HÁSKÓLINN Í REYKJAVÍK
REYKJAVIK UNIVERSITY

Computer Graphics
T- 511 – TGRA

Final Exam

Teacher: Kári Halldórsson

Date: 23. November, 2018

Time: 14:00 - 17:00

Helping materials: non-programmable calculator

Name: _____

Kt.: _____

Answers can be given in English and/or Icelandic.

1. **(10%) Rasterization**
   Describe the process of rasterization in OpenGL, considering the following questions:
   - Where in the OpenGL pipeline does it occur, and what is its purpose?
   - How does the algorithm work and what are its inputs?
   - What values does it affect and which processes does it run?

2. **(10%) Depth testing**
   Describe the process of depth testing in OpenGL.
   What is the purpose of it?
   What values are used and how, and where/when are they calculated?
   How is the data processed between different parts of the calculations?

3. **(10%) Shaders**
   Describe the input and output of the OpenGL pipeline's two main shaders, considering the following questions:
   What types of "global" variables can be defined in each shader?
   How are the values of each type of variable affected?
   What main output variable is set in each shader?

4. (10%) Cohen-Sutherland Clipping

A clipping window has the following geometry:

Window(left, right, bottom, top) = (-16, 16, -9, 9)

A line with the following end points is drawn in the world:

P1: (22, 11)
P2: (10, 5)

Show how the Cohen-Sutherland clipping algorithm will clip these lines and what their final endpoints, if any, are. Show the coordinate values of P1 and P2 after each pass of the algorithm.

5. **(10%) Window-2-Viewport mapping**
   A second line is drawn into the same window as in the previous example (4. Cohen-Sutherland clipping). This line has the endpoints:
   P1 = (-5, 7) & P2 = (12, -2)
   In which pixels on a 1920x1080 viewport (bottom left corner (0,0)) will the line's endpoints be rendered?

6. (40%) Matrices and transformations

a) (10%)
A camera is set up to be positioned in (-2, 3, 1)
looking at the point (1, -1, -1).
It has an up vector (0,1,0).
Find the values for the camera's coordinate frame, clearly showing each of the four parts of the coordinate frame and what they are.

b) (5%)
Show how this coordinate frame would commonly be represented in a matrix. What matrix is this and what are its values in this particular case?

c) (10%)
The camera should have a field of view of 120°, an aspect ratio of 16:9, a near plane at 1 and a far plane at 10. Find the exact values for a matrix that calculates this camera.
Which matrix in your shader should be set to these values?

d) (10%)
Vertex data should be drawn into a coordinate frame that has been first scaled double in all dimensions, then rotated by 30° about the z-axis and finally translated by (2, 4, 7).
Represent this coordinate frame in a matrix. Which matrix would this commonly be?

e) (5%)
A vertex is run through the vertex shader.
It has the position values (1, 1, 1).
Given the matrix values calculated in parts a, b & c, what value will the vertex have in clip coordinates?
Will this vertex be within the viewing volume and thus (other tests notwithstanding) be rendered as part of the final image? Explain.

7. **(10%) Lighting Calculations**

A single light is in the light model in an OpenGL program. It has the ambient values (0.0, 0.0, 0.0), diffuse values (0.5, 0.3, 0.7), specular values (0.3, 0.8, 0.7) and position (-3.0, -2.0, 2.0). There is also a global ambient factor of (0.3, 0.2, 0.4) in the light model. A camera is positioned in (3.0, 3.0, 4.0) and looks towards P.

P has the color values: ambient (0.4, 0.7, 0.3), diffuse (0.4, 0.7, 0.2) and specular (0.6, 0.6, 0.6). It has a shininess value of 21. It has the position (0.0, 1.0, 1.0) and a normal (-1.0, -1.0, 3.0).

What will be the red color value for P on the screen?

Bonus 3%
In which movie does the following dialog occur?
Who is character A?
Who is character B?

A: Your friend is quite a mercenary. Wonder if he really cares about anything… or anybody.
B: I care!