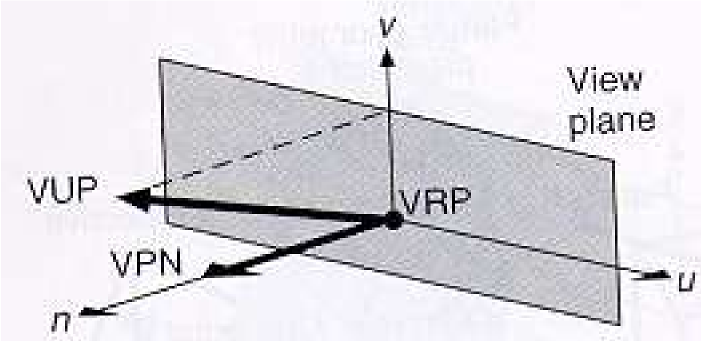
Viewing Coordinate System and Viewing Plane

- **Specifying the viewing coordinate system (VCS)**



- Pick the origin of VCS: view reference point (VRP)

  * It can be thought as the position of the camera

  * The VRP is specified in world coordinates

- Select view-plane normal (VPN) (positive direction of the *n*-axis)

  * The direction of VPN is specified by the directed line segment from VRP to a point specified by the user in world coordinates

  * VPN determines the orientation of the view plane (it is normal to the view plane)

- Select view-up (VUP) vector (positive direction of the *v*-axis)

  * VUP can have any convenient direction, not parallel to the VPN vector

  * Positive *v*-axis is defined by taking the projection of the VUP vector onto the plane that is perpendicular to the VPN vector (projector is parallel to VPN)

  * VPN will be perpendicular to VUP's projection

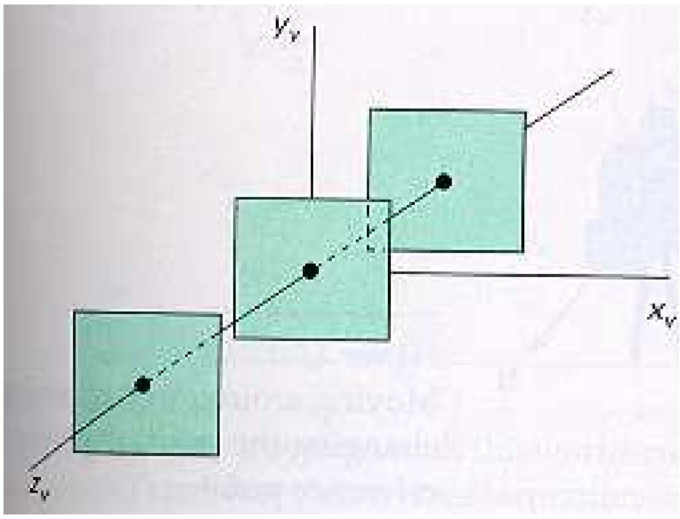
- Select the positive direction of the *u*-axis in a way that *u*, *v*, and *n* form a right-handed coordinate system

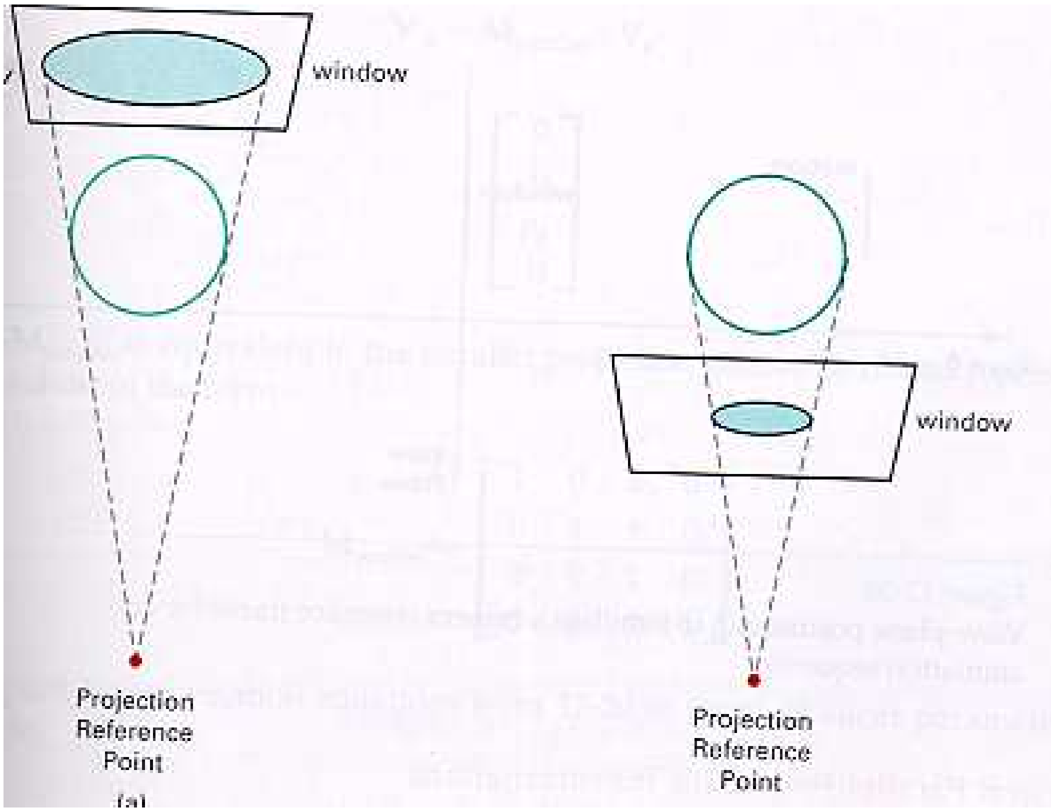
- **Positioning the view plane**

  - Choose the position of the view plane along the *n*-axis by specifying the distance from the VRP (*focal length*)

  - VPN must be normal to the view plane

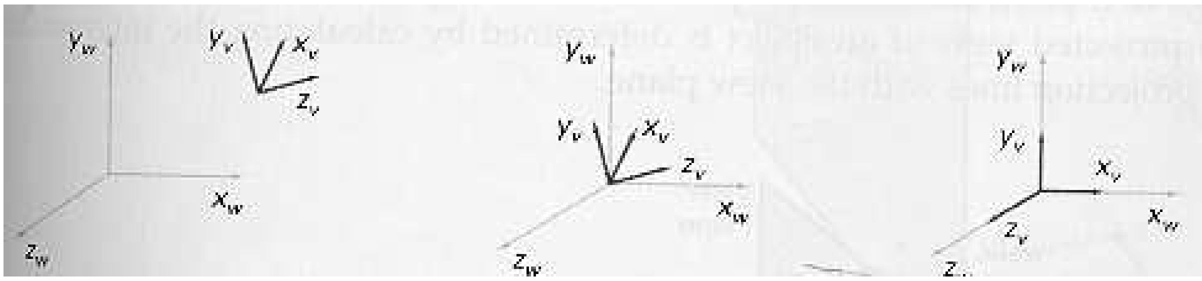
  - The view plane can be in front, cut through, or behind the objects





- **Transformation from world to viewing coordinates**

  - Object descriptions must be converted into the viewing coordinate system

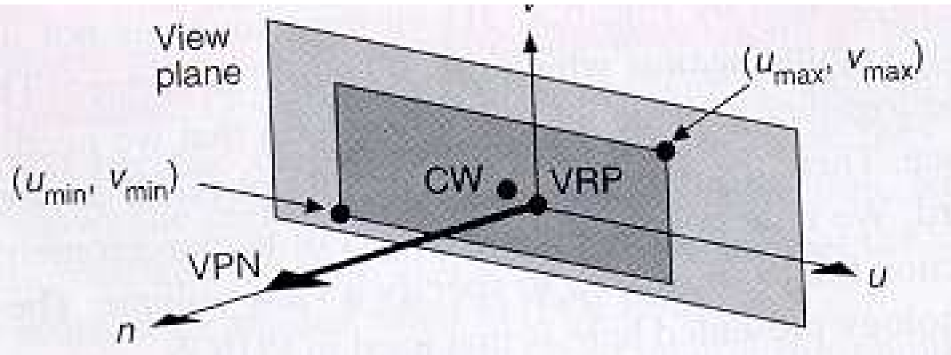


$$n = \frac{VPN}{\|VPN\|},\ u = \frac{VUP\ x\ VPN}{\|VUP\ x\ VPN\|},\ v = n\ x\ u$$

$$T = \begin{bmatrix} 1 & 0 & 0 & -VRP_x \\ 0 & 1 & 0 & -VRP_y \\ 0 & 0 & 1 & -VRP_z \\ 0 & 0 & 0 & 1 \end{bmatrix},\ R = \begin{bmatrix} u_x & u_y & u_z & 0 \\ v_x & v_y & v_z & 0 \\ n_x & n_y & n_z & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix},$$

View Orientation Matrix: RT

- **View window**



  - It determines the portion of the image that will be mapped onto the viewport

  - It can be anywhere on the view plane (CW ≠ VRP in general)

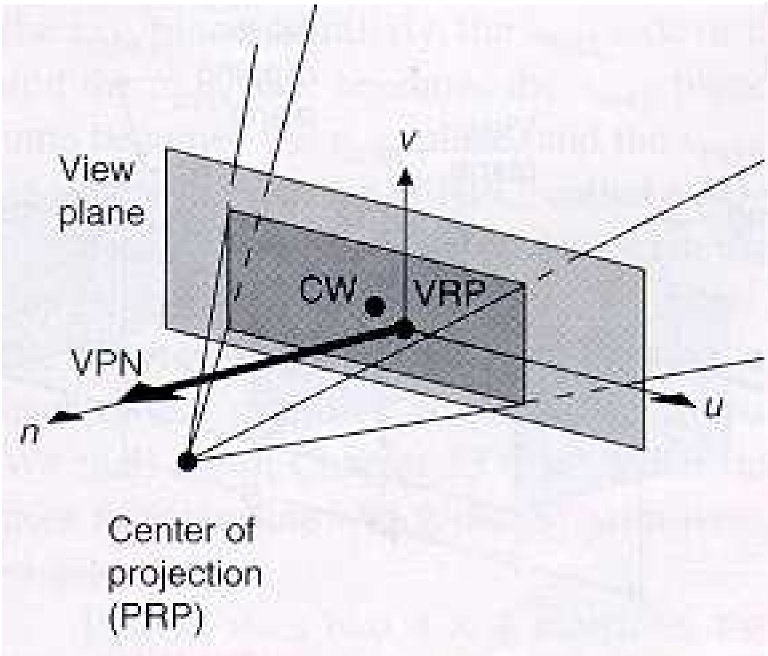
Specifying the center (perspective) or direction (parallel) of projection

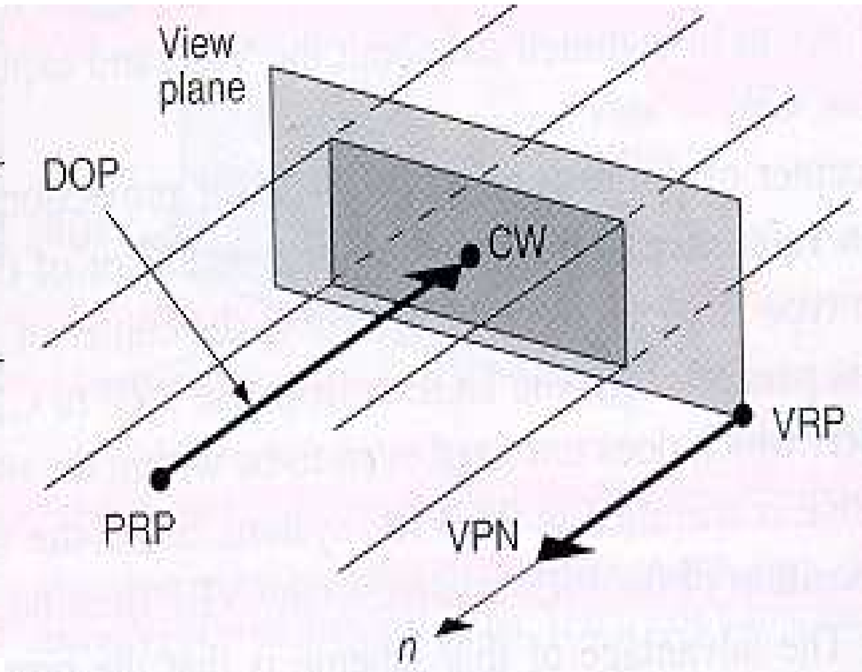
- Both are defined by the projection reference point (PRP)

- If the projection is perspective, the PRP is the center of projection

- If the projection is parallel, the direction of projection is from PRP to CW

- The PRP is specified in the VCS





- **Defining the view volume**

  - Only objects within the view volume will be projected onto the view plane

  - Shape of the view volume depends on the projection type

  - Size of the view volume depends on the size of the view window

  - Perspective projection: semi-infinite pyramid

  - Parallel projection: infinite parallelepiped

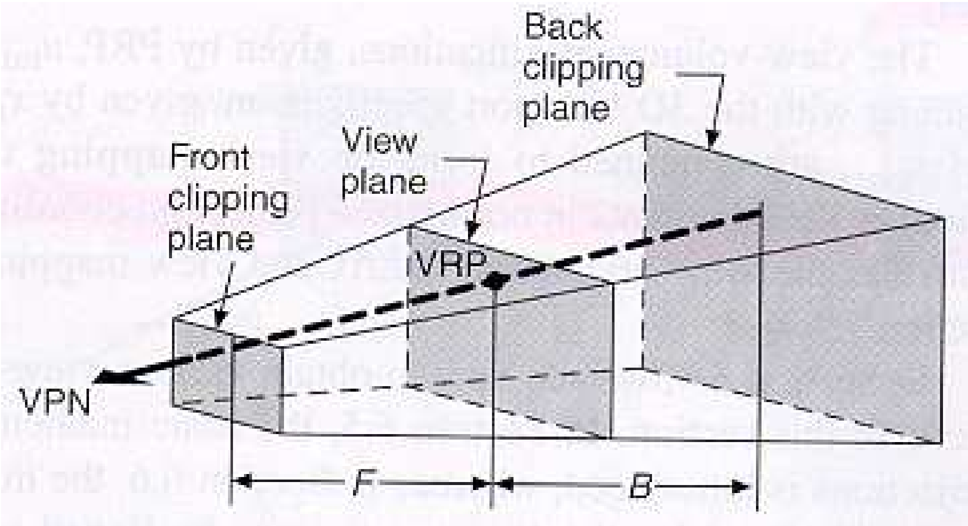
- **Finite view volume**

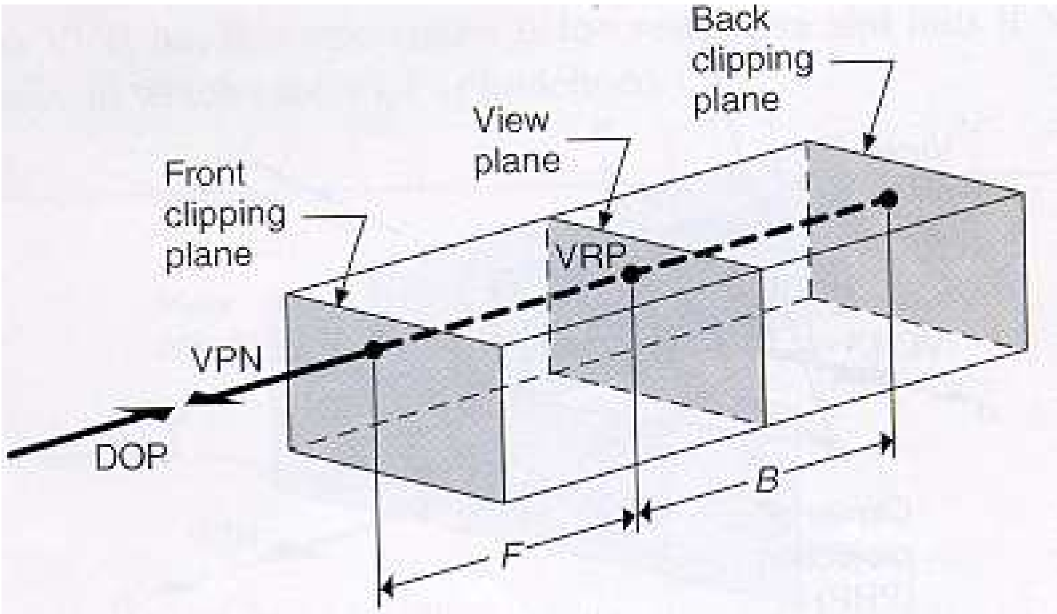
  - Specify the front and a back clipping planes

  - They are parallel to the view plane

  - They allow us to eliminate objects that are in front or behind the object(s) we want to look at

  - In the case of perspective projection, the finite view volume is called frustum





- **Positioning the front and back clipping planes**

  - They can be in any position relative to the view plane as long as the PRP is not between them