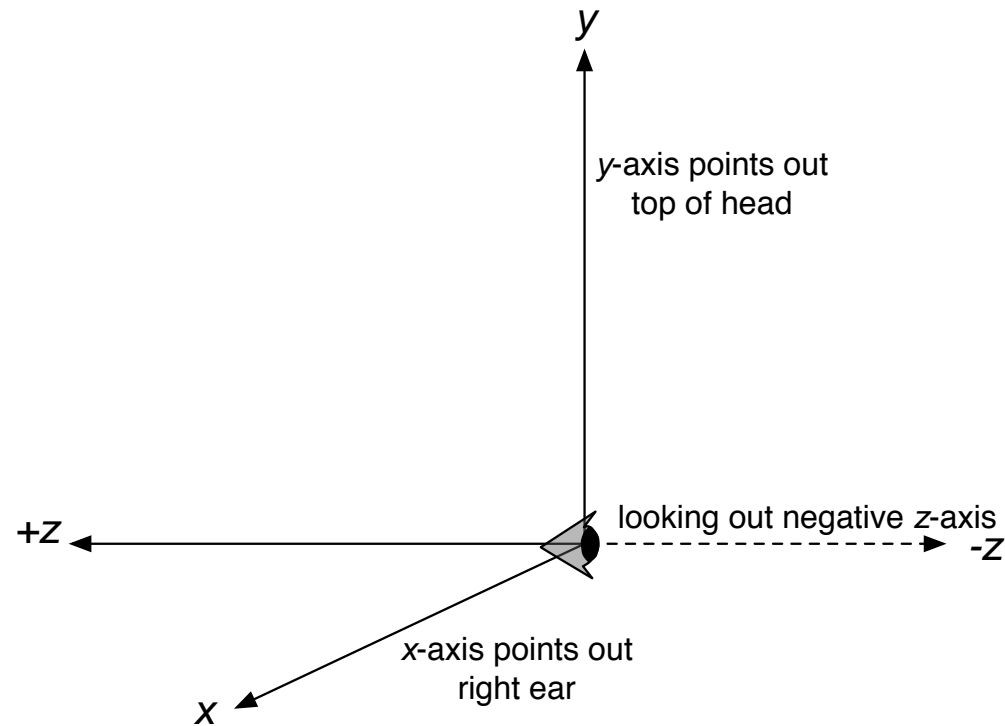
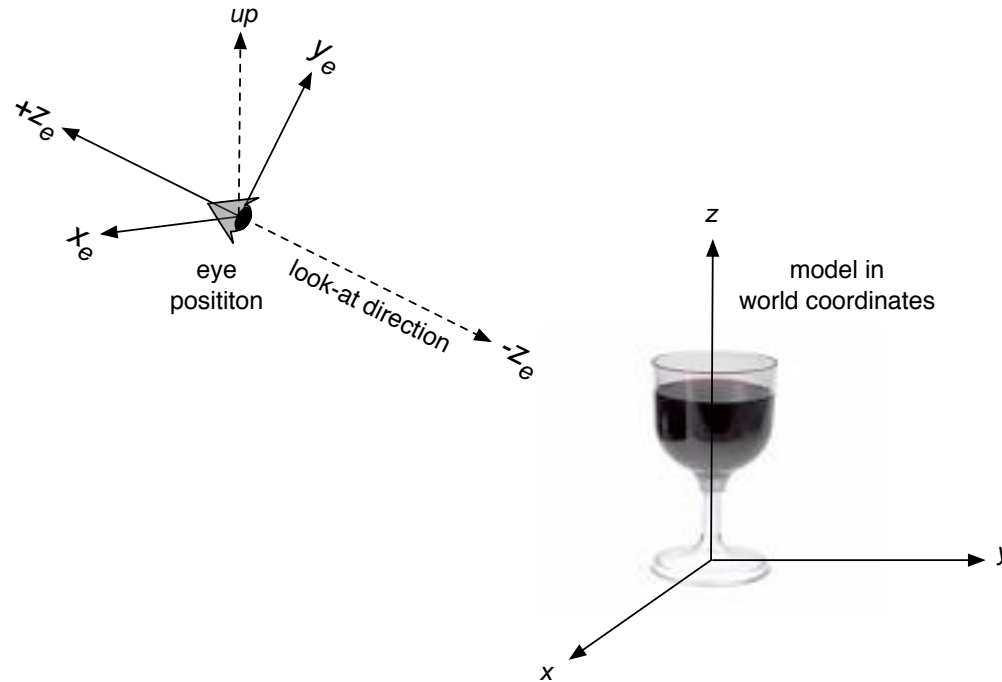


## Eye (or Camera) Coordinate System

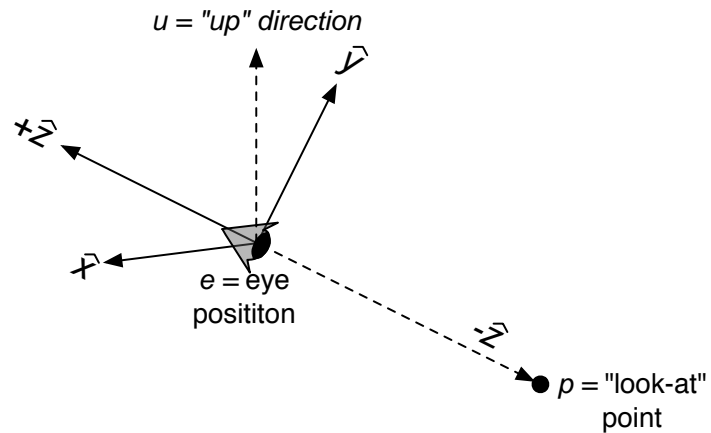


## Eye Coordinates vs World Coordinates



The *view matrix*  $V$  transforms objects in the scene from world coordinates to eye (camera) coordinates.

# Look-at Transformation Parameters



Orthogonal vectors  $(\hat{x}, \hat{y}, \hat{z})$  from **up-direction**  $u$ , **eye position**  $e$ , and **"look-at" point**  $p$  :

$$\begin{aligned} z &= e - p \\ \hat{z} &= \frac{z}{\|z\|} \\ x &= u \times z \\ \hat{x} &= \frac{x}{\|x\|} \\ \hat{y} &= \hat{z} \times \hat{x} \end{aligned}$$

## View Matrix from “Look-At” Parameters

$e$  = eye (camera) position

$p$  = look-at point

$u$  = up-direction

$$z = e - p$$

$$\hat{z} = z / \|z\|$$

$$x = u \times z$$

$$\hat{x} = x / \|x\|$$

$$\hat{y} = \hat{z} \times \hat{x}$$

$$V = \underbrace{\begin{bmatrix} \hat{x}_x & \hat{x}_y & \hat{x}_z & 0 \\ \hat{y}_x & \hat{y}_y & \hat{y}_z & 0 \\ -\hat{z}_x & -\hat{z}_y & -\hat{z}_z & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}}_{\text{rotate onto } -z} \underbrace{\begin{bmatrix} 1 & 0 & 0 & -e_x \\ 0 & 1 & 0 & -e_y \\ 0 & 0 & 1 & -e_z \\ 0 & 0 & 0 & 1 \end{bmatrix}}_{\text{translate eye}}$$