CS559 Final Exam

December 20, 2000

Please be sure to write your CS login on every page!

Please read the instructions carefully.

This exam is closed book and closed notes.

You will have the full exam period to complete the test, although the exam is designed to be completed in less time.

If you need additional space for your answers, please use the back of the page. If you do use the back of a page please indicate this on the front.

It is acceptable to leave results in fractional form, or as irrational numbers.

NOTES:

Unless otherwise stated, all angle measurements are in degrees, measured counter clockwise.
Unless otherwise stated, rotation and scale transforms rotate about the origin.
Unless otherwise stated, assume the "post-multiply" convention for matrix transforms.

Useful Facts:

$\sin(30) = 1/2$ $\quad$ $\cos(45) = 1/\sqrt{2}$

$\cos(30) = \sqrt{3}/2$ $\quad$ $\sin(45) = 1/\sqrt{2}$

$\tan(30) = 1/\sqrt{3}$ $\quad$ $\tan(45) = 1$

Scoring

Question I	15	/ 18 pts
Question II	18	/ 21 pts
Question III	12	/ 12 pts
Question IV	8	/ 8 pts
Question V	14	/ 16 pts
Question VI	16	/ 25 pts

Question I: Multiple multiple choice (18 points)

Please select ALL correct answers, and cross out all incorrect answers. There may be no correct answers to a question.

Example: Soft Shadows:

~~A.~~ are an artifact of not implementing shadows correctly
~~B.~~ are created by low-pass filtering
C are difficult to do with standard ray-tracing
D. were not discussed in CS559 this past semester because we ran out of time

CD

1. The Motion Picture Experts Group:
   A. devised standards for the representation and compression of video data
   B. did not care about audio because they were only experts on pictures
   C. addressed audio in a popular way in the 3rd version of their standard
   D. included an audio compression method in their first standard (MP1) that proved very popular
2. Bezier Curves:
   A. interpolate their endpoints
   B. have 4 control points per curve segment
   C. are very popular in drawing programs
   D. are just a variant of Hermite curves

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3. The lighting model that was developed by (and attributed to) Bui-Tong Phong:
   A. requires interpolation of normal vectors, and is therefore expensive to use
   B. introduced a novel specular term that was a hack based on empirical observations
   C. introduced a novel way to handle diffuse lighting
   D. does not necessarily take shadows into account
4. A 3D Rotation
   A. Can represent a mirror reflection about any axis.
   B. Cannot be represented by a set of numbers without a singularity.
   C. Can always be represented by a rotation about the Z axis, followed by a rotation about the X axis, followed by another rotation about the Z axis.

-1

5. Lightmaps:
   A. Are good for situations where there are many specular objects in the scene
   B. Allow radiosity computations to be viewed interactively
   C. Are an alternative method for computing global illumination
   D. Use texture-mapping machinery to simulate lighting effects
   E. Are used for computing the shadows from a point light source.
6. Z-buffering is preferred over the painters algorithm for graphics hardware because:
   A. we like to implement texture mapping in hardware
   B. the painters algorithm must store the locations of all of the objects before drawing any of them
   C. integer division is expensive to implement in hardware
   D. Phong shading is more realistic
   E. There are many cases that cannot be handled by the painters algorithm

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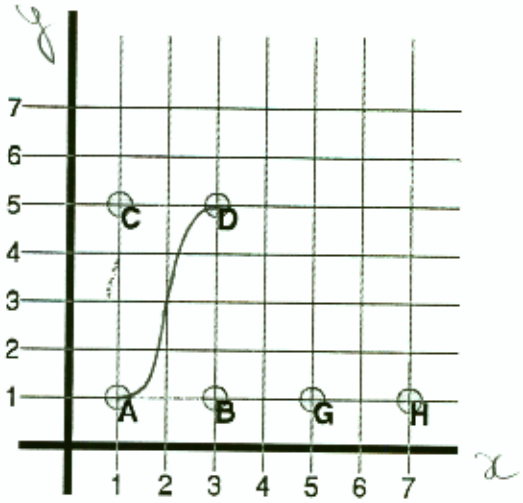
Question II: It Depends... (21 points)

As you have learned this semester, the answer to so many questions in graphics is "it depends." In this question, describe a situation where:

1. A Ray-Tracer is a good choice for a rendering algorithm.
   If you want a better lighting and shading model than typical 3D rendering choices.
2. A Ray-Tracer is a bad choice for a rendering algorithm.
   If you care about rendering speed (and want it fast)
3. Rational (as opposed to normal) B-Spline curves are required.
   X
4. A Radiosity renderer (e.g. one that computes global illumination) is appropriate.
   If we don't care about real time and need realistic lighting (for example in architectural models)
5. Lightmaps would work well for a given scene.
   If the light sources don't move (and neither do objects if we take shadows into account).
6. The order in which objects are drawn is important for Z-buffering.
   If we have transparent (alpha-channel ≠ 1) objects
7. The visibility of two polygons cannot be correctly generated by the painters algorithm.
   If the two polygons intersect.

Question III: Bezier Curves: (12 points)

In the following illustration, an artist is creating a curve by piecing together 2 cubic bezier curve segments. Segment 1 uses the 4 control points A,B,C, and D (in that order). Segment 2 uses control points E,F,G and H (in that order). Points E and F are not shown in the illustration. The scales of the co-ordinate system are as shown (e.g. point B is at (3,1)).



1. For the combined curve to have C(0) continuity, what restrictions are there on:
   A. Point E? E = D
   B. Point F? no restriction
2. For the combined curve to have C(1) continuity, what restrictions are there on the position of point F? F is at (5, 5)
3. For the combined curve to have G(1) continuity, what restrictions are there on the positions of point F? $F_x > 3$; $F_y = 5$
4. Sketch (on the graph) curve segment 1.

-0

Question IV: Lighting (8 points)

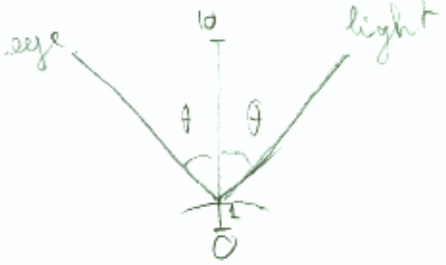
A white sphere of radius 1 is placed at the origin (such that the top point of the sphere is 0,1,0).
Assume the lighting model used by OpenGL (and discussed in class). The sphere's specular reflectance value is Ks and the sphere's diffuse reflectance value is Kd.

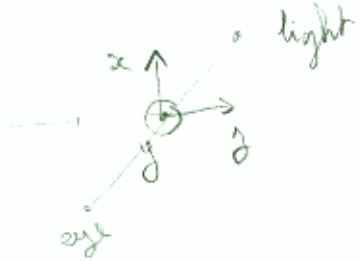
1. If the sphere appears the same brightness no matter where you look from, what can you say about Kd and Ks? $K_s = 0$ (perfectly diffuse)

2. In the situation described in #1, where (in the ceiling, y=10) would you place the light source such that the top of the sphere appeared to be the brightest point on the sphere?
(0, 10, 0)

3. Suppose the sphere was very shiny, and both the viewer and the lightsource are on the ceiling (y=10). Write equations for the position of the light source Lx and Lz given the position of the eye point (Ex and Ez) such that the top of the sphere appears to be the brightest point.

$$L_x = -E_x$$
$$L_z = -E_z$$





Question V: Homogeneous Transformations (16 points)

Provide a 4x4 matrix that does each of the following:

Example: Translate every object up (along the Y axis) by 1 unit

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

1. projects all points vertically down onto the floor (y=0)

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

2. rotates 90 degrees clockwise around the y axis

$$\begin{bmatrix} 0 & 0 & 1 & 0 \\ 0 & 1 & 0 & 0 \\ -1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

-1

3. scales the object by ½, with the center of scaling at point 3,4,5

$$\begin{bmatrix} 1 & 0 & 0 & 3 \\ 0 & 1 & 0 & 4 \\ 0 & 0 & 1 & 5 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1/2 & 0 & 0 & 0 \\ 0 & 1/2 & 0 & 0 \\ 0 & 0 & 1/2 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & -3 \\ 0 & 1 & 0 & -4 \\ 0 & 0 & 1 & -5 \\ 0 & 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 3 \\ 0 & 1 & 0 & 4 \\ 0 & 0 & 1 & 5 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1/2 & 0 & 0 & -3/2 \\ 0 & 1/2 & 0 & -2 \\ 0 & 0 & 1/2 & -5/2 \\ 0 & 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} 1/2 & 0 & 0 & 3/2 \\ 0 & 1/2 & 0 & 2 \\ 0 & 0 & 1/2 & 5/2 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

4. reflects around the plane x=4

$$\begin{bmatrix} 1 & 0 & 0 & 4 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} -1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & -4 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 4 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} -1 & 0 & 0 & 4 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} -1 & 0 & 0 & 8 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

-1

Question VI: Short Answer

1. Describe why tri-linear filtering is important to the implementation of texture mapping

+1 Textures are scaled above and below their original scale. Point sampling gives a blocky, jaggy appearance to the texture; tri is best.

2. Explain why Floyd-Sternberg error diffusion is preferable to ordered dithering.

Floyd-Sternberg gives better results than ordered dithering.

3. Explain why ordered dithering is preferable to Floyd-Sternberg error diffusion.

Ordered dithering is simpler and faster than FS error diffusion.

4. Explain why 24 frames per second is (generally) a sufficient rate for avoiding perceivable flicker for a movie, but why we often need higher frame rates for video and computer CRT displays.

-3 true, but not one of the major reasons

Movies have "built-in" motion blur; and this combined with persistence of vision make 24 fps acceptable. This is not the case with CRTs because we do not render motion blur.

5. Explain the difference between bump mapping and displacement mapping. Describe why bump mapping may be preferred, and cases where displacement mapping is better.

Bump mapping: changes the normals on the texture to get different specular lighting.

better but ~~slower~~ than displacement.