CS 559: Computer Graphics - Final Exam

May 14, 2002

Name: _____

ID: _____

Login: _____

- You have 2 hours to complete the exam.
- Before beginning, write your name, ID number and login on the front page, and your login on every page.
- On your desk you may have something to write with, one double-sided piece of paper with anything on it, an optional ruler, and nothing else.
- Do all your work on the pages provided, going to the back side if necessary. If you do use the back, indicate on the front side that there is something on the back.
- If you need to make assumptions in order to answer a question, say what they are. However, all the questions should be unambiguous.

Question 1: ____/14

Question 2: ____/4

Question 3: ____/9

Question 4: ____/3

Question 5: ____/3

Question 6: ____/12

Question 7: ____/4

Question 8: ____/6

Question 9: ____/3

Question 10: ____/4

Question 11: ____/8

Total: ____/70

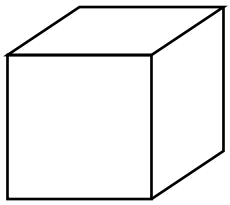
Question 1: (14 points)

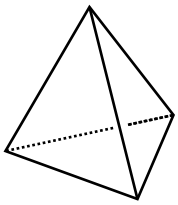
Answer each of the following questions with one or two sentences. This question continues onto the next page.

a. Consider the problem of modeling Christmas gifts of various sizes wrapped in the same patterned wrapping paper. The basis for your model will be a texture mapped box. Would you account for the different box sizes by applying a simple scaling transformation to a generic box, or by using a parametric model for the box? Why?

b. Give one reason why you might prefer rational curves (such as NURBS) over B-spline curves.

c. Would a cube or a tetrahedron be a preferable starting shape for the sphere subdivision scheme discussed in class? Why? Both shapes are sketched below.





d. A basic ray-tracer, as discussed in class, takes 1 minute to render a scene at 100×100 resolution. How long would the same ray-tracer take to render the same scene at 400×400? Assume that no anti-aliasing is performed.

e. How would you determine whether an object was bump mapped or displacement mapped? Assume you can rotate the object to look at it from different angles.

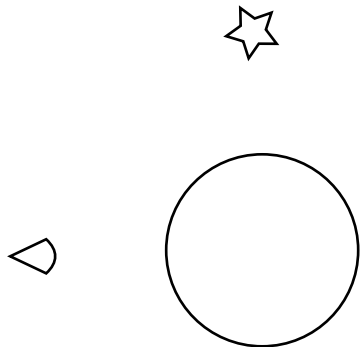
f. Which animation method dominates the animation of human characters for film and computer games?

g. Which animation method offers the greatest control over the final appearance of the animation?

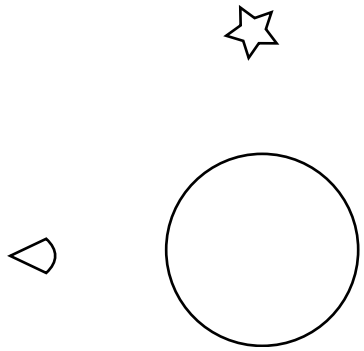
Question 2: (4 points)

The images below show a sphere lit from above and viewed by a viewer on the left. Assume the light is a point source, and that the sphere is lit by the standard lighting model, such as that used in OpenGL.

a. On the image below, mark the approximate location of the brightest point on the sphere, assuming that the diffuse coefficient is 0.4, the specular coefficient is 0.4, the specular power is 5, and the ambient coefficient is 0.2.

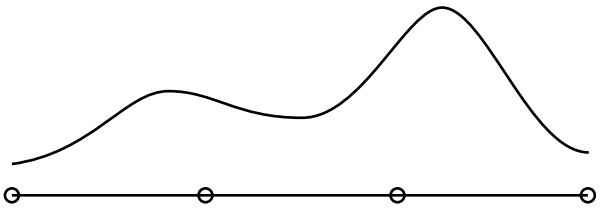


b. On the image below, mark the approximate location of the brightest point on the sphere, assuming that the diffuse coefficient is 0.4, the specular coefficient is 0.0, the specular power is 1, and the ambient coefficient is 0.2.

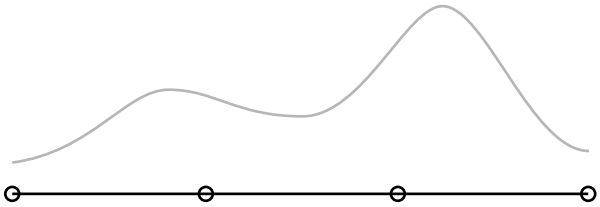


Question 3: (9 points)

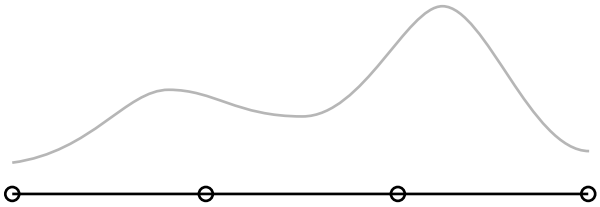
The figure below plots the accurately computed brightness of each point on a flat polygonal surface, as might be computed using the standard lighting model. The vertices of the polygonal surface are shown as small circles, indicating that there are three faces involving four vertices. The brightness at each point is due to some light sources and a particular viewer position, none of which are shown.



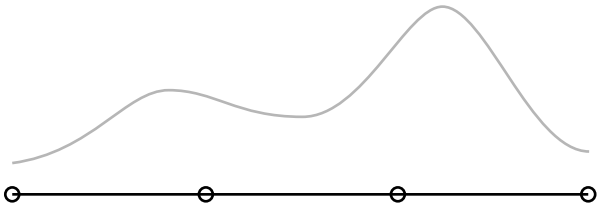
a. On the figure below, plot the intensity that the viewer would see at each point if a flat shading model was used. Assume that the reference point for the flat shading is the leftmost vertex of each face. The accurate values are lightly shown to help you.



b. On the figure below, plot the intensity that the viewer would see if Gouraud shading interpolation was used.

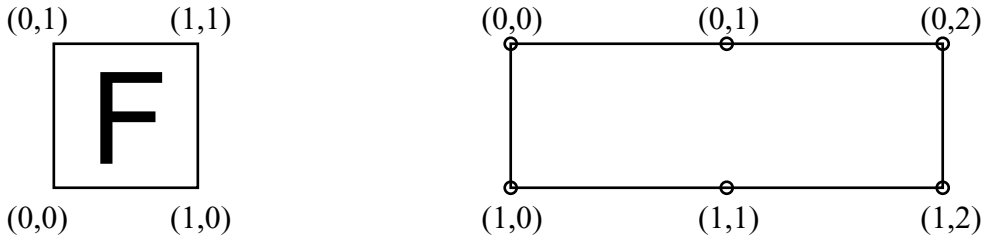


c. On the figure below, plot the intensity that the viewer would see if Phong shading interpolation was used.



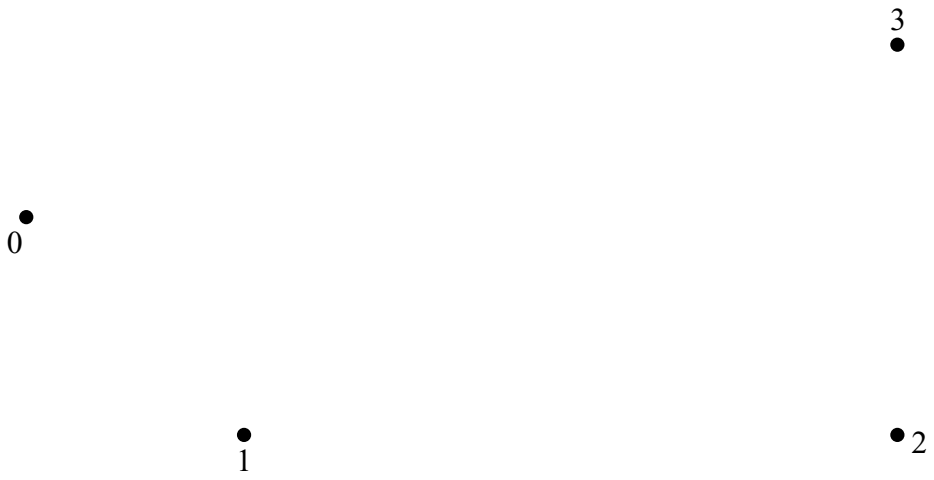
Question 4: (3 points)

Show the result of applying the texture map shown on the left to the polygon shown on the right. The texture coordinates for each point on the polygon are indicated, and repeat mode is used for the boundary conditions.



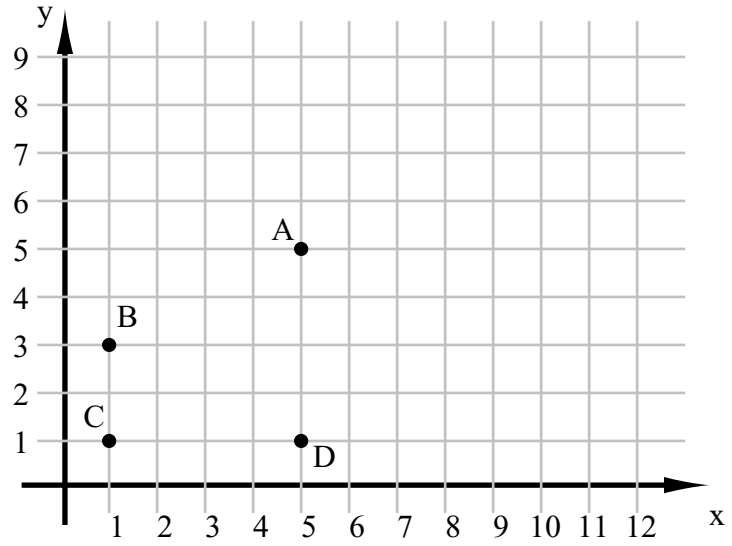
Question 5: (3 points)

Use de Casteljau's algorithm to find the $t = \frac{3}{4}$ point on the Bezier curve defined by the control points below. Show your working, and if you don't have a ruler just be as accurate as you can.



Question 6: (12 points)

In the figure below, a designer is joining two cubic Bezier curve segments in order to form a longer curve. The left segment uses the control points **A**, **B**, **C** and **D** in that order. The right segment will use control points **E**, **F**, **G** and **H**, which are not shown. The coordinate system is indicated, and in the following questions be as precise as possible. For instance, if you know exactly where a point should be, give its coordinates.



a. For the combined curve to have C^0 continuity, what, if any, restrictions are there on:
   (i) Point **E**?

   (ii) Point **F**?

b. For the combined curve to have C^1 continuity, what, if any, restrictions are there on point **F**?

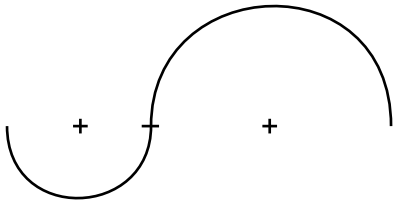
c. For the combined curve to have G^1 continuity, what, if any, restrictions are there on point **F**?

d. Which points on the right curve are constrained if C^2 continuity is desired at the join?

e. Sketch the left segment on the figure. Be sure to respect the properties of Bezier curves.

Question 7: (4 points)

The figure below shows two pieces of circular arcs, joined at the point indicated by the small horizontal bar. The center of each circle is also marked, and the centers lie on a straight line through the join point.

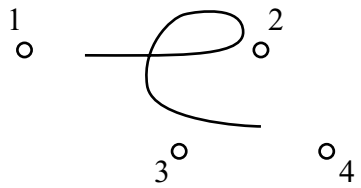


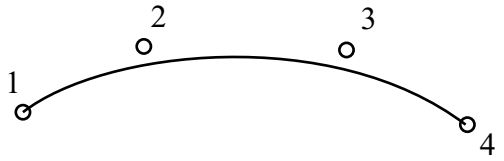
a. Each arc is uniformly parameterized such that $t = 0$ is at the left-most point on the arc, $t = 0.5$ is at the midpoint of each arc, and $t = 1$ is at the right-most point. Do the arcs join with C^1 continuity?

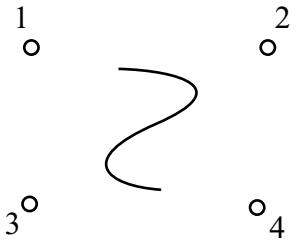
b. Do the arcs join with G^1 continuity?

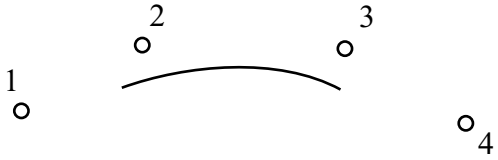
Question 8: (6 points)

For each of the curves below, indicate whether or not it could be a B-spline segment for the four control points shown. If the segment could not be a B-spline, state a reason why. No control points are repeated.







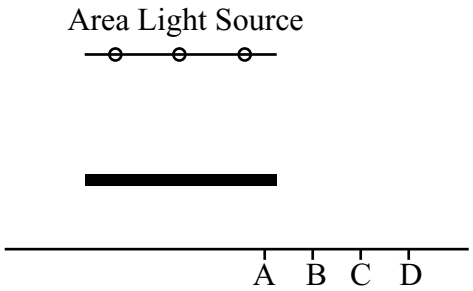


Question 9: (3 points)

You wish to find the parameter values for any intersection points between a ray, $\mathbf{x} = \mathbf{x}_0 + t\mathbf{d}$ with $\mathbf{x}_0 = (x_0, y_0, z_0)$ and $\mathbf{d} = (d_x, d_y, d_x)$, and an infinite tube centered at the origin and aligned with the z-axis. The implicit equation of the tube is $x^2 + y^2 - 1 = 0$. What equation do you need to solve?

Question 10: (4 points)

Consider the area light source, shadowing object and surface shown below. For ray-tracing, the area light source is approximated as three point sources distributed as shown.



a. Which point, A, B, C or D, will be the brightest?

b. Which point will be the darkest?

c. What is the relationship between the brightness at point B and the brightness at point C?

Question 11: (8 points)

Recall the notation used in class for light paths. For example, the OpenGL model for diffuse illumination captures LDE paths.

a. What class of paths is captured by basic ray-tracing?

b. What class of paths is captured by a radiosity algorithm?

c. Sketch a situation in which radiosity and basic ray-tracing will give significantly different answers. Your diagram must contain a path that is captured by basic ray-tracing but not radiosity, and one that is captured by radiosity but not basic ray-tracing. Label these paths. Also indicate:

- the location of the light source
- the location of the viewer
- whether or not each surface is diffuse or specular (mirror-like)