CSE Computer Graphics Spring 2015 Final UTA

NAME:

Prob #	1	2	3	4	5	6	7	8
Points	6	12	12	15	16	16	14	9

Time: 80 Minutes

NOTES:

a. **Credit is only given to the correct numerical values.**
b. **All numerical values must be calculated with three digits of accuracy after the decimal point.**
c. **Do not write on the back side of the papers.**

1. In a ray tracing problem, given the equation of a ray $\begin{cases} x(t) = -t + 3 \\ y(t) = -4t + 13 \\ z(t) = -2t + 6 \end{cases}$ and a sphere centered at (1,0,2) with radius 5. Find the reflection ray.

Intersection point is (1,5,2).

N = (1,5,2) – (1,0,2) = (0,5,0)
L=(-1,-4,-2)

$$R = 2N(N \cdot L) - L$$

2. Given the triangle ABC in a three dimensional right-handed coordinate system,
A=(1,1,0), B=(6,1,0), C=(1,5,0)
Given the intensities at points A=1200 , B=2400 , and C=2800.

Find the intensity at point P(2,3,0) using Gouraud interpolative shading

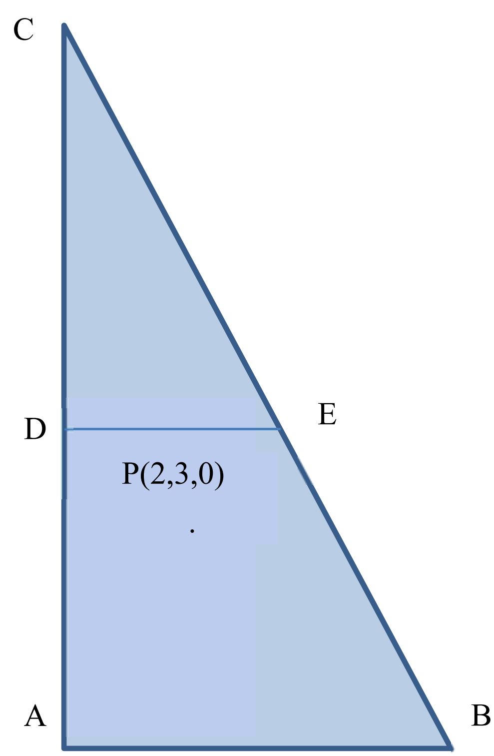
$$v_p = v_1 - (v_1 - v_2)\frac{(P_1 - P)}{(P_1 - P_2)}$$

$$I_D = 2800 - (2800 - 1200)\frac{(5-3)}{(5-1)} = 2000$$

$$I_E = 2800 - (2800 - 2400)\frac{(5-3)}{(5-1)} = 2600$$

$$x_E = 6 - (6-1)\frac{(5-3)}{(5-1)} = 3.5$$

$$I_p = 2000 - (2000 - 2600)\frac{(1-2)}{(1-3.5)} = 2240$$



3. Equation of a parametric surface is given as

$$x(u,v) = 60\,u^2v^2 + 24\,uv^2 + 12\,u\,v - 4\,v$$
$$y(u,v) = 18\,u^2v - 20\,u^2 + 12\,u\,v + 10u$$
$$z(u,v) = 24\,u^2\,v^2 + 6\,u\,v - 20$$

Find the normalized normal to this surface at point corresponding to u=0.5 and v=0.25

Normal to the surface @ u=0.5 and v=0.25 is: ____________________________

Normalized normal is: _________________________

$$\begin{cases}\frac{dx}{du} = 120uv^2 + 24v^2 + 12v \\ \frac{dy}{du} = 36uv - 40u + 12v + 10 \\ \frac{dz}{du} = 48uv^2 + 6v\end{cases} \quad \text{and} \quad \begin{cases}\frac{dx}{dv} = 120u^2v + 48uv + 12u - 4 \\ \frac{dy}{dv} = 18u^2 + 12u \\ \frac{dz}{dv} = 48u^2v + 6u\end{cases}$$

$$@u = 0.5, v = 0.25\begin{cases}\frac{dx}{du} = 8.25 \\ \frac{dy}{du} = -2.50 \\ \frac{dz}{du} = 3.00\end{cases} \quad \text{and} \quad @u = 0.5, v = 0.25\begin{cases}\frac{dx}{dv} = 15.50 \\ \frac{dy}{dv} = 10.50 \\ \frac{dz}{dv} = 6.00\end{cases}$$

N = [-46.50 -3.00 125.375] Or N = [46.50 3.00 -125.375]
N = [-0.348 -0.0224 0.937] Or N = [0.348 0.0224 -0.937]

4. Consider a parametric surface S(u,v). This surface is quadric in the u direction and linear in the v direction. The parametric equations of the two curves at the two boundaries are given:
Parametric equation of the curve corresponding to v=0: **C0(u) = u² +2u**
Parametric equation of the curve corresponding to v=1: **C1(u) = 3u²+5u-4**

a. Find the coefficient matrix C for this surface.(You MUST show the numerical values of the matrix C . No partial grade will be given for an incomplete solution)

$$S(u,v) = \begin{bmatrix} u^2 & u & 1 \end{bmatrix} \begin{bmatrix} c_{11} & c_{12} \\ c_{21} & c_{22} \\ c_{31} & c_{32} \end{bmatrix} \begin{bmatrix} v \\ 1 \end{bmatrix}$$

$S(u,v) = c_{11}u^2v + c_{12}u^2 + c_{21}uv + c_{22}u + c_{31}v + c_{32}$
$@v = 0 \quad S(u,0) = c_{12}u^2 + c_{22}u + c_{32}$
⇨ $\boldsymbol{c_{12} = 1, c_{22} = 2, c_{32} = 0}$

$@u = 0 \quad S(0,v) = c_{31}v + c_{32}$
⇨ $\boldsymbol{c_{31} = -4}$

$@v = 1 \quad S(u,1) = c_{11}u^2 + c_{12}u^2 + c_{21}u + c_{22}u + c_{31} + c_{32}$
⇨ $\boldsymbol{c_{11} = 2, c_{21} = 3}$

b. Find the equation of the curve corresponding to v=0.5

$$S(u,0.5) = 2\,u^2 + 3.5u - 2$$

5. The viewing parameters for a perspective projection are given as:

VRP(WC)=(**0,0,0**) VPN(WC)=(**0, 0,1**)
VUP(WC)=(**0,1,0**) PRP (VRC)=(**2,8,10**)

u_{min} (VRC) = **-3** u_{max} (VRC) = **5**
v_{min} (VRC) = **-15** v_{max} (VRC) = **5**
n_{min} (VRC) = **13** n_{max} (VRC) = **15**

Find the sequence of transformations which will transform this viewing volume into a unit cube which is bounded by the planes: x=z ; x=-z ; y=z ; y=-z ; z=zmin ; z=1

a. Find the **Translation matrix** (Matrix #5)
b. Find the **Shear matrix** (Matrix #6)
c. Find the **scale matrices** (Matrix #7 and Matrix #8).
d. Find the **zmin** after all transformations are done.

Matrix #2: Rx

1	0	0	0
0	1	0	0
0	0	1	0
0	0	0	1

Matrix #1: Translate

1	0	0	0
0	1	0	0
0	0	1	0
0	0	0	1

Matrix #4: Rz

1	0	0	0
0	1	0	0
0	0	1	0
0	0	0	1

Matrix #3: Ry

1	0	0	0
0	1	0	0
0	0	1	0
0	0	0	1

Matrix #6: Shear

1	0	-0.10	0
0	1	-1.30	0
0	0	1	0
0	0	0	1

Matrix #5: Translate

1	0	0	-2
0	1	0	-8
0	0	1	-10
0	0	0	1

Matrix #8: Scale

Matrix #7: Scale

0.50	0	0	0
0	0.20	0	0
0	0	0.20	0
0	0	0	1

Zmin= 0.6

6. Given the triangle ABC in a three dimensional right-handed coordinate system,
A=(0,0,3), B=(8,0,3), C=(5,6,3)
The light source with an intensity of I=10000 is located at (7,1,6) and the viewer (eye) is located at (3,4,7) and K_a=0 ; K_d=0.5 ; K_s=0.2 ; n=2

Given point P(3,1,3) on the triangle ABC:

a. Find the diffuse intensity at point P
Notes:
Do not use any shading model and ignore f_{att}

$\overrightarrow{AB} = (8,0,3) - (0,0,3) = (8,0,0)$
$\overrightarrow{AC} = (5,6,3) - (0,0,3) = (5,6,0)$
$\vec{N} = \overrightarrow{AB} X \overrightarrow{AC} = (0,0,48)$
$\hat{N} = (0 \;\; 0 \;\; 1)$
$\vec{L} = (7,1,6) - (3,1,3) = (4,0,3)$
$\hat{L} = (0.8 , 0 , 0.6)$
$I_{Diffuse} = I * k_d * (\hat{N} \cdot \hat{L}) = 10000 * 0.5 * 0.6 = 3000$

b. Find the specular intensity at point P from the viewer's point of view

- Do not use any shading model and ignore f_{att}
-
- $\vec{V} = (3,4,7) - (3,1,3) = (0,3,4)$
- $\hat{V} = (0 \;, 0.6 , 0.8)$
- $\hat{R} = 2 * \hat{N} * (\hat{N} \cdot \hat{L}) - \hat{L} = (-0.8 \; 0 \; 0.6)$
- $\hat{R} \cdot \hat{V} = 0.48$
- $I_{Specular} = I * k_s * (\hat{R} \cdot \hat{V})^n = 460.8$

7. Answer each question.

a) How many triangles are drown if we use six vertices between glBegin(GL_TRIANGE_FAN) and glEnd()?

Answer: ___4____

b) Given the RGB values of a point, R=0.5, G=0.6, B=0.2, Find the CMYK values of that point:

C = 1-R=1-0.5=0.5
M = 1-G=1-0.6=0.4
Y = 1-B=1-0.2=0.8
K = min(C,M,Y)=0.4

c) All calls to "glVertex3d" should occur between which two other calls?

glBegin()______________
glEnd()_________________

d) The location of a point light influences the ambient intensity.
- ☐ True
- ☐ False

e) For a given point, the diffuse value depends on the location of the observer.
- ☐ True
- ☐ False

f) In the Phong's illumination model, the higher values of the exponent, n, corresponds to more highlights.
- ☐ True
- ☐ False

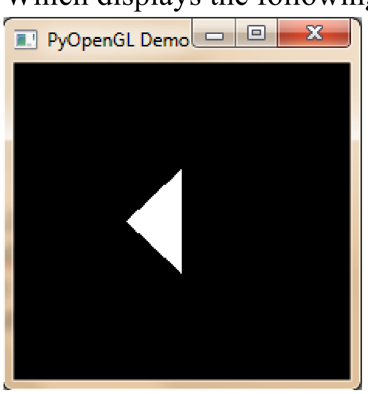
g) The origin of the RGB cube (0,0,0) corresponds to Red.
- ☐ True
- ☐ False

8. Consider the following OpenGL program:

```
from OpenGL.GL import *
from OpenGL.GLU import *
from OpenGL.GLUT import *
def display():
	glClear(GL_COLOR_BUFFER_BIT)
	glBegin(GL_TRIANGLES)
	glColor3f(1,1,1)
	glVertex3f(-1,0,0)
	glVertex3f(1,0,0)
	glVertex3f(0,1,0)
	glEnd()
	glFlush()
	glutSwapBuffers()
glutInit(sys.argv)
glutInitDisplayMode(GLUT_DOUBLE|GLUT_RGB)
glutCreateWindow(b"PyOpenGL Demo")
glutDisplayFunc(display)
glMatrixMode(GL_PROJECTION)
glLoadIdentity()
glRotate(90,0,0,1);

glFrustum(-1,1,-1,1,1,30)
gluLookAt(0,0,3,0,0,0,0,1,0)
glMatrixMode(GL_MODELVIEW)
glLoadIdentity()
glutMainLoop()
```

Which displays the following:



a. If the code in line 23 is replaced with:

```
gluLookAt(0.0, 0.0, 3.0,  1.0,  0.0,  0.0,  0.0,  1.0,  0.0)
```

What happens to the image on the screen? (all other lines stay the same).

- ☐ The size of the image of the object on the screen get larger
- ☐ The size of the image of the object on the screen get smaller
- ☐ The image of the object on the screen moves down
- ☐ The image of the object on the screen moves up
- ☐ The image of the object on the screen rotate clockwise
- ☐ The image of the object on the screen rotate counter-clockwise
- ☐ Nothing changes

b. If the code in line 22 is replaced with :

```
gluFrustrum(-1, 1, -1, 1, 0.5, 30)
```

What happens to the image on the screen? (all other lines stay the same).

- ☐ The size of the image of the object on the screen get larger
- ☐ The size of the image of the object on the screen get smaller
- ☐ The image of the object on the screen moves to the right
- ☐ The image of the object on the screen moves to the left
- ☐ The image of the object on the screen rotate clockwise
- ☐ The image of the object on the screen rotate counter-clockwise
- ☐ Nothing changes

c. If we add this code to line 21:

```
glRotate(15.0, 0.0, 0.0,  1.0)
```

What happens to the image on the screen? (all other lines stay the same).

- ☐ The size of the image of the object on the screen get larger
- ☐ The size of the image of the object on the screen get smaller
- ☐ The image of the object on the screen moves down
- ☐ The image of the object on the screen moves up
- ☐ The image of the object on the screen rotate clockwise
- ☐ The image of the object on the screen rotate counter-clockwise
- ☐ Nothing changes