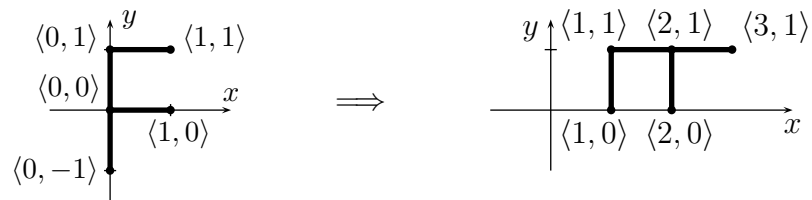
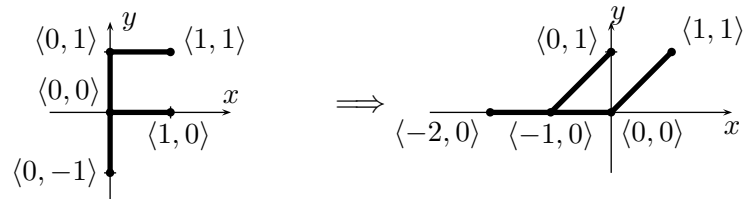


CSE 167 - Intro to Computer Graphics - Fall 2004
Study Problems for Midterm #1

1. Give 4×4 matrices that represent
 - a. The translation specified by `glTranslate3f(1, 2, -1)`.
 - b. The rotation specified by `glRotatef(30.0, 0, 1, 0)`.



2. Express the transformation that maps the “F” shown above on the left to the “F” on the right, in the form $A(\mathbf{x}) = M\vec{x} + \mathbf{u}$, where M is a 2×2 matrix and $\mathbf{u} \in \mathbb{R}^2$.
3. Give a 3×3 homogeneous matrix that represents the **inverse** of the above transformation.
4. Give a sequence of (pseudo) OpenGL commands that will draw the “F” in the position shown above on the right, given a routine `drawF()` that draws the “F” in the position shown on the left. You should use commands chosen from among the following: `drawF()`, `glLoadIdentity()`, `glMatrixMode()`, `pglScalef()`, `pglTranslatef()`, `pglRotatef()`.



5. An affine transformation $A(x) : \mathbb{R}^2 \rightarrow \mathbb{R}^2$ maps the “F”-shape shown above on the left to the “F” on the right.
 - a. Give a 3×3 matrix that represents A over homogeneous coordinates.

b. Give a 3×3 matrix that represents A^{-1} over homogeneous coordinates.

6. Consider the following sequence of OpenGL commands:

```
glMatrixMode(GL_MODELVIEW);  
glLoadIdentity();  
glRotatef( 180.0, 1, 0, 0 );  
glRotatef( 90.0, 0, 0, 1 );  
glScalef( 2, 2, 2 );  
glTranslatef( 3, 4, 5 );
```

Show explicitly the contents of the 4×4 ModelView matrix after these commands have been executed.

7. Suppose you wish to animate an Earth-like planet in a Solar system. The Sun is stationary at the origin, the Earth rotates in a circular orbit in the xz -plane at distance 4 from the sun. The earth revolves around the sun once every 365 days, and it rotates on its axis once every day. You are supplied with a routine `drawEarth`, which acts similarly to `glutWireSphere`, drawing the earth as a sphere centered at the origin. In addition to `drawEarth()`, you may also use the commands `glMatrixMode()`, `glLoadIdentity()`, `glTranslatef()`, `glRotatef()`, `glScalef()`. Your task: assuming the value of t is already set, where t measures time in days, give a sequence of commands that draws the Earth in its correct position. Assume the sun is positioned at the origin. (You do not need to draw the Sun, or to update the value of t .)

8. Consider the map $A : \mathbb{R}^3 \rightarrow \mathbb{R}^3$ that is defined by

$$A : \langle x, y, z \rangle \mapsto \langle x/z, y/z, 0 \rangle.$$

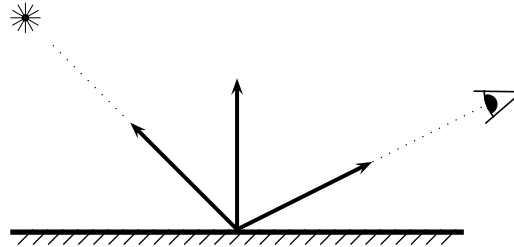
- Is this map linear? Why or why not?
- Is this map affine? Why or why not?
- Is it possible to represent this map with a 3×3 matrix? If so, give the matrix.
- Is it possible to represent this map with a 4×4 matrix? If so, give the matrix.

9. A point light source is placed at $\langle 0, 10, 0 \rangle$ and casts shadows onto the plane defined by $y = 0$ (the xz -plane.. Give the matrix representation of the transformation that takes a vertex \mathbf{v} to its shadow on this plane.

10. Give the 4×4 matrix of a rigid, orientation-preserving, linear transformation which maps the positive x -axis to the line that passes through the center of the first octant. That is, the transformation must map $\langle 1, 0, 0 \rangle$ to $\langle 1/\sqrt{3}, 1/\sqrt{3}, 1/\sqrt{3} \rangle$.

11. Describe the Phong lighting model by doing the following. We are restricting attention to a single wavelength (color) of light.

a. Label the three vectors shown in the figure with the names we used for them in class (and in the textbook).



b. The Phong lighting model uses five different scalar values to describe material properties (at a single wavelength). List these five values: give their names (mathematical symbols) along with short descriptions of their meanings (two to four words is enough).

i:

ii:

iii:

iv:

v:

c. Give the equation for the Phong lighting calculation for a single wavelength of light, and a single light source (do not use the halfway vector for this part). Give also the formula for the reflection vector \mathbf{r} .

d. Describe how the equation in **c.** is modified when using the halfway vector. Give the formula for the halfway vector.

12. In the Phong lighting model, the various material properties mostly depended on the wavelength (e.g., diffuse and specular reflectivity coefficients). However, the specular exponent (also called the shininess coefficient) is required to be the same for all wavelengths. Explain the reason for this. What unwanted visual effects might occur if different wavelengths used different specular exponents?

13. When is it preferable to use orthographic viewing transformations? When is it preferable to use perspective transformations? Explain why.

14. Describe the differences between Phong and Gouraud shading. What are their relative advantages and disadvantages?

15. What are the three (or, four) kinds of light used in the Phong lighting model? Draw pictures illustrating the different kinds of reflection in the Phong lighting model.

16. Let $\mathbf{u} = \langle 1, 1, 1 \rangle$. Let $\mathbf{v} = \langle 1, 0, 0 \rangle$. What is the projection of \mathbf{v} onto \mathbf{u} ? What is the result of rotating \mathbf{v} 90° degrees around \mathbf{u} with direction of rotation given by the right hand rule?

17. Describe how double buffering works and its purpose.

18. Describe “z-fighting”.

19. Define the term “aspect ratio”.

20. Describe how the painter’s algorithm is used. What are the disadvantages to using the painter’s algorithm?

21. Describe the purpose of the depth buffer and how it is used.

22. Consider the cylinder

$$\{\langle x, y, z \rangle : x^2 + z^2 = 1, 0 \leq y \leq 1\}.$$

Give a parametric equation for this cylinder (the side only, not the top and bottom). Use this to find a formula for the normal vectors of the cylinder’s surface. Be sure your normals are pointing outwards.