

1. Your grade in this problem, out of 14 points, will, if higher, **replace** the 14 point PART 4 of the midterm exam.

The homework is based on Hearn and Baker's problem 6-4, page 343. Use the approach given on pages 303-304 with Figure 6-8.

The program should not use OpenGL or other graphics output.

It should prompt the user for inputs as follows:

First, input the 4 positive integers to determine one screen viewport.

Second, input the 4 values to determine a clipping window in world-coordinates.

Third, input a 3x3 floating point matrix to be used for the modeling transformation. (That is just 9 numbers. First, input the 3 numbers of the first row. Then the 3 numbers of the 2nd row, and then the 3rd row.)

After accepting the above parameters of a viewing pipeline, the program should run the loop:

- Prompt for and input 2 floating point numbers as coordinates of a point P in model coordinates.
- Transform P using the model transformation and print the result.
- Transform the above result to normalized coordinates and print those normalized coordinates.
- Transform the normalized coordinates to screen coordinates and print the screen coordinates.

The run can be ended by the user killing the process by typing Control-C; you don't need to program anything to make this happen.

You can test the program by first inputting an identity model transformation and then entering the coordinates of the corners of the clipping window. Second, run the program again to test the model transformation feature.

Submit the program to project **hw3** for grading.

2. Here is a model of an approximate cube:

Points:

A(0, -1, -3) B(1, -1, -4) C(0, -1, -5) D(-1, -1, -4)
E(0, -2.4, -3) F(1, -2.4, -4) G(0, -2.4, -5) H(-1, -2.4, -4)

Edges: AB, BC, CD, DA, EF, FG, GH, HE
AE, BF, CG, DH

Some of the most popular transformations in computer graphics today are non-linear (actually projective). It is also useful to have a transformation that transforms points in space into points in a plane.

Using a calculator or computer, transform each of the 8 points above to 2-d points using the formulas:

$$x' = \frac{x}{z} \quad y' = \frac{y}{z}$$

Then plot them on graph paper, label them with their original letters, and connect with straight lines the pairs of plotted points corresponding to the edges of the cube.

3. If you know rotation matrices like

$$R_{\Theta} = \begin{bmatrix} \cos \Theta & -\sin \Theta \\ \sin \Theta & \cos \Theta \end{bmatrix}$$

you do not have to memorize the angle sum formulas

$$\cos(\Theta + \Phi) = \cos \Theta \cos \Phi - \sin \Theta \sin \Phi$$

$$\sin(\Theta + \Phi) = \sin \Theta \cos \Phi + \cos \Theta \sin \Phi$$

because you can derive them by calculating the product of two matrices. Write the two matrices R_{Θ} and R_{Φ} , do the calculations, and check against the given angle sum formulas.

4. Write the six 3-d rotation matrices in approximate numerical for rotations around the x -axis, y -axis, and z -axis by (1) 90° , and by (2) 30° . Use $\sin 30^\circ = 0.5$ and $\cos 30^\circ = 0.87$.

Demonstrate that two (your choice) of the 90° rotations do not commute: Demonstrate it in 2 ways:

- (a) Multiply the matrices in the two different orders and check if the two products are different.
 - (b) Perhaps using a real model (such as a teddy bear), apply the rotations in two different orders and sketch on paper the results. (See HB pages 265-266).
5. Practice calculating dot products (\cdot) and cross products (\times) of 3-d vectors: Write down three 3-d vectors none of whose components are zero, and not with the same directions. Calculate the three dot products of all pairs of the vector. Calculate the three cross products of all pairs, in arbitrary order.

See Hearn and Baker and Schaums for help on dot and cross products. Notice that $\mathbf{V}_1 \times \mathbf{V}_2 = -\mathbf{V}_2 \times \mathbf{V}_1$.