CS 543 – Fall 2018 – Exam 2

Name:

Instructions: Read questions carefully before answering. Do not hesitate to ask for clarifications. Show all work. Note: Partial credits are given, so do not leave anything blank! Ask for extra paper if you need some. Good luck!

Question 1 (20 points): Brief Descriptions/OpenGL

Give brief descriptions of the following/Fill in the blanks:

a. (4 points) Name two light abstractions supported by OpenGL

b. (4 points) What is depth compression, which occurs during perspective transformation?

c. (4 points) During transmission of the light vector through a refractive object, when light goes from a medium to a less dense medium, the light vector is bent ______________ the normal, and when light goes from a medium to a more dense medium the light is bent ______________ the normal

d. (4 points) Pitch of a Camera

e. (4 points) What’s the difference between an isotropic and an anisotropic material?
Question 2 (15 points): Texture Mapping

a. (10 points) During cube mapping, the reflected vector \( \mathbf{R} \) is calculated as \((x,y,z) = (-6,-4,3)\). Using \( \mathbf{R} \) to look up the cube map, what face of the cube is looked up? What are the values of \( s \) and \( t \) used to perform this look up?

b. (5 points) OpenGL requires that the dimensions (Width, Height) of textures should be powers of 2. If you want to use a texture with dimensions that are NOT powers of 2, what are two options to fix this?

Question 3 Lighting and Shading (20 points)

a. (4 points) Explain how toon shading is done.
a) (16 points) Assuming that the vertices of a 2D polygon have the properties described in Table 1, what is the RGB color at location (70, 60) when Gouraud shading is used?

<table>
<thead>
<tr>
<th>Vertex</th>
<th>X, Y</th>
<th>R, G, B (after Phong lighting model has been applied)</th>
</tr>
</thead>
<tbody>
<tr>
<td>V₁</td>
<td>10, 20</td>
<td>100, 200, 10</td>
</tr>
<tr>
<td>V₂</td>
<td>90, 20</td>
<td>200, 10, 100</td>
</tr>
<tr>
<td>V₃</td>
<td>90, 120</td>
<td>10, 100, 200</td>
</tr>
<tr>
<td>V₄</td>
<td>10, 120</td>
<td>10, 100, 200</td>
</tr>
</tbody>
</table>
Question 4: Projection (15 points)

a) (10 points) For orthographic projection, we project the original view volume (cuboid) onto the Canonical (default) View Volume (CVV). DirectX, another graphics API, does a similar orthographic projection except that its version of the CVV is shortened along the z-axis, and ranges from 0 to 1 instead of –1 to 1 for the CVV in OpenGL. The x and y ranges are the same for both DirectX and OpenGL (1) Write out the 4x4 matrix for the OpenGL orthographic projection matrix and (2) On your OpenGL 4x4 matrix, circle what matrix elements would be different for DirectX.

b) (5 points) After applying the matrix in part a to the vertices of a straight line, how would straight lines with directions that are perpendicular to the z axis before transformation get transformed?
5 Hierarchical 3D Transformations (15 points)

Consider the start scene shown in Figure 1a with the X, Y, and Z axes demarcated by red, green, and blue arrows, respectively, and a teapot drawn at the origin. Given the OpenGL fragment shown in Figure 1b, circle the letter below the scene from among the four choices that best matches the scene that would result from the code fragment. Assume that the final value of the ctm is passed to the vertex shader and applied to an untransformed teapot.

```cpp
PushMatrix( );
    ctm *= Translate( 0.0, 75.0, 0.0 );
    ctm *= Rotate( 90.0, 0.0, 0.0, 1.0 );
    ctm *= Translate( 75.0, 0.0, 0.0 );
    ctm *= Rotate( -180.0, 0.0, 1.0, 0.0 );
    ctm *= Rotated( 90.0, 0.0, 0.0, 1.0 );
    ctm *= Scale( 15.0, 15.0, 15.0 );
drawSolidTeapot( );
PopMatrix( );
```

Figure 1: (a) Start scene. (b) Additional OpenGL code.

Options:
- a.
- b.
- c.
- d.
- e. None of the above
Question 6: Viewing (15 points)

Using the header file mat.h in your projects, a programmer made the following sequence of commands.

vec3 eye = (4,4,4);
vec3 look = (0,1,0);
vec3 up = (2,1,0);

m = lookAt(eye, look, up);

The variable m then contained the following 4x4 matrix.

\[
\begin{pmatrix}
a & b & c & d \\
e & f & g & h \\
i & j & k & l \\
m & n & o & p \\
\end{pmatrix}
\]

(15 points) What would the values of the matrix elements e, f, g in the matrix above? (Show all your work!!!)