Instructions:

This is closed book exam. One 8.5 x 11 page of notes are allowed. Calculators can be used for numerical calculations only (not as electronic notebooks). Please write your answers neatly in the spaces provided. Raise your hand if you have any questions.

Student Name: ____________________

1) Computer Viewing (20 points)

The goal of perspective projection is to transform 3D coordinates (x,y,z) into 2D coordinates on the projection plane. Most graphics systems put the center of projection at (0,0,0) and project 3D points onto the plane z=d, and the projection formulas are: “xp = x * d / z”, and “yp = y * d / z”.

a) Some graphics systems put the center of projection at (0,0,-d) and project 3D points onto the plane z=0. Draw side-view diagrams to show what this would look like.

b) What would the projection formulas for (xp, yp) be in this case?

2) Line Drawing (20 points)

Consider the following simple line drawing code:

```c
int Image[10][10];
void draw_line(int x1, int y1, int x2, int y2, int value)
{
    // Calculate step size
    int dx = x2 - x1;
    int dy = y2 - y1;
    double step = (double)dx / (double)dy;

    // Draw points on line
    double x = x1 + 0.5;
    for (int y = y1; y <= y2; y++)
    {
        Image[y][((int)x)] = value;
        x += step;
    }
}
```
a) Which pixels are modified when we draw a line from (2,2) to (4,8)?

b) What would happen if the line we draw has \( dy < dx \)?

c) What would happen if the line we draw has \( dy < 0 \)?

3) **Hidden Surface Removal (20 points)**

Assume that you are given \( N \) convex polygons with \((x,y,z)\) coordinates for each vertex.

a) Describe the major steps in the painters algorithm for hidden surface removal.

b) Illustrate an example with several polygons where the painters algorithm will fail.

c) Give one advantage of the painters algorithm over the Z-buffer algorithm.

4) **Shading Models (20 points)**

The Phong shading model simulates diffuse (\( D \)), specular (\( S \)), and ambient (\( A \)) reflections of light off objects with known light reflection properties (\( Kd, Ks, Ka \)). When a light source is pure white, the output intensity is given by: \( I = Kd \times D + Ks \times S + Ka \times A \).

a) Use diagrams and equations to explain the \( D \) term in the equation above.

b) Use diagrams and equations to explain the \( S \) term in the equation above.

5) **Polygon Drawing (20 points)**

Assume that your task is to draw a polygon with coordinates (0,0), (2,6), (4,8), (9, 3), with a solid color (R,G,B).

a) Describe the major steps in the “flood fill” polygon drawing algorithm.

b) Draw a diagram to illustrate how the algorithm would fill in the polygon above.