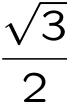
CS559 2014 Final Exam

Closed Book and Closed Notes.

You will have the entire exam period (until 4:45pm) to complete the exam. The exam is designed to take less time (yes, really this time!)

Please write your name on every page!

Write numerical answers in fractional form or use radicals (square root symbols) – we would prefer to see than .866. You should not need a calculator for this exam.

Unless otherwise noted, assume that everything is a right-handed coordinate system and that angles are measured counter clockwise (i.e. to find the direction of rotation, point your thumb along the axis and curl your fingers).

Please keep your answers concise and readable. Answers that are excessively wordy or illegible will be considered incorrect. If you need more space, use the back of the page, but put a note telling us to look there.

Note: there are some questions at the back of the exam for which there a lots of possible right answers.

There are 12 Questions on this exam.

There are 100 points on this exam.

### Question 1: Transformation Matrices (8pts = 4 \* 2)

Consider a 3D transformation N (a 4x4 homogeneous coordinate matrix) that is created by composing a rotation and a uniform scale.

|  |  |  |  |
| --- | --- | --- | --- |
| a | b | c | d |
| -3 | 0 | 0 | e |
| i | j | k | f |
| g | h | i | 1 |

The matrix has the elements:

Each answer is 1 number:

1. What is the maximum value of a? 0
2. What is the maximum value of b? 3
3. What is the minimum value of b? -3
4. What is the length of vector (g,h,i)? 0

### Question 2: Subdivision (8pts = 2 \* 4)

The control mesh (the initial polygon for subdivision) in all of these examples is a tetrahedron.

A Tetrahedron is a 4‐sided polyhedron where every side is a triangle.

Describe the polygons (number and number of sides) you would have if you did:

0) No subdivision (example)

4 polygons, all with 3 sides

A) One round of Catmull‐Clark subdivision

12 polygons all with 4 sides

B) One round of Butterfly (or modified Butterfly) subdivision

16 polygons all with 3 sides

### Question 3: Discrete Convolution (8pts = 1 \* 8)

Given the signal:

F = [ 0 0 4 8 4 0 0 8 8 0 0 4 0 0]

Convolve the signal with the kernel

G = [ ½ -1 ½ ]

Use the boundary condition that out of bounds values are zero.

[ 0 2 0 -4 0 2 4 -4 -4 4 2 -4 2 0 ]

### Question 4: Déjà vu: Bezier Curve (8pts = 1 \* 8)

We asked about Bezier curves on the midterm. We thought we’d try again. Note: you may have seen a similar question before, but this question may be a little different.

Consider a cubic Bezier curve with the control points (0,0), (8,0) (8,12) (16,12).

Where is this curve at u=.5?

(0,0) (8,0) (8,12) (16,12)

(4,0) (8,6) (12,12)

(6,3) (10,9)

(8,6)

### Question 5: Ray Tracing (5pts = 5 \* 1)

Some lighting effects are easy to do in a **basic** “from the eye” ray tracer. (B)

Other lighting effects require **distribution** ray tracing to do in a “from the eye” ray tracer. (D)

Some lighting effects are hard to do in any “from the eye” ray tracer. (**N - neither**)

For each of the following, say B, D or N:

5.A Reflection of a diffuse surface seen in a flat mirrored surface. B

5.B Reflection of a diffuse surface seen in a curved mirrored surface. B

5.C Reflection of a diffuse surface seen in a flat diffuse surface N

5.D Shadows cast by a curved, diffuse object onto a flat diffuse object from an area light source. D

5.E Shadows cast by a curved, diffuse object onto a flat diffuse object from a point light source B

### Question 6: Ray Tracing vs. Interactive Rendering (4pts = 2 \* 2)

Give an example of two more effects that distribution ray tracing makes possible (beyond a simple backwards ray tracer). Do not pick one of the things already in Question 5.

Depth-of-field

Better sampling of high frequencies (small features, sharp edge, …)

Glossy/imperfect reflections

### Question 7: Ray Tracing vs. Interactive Rendering (5pts = 5 \* 1)

Environment mapping is a texture mapping trick used to create lighting effects in interactive rendering that would normally require ray tracing. From the list in Question 5, which effects does environment mapping do? (your answer should be a list of zero or more letters)

Only B (+5, -1 for any other) – environment mapping only works for curved objects.

### Question 8: Downsampling (12pts = 3 \* 4)

Students were asked to down sample 1D images by a factor of 2 (that is, to return a version that had half as many samples).

Some of the students used the uniform averaging filter [1/3 1/3 1/3], while others used the binomial filter [1/4 1/2 1/4].

The instructor tested their programs using a test image that was a long sequence alternating between 0 and 12. Sometimes, the test started with 0, other times it started with 12.

(e.g. [0 12 0 12 0 12 …] and [12 0 12 0 12 0 12 0 …])

In grading the instructor did not look at the first few entries of the answer.

Question 8A:

Give an example of a correct answer for the binomial filter (there may be more than 1). You can skip the first 2 entries of the answer, and you only need to give a few values)

6 6 6 6 6 6 …

Question 8B:

4 4 4 4 4 4 … or 8 8 8 8 8 8 8 …

Give an example of a correct answer for the averaging filter (there may be more than 1). You can skip the first 2 entries of the answer, and you only need to give a few values)

Question 8C:

Which of A or B has another correct answer? Say A or B and give that alternate answer.

B, whichever one you didn’t give in part B

### Question 9: Texture Mapping (12 pts = 9+3)

A single polygon (quadrilateral) has its four corner positions as:

(0,0,0), (0,.5,0), (.5,.5,0), (.5,0,0)

these vertices have the following texture coordinates

(.5, .25), (.75, .25), (1, .75), (.5, .75)

The texture is a 4x4 checkerboard (so each square is .25x.25)

C:\LocalUsers\gleicher\Dropbox\559 Prep\4x4check.emf

The polygon is drawn in Normalized Device Coordinates (NDC) – this is what OpenGL has if its two transformation matrices are both the identity. Lighting is turned off (texturing is turned on – so the color of a pixel is the color of the texture). These coordinates go from -1 to 1 in each dimension.

9A) Sketch what the screen would look like when this polygon is drawn:

|  |  |
| --- | --- |
| final-screen | You can assume that the viewport (window) is square, as shown in the picture. The lines are evenly spaced.  In correct quadrant (2)  Left edge is dark (2)  Other edges half and half (3)  Diagonal (2) |

9B) describe how the answer to part A would change if the Z values of the vertex positions were changed to:

(0,0,-.5), (0,.5,-.5), (.5,.5,-.5), (.5,0,-.5) (note: only the Z values have changed)

NO Change

### Question 10: Multiple Choice (22pts = 11\*2)

Imagine an RGB monitor that displays “pure” colors – each color displays a single wavelength. (for example, a red pixel would display a single wavelength in the red part of the spectrum). Call this a “pure primary” monitor.10.1 For someone who is a tri-chromat, this “pure primary monitor”: D  
A. Would not be sable to how white.  
B. Would not be able to show yellow.  
C. Would not be able to different shades of green.  
D. All of the above  
E. None of the above

10.2 For someone who is color blind (missing one kind of cone) C  
A. At least one of red, green and blue would appear black.  
B. It is possible that any red color (R,0,0 for R in range (0,255)) will look the same as medium green.   
C. For a specific bright red color there is a small set of green colors that will look the same.  
D. All of the above  
E. None of the above

10.3 With different color spaces B  
A. Sometimes we prefer CMY (or CMYK) to RGB because it can represent a wider range of colors  
B. HSV color space is sometimes preferred to RGB because it is convenient for artists  
C. RGB can represent all colors of visible light  
D. All of the above  
E. None of the above

10.4 MIP-Maps B  
A. Are required to do texture mapping  
B. Are a way to perform the pre-filtering of an image before sampling  
C. Address aliasing in texture mapping by post-filtering after sampling  
D. All of the Above  
E. None of the Above

10.5 For fancy texture mapping D  
A. Bump mapping doesn’t actually change the shape of the surface  
B. Shadow maps store a picture of what a light source sees  
C. Environment maps can be used with spheres or cubes for the textures  
D. All of the above  
E. None of the above

10.6 To prevent aliasing, you might… A  
A. De-focus a camera to make sure an actor’s checkered shirt doesn’t create weird patterns on TV.  
B. Blur an image after drawing it to get rid of the jaggies caused by line drawing  
C. Turn off Mip-Mapping  
D. All of the Above  
E. None of the Above

10.7 Chaikin’s corner-cutting method B  
A. Is used to smoothly interpolate the control points  
B. Converges to a quadratic B-Spline in the limit  
C. Is an efficient way to make smooth surfaces in 3D  
D. All of the Above  
E. None of the Above

10.8 You might prefer an approximating curve or surface (like a Bezier or B-Spline curve or Catmull-Clark subdivision surface) to an interpolating curve or surface (like a Catmull-Rom cardinal spline or Butterfly subdivision surface) because: B  
A. It’s easier to control what happens at the control points  
B. It’s easier to control what happens between the control points  
C. It’s the only way to get higher order continuity (e.g. C(2))  
D. All of the Above  
E. None of the Above

10.9 Shadow Maps… E  
A. Are textures with dark splotches that darken shadowed regions  
B. Can create soft shadows easily because they consider area light sources  
C. Can be done for scenes with moving objects with a single rendering pass  
D. All of the Above  
E. None of the Above

10.10 When we convert an RGB image to grayscale, we A  
A. We usually weight green more than blue since our eyes are more sensitive to it  
B. Can simply ignore the red channel  
C. Can preserve contrast by using a point process  
D. All of the Above  
E None of the Above

10.11 SVG … D  
A. Does sampling when drawing so the browser can anti-alias the primitives if it chooses to  
B. Supports Bezier curves, but if you want to draw Catmull-Rom splines you can convert them  
C. Provides a way of specifying geometric primitives  
D. All of the above  
E. None of the above

Writing an exam is an example of a sampling problem: there are far too many topics to ask questions about, and we can only ask about a few. And, part of the idea of giving a final exam is to make sure that you do some review/study at the end of the semester to help the material sink in. So, here are some questions that try to check that more directly.

### Question 11: (2 pts)

Name a topic that we covered in class (in lectures and readings and assignments) but has not appeared in the exam:

### Question 12: (3 pts = 3\*1)

Give three of the most interesting facts about graphics that you reviewed while studying, which were not asked about on the exam. (These should be things that you learned in class, either from the lectures or the readings). Do not include topics from the virtual reality of history of special effects lectures, as you were specifically told those would not be on the exam, and should have had the sense not to study them.

**11A)**

**11B)**

**11C)**