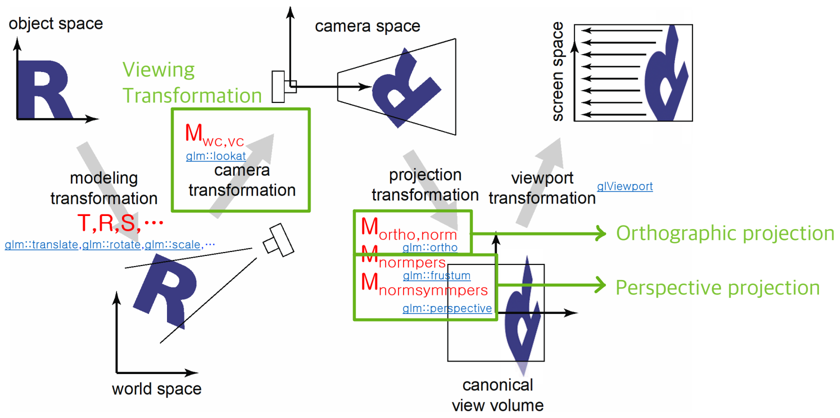
5. Viewing Transformation

> 💡 **Graphics Pipeline Overview**
> **Viewing Transformation**

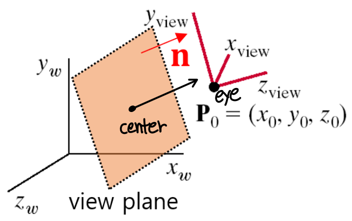
Graphics Pipeline



Viewing Transformation

Viewing Parameter

1. 카메라 위치 **P_0 = (x_0 , y_0 , z_0)**
2. View plane 에 수직 vector 인, View Plane Normal *VPN*: **n = z_view**
   a. *VPN* 방향이, 카메라 방향(Viewing Coordinate System)의 z 축인 **z_view** 으로
3. View up: **v = y_view**
   a. 카메라 방향(Viewing Coordinate System)의 머리 방향 y 축 **y_view**
4. **u** 는 **v** 와 **n** 으로 구한다. **u = v × n, u = x_view**
   a. (1), (2), (3) 은 사용자가 정하는 parameter
   b. (4) 는 (2) (3) 으로 계산하는 것

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In OpenGL function,
glm::lookAt(glm::vec3(eye.x, eye.y, eye.z),
            glm::vec3(center.x, center.y, center.z),
            glm::vec3(up.x, up.y, up.z))
```

$$n=\frac{\text{eye}-\text{center}}{\|\text{eye}-\text{center}\|},\quad v=\frac{\text{up}}{\|\text{up}\|}$$

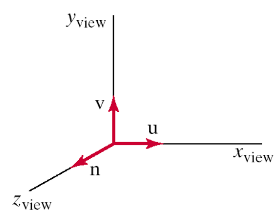
$P_0 = (x_0, y_0, z_0)$

eye

Center

n

v = y view

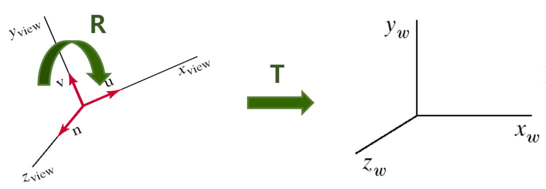


Viewing Transformation - M_WC,VC

> 💡 World Coordinate 에서 Viewing Coordinate 로 변환하는 행렬 M_WC,VC 을 구해보자

- (이해)

1. **P_0** 가 원점 (0, 0, 0) 이 되게 하자 ⇒ Translation
2. $x\_view = u$, $y\_view = v$, $z\_view = n$ 이 각각 x, y, z 축이 되게 하자 ⇒ Rotation
   a. u 를 R 하면 x = (1, 0, 0) 이 되어야 한다 ⇒ $R\_u = x$
   b. v 를 R 하면 y = (0, 1, 0) 이 되어야 한다 ⇒ $R\_v = y$
   c. n 를 R 하면 z = (0, 0, 1) 이 되어야 한다 ⇒ $R\_n = z$



$$\mathbf{R}\begin{bmatrix} u_x & v_x & n_x \\ u_y & v_y & n_y \\ u_z & v_z & n_z \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

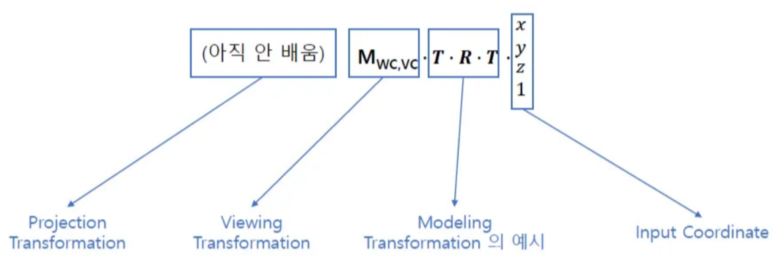
$$\mathbf{RU} = \mathbf{I}, \therefore \mathbf{R} = \mathbf{U}^{-1} = \mathbf{U}^T$$

cf) Rotation 행렬과 Reflection 행렬은
Orthogonal matrix 라서, 역행렬=transpose

- (결과)

$$\begin{aligned} \mathbf{M}_{WC,\,VC} &= \mathbf{R}\cdot\mathbf{T} \\ &= \begin{bmatrix} u_x & u_y & u_z & -\mathbf{u}\cdot\mathbf{P}_0 \\ v_x & v_y & v_z & -\mathbf{v}\cdot\mathbf{P}_0 \\ n_x & n_y & n_z & -\mathbf{n}\cdot\mathbf{P}_0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \end{aligned}$$

전체 Graphics pipeline 에서의 이해



QUIZ) Viewing Transformation

The viewing parameters are given as below:

- View-up vector $\mathbf{v} = (0, -1, 0)$
- View plane normal (VPN) $\mathbf{n} = (0, 0, -1)$
- Viewing coordinate origin $\mathbf{o} = (-1, -2, -3)$

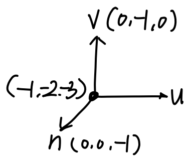
Find $\mathbf{u}$ to complete the **uvn** viewig coordinate system.

하나를 선택하세요.

- a. (0, 1, 0)
- b. (-1, 0, 0)
- c. (0, 0, 1)
- d. (1, 0, 0) ✔

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

정답 : (1, 0, 0)



$u = v \times n$

$$\begin{matrix} v & 0 & -1 & 0 & 0 & -1 \\ n & 0 & 0 & -1 & 0 & 0 \end{matrix}$$

$(-1\times-1 - 0\times0), (0\times0 - 0\times-1), (0\times0 - -1\times0)$

$\therefore (1, 0, 0)$

Find the 4X4 homogenous matrix to perform viewing transformation, given as #1 question.

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 1 \\ 0 & 1 & 0 & 2 \\ 0 & 0 & 1 & 3 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

정답 : $\begin{bmatrix} 1 & 0 & 0 & 1 \\ 0 & -1 & 0 & -2 \\ 0 & 0 & -1 & -3 \\ 0 & 0 & 0 & 1 \end{bmatrix}$

$$\mathbf{M}_{WC,VC} = \mathbf{R} \cdot \mathbf{T}$$
$$= \begin{bmatrix} u_x & u_y & u_z & -\mathbf{u} \cdot \mathbf{P}_0 \\ v_x & v_y & v_z & -\mathbf{v} \cdot \mathbf{P}_0 \\ n_x & n_y & n_z & -\mathbf{n} \cdot \mathbf{P}_0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} 1 & 0 & 0 & -(-1) \\ 0 & -1 & 0 & -(2) \\ 0 & 0 & -1 & -(3) \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$-(1,0,0)\cdot(-1,-2,-3)$

$-(0,-1,0)\cdot(-1,-2,-3)$

$-(0,0,-1)\cdot(-1,-2,-3)$

$$= \begin{bmatrix} 1 & 0 & 0 & 1 \\ 0 & -1 & 0 & -2 \\ 0 & 0 & -1 & -3 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Point A(4, 5, 6) is defined in the world coordinate system. How is A viewed from the viewing coordinate system as defined in question #2? In other words, apply the viewing transformation to A.

하나를 선택하세요.

- a. (5, -7, -9) ✔
- b. (5, 7, -9)
- c. (-5, -7, -9)
- d. (5, 7, 9)

답이 맞습니다.

$$\begin{bmatrix} 1 & 0 & 0 & 1 \\ 0 & -1 & 0 & -2 \\ 0 & 0 & -1 & -3 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 4 \\ 5 \\ 6 \\ 1 \end{bmatrix}$$

정답 : (5, -7, -9)

$$\begin{bmatrix} 1 & 0 & 0 & 1 \\ 0 & -1 & 0 & -2 \\ 0 & 0 & -1 & -3 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 4 \\ 5 \\ 6 \\ 1 \end{bmatrix}$$

$$= \begin{bmatrix} 4+1 \\ -5-2 \\ -6-3 \\ 1 \end{bmatrix}$$

$$= \begin{bmatrix} 5 \\ -7 \\ -9 \\ 1 \end{bmatrix}$$