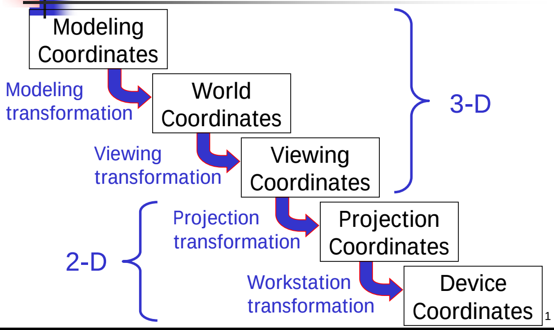
3-D Viewing Process



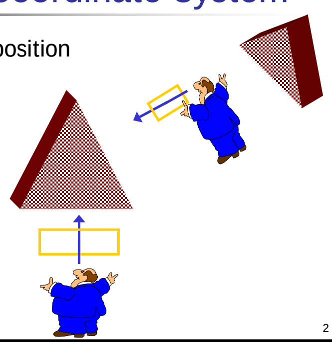
1

Viewing Coordinate System

Identify viewer position relative to scene

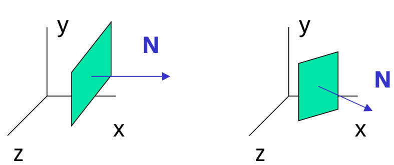
Viewer “looks through” a window

Must specify position and view direction



2

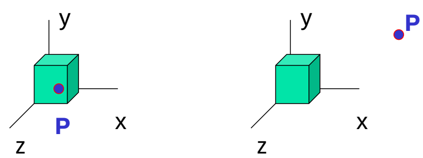
View Plane



View plane defined by normal vector (**N**)

3

View Reference Point

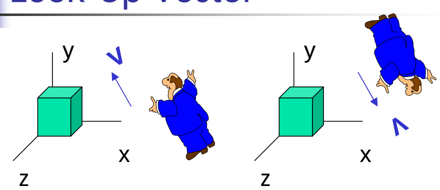


Reference point (**P**) can be:

- a point in the scene we are looking at
- a vantage point from which we are looking

4

Look-Up Vector



View-plane normal vector and reference point are not enough

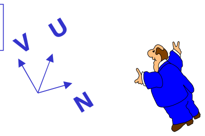
We also need to specify orientation of view(er)

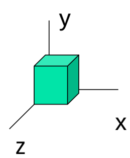
View-up vector (**V**) must be normal to **N** (adjust?)

5

Viewing Coordinates (uvn)

UVN is a right hand system.
What if we use –N?





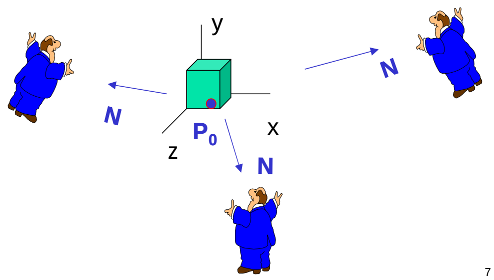
Viewing coordinate system based on vectors **U,V,N**

Corresponds to (x_v, y_v, z_v) coordinates

6

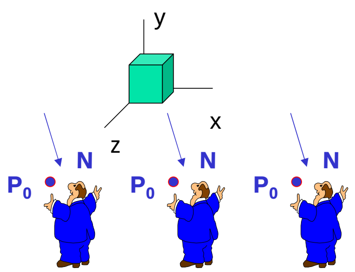
Changing Views (1)

Maintain $\mathbf{P_0}$, change **N**



Changing Views (2)

Maintain **N**, change $\mathbf{P_0}$



Transforming World to View

- Translate
  - View reference point
    - Origin of viewing coordinates
  - To world coordinate origin
- Then rotate
  - Align x_v,y_v,z_v with x_w,y_w,z_w

Translation

$$\mathbf{P_0} = (x_0, y_0, z_0)$$

View reference point

$$\mathbf{T} = \begin{bmatrix} 1 & 0 & 0 & -x_0 \\ 0 & 1 & 0 & -y_0 \\ 0 & 0 & 1 & -z_0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Translation transformation

10

Rotation (1)

$$\mathbf{R} = \mathbf{R_z} \cdot \mathbf{R_y} \cdot \mathbf{R_x}$$

Composite rotation

Unit vectors indicating view coordinate system

normal $\mathbf{n} = \frac{\mathbf{N}}{|\mathbf{N}|} = (n_1, n_2, n_3)$

right $\mathbf{u} = \frac{\mathbf{V} \times \mathbf{N}}{|\mathbf{V} \times \mathbf{N}|} = (u_1, u_2, u_3)$

up $\mathbf{v} = \mathbf{n} \times \mathbf{u} = (v_1, v_2, v_3)$

11

Rotation (2)

x = (1,0,0) becomes u

Form composite rotation transformation from unit vector components

$$\mathbf{R} = \begin{bmatrix} u_1 & u_2 & u_3 & 0 \\ v_1 & v_2 & v_3 & 0 \\ n_1 & n_2 & n_3 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

12

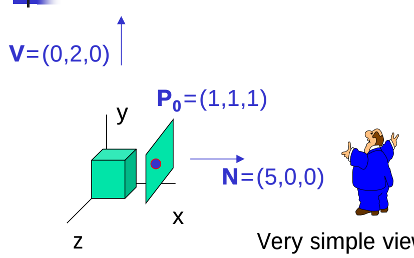
World-to-View Transformation

$$\mathbf{T} = \begin{bmatrix} 1 & 0 & 0 & -x_0 \\ 0 & 1 & 0 & -y_0 \\ 0 & 0 & 1 & -z_0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \qquad \mathbf{R} = \begin{bmatrix} u_1 & u_2 & u_3 & 0 \\ v_1 & v_2 & v_3 & 0 \\ n_1 & n_2 & n_3 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\mathbf{M}_{WC,VC} = \mathbf{R} \cdot \mathbf{T} = \begin{bmatrix} u_1 & u_2 & u_3 & 0 \\ v_1 & v_2 & v_3 & 0 \\ n_1 & n_2 & n_3 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} 1 & 0 & 0 & -x_0 \\ 0 & 1 & 0 & -y_0 \\ 0 & 0 & 1 & -z_0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

13

World-to-View Example (1)



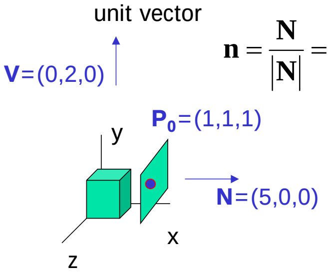
Very simple viewing transformation

14

World-to-View Example (2)

Compute view-normal unit vector

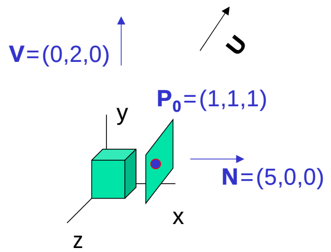
$$\mathbf{n} = \frac{\mathbf{N}}{|\mathbf{N}|} = \frac{(5,0,0)}{5} = (1,0,0)$$



15

World-to-View Example (3)

Compute **u** unit vector

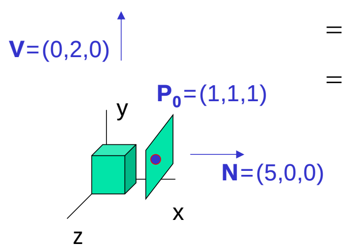


$$\mathbf{u} = \frac{\mathbf{V}\times\mathbf{N}}{|\mathbf{V}\times\mathbf{N}|} = \frac{(0,2,0)\times(5,0,0)}{|(0,2,0)\times(5,0,0)|} = \frac{(0,0,-10)}{10} = (0,0,-1)$$

16

World-to-View Example (4)

Compute view-up unit vector

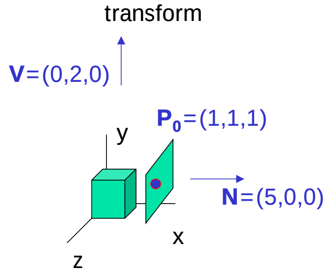


$$\mathbf{v} = \mathbf{n}\times\mathbf{u} = (1,0,0)\times(0,0,-1) = (0,1,0)$$

17

World-to-View Example (5)

Compute rotation transform

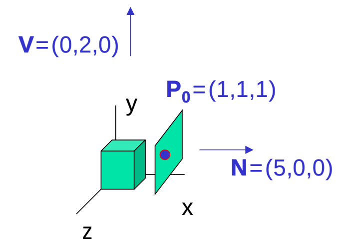


$$\mathbf{R} = \begin{bmatrix} u_1 & u_2 & u_3 & 0 \\ v_1 & v_2 & v_3 & 0 \\ n_1 & n_2 & n_3 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} 0 & 0 & -1 & 0 \\ 0 & 1 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

18

World-to-View Example (6)

Compute translation transform

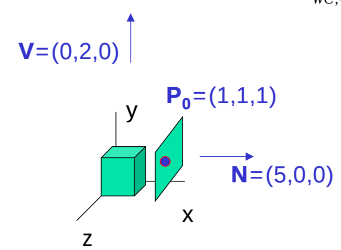


$$\mathbf{T} = \begin{bmatrix} 1 & 0 & 0 & -x_0 \\ 0 & 1 & 0 & -y_0 \\ 0 & 0 & 1 & -z_0 \\ 0 & 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & -1 \\ 0 & 1 & 0 & -1 \\ 0 & 0 & 1 & -1 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

19

World-to-View Example (7)

Compute world-to-view transform

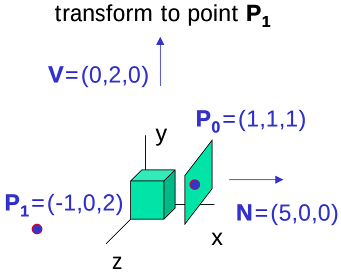


$$\mathbf{M}_{WC,VC} = \mathbf{R} \cdot \mathbf{T} = \begin{bmatrix} 0 & 0 & -1 & 1 \\ 0 & 1 & 0 & -1 \\ 1 & 0 & 0 & -1 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

20

World-to-View Example (8)

Apply world-to-view transform to point $\mathbf{P_1}$



$$\mathbf{P}_1' = \mathbf{M}_{WC,VC} \cdot \mathbf{P}_1 = \begin{bmatrix} 0 & 0 & -1 & 1 \\ 0 & 1 & 0 & -1 \\ 1 & 0 & 0 & -1 \\ 0 & 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} -1 \\ 0 \\ 2 \\ 1 \end{bmatrix} = \begin{bmatrix} ? \\ ? \\ ? \\ ? \end{bmatrix} = \begin{bmatrix} -1 \\ -1 \\ -2 \\ 1 \end{bmatrix}$$

21