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Midterm

1. Let a 4×4 matrix be given by

$$\begin{bmatrix} 2 & 0 & 0 & 2 \\ 0 & 2 & 0 & 2 \\ 0 & 0 & 2 & 2 \\ 0 & 0 & 0 & 1 \end{bmatrix}.$$

When interpreted as an affine map, what is the action of this matrix?

2. Let a 3D (oriented) triangle be given by the vertices

$$\mathbf{p}_1 = \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix}, \quad \mathbf{p}_2 = \begin{bmatrix} 0 \\ 6 \\ 0 \end{bmatrix}, \quad \mathbf{p}_3 = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix},$$

Find the normalized normal to this triangle.

3. What is the aspect ratio of a rectangle? Will it change when an affine map is applied to the rectangle? Explain.

4. What is a viewing frustum? Draw a 2D sketch and label it.

5. Can an affine map take a rectangle to a parallelogram which is not a rectangle? Explain.

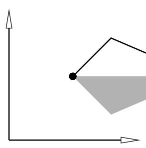
6. Suppose we have a viewport defined by the lower-left point $\mathbf{l} = [10, 10]^{\mathrm{T}}$, width 20 and height 10. Given the point $[0, 0]^{\mathrm{T}}$ in 2D NDC coordinates, what is the corresponding point in the viewport? Recall that NDC coordinates live in the range [-1,1] in each coordinate.

7. Explain the concept of a $z-$buffer.

8. Sketch an arbitrary 2D triangle and mark its vertices as $\mathbf{p}_1, \mathbf{p}_2, \mathbf{p}_3$. Any point in the triangle has barycentric coordinates (u, v, w). Mark all points with $u = w$.

9. Sketch the elements of the OpenGL camera model (i.e., the input parameters to `gluLookAt`).

10. Circle the set of transformations which maps the light triangle to the dark triangle. The marked point is assumed to have coordinates $[50, 50]$.



A) Translate(-50,-50), Reflect about x, Translate(50,50)
B) Translate(-50,-50), Rotate 180, Translate(50,50)
C) Translate(-50,-50), Reflect about y, Translate(50,50)
D) Translate(50,50), Shear -20 in y, Translate(-50,-50)
E) None of the above

11. Let R be a rotation matrix and let $\mathbf{p}$ be a point. For a point $\mathbf{x}$, give the equation which rotates $\mathbf{x}$ around $\mathbf{p}$, using the matrix R.

12. Suppose `Square()` draws a unit square in the $z = 0$ plane, centered at the origin. Sketch what will be displayed as the result of the following OpenGL pseudo-code.

```
  glTranslatef(2, 0, 0);
   glRotatef(45, 0, 0, 1);
 Square();
```

13. Let the homogeneous coordinates of a point be given by $[2, -2, -2, 2]^{\mathrm{T}}$. What are its affine coordinates?

14. Suppose you want to use the function

```
gluPerspective(fieldofview,aspect,znear,zfar)
```

to make your object appear smaller. Which parameter do you need to change and how?