Student ID:								

CS-112: Introduction to Computer Graphics

Midterm - Winter 2020

3/3/2020

Total Points: 60

Name: ______________________________

Pledge: I neither received nor gave any help from or to anyone in this exam.

Signature: ______________________________

Useful Tips

1. All questions are multiple choice questions --- please indicate your answers very clearly. **Please circle your choice clearly**.
2. **Some questions have more than one answer. Full credit is given for marking all the correct answers.**
3. Use the blank pages as your worksheet. Put the question number when working out the steps in the worksheet. Also, do your work clearly. This will help us give partial credit.
4. If you need more work sheets, feel free to ask for extra sheets.
5. Staple all your worksheets together with the paper at the end of the exam. If pages of your exam are missing since you took them apart, we are not responsible for putting them together.
6. **The number of minutes you should spend on each question is roughly equal to the number of points assigned to the question.**

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1) [4+4+3+2+2+3=18] Consider a gray world with no ambient and specular lighting (only diffuse lighting). The screen coordinates of a triangle $\mathbf{P_1P_2P_3}$ are P_1 = (100,100), P_2 = (300, 150), P_3 = (200, 200). The gray values at P_1, P_2 and P_3 are ½, ¾, and ¼ respectively. Light is at infinity and its direction and gray color are (1,1,1) and 1.0 respectively. The coefficient of diffuse reflection is ½. The normals at P_1, P_2 and P_3, are N_1=(0,0,1), N_2=(1,0,0) and N_3=(0,1,0) respectively. *(Note: Assume the z coordinates of the three points P_1, P_2, and P_3 to be 0). **No need to normalize the normal**).*

a. The illumination at the three vertices P_1, P_2 and P_3, are given by:

i. (1/2, 3/4, 1/4)
ii. (1/4, 3/8, 1/8)
iii. (1/2,1/2,1/2)

b. The interpolation coefficients of a point P inside the triangle whose coordinates are (220,160) are given by:

i. (2/5, 1/5, 2/5)
ii. (1/4, 3/8, 3/8)
iii. (1/5, 2/5, 2/5)
iv. (1/4, 1/2, 1/4)

c. The illumination at P using Gouraud Shading is:

i. 15/32
ii. 1/4
iii. 9/40
iv. 1/2

d. The interpolated normal at P is given by:

i. (2/5, 2/5,1/5)
ii. (1/5, 2/5, 2/5)
iii. (1/2, 1/4,1/4)
iv. (3/5, 1/5, 1/5)

e. The interpolated color at P is given by:

i. 1/5
ii. 1/2
iii. 1/4
iv. 3/8

f. The illumination at P using Phong Shading is:

i. 15/32
ii. 1/4
iii. 9/40
iv. 1/2

2) [2+1+3=6] You are given a display which has a gray intensity resolution of 16 (4 bits).

a. The most common artifact of this limited resolution is

- **i.** Blurring
- **ii.** Pixelation
- **iii. Contouring**

b. You would like to increase your intensity resolution to 29. What technique would you use?

- **i.** Anti-Aliasing
- **ii. Dithering**
- **iii.** Quantization

c. This will come at the cost of sacrificing the spatial resolution by what factor in each dimension?

- **i.** 1
- **ii. 2**
- **iii.** 4
- **iv.** 8

3) [2+2+2=6] Consider a 1-D texture of size 256.

a. The minimum number of pixels on a line that is texture mapped using this 1D texture is:

- **i.** 256
- **ii.** 128
- **iii. 512**

b. Texture mapping a line of 128 pixels with this 1-D texture will lead to:

- **i.** Blurring
- **ii. Aliasing**
- **iii.** Screen-door effect

c. In order to alleviate this artifact, we can filter the 1-D image to:

- **i.** 32 pixels
- **ii. 64 pixels**
- **iii.** 128 pixels
- **iv.** 256 pixels
- **v.** 512 pixels

4) [2+2=4] You are rendering a scene where particle moves in a sinusoidal wave that makes 40 cycles in 1 sec.

a. What is minimum frame rate at which you should render the scene to avoid aliasing artifacts?

i. 10 fps
ii. 60 fps
iii. 40 fps
iv. 80 fps

b. When you render the scene in an artifact free manner at this frame rate and apply post processing to get to 20 fps, what kind of artifact would you see?

i. Spatial Aliasing
ii. Temporal Aliasing
iii. Motion blur
iv. Spatial Blurring

5) [5+4=9] Consider a triangle $P_1P_2P_3$ in 3D whose screen coordinates after the projection transformation is given by P_1 = (100,100), P_2 = (300,200), P_3 = (200, 200). Their depths are 10, 20 and 40 respectively.

a. The interpolation coefficients of a point P inside the triangle whose coordinates are (200,175) is given by

i. 1/3, 1/3, 1/3
ii. ¼, ¼, ½
iii. ½, ¼, ¼
iv. ¼, ½, ¼

b. The closest integer to the depth of the point P is given by

i. 17
ii. 23
iii. 27
iv. 20
v. 15
vi. 18

6) [3+5=8] Consider the following notation for scaling and translations:

$$S(a,b,c) = \begin{pmatrix} a & 0 & 0 & 0 \\ 0 & b & 0 & 0 \\ 0 & 0 & c & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}, \quad T(r,s,t) = \begin{pmatrix} 1 & 0 & 0 & r \\ 0 & 1 & 0 & s \\ 0 & 0 & 1 & t \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

And the following notation for rotations around the x-axis (and similar notation for $R_y(\beta)$ and $R_z(\beta)$).

$$R_x(\beta) = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos\beta & -\sin\beta & 0 \\ 0 & \sin\beta & \cos\beta & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

Next, consider the following OpenGL code.

```
double A [16], B [16], C [16];
glMatrixMode (GL_MODELVIEW);
glLoadIdentity ();
glTranslated (8.0, 2.0, -4.0);
glPushMatrix ();
glScaled (2.0, 3.0, 1.0);
glMultMatrixd (B);
glGetDoublev (GL_MODELVIEW_MATRIX, C);
glPopMatrix ();
glRotated (40.0, 0.0, 1.0, 0.0);
glScaled (2.0, -1.0, 3.0);
glMultMatrixd (C);
glRotated (-120.0, 1.0, 0.0, 0.0);
glGetDoublev (GL_MODELVIEW_MATRIX, A);
```

a. The value of matrix C in terms of product of *B, S, T, R_x, R_y, R_z* is:

i. *B S(2,3,1) T(8,2,-4)*
ii. *T(8,2,-4) B S(2,3,1)*
iii. ***T(8,2,-4) S(2,3,1) B***
iv. *S(2,3,1) B T(8,2,-4)*

b. The value of matrix A in terms of product of *B, S, T, R_x, R_y, R_z* is:

i. *R_y(40) T(8, 2, -4) S(2,-1,3) C R_x(120)*
ii. ***T(8, 2, -4) R_y(40) S(2,-1,3) C R_x(120)***
iii. *R_x(120) C S(2,-1,3) R_y(40) T(8, 2, -4)*
iv. *S(2,-1,3) R_y(40) T(8, 2, -4) C R_x(120)*

7) [5] Consider a projector whose 2D color gamut, defined by the chromaticity coordinates of its R, G, B primaries, is R(0.6,0.3), G(0.3,0.6) and B(0.1,0.1).

a. In what proportions should the R, G and B primaries be mixed to produce a display with white point (0.3,0.3)?

- **i.** *(1/7, 3/7, 3/7)*
- **ii.** ***(2/7, 2/7, 3/7)***
- **iii.** *(4/7, 1/7, 2/7)*
- **iv.** *(1/7, 1/7, 5/7)*

8) [1+1+2=4] Consider an octree data structure for spatial subdivision being used for view frustum culling.

a. Each node of an octree has:

- **i.** 2 children
- **ii.** 4 children
- **iii.** **8 children**
- **iv.** 16 children

b. If the bounding volume of the root of the octree is known, you can calculate the bounding volume of:

- **i.** Only the level 1 nodes
- **ii.** **All the other nodes**
- **iii.** Only the leaf nodes

c. View frustum culling is effectively finding:

- **i.** **A cut of the octree**
- **ii.** Height of the octree
- **iii.** Ordered traversal of the octree