Computer Graphics

(Comp 4190.410)

Midterm Exam: October 25, 2005

1. (15 points) Answer the following questions.
   (a) (3 points) Give an example of line segment for which the Cohen-Sutherland algorithm works better than other line clipping algorithms.
   (b) (4 points) Classify the type of input line segments for which the Cohen-Sutherland algorithm uses the largest number of operations.
   (c) (4 points) Discuss the main difference between line clipping and polygon clipping.
   (d) (4 points) Is it possible to apply the Sutherland-Hodgman polygon clipping algorithm to a non-convex clipping window? Explain why.

2. (10 points) Answer the following questions.
   (a) (5 points) Describe the general procedure for a 3-dimensional viewing transformation.
   (b) (5 points) What is the main motivation for normalization transformation?

3. (10 points) Answer the following questions on antialiasing techniques.
   (a) (5 points) Can you interpret a weighting mask as a filter? Justify your answer.
   (b) (5 points) What is the main computational difficulty in applying filtering techniques? How can we resolve this problem?

4. (20 points) We want to draw a line $L : ax + by + c = 0$ (of slope $m > 1$) from y_0 to $y_n = y_0 + n$, where a, b, c, y_0 are integers. (Note that in our textbook we took $a = \Delta y$ and $b = -\Delta x$.) The corresponding x values at the two end points may not have integer values. Let $x_0 = round(-\frac{by_0+c}{a})$ and take (x_0, y_0) as the starting point for a modified scanline algorithm. On pages 198–199 of the textbook, we use the relation

$$x_{k+1} = x_k + \frac{2\Delta x}{2\Delta y},$$

   and increment a counter with the value of $2\Delta x$ at each step and compare the resulting counter to Δy. However, in our case, the point (x_0, y_0) is not located on the line L; namely, $ax_0 + by_0 + c \neq 0$. The starting value of the counter may not be 0. Discuss how to set the starting value of the integer counter and justify your answer.

5. (15 points) Given a plane in the 3-dimensional space:

$$ax + by + cz + d = 0,$$

   we apply a translation $T(1, 2, 3)$, a scaling transformation $S(3, 2, 1)$, and a rotation $R_x(90°)$ in that order. Compute the resulting plane equation

$$Ax + By + Cz + D = 0,$$

   using the relation: $\hat{\mathbf{n}}^T \cdot M^{-1} \cdot M \cdot \hat{\mathbf{x}} = \hat{\mathbf{n}}^T \cdot \hat{\mathbf{x}} = 0$ for a non-singular transformation M.

6. (20 points) Consider a triangular clipping window with three corners $(0,0), (1,0), (0,1)$.

   (a) (10 points) Discuss how to extend the Cohen-Sutherland line clipping algorithm.

   (b) (10 points) Discuss how to extend the NLN algorithm to this case.

7. (10 points) Fill in the blanks in the following OpenGL problem that draws a triangle with three vertices $(-0.8, -0.5), (0.0, 0.8), (0.8, 0.5)$. The callback function 'display' clears window, describes primitives to draw, and swaps buffers.

```
#include <GL/glut.h>

void display()
{
        __________( GL_COLOR_BUFFER_BIT );

        __________( ______________________ );

                ____________( -0.8f, -0.5f );

                ____________( 0.0f, 0.8f );

                ____________( 0.8f, -0.5f );

        __________();

        __________();
}

int main(int argc, char** argv)
{
        glutInitDisplayMode( GLUT_DOUBLE|GLUT_RGB );
        glutCreateWindow( "OpenGL program for Mid-term exam" );
        glutDisplayFunc( display );
        glutMainLoop();
        return 0;
}
```