Lab 10—Basics of Computer Graphics

Objective: To apply knowledge of rotations and projections to simple problems that arise in elementary computer graphics.

Consider a very simple object—a cube in space. Let its edges be parallel to the coordinate axes and have unit length. Place one vertex at the origin. Then the vertices are defined by the vectors:

```
v1=[0;0;0]
v2=[1;0;0]
v3=[0;1;0]
...
v8=[1,1,1]
```

1. Assume you wish to present this object on a 2-dimensional screen. Treat the screen as R^2 with x-axis horizontal, y-axis vertical, and origin in the lower-left corner. The viewer is considered to be looking down along a z-axis extending straight out from the screen. What vectors in R^2 describe the vertices as they appear on the screen? [Hint: You can decide this without any calculations.] How would this cube appear to the viewer?

2. To provide the viewer with a better visual representation of the object, we decide to show it rotated. Write down the matrix of the linear transformation that first rotates this object by through angle $\pi/6$ about the y-axis, then "tips" it up by rotating it through angle $\pi/6$ about the x-axis, and finally projects the result into the xy-plane of the screen.

3. Act on each of the vertices with the linear transformation you just found. What vectors in R^2 give the new positions of the vertices on the screen?

Lastly, let's have MATLAB draw our rotated object. We will need to connect up the new vertices by straight line segments. How do we do this? Say a line segment extends from (0.1,0.2) to (0.9,0.6). Then in MATLAB we store the x-coordinates of our two points in a vector and the y-coordinates in another vector:

```
x1=linspace(0.1,0.9,2)
y1=linspace(0.1,0.9,2)
plot(x1,y1)
```

Say we want to plot two line segments together, one as above and another from (0.9,0.6) to (0.5,1.0):

```
x2=linspace(0.9,0.5,2)
```

```
y2=linspace(0.6,1.0,2)
plot(x1,y1,x2,y2)
```

4. Plot the rotated cube using MATLAB. Comment on the quality of the graphics and suggest ways of improving the graphics. Particularly, how might one consider using the discarded information concerning the z-coordinates of the vertex points of our cube to incorporate perspective?

5. Use vectors to describe the vertices of a pyramid whose every side has unit length. (Pyramids have five vertices, four attached to the base and one at the pinnacle.) It should have a square base in the xz-plane. Place one vertex at the origin and align the base edges along the x- and z-axes. What vector describes the location of the pinnacle? If you apply the same rotations as above to the pyramid and project the resulting object onto the xy-plane of the screen, what are the coordinates of the vertices?