CS 4204 – Computer Graphics
Exam 1 Review Spring 2008

Concepts you should understand and be able to explain:

Computer graphics
Photorealism
Non-photorealism
Animation
Modeling
Rendering
Graphics system
Application model
Primitives
Event-based programming
Callback function
Object/local coordinates
World coordinates
Screen coordinates
Window-to-viewport transformation
Aspect ratio
Clipping (Cohen-Sutherland)
Rasterization
Vector dot product
Vector cross product
Matrix multiplication
Matrix inversion
Parametric equations of a line
2D and 3D Homogeneous coordinates
(Affine) Transformations
Translation/Rotation/Scale/Shear
Composite transformations
Fixed-point transformations
Transformation of points
Transformation of coordinate systems
Hierarchical scene modeling
Scenegraph
Articulated model
Rotation about an arbitrary axis
Modeling transformation
Viewing transformation
Projection transformation
Parallel vs. perspective projections
Oblique vs. orthographic parallel views
Vanishing points

Short Answer:
Answer the following questions in paragraph form. Be complete but concise.

1. What are homogeneous coordinates, and why are they used in computer graphics?

2. Define "primitive" as it relates to graphics programming. Why might a graphics package provide only low-level primitives? Give an example of a higher-level primitive not available in most packages, and when such a primitive might be useful.

3. What is a *shear* transformation? Give a matrix for a general 2D y-shear, and explain why that matrix produces the desired result.

4. Explain the concept of looking at transformations as a change in coordinate system, rather than as a change in the object. Give an example of a situation where looking at transformations as a change in coordinate system might be useful.

5. What is an *application model*? How is it distinguished from the graphics that are rendered on the screen? What is the name of the process that implements a mapping between the application model space and screen space? How does this process work?

6. Suppose we have a GLUT interface window that is 400x300 pixels, and that we make the following function calls: `gluOrtho2D(-4,4,-3,3)` and `glViewport(0,0,200,150)`. Draw a picture and use it to explain how these function calls set up the window-viewport transformation.

Problems:
Work each problem, showing intermediate steps and explaining when necessary. Circle your final answer.

7. Give the 2D homogeneous matrix for each of the transformations in parts a-c. Leave composite transformations in factored form:
    a. Scale in the x-dimension by 2 and the y-dimension by 3 with fixed point (4,2)
    b. Rotate by –30 degrees about the point (-2, 3)
    c. Reflect about the line y = -5
    d. Check your work on part c by applying the resulting matrix to the line segment from (1,3) to (6,2). What are the new endpoints?

8. Two endpoints A(13, 11) and B(4,15) describe the line segment $\overline{AB}$.
    a. Give the equation of the line in parametric form.
    b. Assume that AB is a polygon edge. Find the intersection of this edge with the scanline y=13.

9. Triangle ABC has vertices at (1,1), (2,3), and (3,1). Find the matrix that performs a scale of this triangle by 2 in the x direction while keeping vertex (2,3) fixed. Apply this matrix to the vertices and find the new vertices of ABC.

10. Give the 3D homogeneous coordinate transformation that rotates a point about the line:
```
x(t) = 0
y(t) = t
z(t) = t
```
by `d` degrees. Leave matrices in factored form. (Hint: draw a picture of the line)

11. The following questions refer to the projection of 3D points onto the viewplane given by x = -10. Assume that the up vector is (0, 1, 0).
    a. Given an arbitrary point (x,y,z) what is the corresponding 2D projected point on the viewplane using a parallel projection (the direction of projection is (1,0,0))?
    b. Given an arbitrary point (x,y,z), what is the corresponding 2D projected point on the viewplane using a perspective projection with the center of projection (CoP) at (a,b,c)?

12. A line segment is given by its two endpoints (10,10) and (32,15).
    a. What is the point-slope formula for this line?
    b. What is the parametric equation for this line?

c. Suppose we have a window with lower left corner (8,12), width of 20 pixels and height of 20 pixels. Find the intersections of this line with the edges of the window, and specify the new clipped vertices.

13. Quadrilateral ABCD has vertices at (0,0), (0,75), (30,60), and (20,-10). What are the vertices after ABCD has been clipped to a window 50 units wide and 140 units high, centered at the origin?

14. Derive the equation of the plane (alternate notation) for the plane containing the points (0,0,0), (5,0,0) and (10,10,10).

15. Give a matrix transformation for a rotation about the line through the points (0,10,0) and (0,10,10). *(The transformation may be written out as a product of simple matrix transformations.)*

16. Two triangles, A and B, have been projected onto a window centered at the origin that is 3 units wide and 2 units high.
    The projected vertices for A are: (0,0), (1.4, 1.4), and (1.4, 0).
    The projected vertices for B are: (0.2, 0.9), (0.2, -0.9), and (-2, 0).
    a. Find the locations of these vertices after mapping them to a viewport whose origin is at the lower-left corner, and which is 60 pixels wide by 60 pixels high.
    b. What are the new screen coordinate vertices for triangle B after clipping?