-1}{2} \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

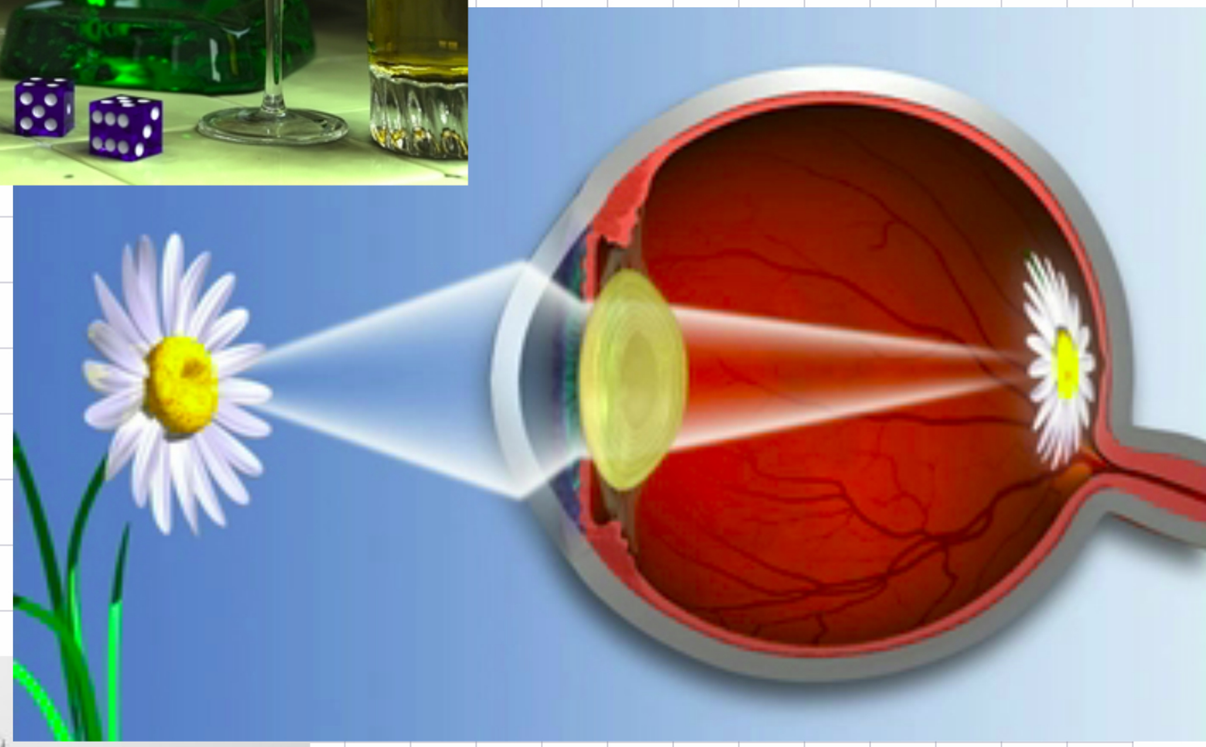
Light and Optical Systems

Alterate world generator:

proper lighting and shadows

Lens:

proper correction for the lens distortion



Light Models

Three light models

Advantages

1. Ray model:

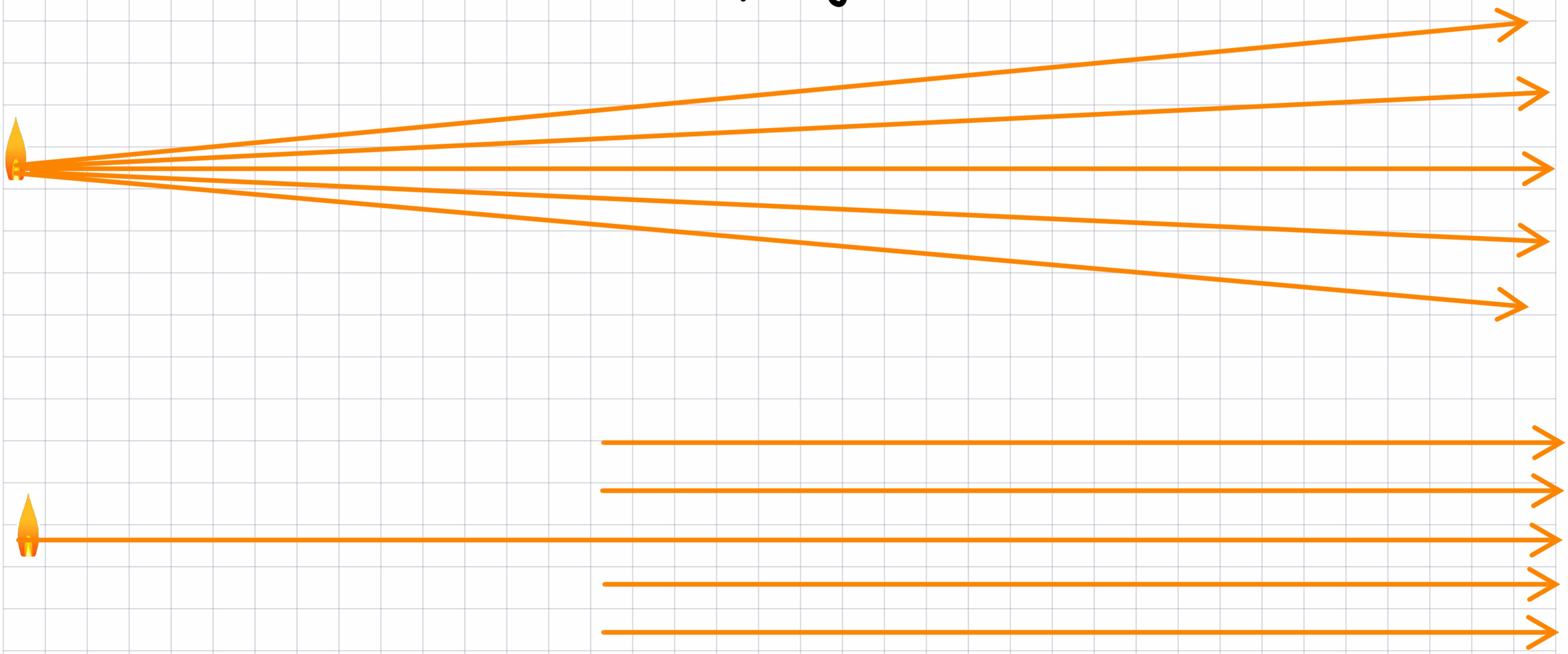
2. Wave model:

3. Particle model:

Point source of light

Light: Ray Propagation

Without mirrors or lenses, rays ALWAYS



Other names:

Light and Materials

We use materials to bend light rays/waves

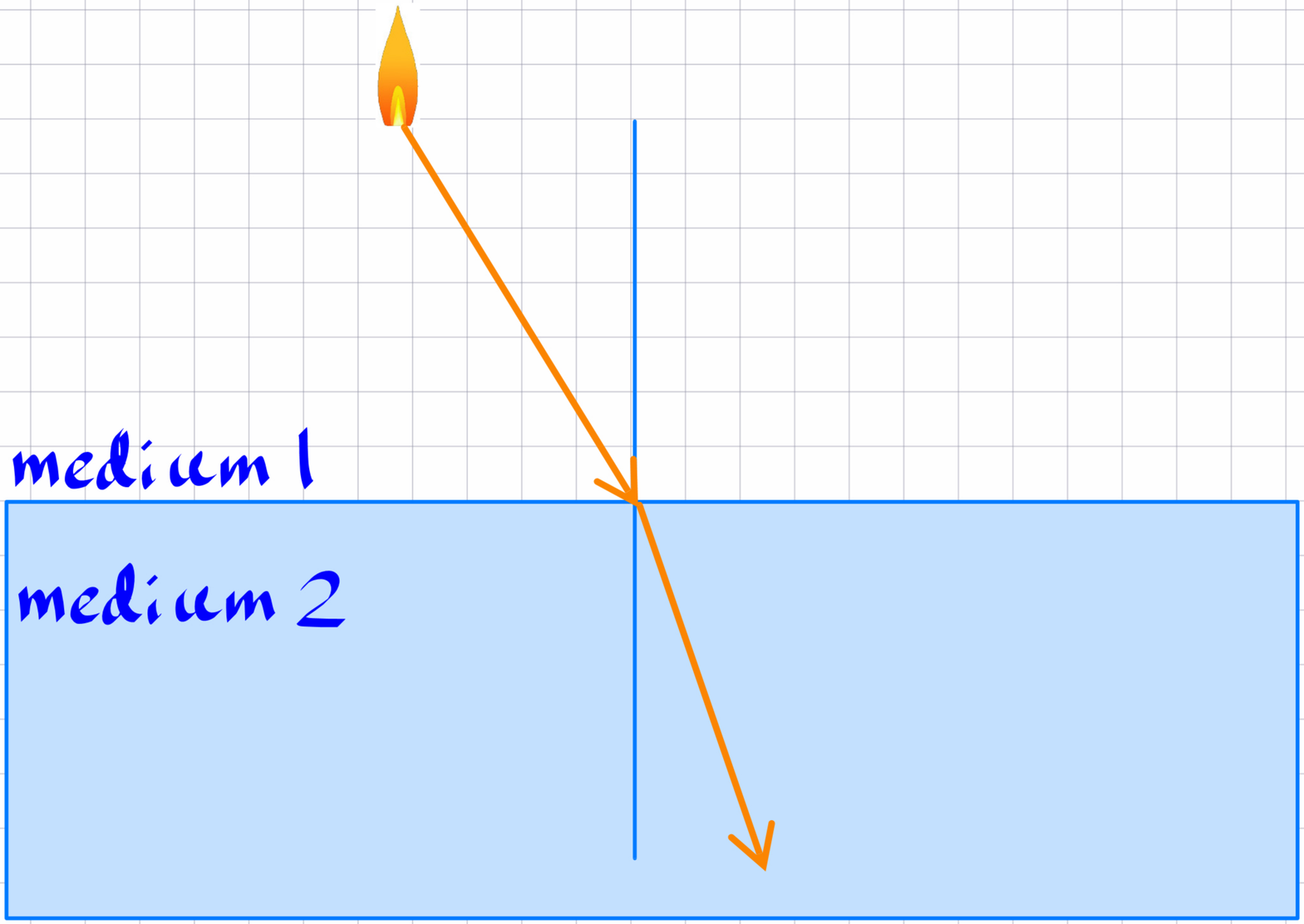
1.

2.

3.

4.

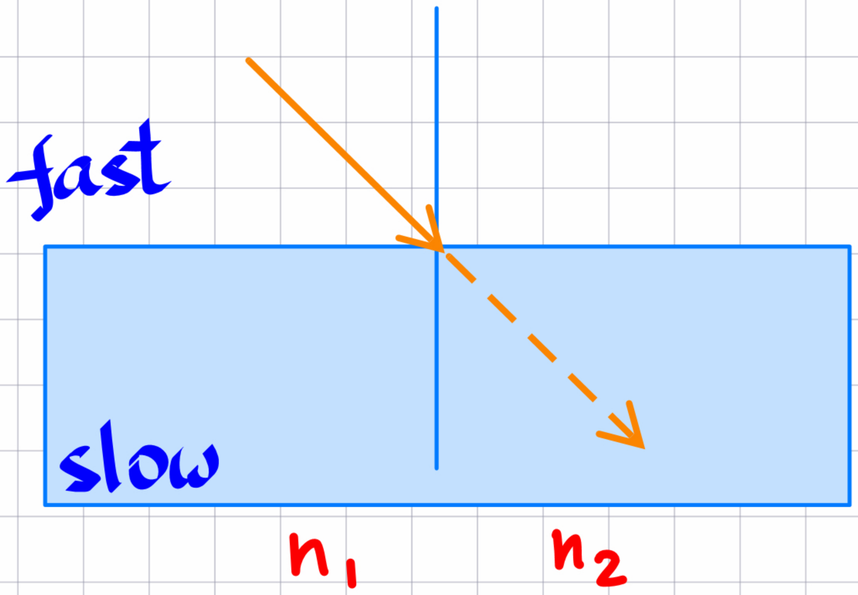
Light and Materials: Refraction

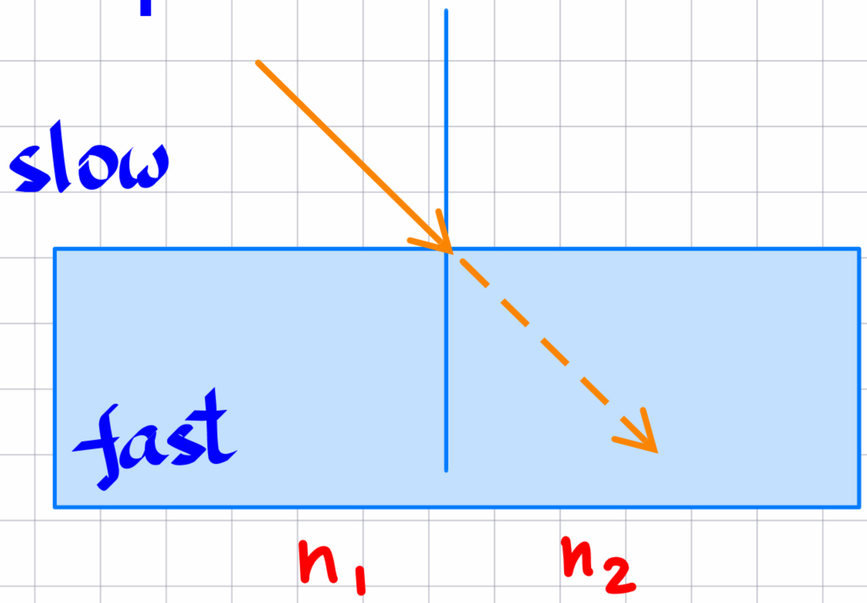


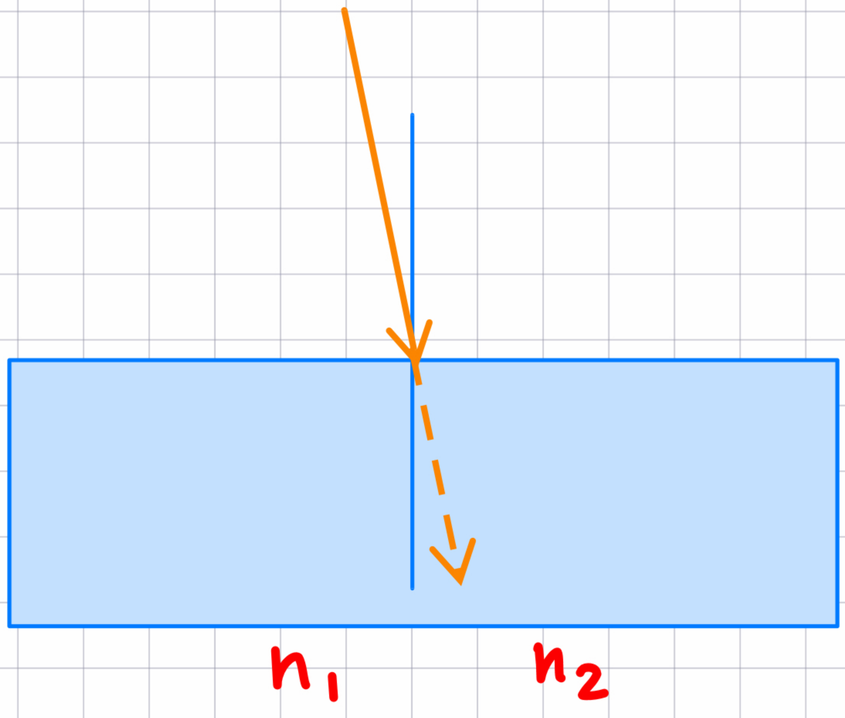
Example

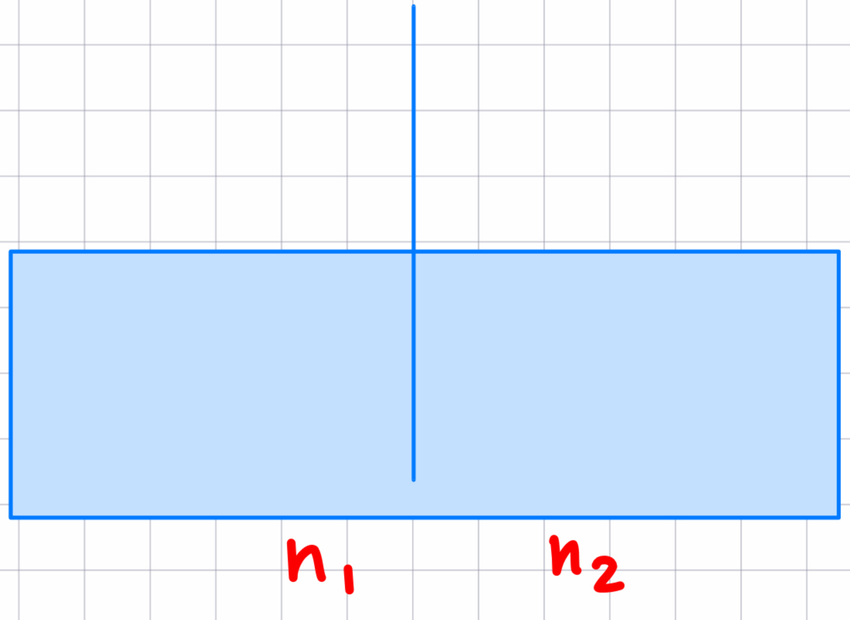
Snell's law:

Refraction Examples



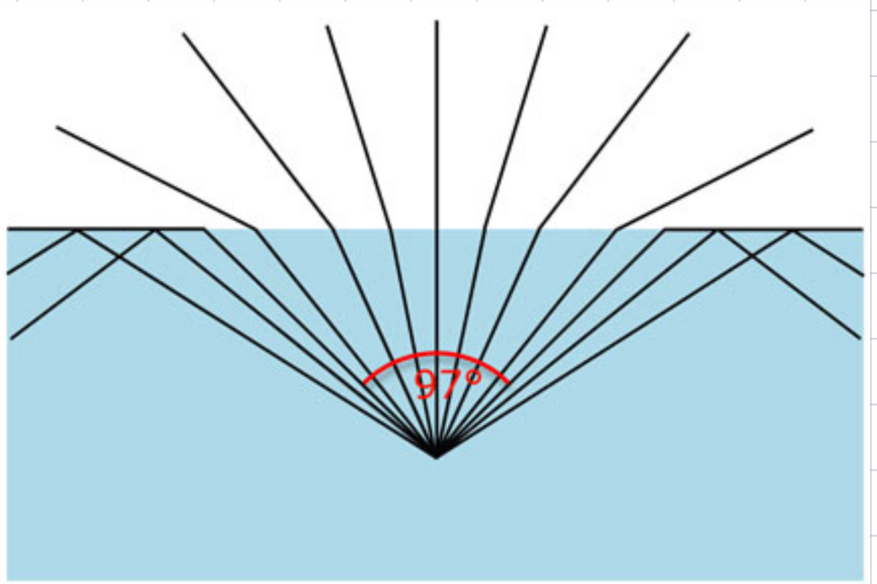




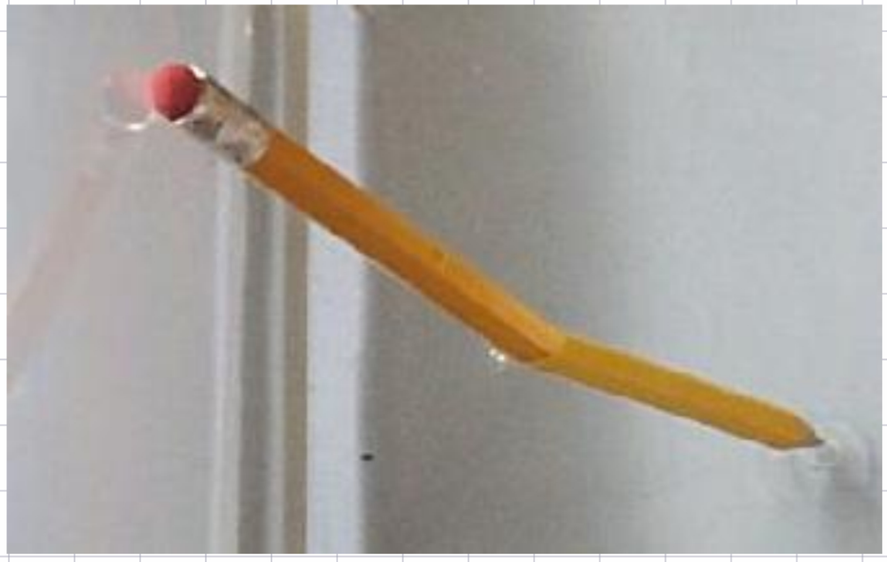


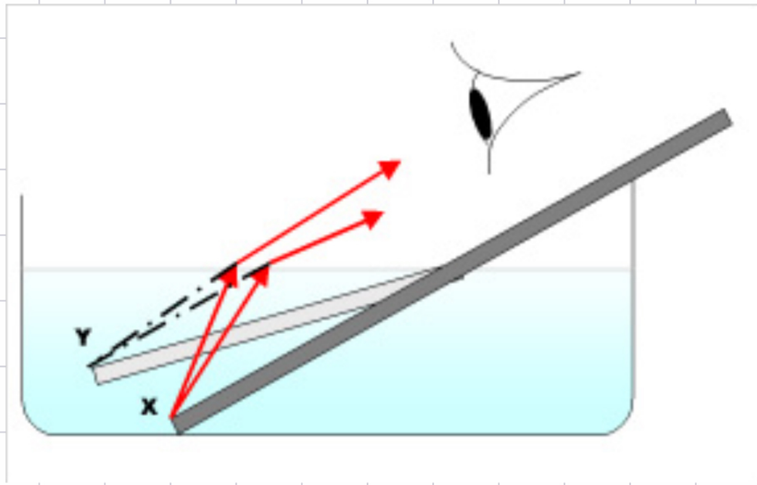
If $\frac{n_1}{n_2}\sin\theta_1$ then

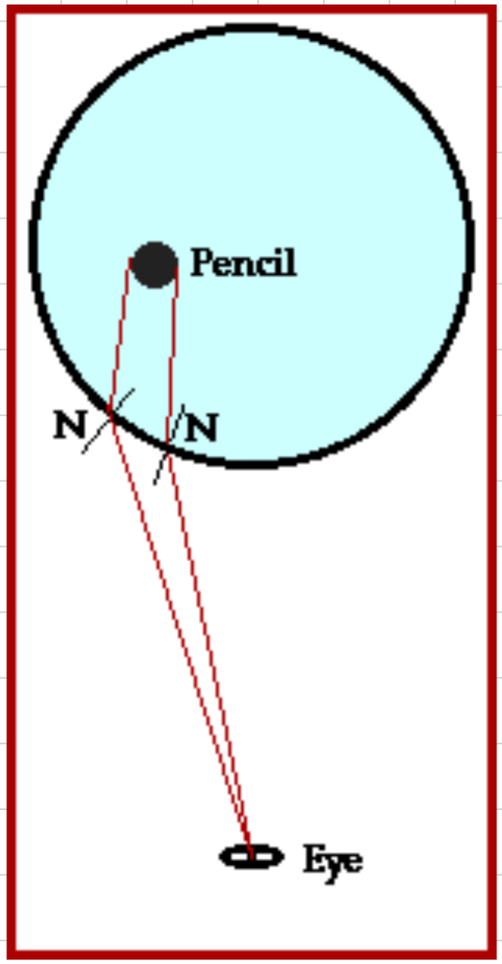
Examples



Examples







Examples