CS 355 Homework #5:
3D Rendering Geometry

1. A camera is located at position $(25, 20, 5)$ in the 3D world and is looking at the point $(25, 40, 25)$ so that the direction $[0, 1, 0]$ points (roughly!) up.

   (a) Use the process we covered in class (a 3D variant of Gram-Schmidt orthonormalization using cross products) to calculate the camera's x, y, and z axis directions.

   (b) Write this camera's world-to-camera transformation as the composition of a rotation matrix and translation matrix. (You do not have to multiply out this matrix.)

   (c) What are the camera-space coordinates of the point $\mathbf{p}_w = (5, 6, 7)$?

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2. A camera is located at position $(20, 5, -40)$ and oriented so that it is pointing parallel to the x-z plane at an angle of 30 degrees off the z axis. (This is the basic setup for Labs #4 and #5.)

   (a) Write this camera's world-to-camera transformation using the composition of a 3D rotation matrix (around the y axis) and a translation matrix. (You also do not have to multiply out this matrix. You may also leave your answer in terms of trig functions.)

   (b) What are the camera-space coordinates of the point $\mathbf{p}_w = (5, 6, 7)$?

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3. A virtual camera has the following parameters:

   - vertical field of view of 60 degrees
   - aspect ratio of 16:9 (horizontal to vertical)
   - near plane $n = 10$
   - far plane $f = 1000$

   (a) What is the clip matrix for this camera?

   (b) What are the clip-space coordinates of the camera-space point $\mathbf{p}_c = (5, -5, 50)$?

   (c) Is this point $\mathbf{p}_c = (5, -5, 50)$ within the view frustum of this camera? How can you tell without doing a division?

   (d) What are the canonical coordinates of this point $\mathbf{p}_c = (5, -5, 50)$?

   (e) If rendered to a high-definition display (1920×1080), what are the screen coordinates of this point?