Exercise 8.1 — 2 pts. In ray tracing, suppose we have a camera

- located at eye position = \[ \begin{bmatrix} -5 \\ 1 \\ 0 \end{bmatrix} \]
- looking at target = \[ \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix} \]
- with up vector = \[ \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix} \]
- with field of view, \( y = 90^\circ \)
- and an image resolution of width = 135 pixels and height = 90 pixels.

All positions are relative to a common world coordinate. At pixel \((i, j) = (82, 22)\), what is the ray \((p_0, d)\) shooting through the center of the pixel? (Here, \(p_0 \in \mathbb{R}^3\) is the source point of the ray, and \(d \in \mathbb{R}^3\) is the unit vector for the direction of the ray; both in the world coordinate.)

**Hint**: \(p_0\) is trivial. For \(d\), see slides on “RayTracing,” page 20 and page 26.

Exercise 8.2 — 2 pts. Suppose we have a triangle with its 3 vertex positions given by

\[
\begin{align*}
p_1 &= \begin{bmatrix} 4 \\ 0 \\ 0 \end{bmatrix}, & p_2 &= \begin{bmatrix} 0 \\ 2 \\ 0 \end{bmatrix}, & p_3 &= \begin{bmatrix} 0 \\ 0 \\ 8 \end{bmatrix}.
\end{align*}
\]

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Now, suppose we have a ray sourced at \(p_0 = \begin{bmatrix} -1 \\ 0 \\ 0 \end{bmatrix}\) with direction \(d = \begin{bmatrix} 2/3 \\ 1/3 \\ 2/3 \end{bmatrix}\). The ray will intersect with the triangle. What is the position \(q \in \mathbb{R}^3\) of this ray-triangle intersection? What is the distance \(t\) traveled by the ray (distance between the source and the intersection)? What are the barycentric coordinates \(\lambda_1, \lambda_2, \lambda_3\) for \(q\) with respect to the triangle \(p_1, p_2, p_3\)?

**Hint**: Follow page 36 of the slides on “RayTracing.” You may use symbolic calculator like Wolfram Alpha for solving equations.