CSE 167 (WI 2025) Exercise 5

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1 Transformation of the Normal Vector

We are given the model-view matrix:

$$VM = \begin{bmatrix} 2 & 0 & 0 & -1 \\ 0 & 3 & 0 & 0 \\ 0 & 0 & \sqrt{2} & -5 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

The transformation of the normal vector follows:
1. Extract the upper-left 3×3 matrix:

$$M = \begin{bmatrix} 2 & 0 & 0 \\ 0 & 3 & 0 \\ 0 & 0 & \sqrt{2} \end{bmatrix}$$

2. Compute $(M^{-1})^T$:

$$(M^{-1})^T = \begin{bmatrix} \frac{1}{2} & 0 & 0 \\ 0 & \frac{1}{3} & 0 \\ 0 & 0 & \frac{1}{\sqrt{2}} \end{bmatrix}$$

3. Apply it to n_{model} and normalize:

$$n_{\text{cam}} = \begin{bmatrix} \frac{3}{7} \\ \frac{2}{7} \\ \frac{6}{7} \end{bmatrix}$$

2 Lambert's Law

The solar irradiance at Earth is:

$$E = 1361 \text{ W/m}^2$$

which means that a surface perpendicular to the sunlight receives **1361 watts per square meter**.

However, the solar panel is tilted at an **angle of** $45°$ **relative to the sunlight**. According to **Lambert's Cosine Law**, the power received by a tilted surface is given by:

$$P = E \cdot A \cdot \cos\theta$$

where:

- P is the power absorbed by the panel.
- $E = 1361 \text{ W/m}^{\mathbf{2}}$ is the irradiance of the sun at Earth.
- $A = 1 \text{ m}^{\mathbf{2}}$ is the area of the panel.
- $\theta = 45°$ is the tilt angle of the panel.

Since:

$$\cos(45°) = \frac{\sqrt{2}}{2} \approx 0.707$$

we substitute:

$$P = 1361 \times 1 \times 0.707$$

$$P \approx 962.7 \text{ W}$$

Thus, the **solar panel receives approximately 962.7 watts of power from the sunlight**.