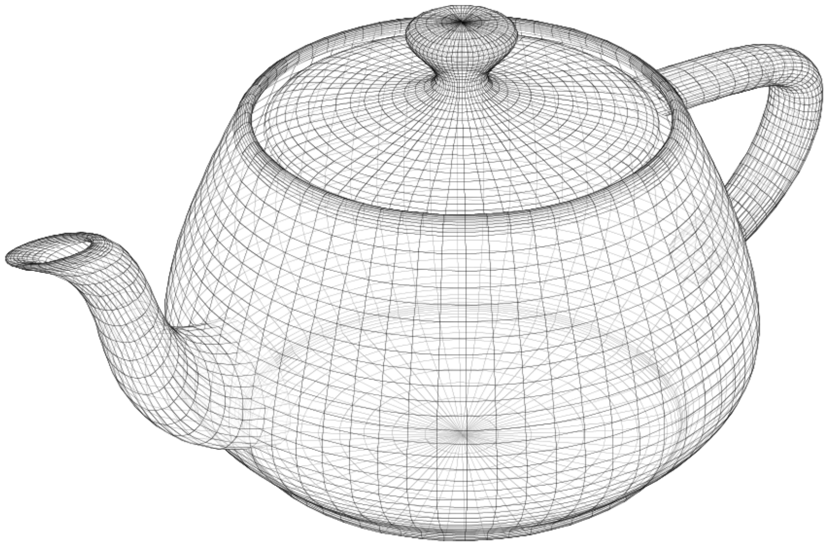
Orthographic Projection



CS 418: Interactive Computer Graphics

Professor Eric Shaffer

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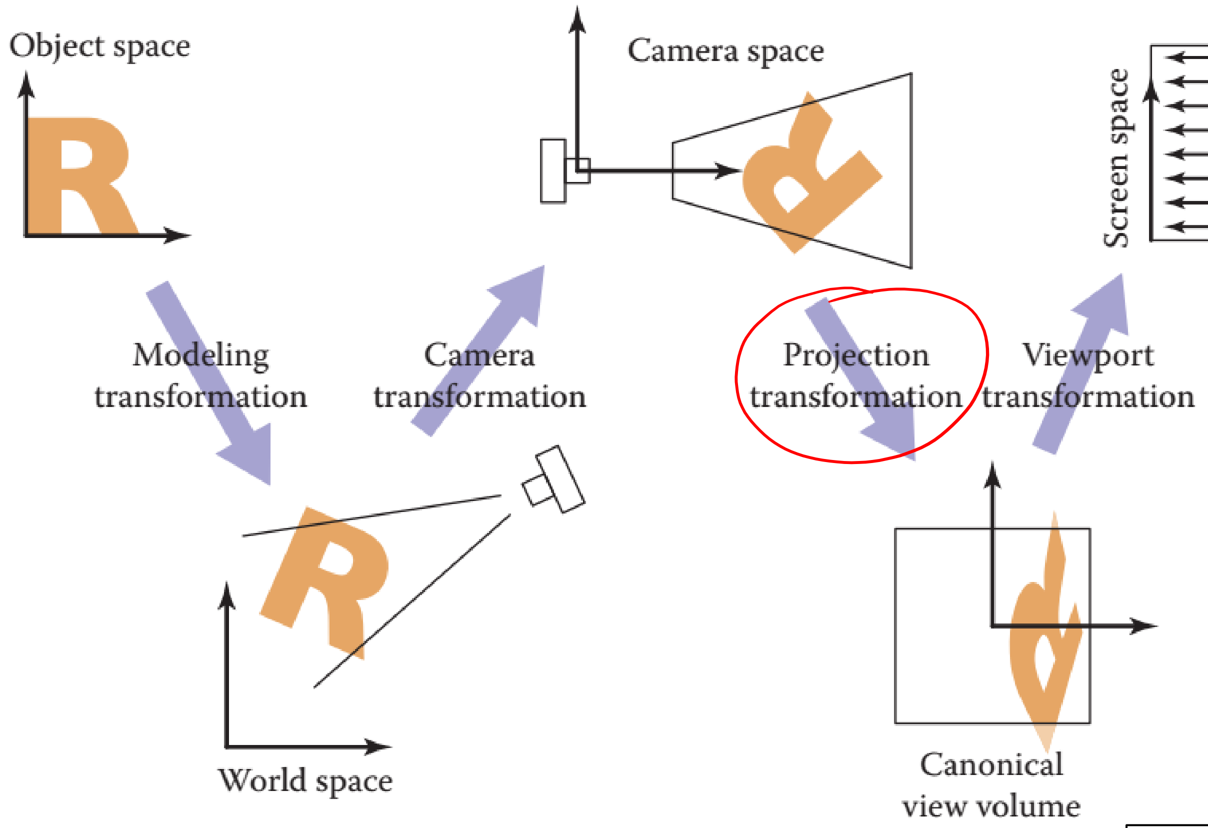
Graphics Pipeline



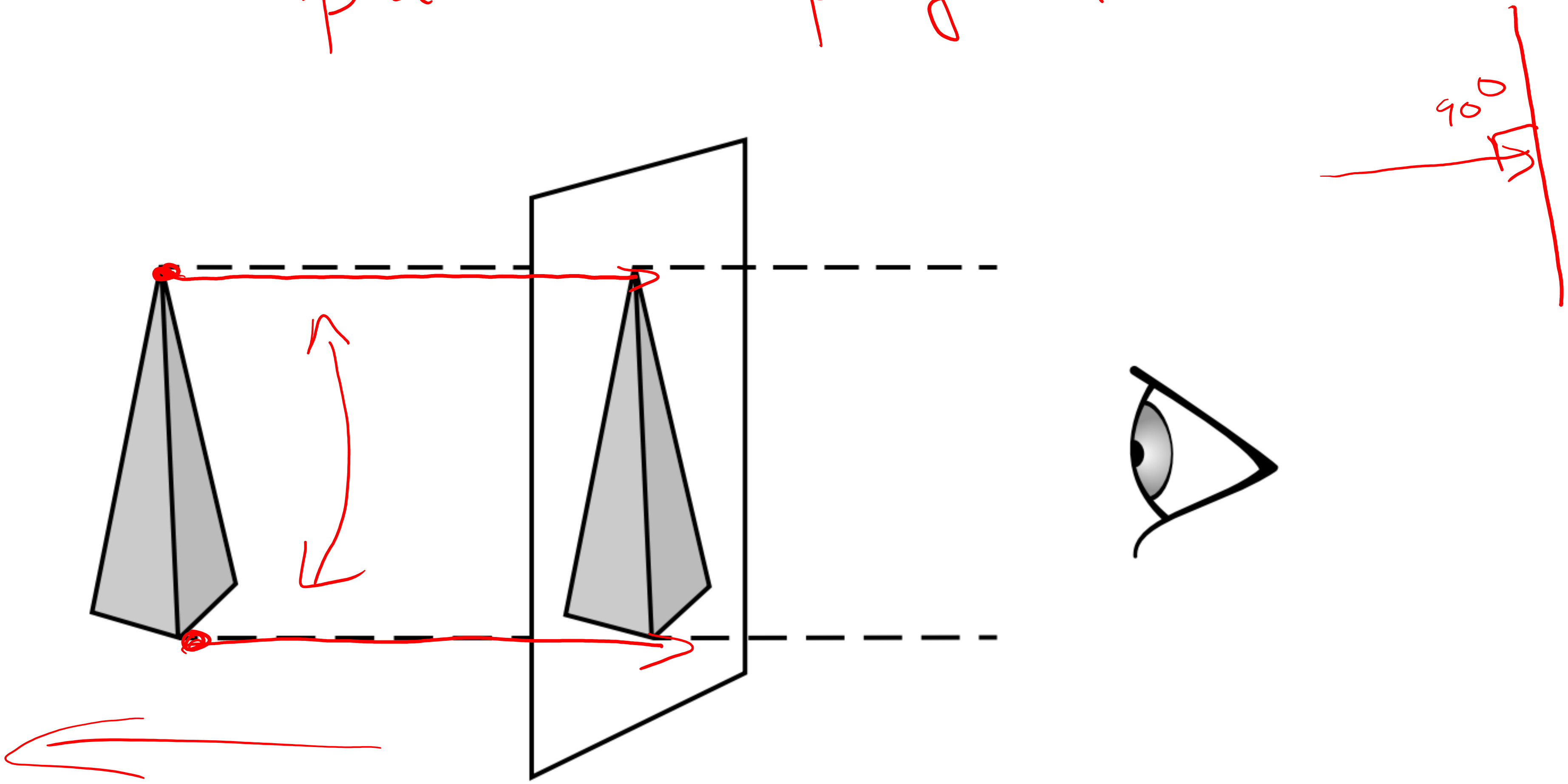
We will call the ***camera transformation*** the ***view transformation***

In WebGL convention, the projection transformation inverts the handedness of the coordinate system

The canonical view volume is a 2x2x2 box centered at the origin with coordinates ranging from [-1,-1,-1] to [1,1,1]

Orthographic Projection

parallel projection



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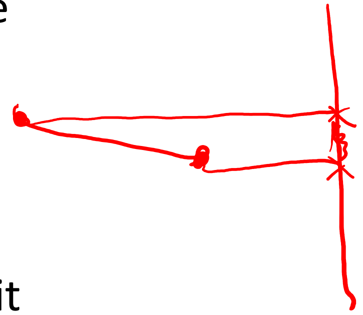
Definition to Know: Foreshortening

Foreshortening is the visual effect or optical illusion that causes an object or distance to appear shorter than it actually is.



...projections squash receding surfaces

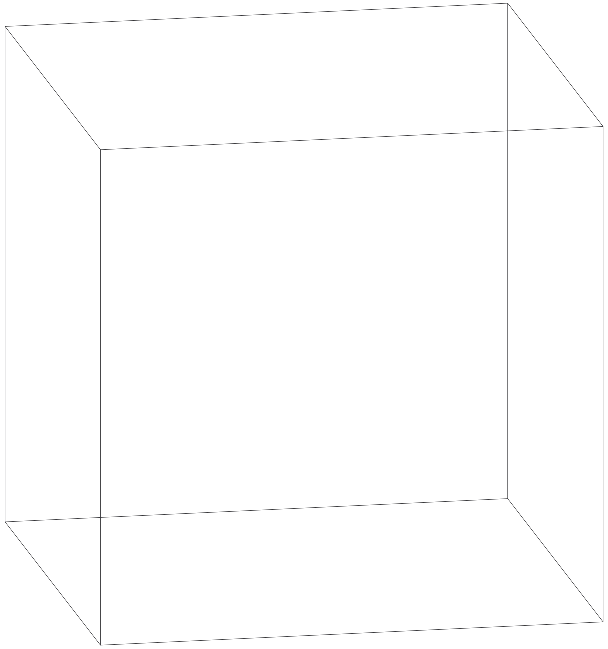
Can foreshortening happen in orthographic projection?

yes

Andrea Mantegna
The Lamentation over the Dead Christ

Clip Space View Volume

So, if we don't do any transformations…where are we and what direction are we looking?



Take a look at
https://developer.mozilla.org/en-US/docs/Web/API/WebGL_API/WebGL_model_view_projection

http://jsfiddle.net/2x03hdc8/

It is a simple WebGL program that lets you draw rectangles

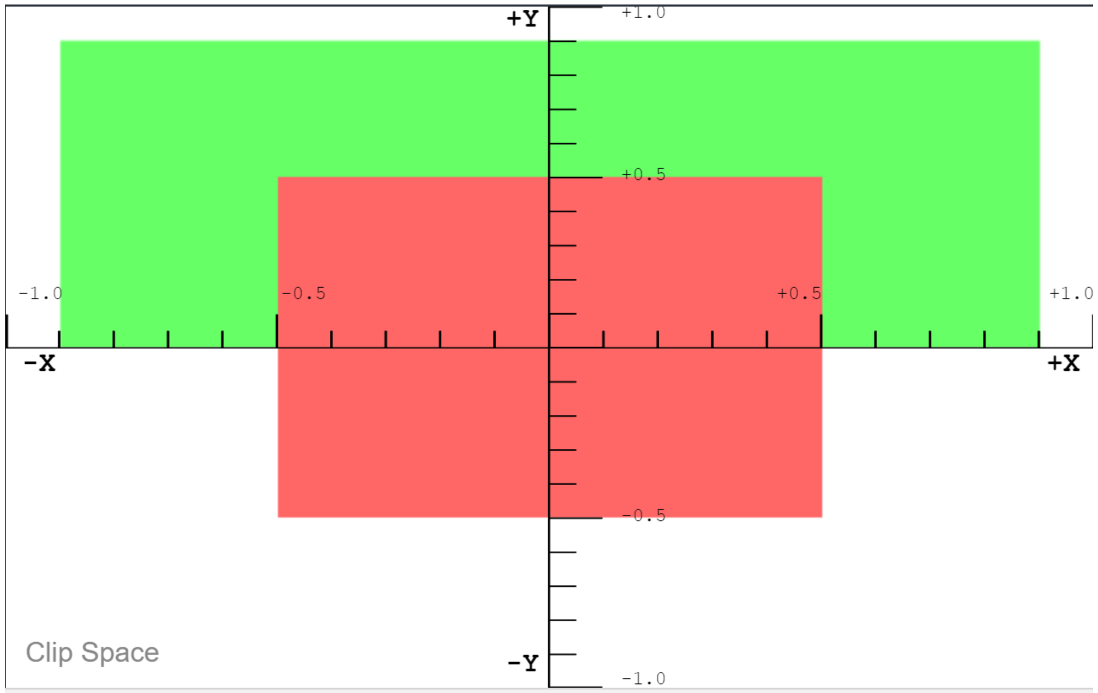
No transformations

By altering the rectangle coordinates, you can figure out the view….

Clip Space View

- Red rectangle has z=0
- Green has z=0.5

What direction are we looking?

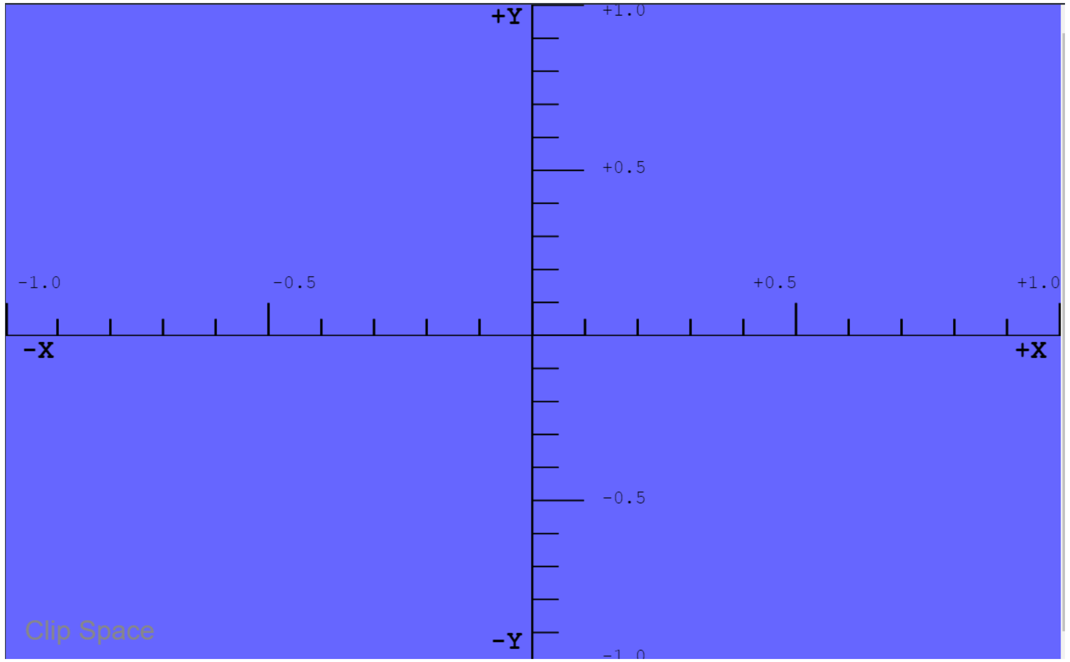


Clip Space View

We add a blue rectangle

It’s at z=-1

Where is the near clipping plane?



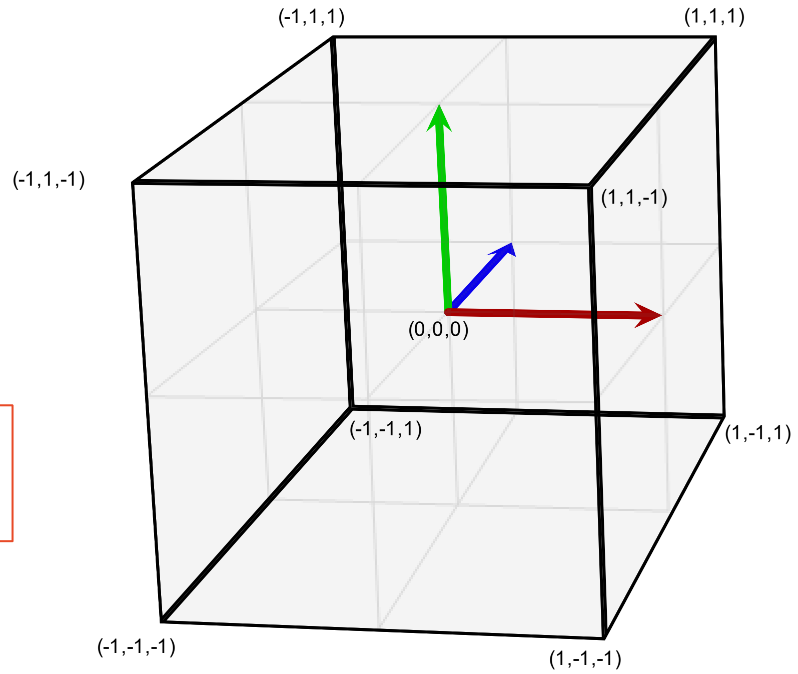
Clip Space View and View Volume

View is looking down Z+

Eyepoint is effectively at (0,0,-1)

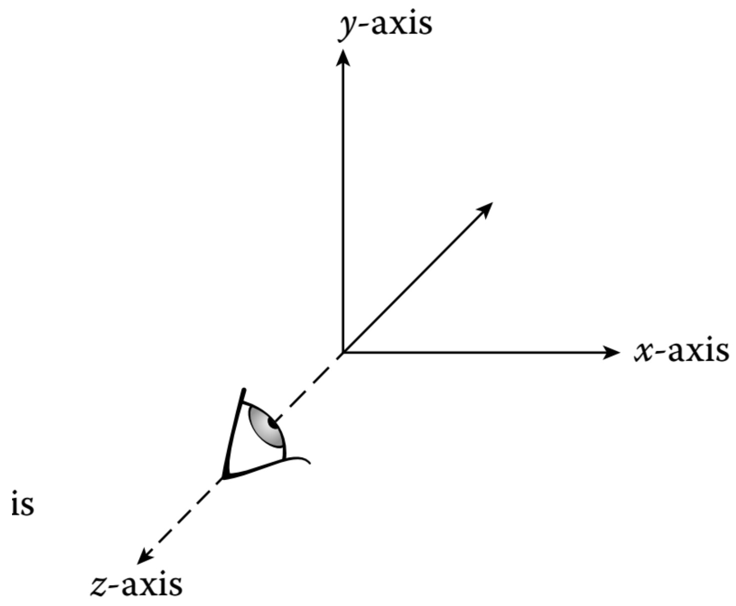
This is a left-handed coordinate system

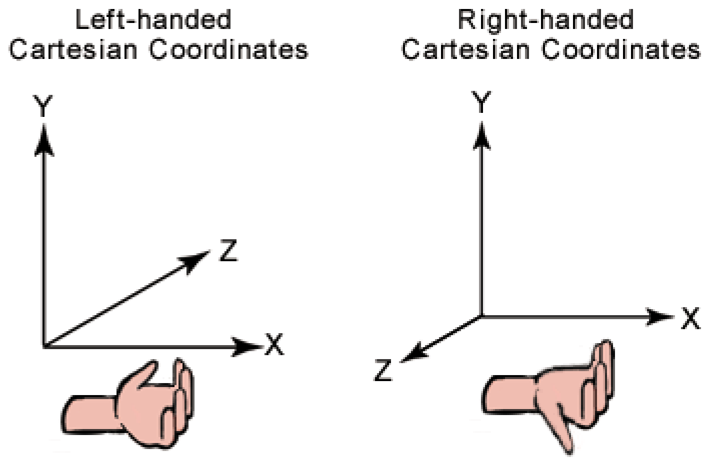
This is a little-known fact….
People often learn to use WebGL without ever learning this.



Clipspace

WebGL Style View

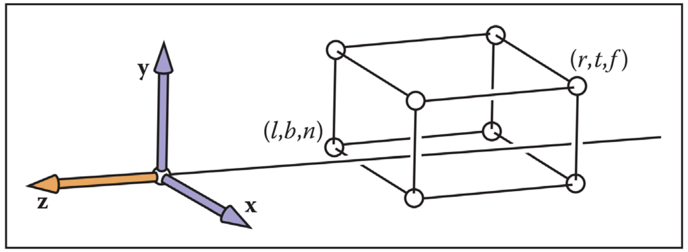


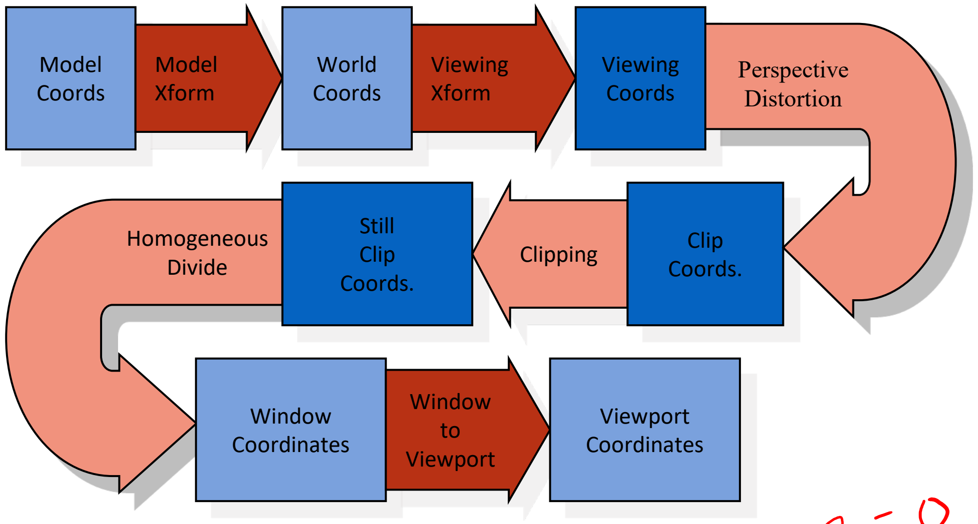


WebGL/OpenGL convention is to assume a right-handed world coordinate system

The ***ortho*** matrix is used to flip this coordinate system by scaling Z by -1
It then matches WebGL clip space

More WebGL Secrets



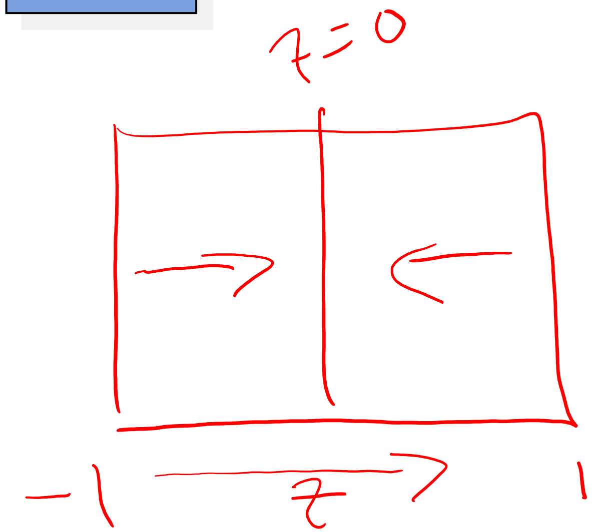


WebGL only performs an orthographic projection

- Everything is projected to the z=0 plane in the normalized view volume
- **But you can distort your geometry to achieve a perspective projection**

The projection occurs when the geometry is in clip space

- Even then, depth information is kept around to do hidden surface removal
- Depth information means transformed z coordinates



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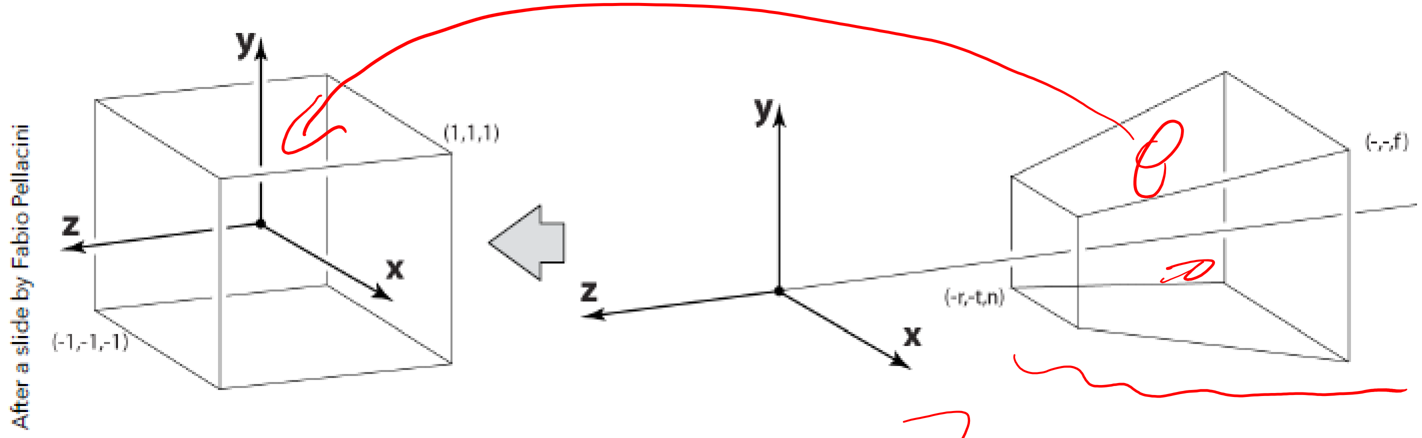
Why Projection Matrices?



- After the view transformation the situation is:
  - The eye is at (0,0,0)
  - The eye is looking down the –Z axis (in WebGL)

- We define a view volume in view coordinates
  - This determines what will be visible when we render
- A projection matrix maps our view volume into the canonical view volume

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Ortho Projection Matrix (Not Orthographic!)

- Classic Orthographic Projection matrix simply zeros the z- coordinate

$$\begin{bmatrix} & & & \\ & \text{W2V} & & \\ & & & \end{bmatrix}\begin{bmatrix} 1 & & & \\ & 1 & & \\ & & 0 & \\ & & & 1 \end{bmatrix}\begin{bmatrix} & & & \\ & \text{View} & & \\ & & & \end{bmatrix}\begin{bmatrix} & & & \\ & \text{Model} & & \\ & & & \end{bmatrix}$$

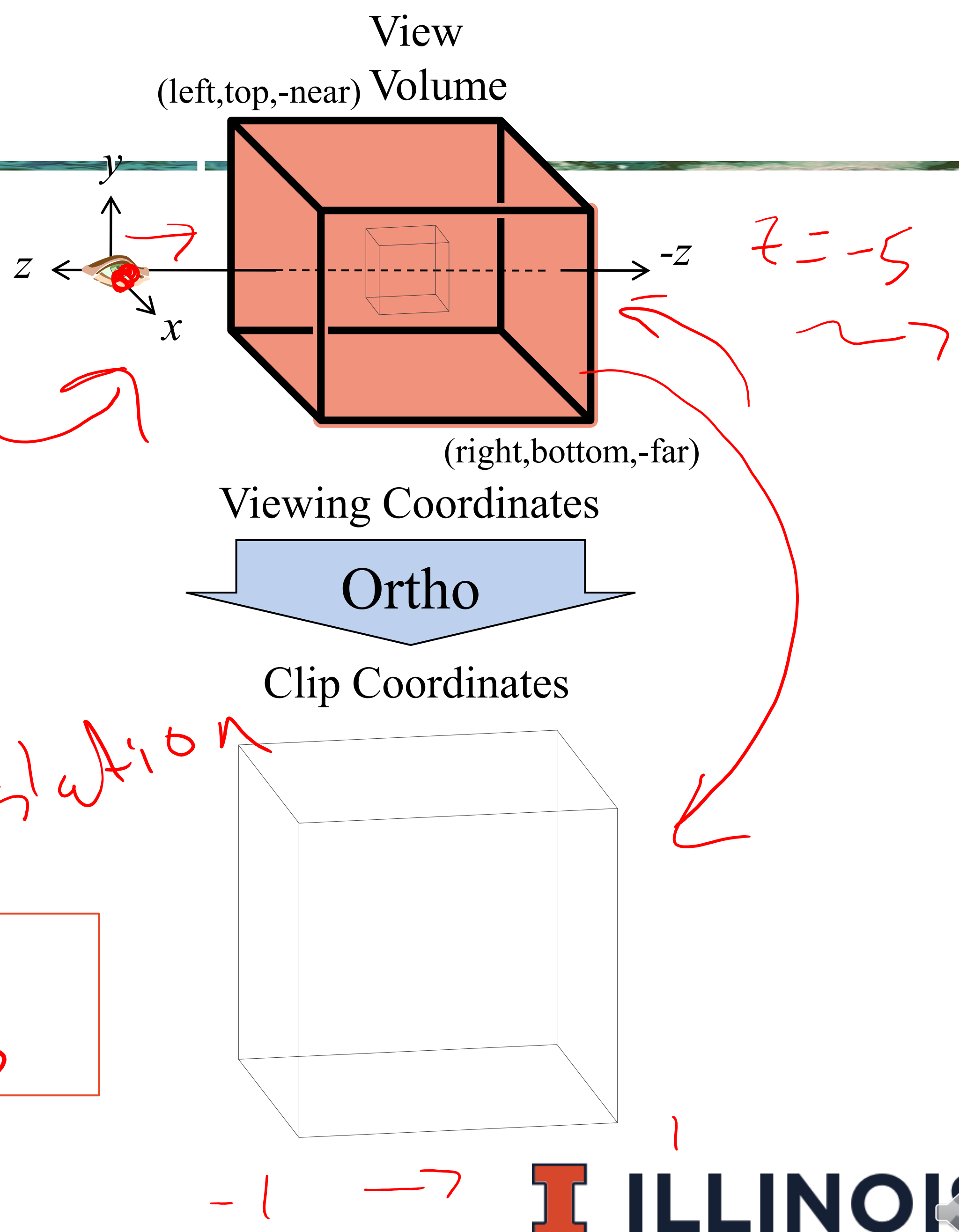
- mat4.ortho(out,left,right,bottom,top,near,far)

scale

Translation

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

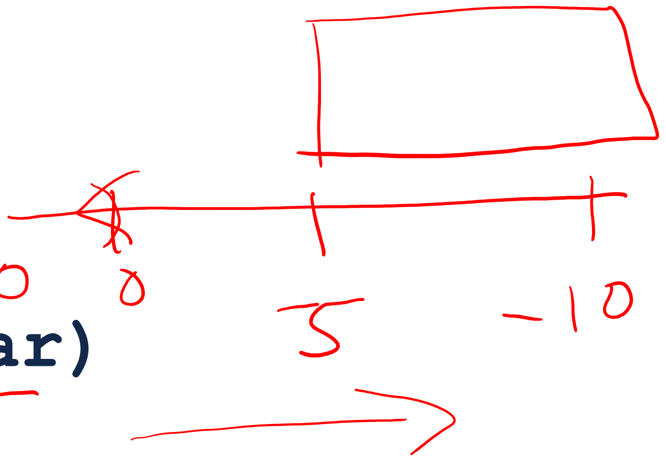
Does the ortho matrix perform a projection? NO



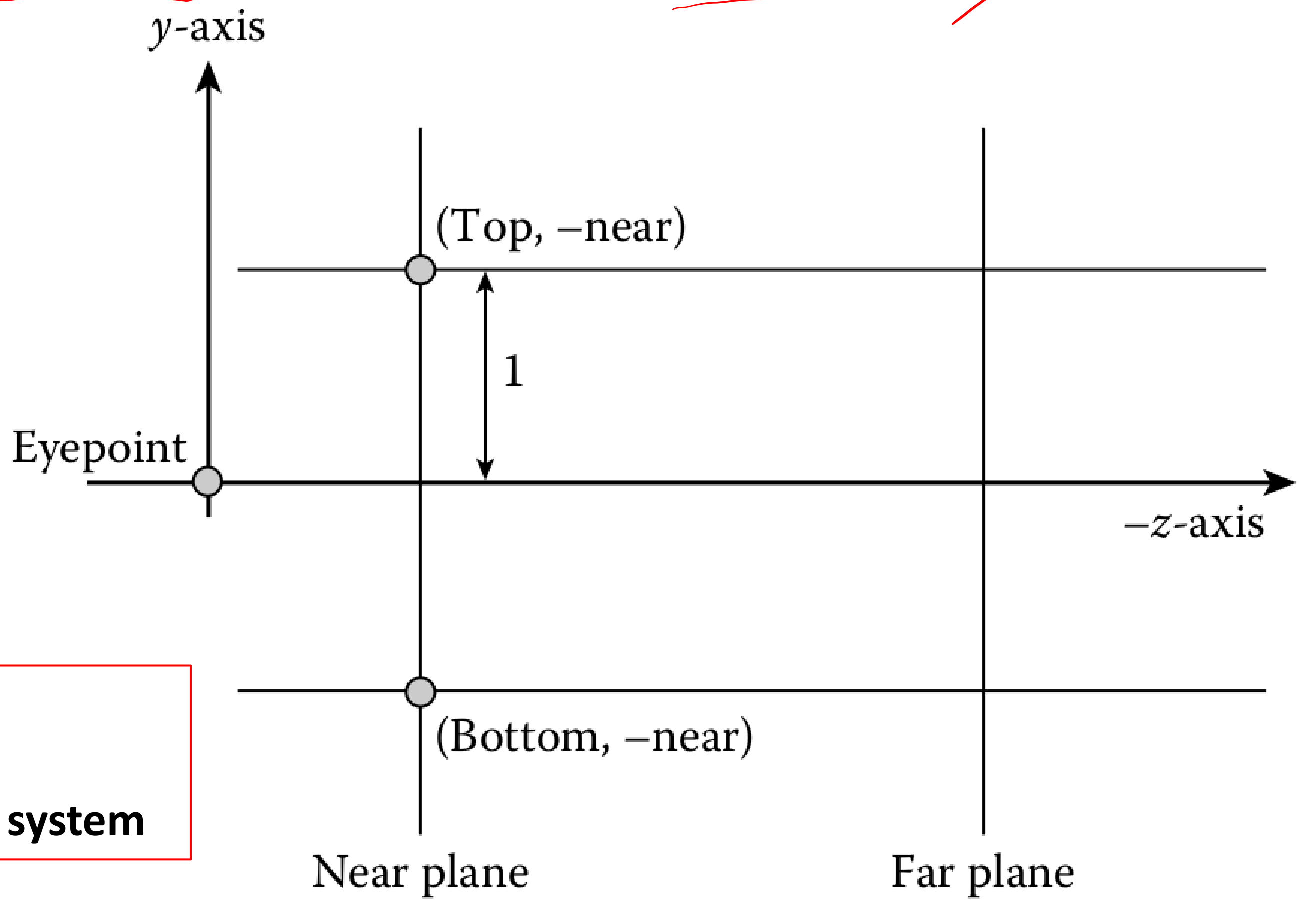
GLMatrix ortho matrix

-10 10 -5 10 5 10

`ortho(left,right,bottom,top,near,far)`



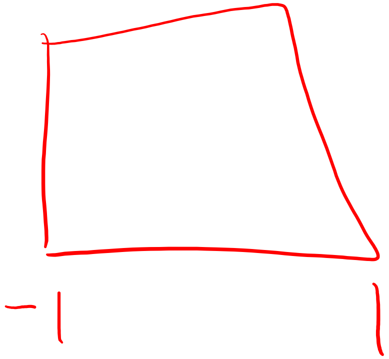
- near and far **are distances down the –z axis from origin**
- l,r,b,t are coordinates of the bounding planes
- what does the matrix do?



Establishes a view volume in view coordinate system

Assumes viewer at origin, looking down –z, right-handed system

GLMatrix ortho matrix




```
ortho(left,right,bottom,top,near,far)
```

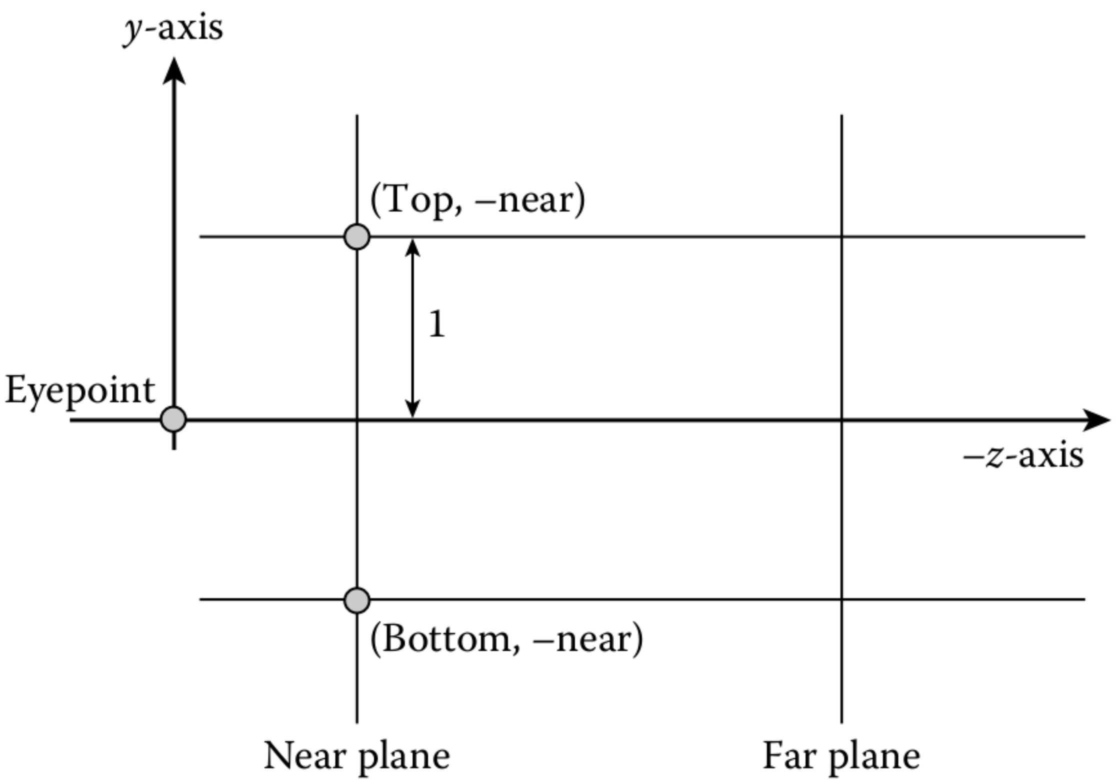
Imagine the eye is at (0,0,0)
We look down the −z axis

The view volume is:
[left, right] =[-1, 1]
[bottom, top]=[-1, 1]

near =-1 → z = 1

far =1 → z = -1

What does the matrix look like?



GLMatrix ortho matrix

```
ortho(left,right,bottom,top,near,far)
```

Imagine the eye is at (0,0,0)
We look down the −z axis

The view volume is:
[left, right] =[-1, 1]
[bottom, top]=[-1, 1]

near =-1

far =1

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

① define view volume
② convert RHS → LHS