Consider a scene consisting of a black cube against a white background. Specified in units of meters, the corners of the bottom face of the cube have world coordinates \((X, Y, Z)\) given by

\[
P_1 = (0.00, 0.00, 0.00),
P_2 = (0.00, 0.00, 0.05),
P_3 = (0.05, 0.00, 0.05),
P_4 = (0.05, 0.00, 0.00).
\]

Another corner of the cube is located at \(P_5 = (0.00, 0.05, 0.00)\). Two rotations are then applied to the cube while keeping the point \(P_1\) fixed at \((0.00, 0.00, 0.00)\) as follows:

1. Keeping the bottom face of the cube in the \(X-Z\) plane, the cube is rotated clockwise by 30\(^\circ\) so that edge \(P_1P_2\) makes an angle of 30\(^\circ\) with the positive \(Z\)-axis.

2. Keeping edge \(P_1P_5\) in the \(Y-Z\) plane, the cube is rotated counterclockwise by 20\(^\circ\) with respect to the \(Y\)-axis so that edge \(P_1P_5\) makes an angle of \(-20\(^\circ\)\) with the positive \(Y\)-axis.

The cube is then translated so that corner \(P_1\) is located at world coordinates \(P'_1 = (0.00, 0.00, 1.00)\). An ideal pinhole camera with focal length \(f = 50\) mm is used to image the cube at its new position.

a) Find the world coordinates of the eight corners of the cube \(P'_1 - P'_8\) after the two rotations and the translation have been applied.

b) Find image coordinates of the projections \(p'_1 - p'_8\) of the eight corners of the cube on the camera focal plane.

c) Carefully sketch the image that is obtained on the camera focal plane.

**NOTE:** the pinhole camera coordinate system specified in the notes is a LEFT-HANDED coordinate system. For this assignment, you can’t just copy formulas for the rotation matrices out of your physics book — those are for a right-handed coordinate system. For this assignment, you must explicitly consider the left-handed coordinate system and modify the rotation matrices appropriately.

**DUE: 2/3/2010**