CMSC 435/634 Computer Graphics Midterm Review

These questions are only a study guide. Questions found here may be on your exam, although perhaps in a different format. Questions NOT found here may also be on your exam. Pay attention to homework and project questions. Note that there will be questions about OpenGL programming in the midterm.

For the midterm:

- On Oct 15^{th} 2013
- Closed book
- One double-sided sheet of letter-size notes permitted
- Everything covered in lecture including **Math, Rasterization, Transforms, Viewing, Pipeline, Mesh, and Curves.**

Before the exam:

- Make sure you understand the concepts related to the key objectives of each lecture.

During the exam:

Strategy: Read through the entire question before you begin it. If you get bogged down on a question, go on and come back later. Even if you don't think you know the entire answer to a question, do what you can in order to get partial credit. If something isn't clear to you, ask.

Odds and Ends

1. What is the most amusing bug you've written in this class?
2. Name one graphics fact about Ivan Sutherland (do some research yourself).

Concepts and Terminology

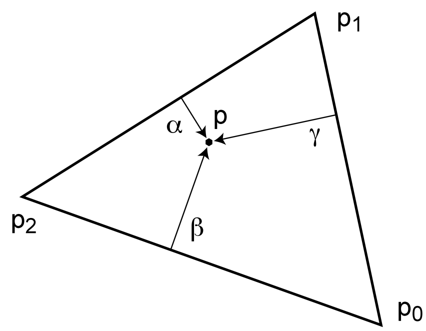
3. Give a short (5 - 10 words) or write an equation if appropriate to define each of the following:

   Dot product; cross product; matrix multiplication; plane normal; triangle normal; line equations; interpolation from a line equation; parametric equation, quadratic equation, homogeneous coordinates; affine transformation; barycentric coordinates; orthogonal (parallel) projection; perspective projection; rasterization; five matrices for computing the pixel coordinates for an object in 3D; vector normalization; graphics pipeline; viewing frustum; Bezier curve; Bezier polygon

Example questions:

a. Write an implicit equation for a sphere at the origin with radius R.
b. Write a parametric equation for a sphere at the origin with radius R.
c. What is the dot product of two vectors, in terms of the length of each vector and the angle between them?

d. What is the length of the cross product of two vectors, in terms of the length of each vector and the angle between them?
e. Give two reasons we use homogeneous coordinates for transformation matrices
f. Barycentric triangle rasterization:



4.

5. $p = \alpha\, p_0 + \beta\, p_1 + \gamma\, p_2$

e.1 How do you compute α, β and γ?

e.2 What are the conditions on a, b and g for a pixel that is inside the triangle?

Display

6. Why do monitors typically have three different phosphers?

7. What is the difference between interlaced and non-interlaced display? Why might you choose one over the other?

8. What are the two coloring techniques commonly used in display technologies?

9. What is a pixel?

10. Why do we use RGB color? What do R, G and B stand for?

Rasterization and Pipeline

11. Describe the Bresenham algorithm for line drawing.
12. Describe the rasterization steps for triangles. How would you color a triangle? How would you compute the normal using the Barycentric coordinates? What is a main benefit of doing this?
13. How do you remove a backface?

Transforms

14. You've been commissioned by the UMBC chess team to create an animation clip for their upcoming series of TV commercials. Your animation will show a chessboard spinning on the tip of the mascot's nose.

a) Rotation angle is a function of time, with the board making three revolutions each second. Initially, the board starts at an angle of zero degrees. Give an equation describing orientation of the board in degrees as a function of time (with t measured in seconds).

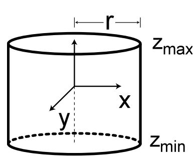
θ(t) =

b) Give the 4x4 transformation matrix which transforms the board into the proper orientation at time **t**, assuming a nose position of **P(x,y,z)**. Assume that the initial position of the board is centered at the origin. You can assume that rotation happens parallel to the floor (which is the XY plane).

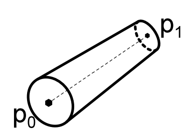
c) What is the value of this matrix when **t** = 7.5 seconds and the mascot's nose is at position **P** = (1, 4, 3)?

15. Assuming we have drawn a cylinder aligned with the z axis, with radius r from zmin to zmax.

    a) How would you build transform functions to create a cylinder of radius r2 between points p0=(x0,y0,z0) and p1=(x1,y1,z1)?



RiCylinder (r, zmin, zmax)



newCylinder(r, x_0,y_0,z_0, x_1,y_1,z_1)

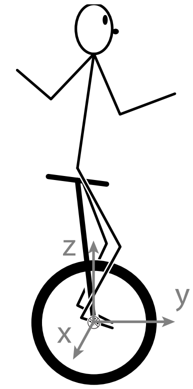
    b) Write the exact OpenGL code for your function newCylinder(r, x0, y0, z0, x1, y1, z1).

16. The OpenGL call, glRotatef(θ, x, y, z), rotates by θ degrees around the vector (x,y,z) through the origin. The rotation is right handed, so if (x,y,z) points toward you, the rotation is counter-clockwise. Write out the 4x4 transformation matrices for glRotatef(θ, 1, 0, 0), glRotatef(θ, 0, 1, 0) and glRotatef(θ, 0, 0, 1).

Viewing

17. You have been asked to model a view from a character on a unicycle. The world coordinates are defined so x and y span the map horizontally and z points up. The unicycle coordinates are centered at the center of the axle, with x pointing right, y pointing forward, and z pointing up.

It may be useful for this problem to know the standard math library function atan2(y, x). This function computes the arctangent of y/x over the full circle, without singularities when x=0, and using the signs of both arguments to correctly determine the quadrant of the resulting angle.

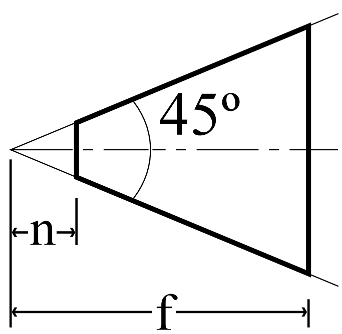


a): If you have a translation function Translate(x,y,z), and three functions to rotate around the coordinate axes, RotateX(θ), RotateY(θ), and RotateZ(θ) (but NO lookAt transform), what sequence of calls transform from world-space to unicycle-space, leaving the unicycle at a world-space location of (u_x, u_y, u_z), pointing in the direction (d_x, d_y)?

b) If the character's head is at (hx, hy, hz) in unicycle-coordinates with horizontal pan angle of q and vertical tilt angle of f, what sequence of calls will transform view space to world space? In view space, the camera should be at the origin, looking down the –z axis, with x pointing right and y pointing up.

c) What are the 4x4 transformation matrices for Translate, RotateX, RotateY, and RotateZ?

18. This is a side-view of a viewing frustum, with the eye at (0,0,0), x axis pointing out of the page, y axis pointing down, and z axis pointing to the right. This frustum has a 45º field of view and near and far planes at n and f:



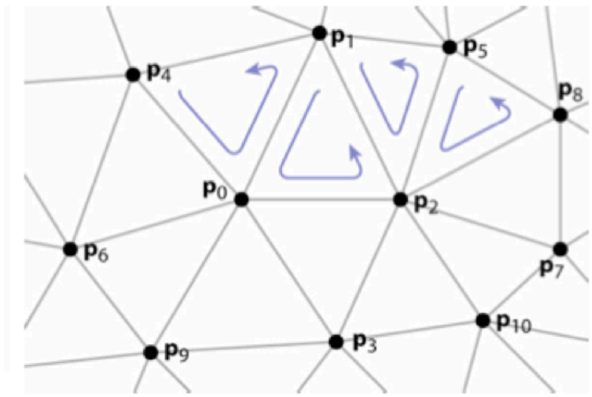
a) What are the eight corners of the frustum?

b) What are the clipping cases? Give an example of each.

Mesh

19. Describe three applications that use mesh.

20. What is the split triangles and index triangles representations? Which one is better and why?
21. List at least three ways to draw triangles in OpenGL and the amount of memory uses for each method.
22. Given a triangle, how to compute the three adjacent triangles?



Curves

23. In the class, we derived the method for transforming curves in canonical form into the polynomial curves. We gave an example of doing so using lines. Now for a curve of $f(u)=-12u^2 + 12u + 1$, find the Bezier representation of degree 3 in the interval [1, 4] and draw the Bezier polygon.