CSE 167 - Intro to Computer Graphics - Fall 2004

Homework #2
This homework is not to be handed in.
Selected answers are included on the last page

1. Suppose the earth is to be drawn at the origin and it is to rotate on its axis at a rate of ω degrees per unit time. The axis of rotation is to be the y-axis. Give the OpenGL commands that will set the model view matrix correctly to render the earth at time t. *Hint: Your answer will need to include a rotation through an angle of* ωt *degrees.*

2. Suppose the sun is positioned at the origin and the earth is revolving around the sun at a rate of ω degrees per unit time and at a distance of 5 units. Also suppose same side of the earth is always facing the sun. The earth always stays in the xz-plane. Give the OpenGL commands that will set the model view matrix correctly to render the earth at time t. *Hint: Your answer will need to include a rotation through an angle of* ωt *degrees.*

3. Let $\mathbf{u} = \langle 0, 1, 0 \rangle$. Consider the rotation $R_{90^\circ,\mathbf{u}}$. Give a 4×4 homogeneous matrix that represents $R_{90^\circ,\mathbf{u}}$.

4. What will the model view matrix equal after the following OpenGL commands?

```
glMatrixMode(GL_MODELVIEW);
glLoadIdentity();
glRotatef( 90.0, 0, 1, 0 );
glRotatef( 90.0, 0, 0, 1 );
```

What will it equal after the commands:

```
glMatrixMode(GL_MODELVIEW);
glLoadIdentity();
glRotatef( 90.0, 0, 0, 1 );
glRotatef( 90.0, 0, 1, 0 );
```

5. Let M be the matrix

$$\begin{pmatrix} 0 & 0 & 1 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \end{pmatrix}.$$

Let $A(\mathbf{x})$ be the transformation of $\mathbb{R}^3$ defined by $A(\mathbf{x}) = M\mathbf{x}$. Give a sequence of OpenGL commands that will cause the same effect as the transformation A (without explicit loading the entries of the matrix!). *Hint: it can be done fairly easily using two rotations.*

6. Let A and M be as in the previous problem. Redo question 4., but use only a single rotation. This is mathematically equivalent to expressing A in the form $A = R_{\theta,\mathbf{u}}$ where $\mathbf{u}$ is a unit vector. *Hint: You can find* $\mathbf{u}$ *without any hard calculations by using symmetry. The value of* θ *can be found from the fact that* $A \circ A \circ A$ *is equal to the identity transformation.*

Selected answers

1. The following commands can be used:

```
glMatrixMode(GL_MODELVIEW);
glLoadIdentity();
glRotatef( ωt , 0, 1, 0 );
drawEarth();
```

2. The following commands can be used:

```
glMatrixMode(GL_MODELVIEW);
glLoadIdentity();
glRotatef( ωt , 0, 1, 0 );
glTranslatef( 5, 0, 0 );
drawEarth();
```

4. The matrices are different! They are

$$\begin{pmatrix} 0 & 0 & 1 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \qquad \text{and} \qquad \begin{pmatrix} 0 & -1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ -1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

You should try visualizing the effects of these transformations and understand why they are different.

5. Further hint: One way to achieve this transformation is with a 90 degree rotation around the z-axis, followed by a 90 degree rotation around the y-axis.