1. Let T be the triangle with vertices **P = (3, 8, 7)**, **Q = (4, 1, 3)**, and **R = (3, 7, 7),** with the given order.

   a. Find an orientation vector for T .

      answer_1 : (-4, -0, -1)

   b. Is T visible to a viewer located at the point **E = (** 0**, 4,** 4**)?**

      answer_2 : 15

   c. Suppose that a single light source shines light parallel to the vector **L = < 2, 4, 2 >**. Moreover, T has **color (112, 62, 215)** at normal incidence. Using the diffuse shading model discussed in class, what color does T appear to be? We are using an integer color model with 8–bit components

      answer_3 : (55.4483, 30.6946, 106.441)

2. Let T be the triangle with vertices **P = (9, 6, 4)**, **Q = (3, 5, 2)**, and **R = (6, 3, 3),** with the given order.

   a. Find an orientation vector for T

      answer_1 : (-5, 0, 15)

   b. Is T visible to a viewer located at the point **E = (4, 1, −2)?**

      answer_2 : -65

   c. Suppose that a single light source shines light parallel to the vector **L = < 4, 0, 7 >**. Moreover, T has **color (124, 89, 127)** at normal incidence. Using the diffuse shading model discussed in class, what color does T appear to be? We are using an integer color model with 8–bit components

      answer_3 : (82.6826, 59.3447, 84.6829)

3. Explain why surface receives the maximum amount of light when the light direction is parallel to the surface normal.

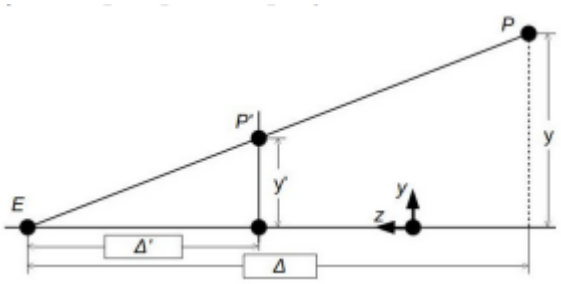
   Answer: Surface receives all the light when the surface normal is facing the light.

4. Suppose that the center of projection is the point E = (0, 0, 15) and the plane of projection is z = 10.

   a. Find the values of Δ and Δ' , the distances indicated in the diagram below. Here P = (x, y, z) is a point, and P′ = (x′ , y′ , z′) is its perspective projection.

   $\Delta' = 5$

   $\Delta = 15 - P_Z$



   b. Find a formula for P′ = (x′ , y′ , z′) in terms of P = (x, y, z)

$$\mathbf{P'} = \left(\frac{5x}{15 - P_Z}, \frac{5y}{15 - P_Z}, 10\right)$$

   c. Find a 4 × 4 matrix that represents perspective projection in this case.

$$\frac{5}{15 - P_Z}\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & -2 & 30 \\ 0 & 0 & -\frac{1}{5} & 3 \end{bmatrix}\begin{bmatrix} x \\ y \\ 30 - 2P_Z \\ 3 - \frac{1}{5}P_Z \end{bmatrix}$$

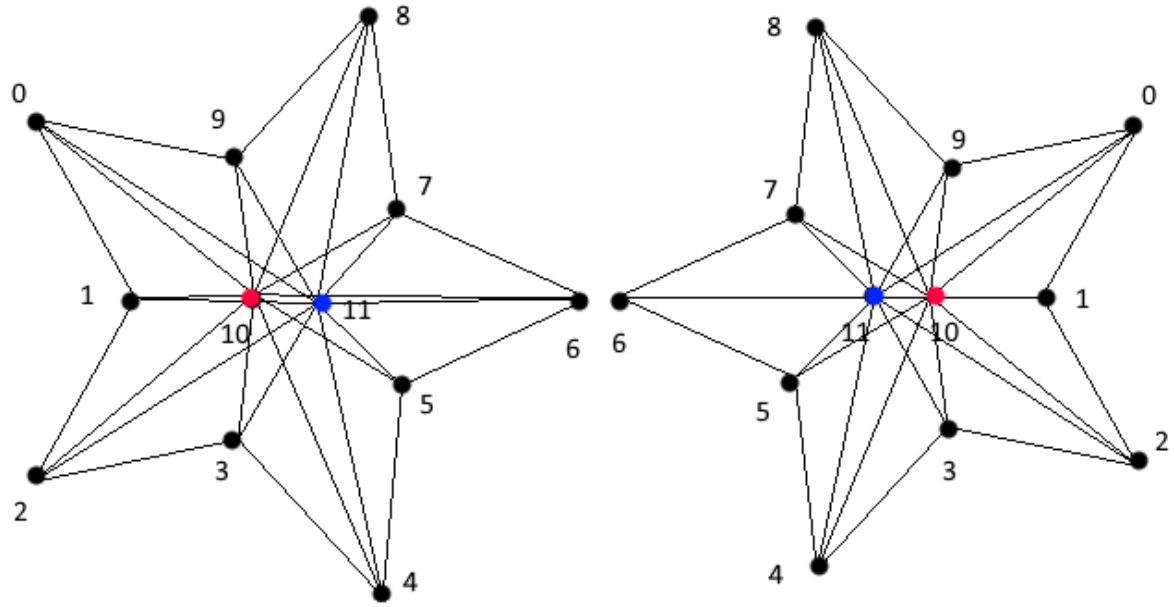
$$= \frac{5}{15 - P_Z}\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & -2 & 30 \\ 0 & 0 & -\frac{1}{5} & 3 \end{bmatrix}\begin{bmatrix} x \\ y \\ P_Z \\ w = 1 \end{bmatrix}$$

   d. Use this matrix to compute the perspective projection of the point **P = (2, 2, 4)**

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & -2 & 30 \\ 0 & 0 & -\frac{1}{5} & 3 \end{bmatrix}\begin{bmatrix} 2 \\ 2 \\ 4 \\ 1 \end{bmatrix} = \begin{bmatrix} 2 \\ 2 \\ 22 \\ 11/3 \end{bmatrix} = \begin{bmatrix} 6/11 \\ 6/11 \\ 6 \\ 1 \end{bmatrix}$$

$$\mathbf{P'} = \left(\frac{6}{11}, \frac{6}{11}, 6\right)$$

5.



We wish to construct a 3D triangular mesh for the star. The vertex array and face list are indicated by the diagram (vertex[10] and vertex[11] are the center of the polygon and they are separated by certain distance.)

a. What is the total number of vertices for polygon above?

   Answer: 12

b. What is the total number of faces for polygon above?

   Answer: 20

c. What is the total number of edges for polygon above?

   Answer: 30