CS559 Final Exam

Please write you login on ALL pages and check to make sure you have all 8 pages!

This exam is designed to take between 40-70 minutes, but you will have the entire exam period to complete it.

Note: The exam is out of 130 points NOT out of 100

Q1: ____ of 30 pts
Q2: ____ of 32 pts
Q3: ____ of 20 pts
Q4: ____ of 21 pts
Q5: ____ of 27 pts

Total: ___ / 130 pts

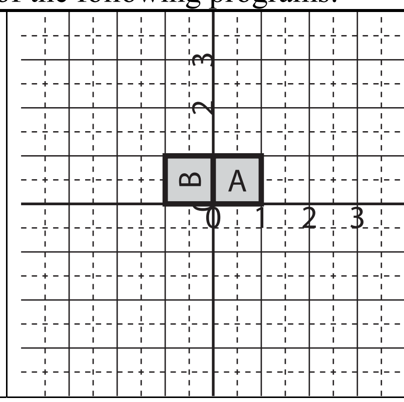
1. Transformations: (30pts)

A 2D graphics system uses a matrix stack (similar to OpenGL), and performs its transformation commands in local coordinates (again, like OpenGL). It has the following commands:

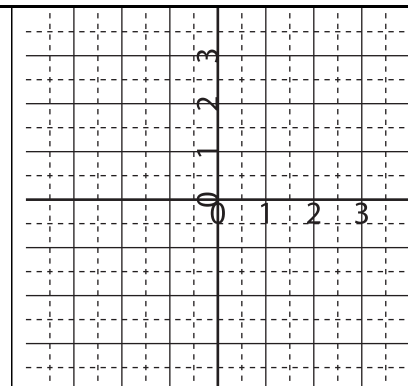
```
Translate x,y
Rotate t          (rotates counterclockwise around the origin)
PushMatrix
PopMatrix
Scale x,y
DrawLetter L          (draws a unit square from (0,0)->(1,1) with the letter L in it)
```

Sketch the output of the following programs:

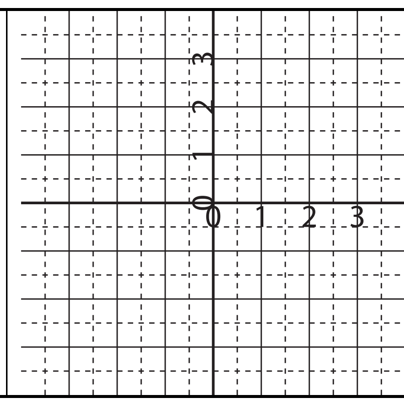
Example:
DrawLetter "A"
Rotate 90
DrawLetter "B"



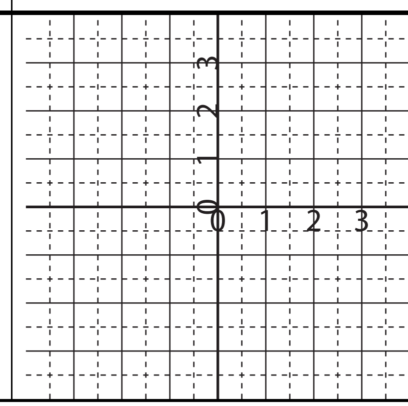
1A:
PushMatrix
Translate 0,2
DrawLetter "A"
PopMatrix
Translate 2,0
DrawLetter "B"



1B:
Translate 2,0
PushMatrix
Scale 3,1
Rotate 45
DrawLetter "A"
PopMatrix
Translate -2,0
DrawLetter "B"

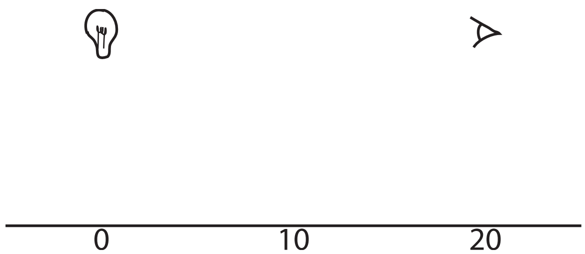


1C:
Rotate 180
PushMatrix
Translate 2,0
Rotate -90
Translate 2,0
DrawLetter "A"
PopMatrix
Translate 0,-1
DrawLetter "B"



2. Lighting and Shading: (32 points)

(Assume everything in this question is in the Z=0 plane, and that the Phong lighting model is used).
A point light source L is placed at (0,10,0). The eye point E is placed at (20,10,0).

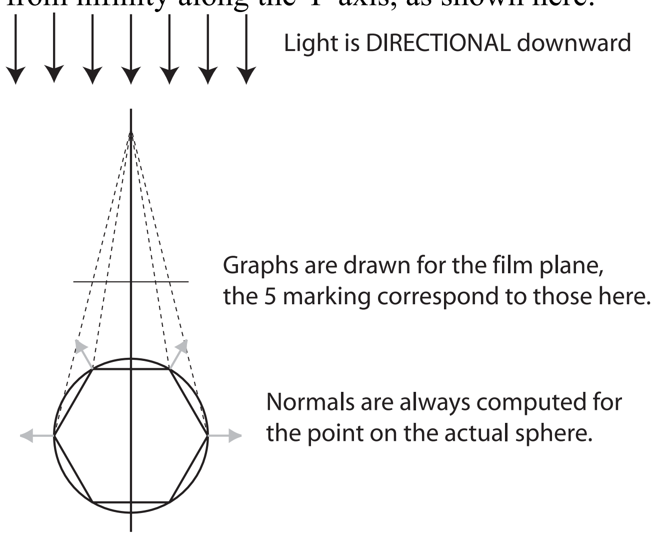


Place an X on the point on the ground where the specular component of the lighting has its maximum brightness.

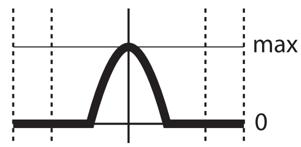
Place an O circling the point on the ground where the diffuse component of the lighting has maximum brightness.

2. Lighting and Shading (continued)

A sphere at the origin is approximated by a very small number of polygons. The camera is placed at (0,20,0) and faces the sphere. A directional light source sends light downward from infinity along the Y-axis, as shown here:



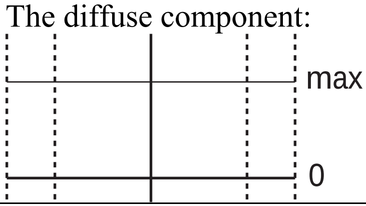
Specular brightness along the X-axis for the actual sphere.



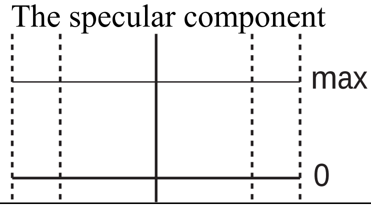
If the actual sphere (not the polygonal approximation) was lit perfectly, the specular component of the light along the film plane (in the X-direction for Z=0) is shown in the graph on the right. For the following questions, sketch a similar graph. (the important thing is the rough shape)

If FLAT SHADING is used, graph the brightness along the film plane for:

The diffuse component:

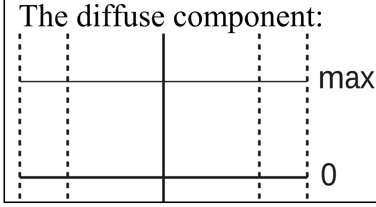


The specular component

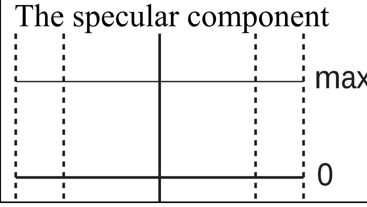


If GOURAUD SHADING is used, graph the brightness along the film plane for:

The diffuse component:

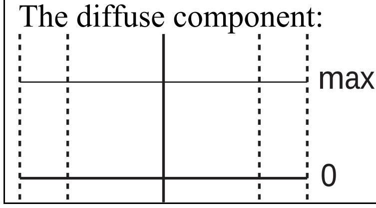


The specular component

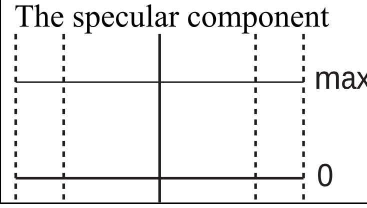


If PHONG Shading is used, graph the brightness along the film plane for:

The diffuse component:



The specular component



3. Rendering (20pts)

A cubic room is painted with matte paint (that is, it does not reflect light specularly). The back wall is painted red. The right side wall is painted blue. The other walls, ceiling, and floor are painted white. A perfectly mirrored (that is, it does not reflect light diffusely) sphere is placed at its center. A white point light source is placed in the ceiling. The camera is in the center of the front wall facing the sphere.

You may assume that the direct lighting on the walls is brighter

The following renderers were used to create an image of the scene:

1) a polygon rasterizer using the painter's algorithm, phong lighting, and goraud shading
2) a scanline renderer with Z-buffer, phong lighting, and phong shading
3) a backwards (standard) ray-tracer using phong lighting and goraud shading
4) a radiosity renderer (using the lambertian linearization)
5) a Monte-Carlo sampling bi-directional ray-tracer Phong lighting and Goraud shading
6) a Monte-Carlo sampling bi-directional ray-tracer Phong lighting and Phong shading

These renderers all implemented the basic algorithms (with no extra hacks like environment maps). All of the surfaces were finely tessellated.

The following is a list of visual effects that would be seen in a real photograph. For each one, list which of the above renderers would show the effect.

1) There is a small bright spot on the sphere from the direct reflection of the light source.

2) There is a reddish tint to the side walls that is more red closer to the back wall

3) There is are bright red marks on the side walls where the mirror reflects the light bouncing off the back wall onto the them

4) A portion of the sphere is blue where it is reflecting the right side wall.

5) The side walls are lighter at the top than at the bottom.

Question 4: Graphics Methods (21 pts)

Here are some graphics techniques that we learned about in class:

1. Marching Cubes
2. Texture Mapping
3. Direct Volume Rendering
4. Displacement Mapping
5. Trim Curves
6. Catmull-Clark Subdivision Surfaces
7. Brezenham's algorithm
8. DeCasteljau's algorithm
9. Modified Butterfly Subdivision Surfaces
10. Procedural Noise
11. Environment Mapping
12. Bump mapping
13. NURBS
14. Spherical Linear Interpolation
15. Quicktime VR

Write down the numbers of ALL the methods that are appropriate for the following problems. If there are none, say "none."

NOTE: there are penalties for both missing right answers as well as listing wrong answers!

A) Hard with Parametric Surfaces, but easier with Subdivision

B) An interpolating surface representation

C) Use to cut one surface against another

D) Makes a surface appear rough without changing the geometry

E) Uses a set of photographs to view an object from anywhere within a region

F) Visualize a 3D scalar field

G) Visualize a 3D vector field

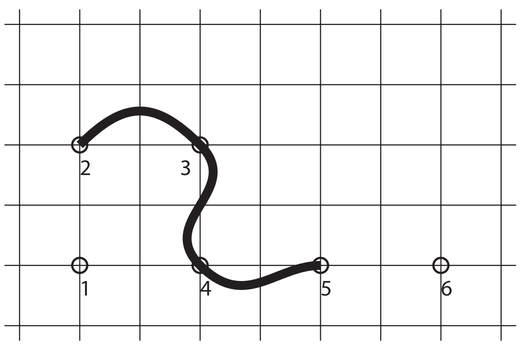
Question 5: Curves (27pts)

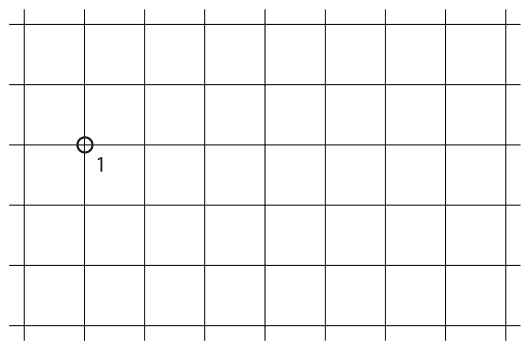
5.A Beziers and Cardinals

The left curve below is a cubic cardinal spline with tension 0 (also known as a Catmul-Rom spline). It is made up of multiple polynomial segments. The control points are labeled, starting with 1.

On the right, sketch a piecewise cubic Bezier curve (made out of multiple segments) that is the same curve. Draw the locations of all the control points. The position of the first control point is given. Label the control points.

Hint: each Bezier segment is independent, so you may need to place multiple points at the same location.





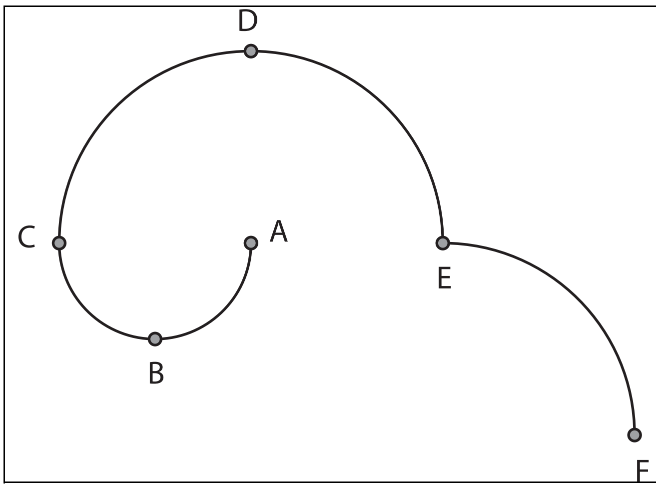
5.B Continuity

Hint 1: recall that we denote parametric continuity of order *n* as C(*n*) and geometric continuity of order n as G(*n*).

B.1 Can a junction point be C(1) but not G(1)? (yes or no)

B.2 Can a junction point be G(2) but not C(1)? (yes or no)

B.3 The curve below is made up of circular arc segments, where each arc segment is a quarter of the circle. The junctions between the segments are labeled in order. All the segments are parameterized going clockwise, and set up so that they cover their entire length in 1 unit of parameter value (therefore, the total curve is at A at 0, B at 1, C at 2, D at 3, …). The arc segments AB and BC are from circles of radius 1, and the rest are from circles of radius 2.



List ALL the junction points that have the following properties:

B.3.1 G(1) but **not** C(1)

B.3.2 G(1) and C(1)

B.3.3 C(0) but **not** C(1)

B.3.4 C(0) but **not** G(1)