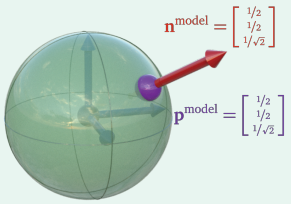
CSE 167 (FA 2022) Exercise 5 — Due 10/26/2022

Exercise 5.1 — 3 pts. (Transformation of the normal vector)

Suppose we have a vertex on a unit sphere model with vertex position and the unit outward vertex normal given by

$$\mathbf{p}^{\text{model}} = \begin{bmatrix} 1/2 \\ 1/2 \\ 1/\sqrt{2} \end{bmatrix}, \quad \mathbf{n}^{\text{model}} = \begin{bmatrix} 1/2 \\ 1/2 \\ 1/\sqrt{2} \end{bmatrix} \tag{1}$$

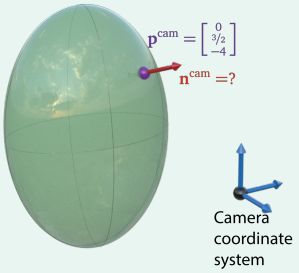


which are raw data stored in our vertex buffer. Using the modelview matrix

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

the sphere is stretched to an ellipsoid (and translated by $(-1, 0, -5)$) placed in the camera coordinate system. In particular, we get that the above vertex is now a point on the ellipsoid, and has the position in the camera coordinate given by $\mathbf{p}^{\text{cam}} = \begin{bmatrix} 0 \\ 3/2 \\ -4 \end{bmatrix}$ because

$$\mathbf{VM} \begin{bmatrix} \mathbf{p}^{\text{model}} \\ 1 \end{bmatrix} = \begin{bmatrix} 2 & 0 & 0 & -1 \\ 0 & 3 & 0 & 0 \\ 0 & 0 & \sqrt{2} & -5 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1/2 \\ 1/2 \\ 1/\sqrt{2} \\ 1 \end{bmatrix} = \begin{bmatrix} 0 \\ 3/2 \\ -4 \\ 1 \end{bmatrix}. \tag{3}$$

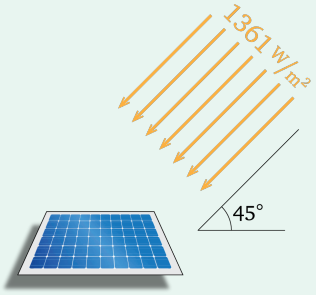


In the camera coordinate, what is the unit outward normal vector $\mathbf{n}^{\text{cam}}$ of the ellipsoid at this point $\mathbf{p}^{\text{cam}} = \begin{bmatrix} 0 \\ 3/2 \\ -4 \end{bmatrix}$?

■

Exercise 5.2 — 1 pt. (Lambert's law)

The *irradiance of the sun* is the energy of sunshine per cross-sectional area per unit time measured at Earth. ("Per cross-sectional area" means that it is measured over a plane perpendicular to the rays.) Ignoring the effect of the atmosphere, the irradiance of the sun is a steady 1361 W/m^2. Let there be a solar panel with an area of 1 m^2 oriented 45° oblique to the sun rays. Assume the ideal case that the solar panel absorbs light perfectly without reflection or dissipation. What is the solar power (in Watts) the entire solar panel receives from the sunlight?



■