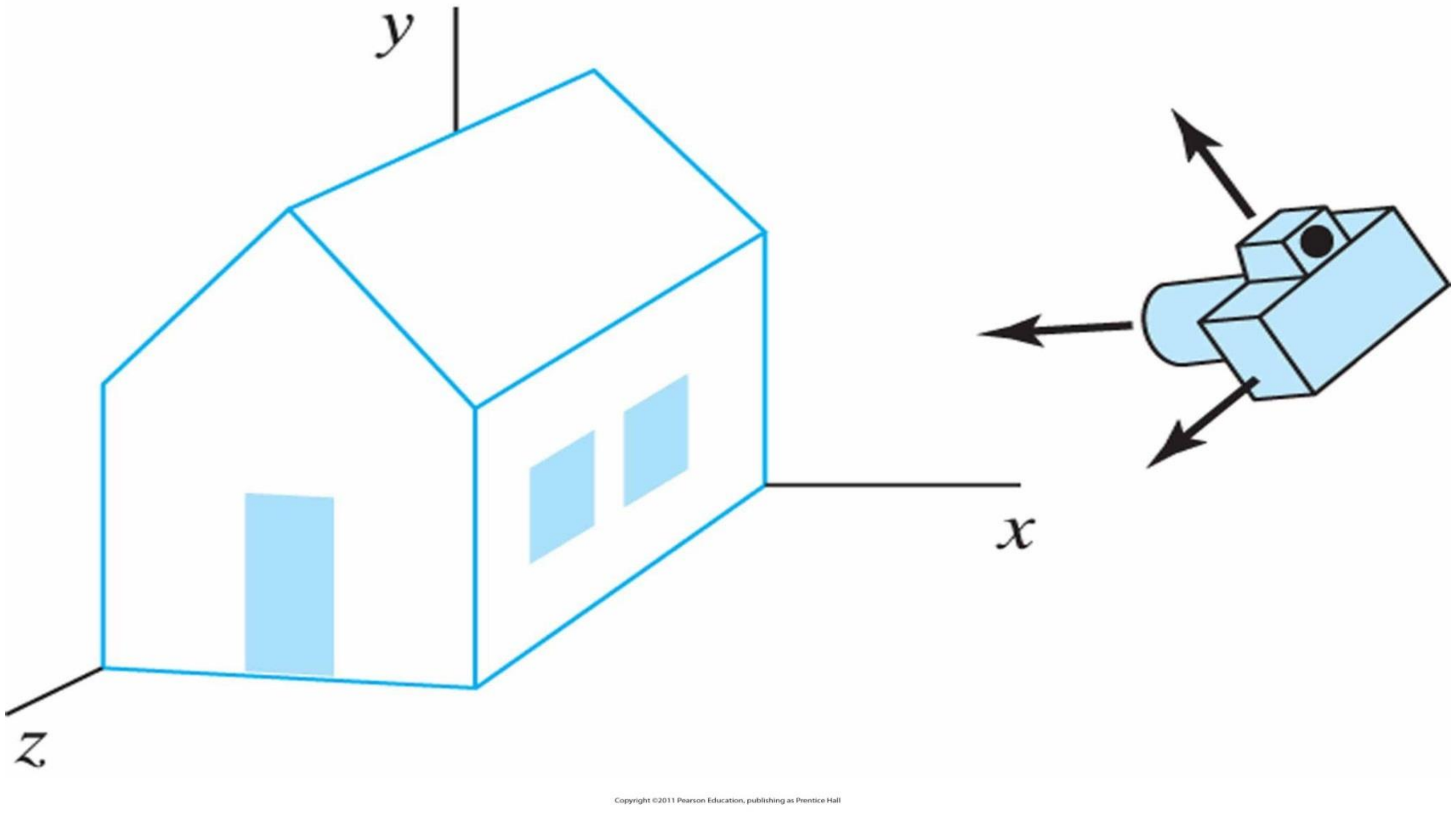
3D Viewing

THAPAR INSTITUTE
OF ENGINEERING & TECHNOLOGY
(Deemed to be University)

3D Viewing

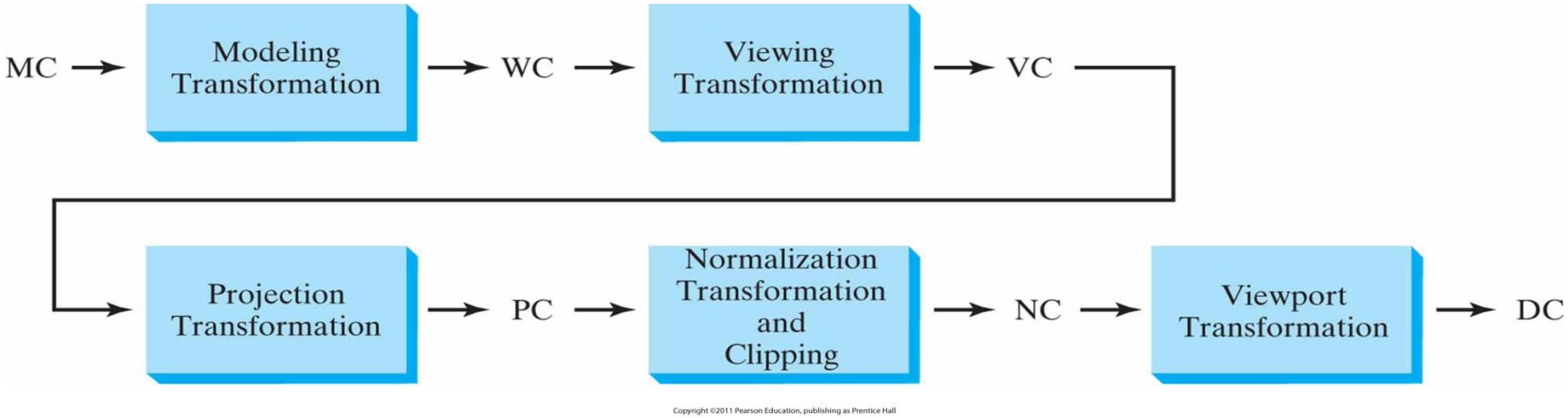
- Procedures for displaying views of a three-dimensional scene on an output device involve many aspects:
  - Generate a 3D scene with objects generally defined with a set of surfaces forming a closed boundary around the object interior.
  - Generate interior of 3D objects, if needed.
  - Project object surfaces views onto the surface of a display device with 3D viewing pipeline.
  - Identification of visible parts.
  - Lighting effects and surface characteristics.

3D Viewing – Photographing

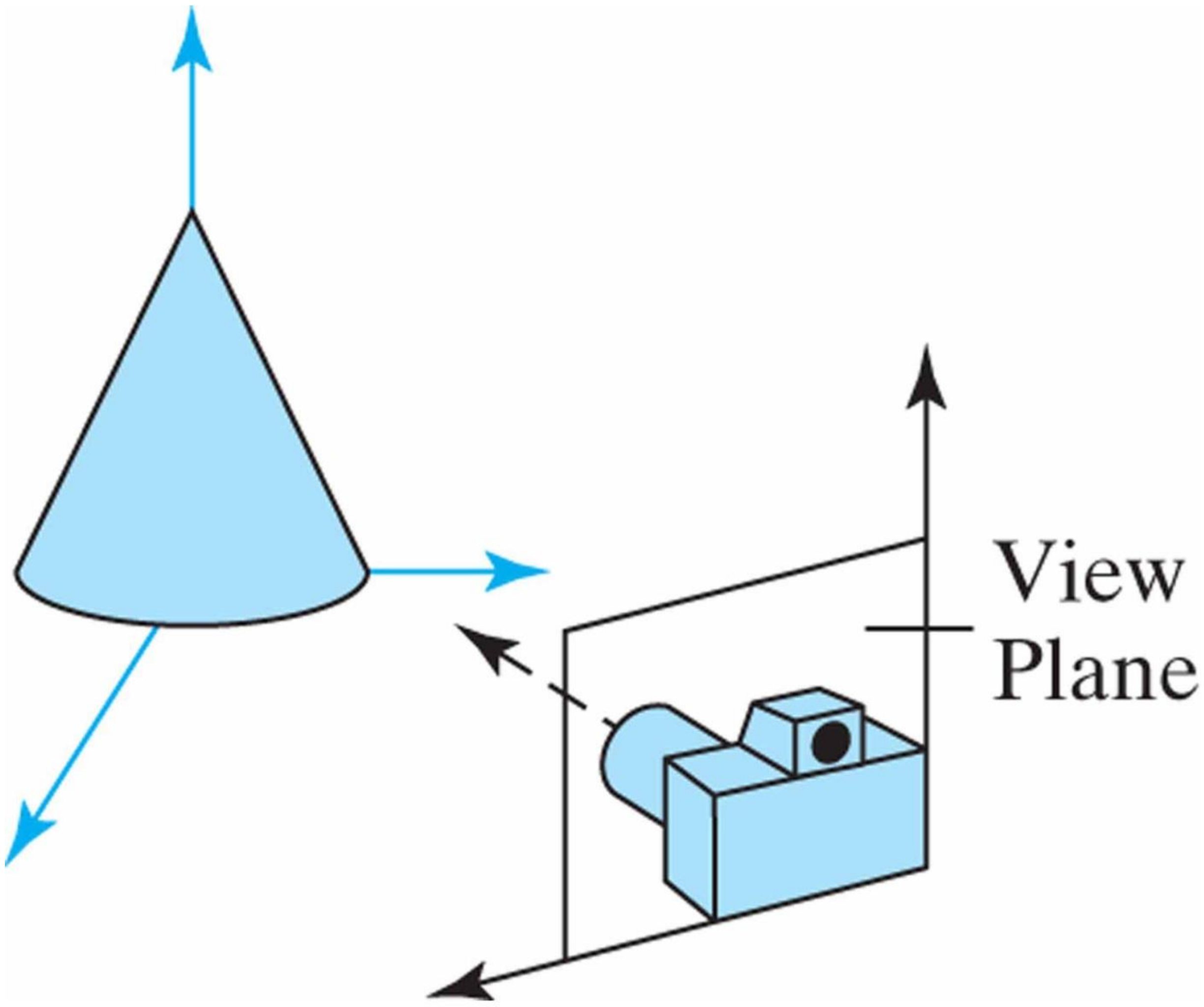


Photographing a scene involves selection of the camera position and orientation

3D Viewing Pipeline

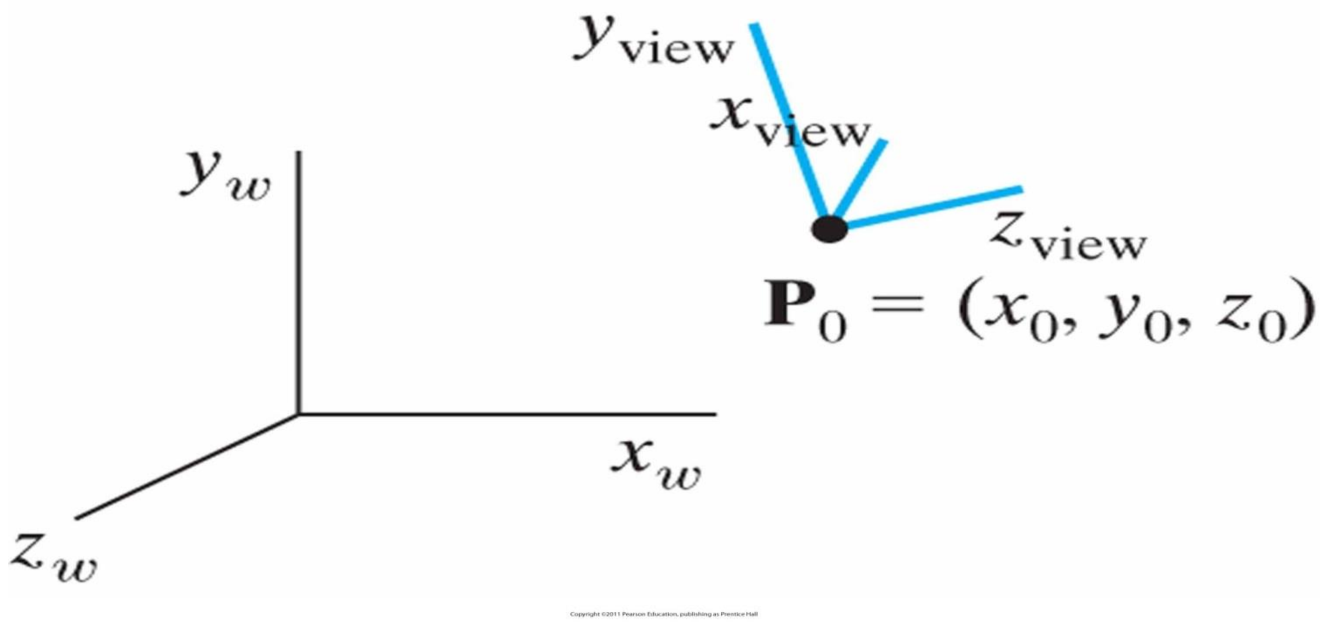


General three-dimensional transformation pipeline, from modeling coordinates (MC) to world coordinates (WC) to viewing coordinates (VC) to projection coordinates (PC) to normalized coordinates (NC) and, ultimately, to device coordinates (DC).

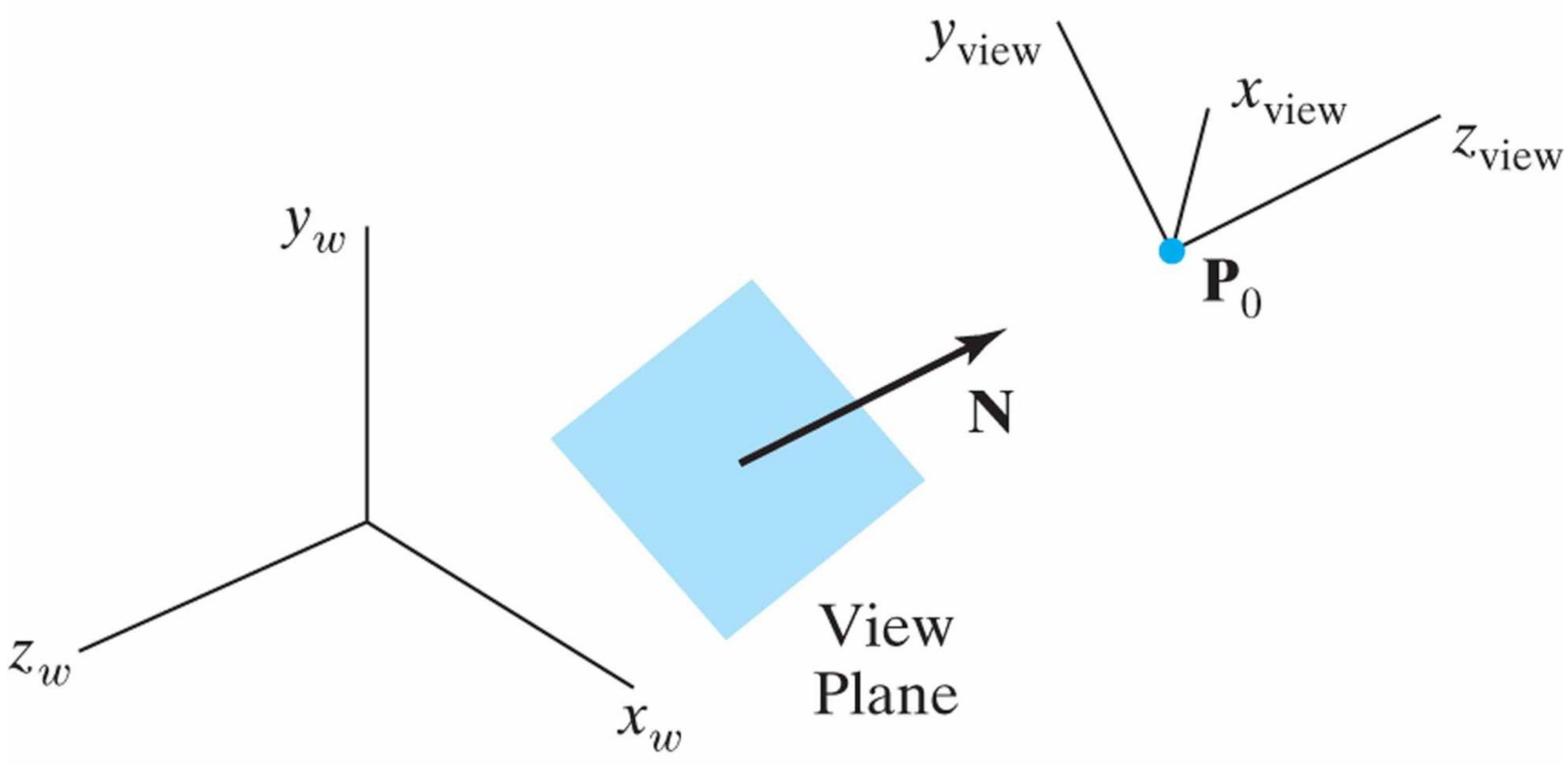


Coordinate reference for obtaining a selected view of a three-dimensional scene.

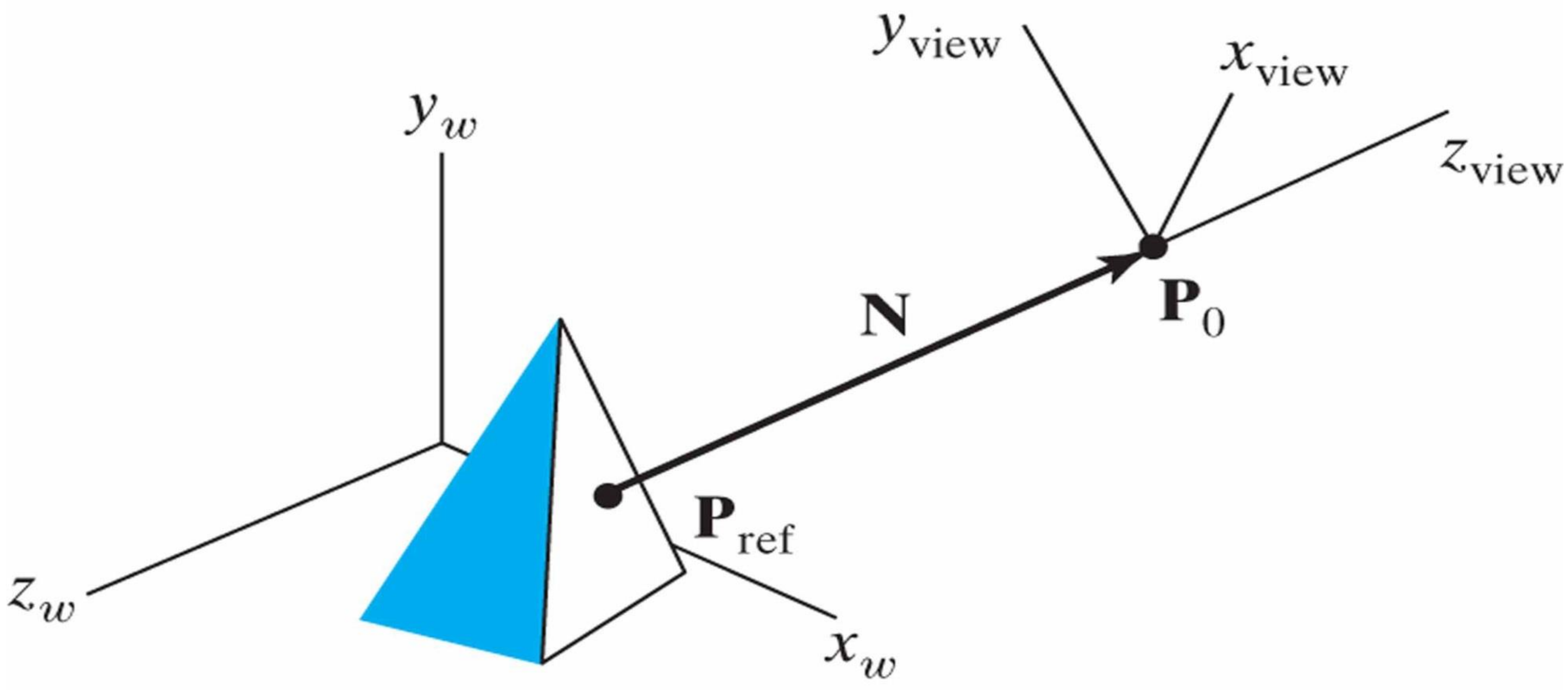
3D Viewing Coordinate Parameters: The View-Plane Normal Vector



A right-handed viewing-coordinate system, with axes x_{view}, y_{view}, and z_{view}, relative to a right-handed world-coordinate frame.

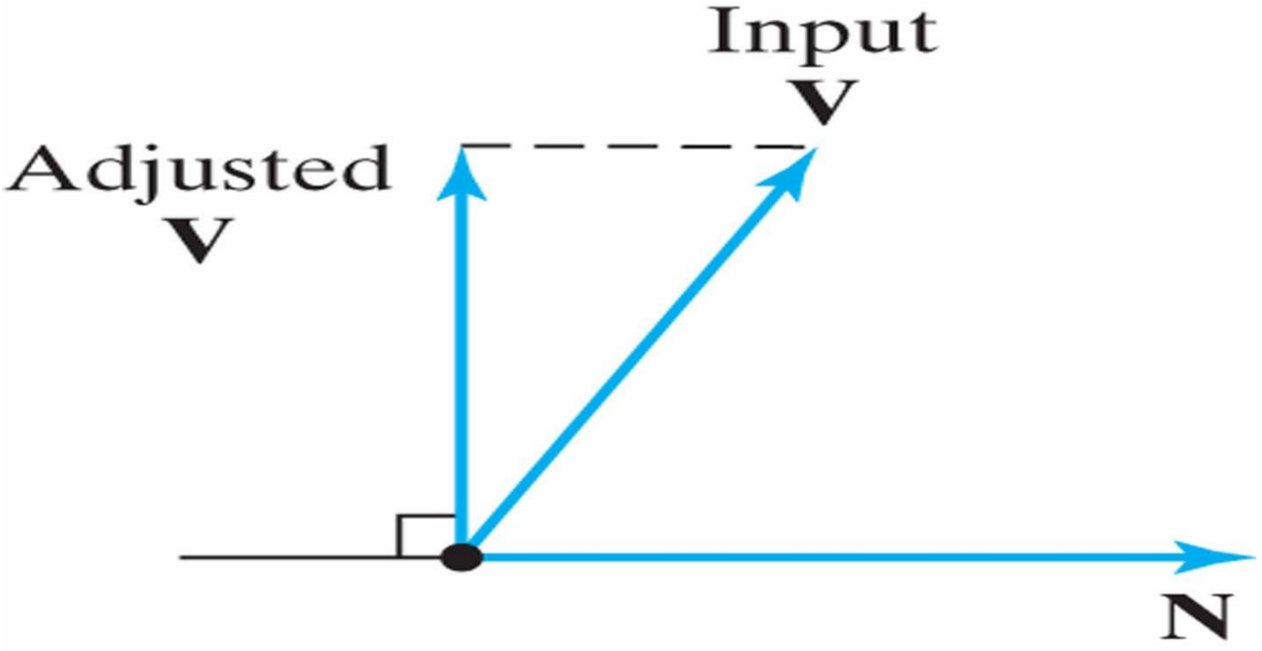


Orientation of the view plane and view-plane normal vector **N**.



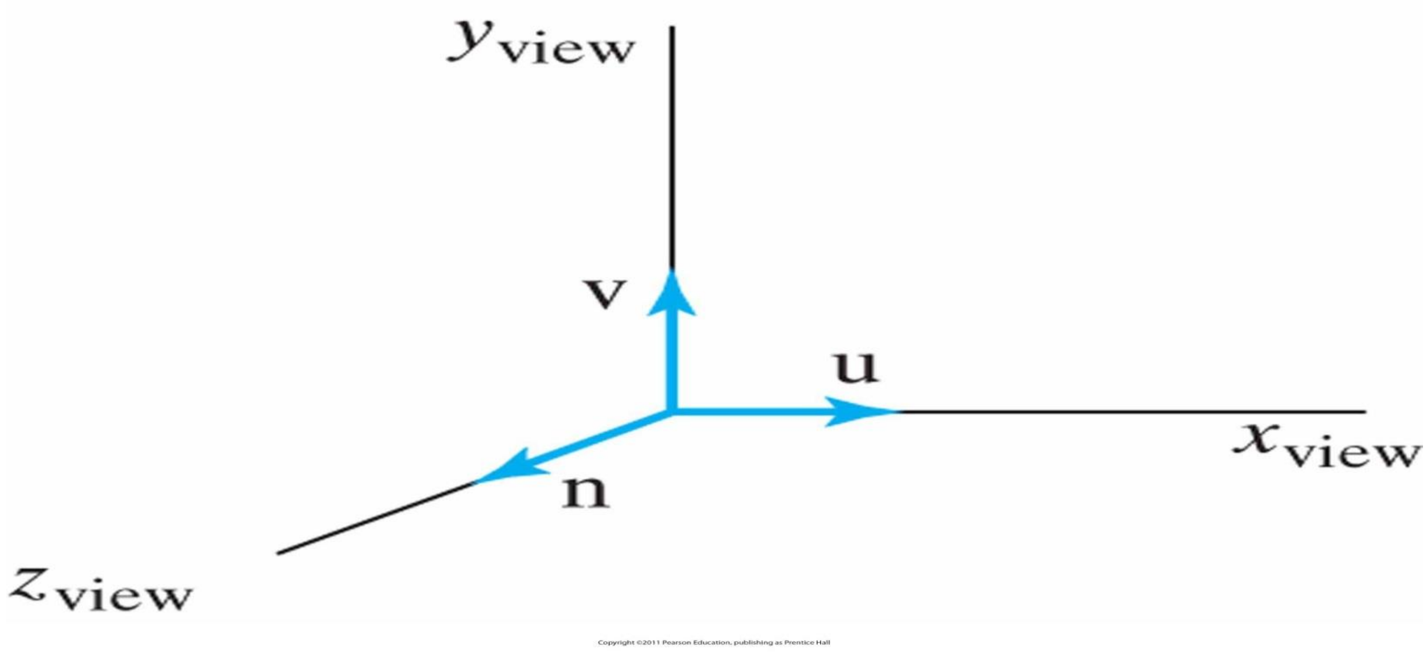
Specifying the view-plane normal vector **N** as the direction from a selected reference point $\mathbf{P}_{ref}$ to the viewing-coordinate origin $\mathbf{P}_0$.

3D Viewing Coordinate Parameters: The View-Up Vector

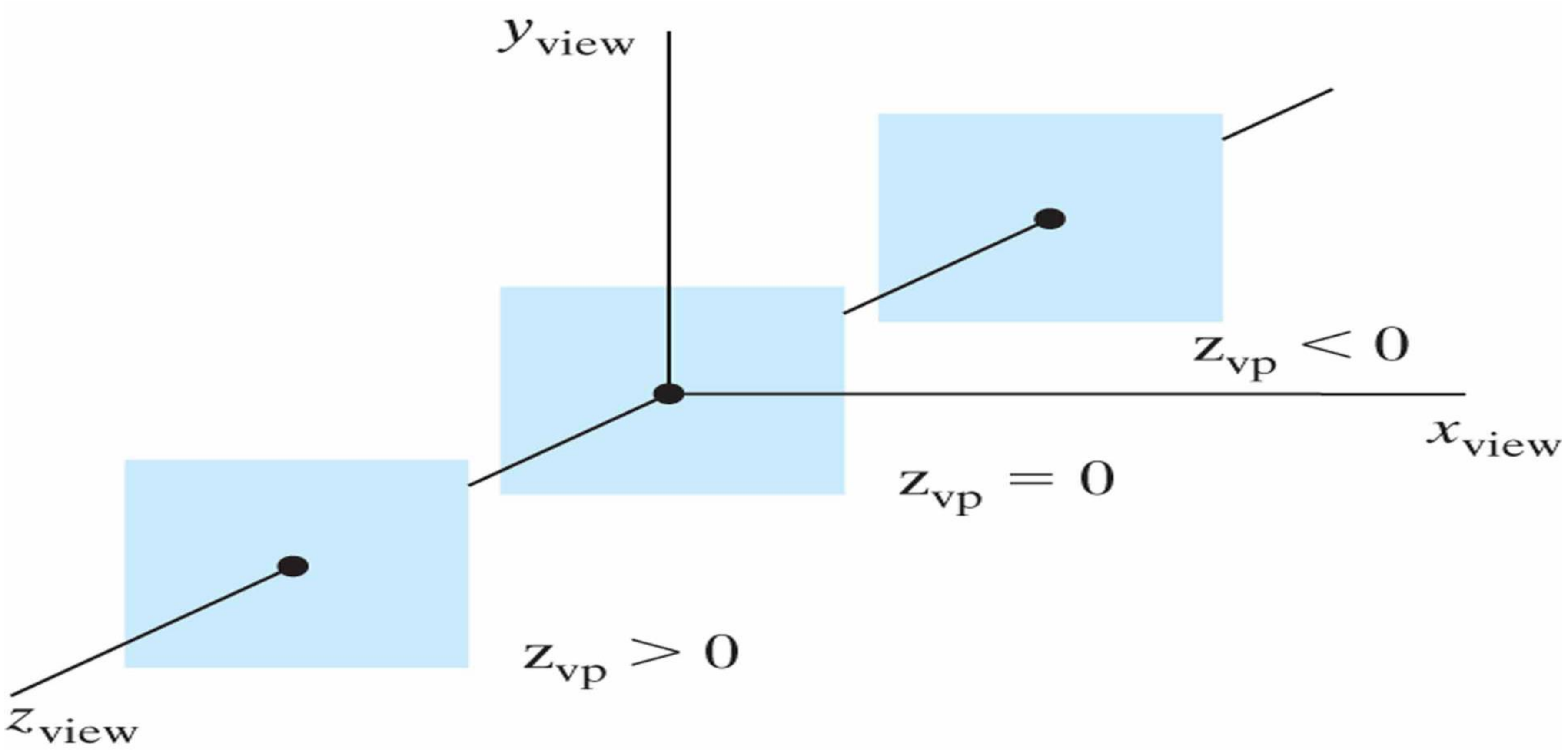


Adjusting the input direction of the view-up vector **V** to an orientation perpendicular to the view-plane normal vector **N**.

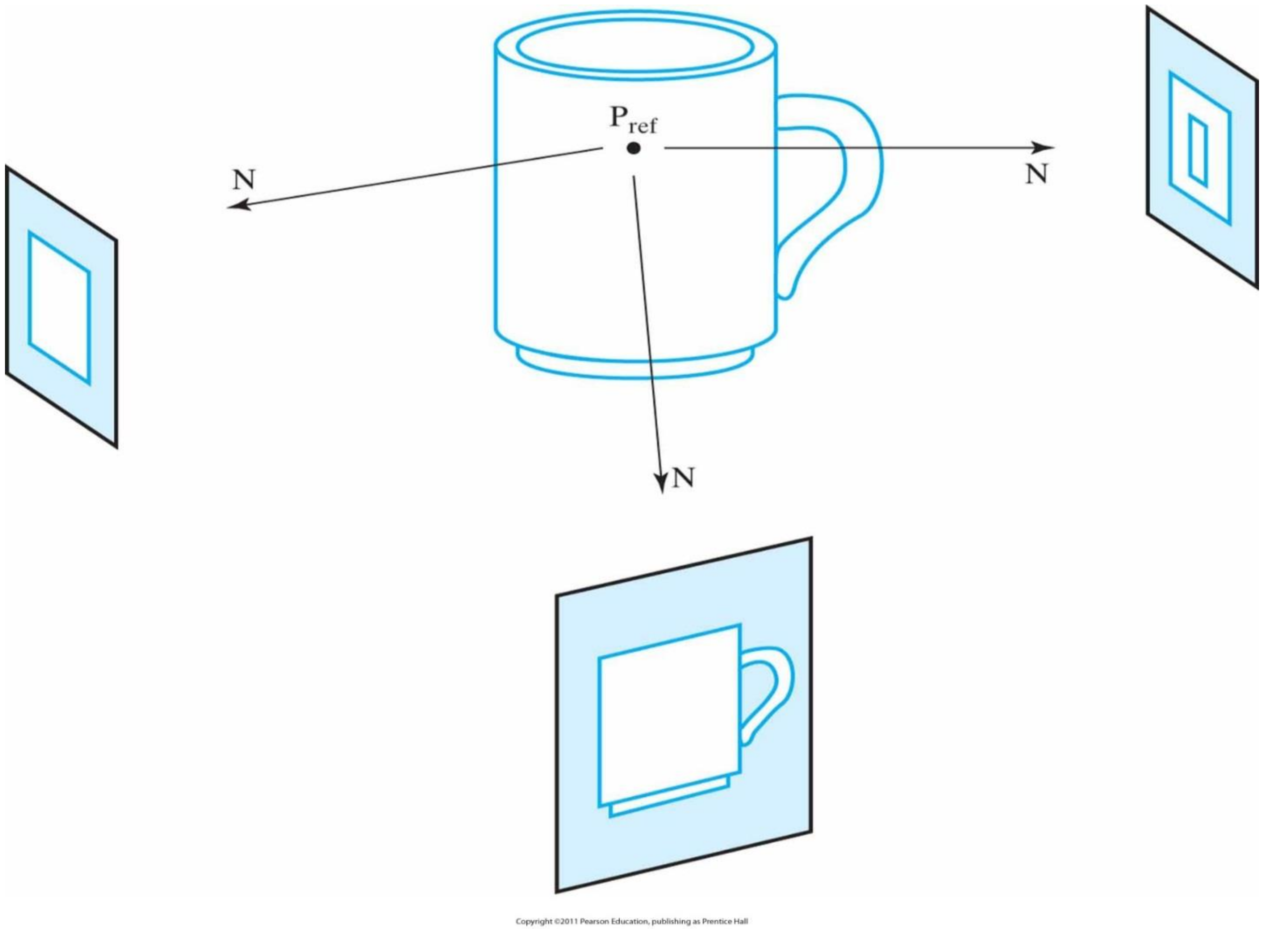
3D Viewing Coordinate Parameters: uvn Reference Frame



A right-handed viewing system defined with unit vectors **u, v**, and **n**.

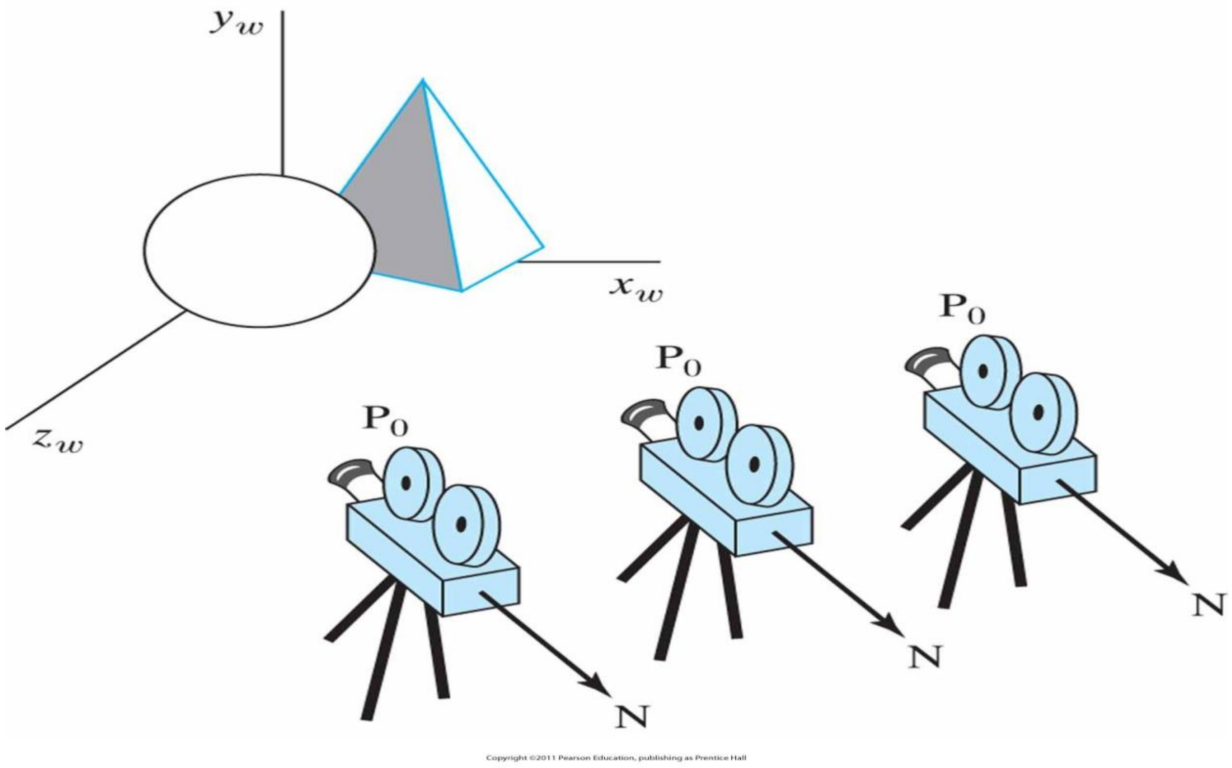


Three possible positions for the view plane along the z_{view} axis.



Viewing an object from different directions using a fixed reference point.

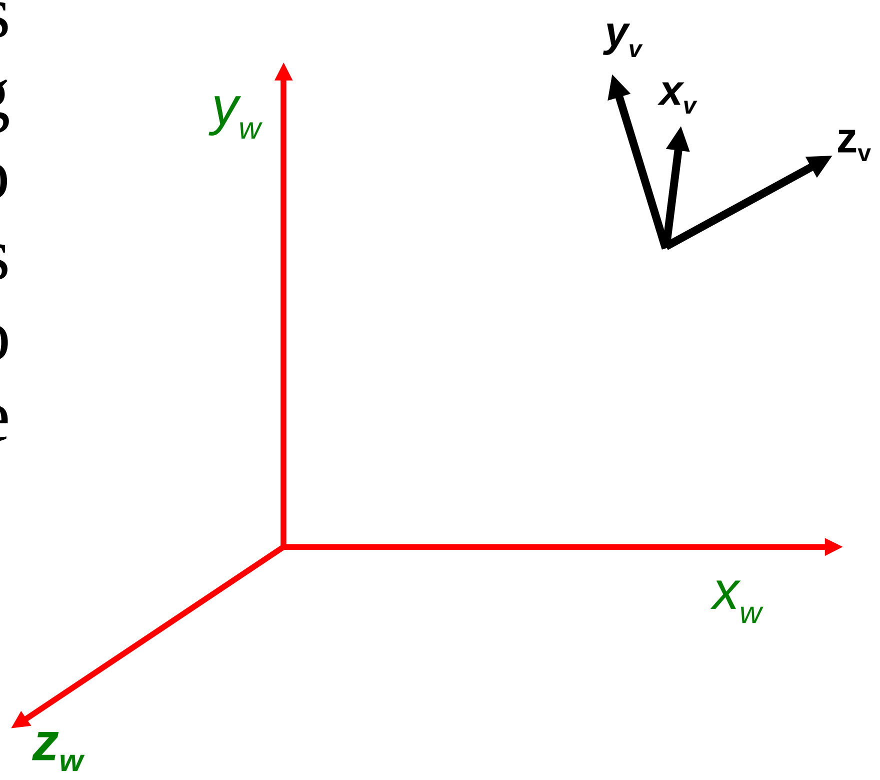
World to Viewing Coordinates



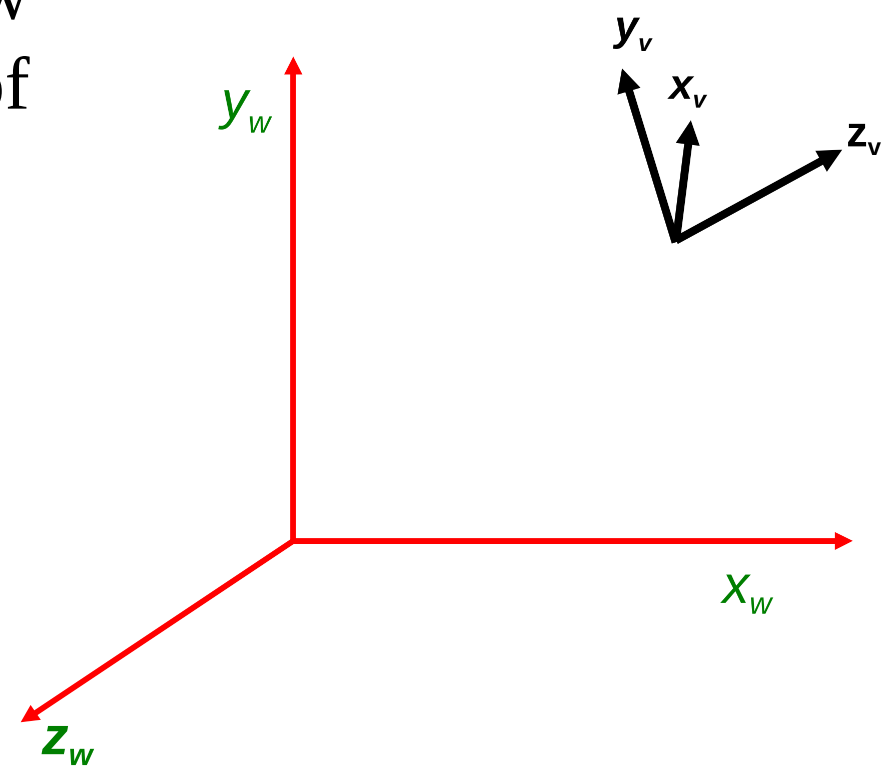
Panning across a scene by changing the viewing position, with a fixed direction for **N**.

Transformation From World To Viewing Coordinates

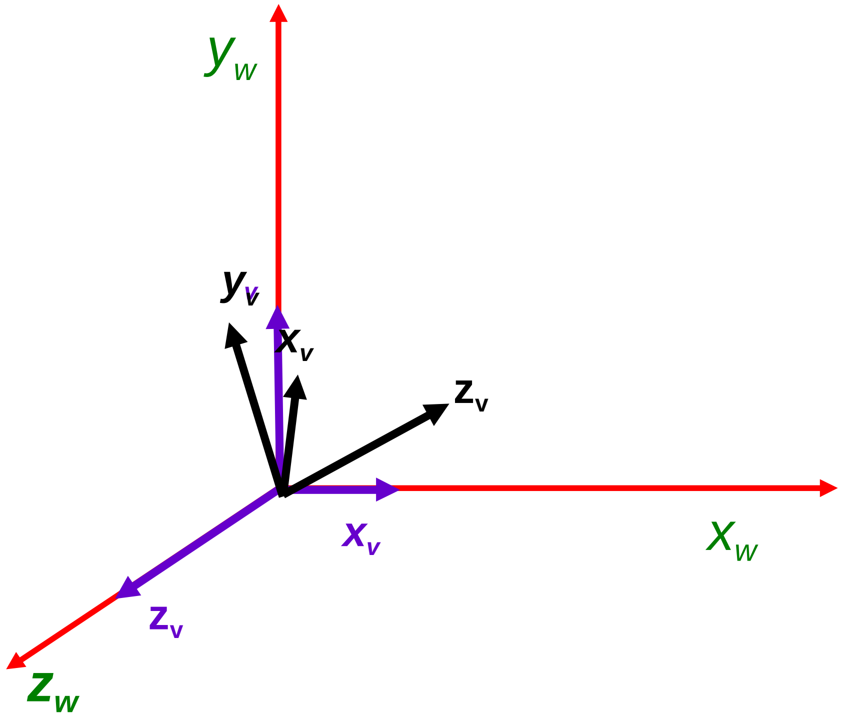
Conversion of object descriptions from world to viewing coordinates is equivalent to transformation that superimpoes the viewing reference frame onto the world frame using the translation and rotation.



First, we translate the view reference point to the origin of the world coordinate system



Second, we apply rotations to align the x_v, y_v and z_v axes with the world x_w, y_w and z_w axes, respectively.



If the view reference point is specified at word position (x_0, y_0, z_0), this point is translated to the world origin with the translation matrix **T.**

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

- The rotation sequence requires 3 coordinate-axis transformation depending on the direction of **N.**
- First we rotate around x_w-*axis* to bring z_v into the x_w -z_w plane.

$$\mathbf{R}_x = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & Cos\theta & -Sin\theta & 0 \\ 0 & Sin\theta & Cos\theta & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Then, we rotate around the world y_w axis to align the z_w and z_v *axes*.

$$\mathbf{R}_y = \begin{bmatrix} Cos\alpha & 0 & Sin\alpha & 0 \\ 0 & 1 & 0 & 0 \\ -Sin\alpha & 0 & Cos\alpha & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

The final rotation is about the world z_w axis to align the y_w and y_v *axes.*

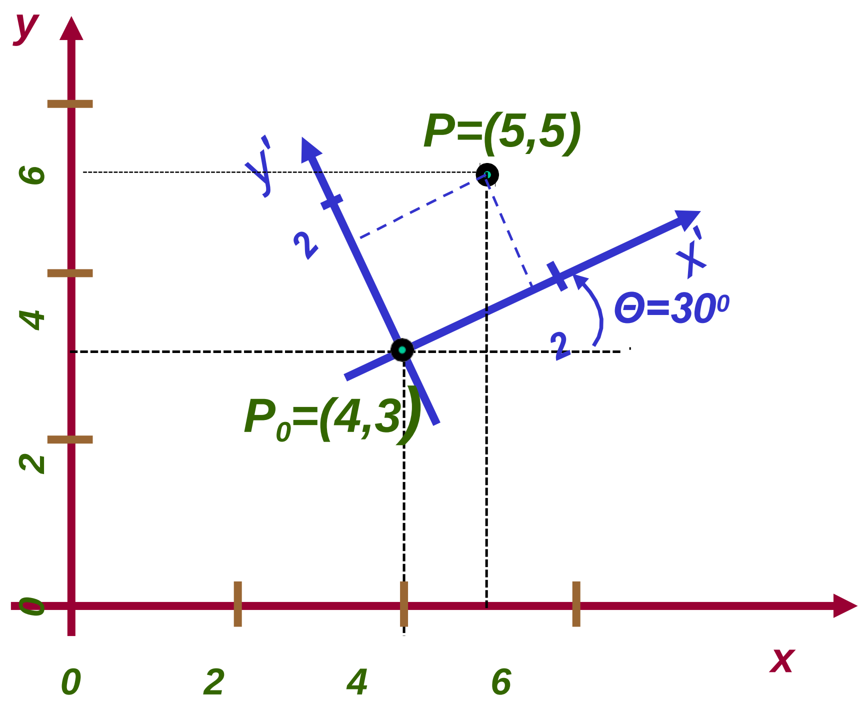
$$\mathbf{R}_z = \begin{bmatrix} Cos\beta & -Sin\beta & 0 & 0 \\ Sin\beta & Cos\beta & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

The complete transformation from world to viewing coordinate transformation matrix is obtaine as the matrix product

$$\mathbf{M}_{wc,vc} = \mathbf{R}_z \cdot \mathbf{R}_y \cdot \mathbf{R}_x \cdot \mathbf{T}$$

Transformation From World To Viewing Coordinates:

An Example For 2d System

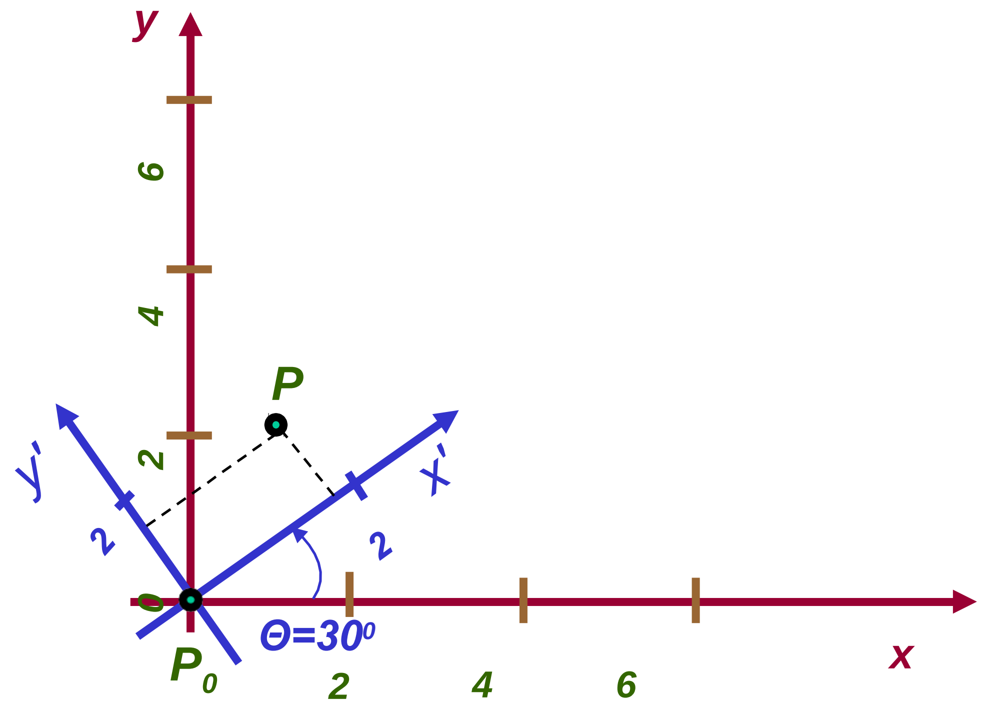


Transformation From World To Viewing Coordinates:

An Example For 2d System

Translation:

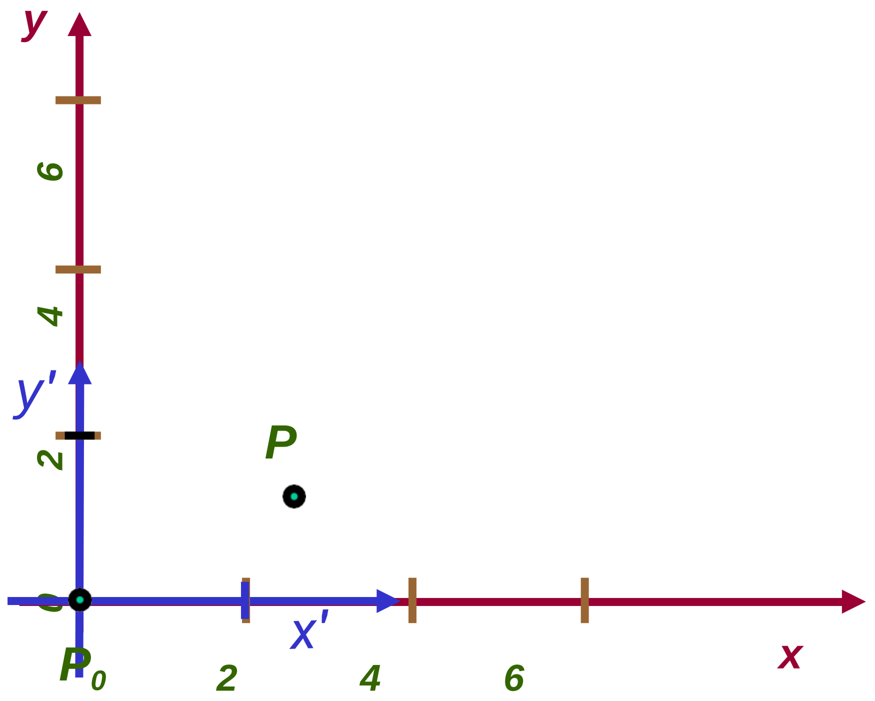
$$\mathbf{T} = \begin{bmatrix} 1 & 0 & -4 \\ 0 & 1 & -3 \\ 0 & 0 & 1 \end{bmatrix}$$



Transformation From World To Viewing Coordinates:
An Example For 2d System

Rotation

$$\mathbf{R} = \begin{bmatrix} 0.866 & 0.5 & 0 \\ -0.5 & 0.866 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$



Transformation From World To Viewing Coordinates: An Example For 2d System

New coordinates

$$\mathbf{M}_{wc.vc} = \begin{bmatrix} 0.866 & 0.5 & 0 \\ -0.5 & 0.866 & 0 \\ 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} 1 & 0 & -4 \\ 0 & 1 & -3 \\ 0 & 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} x' \\ y' \\ 1 \end{bmatrix} = \begin{bmatrix} 0.866 & 0.500 & -4.964 \\ -0.500 & 0.866 & -0.598 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 5 \\ 5 \\ 1 \end{bmatrix} = \begin{bmatrix} 1.866 \\ 1.232 \\ 1 \end{bmatrix}$$

Transformation From World To Viewing Coordinates:
An Example For 2d System

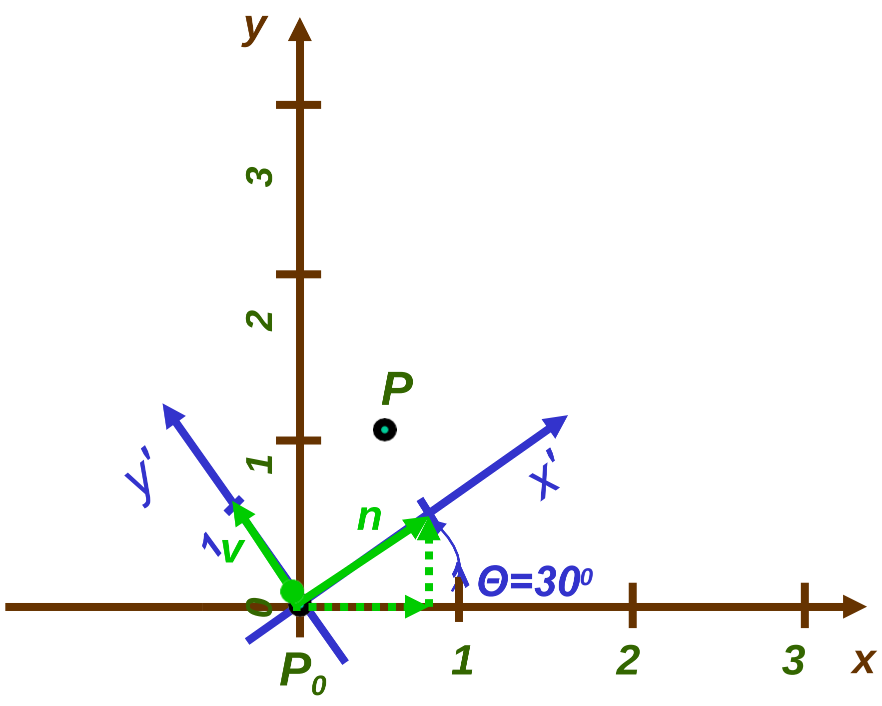
Alternative Method

$$\mathbf{n} = (0.866 \quad 0.500)$$

$$\mathbf{v} = (-0.500 \quad 0.866)$$

$$\mathbf{R} = \begin{bmatrix} 0.866 & 0.500 & 0 \\ -0.500 & 0.866 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$\mathbf{x}' = \mathbf{R} \cdot \mathbf{T} \cdot \mathbf{x}$$



Summary

- Discussed the general 3-D viewing transformation pipeline.
- Discussed about the viewing coordinates which specify the view plane, view reference point, view-plane normal vector, view-up vector, unv system.