Name _____

CS559 Midterm Exam
October 28, 2008, 7:15pm

This exam is closed book and closed notes.

You will have the entire period (until 9:00pm) to complete the exam, although the exam is designed to take less time.

Please write your name and CS login on every page! (we may unstaple the exams for grading)

Write numerical answers in fractional form or use radicals (square root symbols) – we would prefer to see $\frac{\sqrt{3}}{2}$ 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. E.g. to find the direction of rotation, point your thumb along the axis and curl your fingers.

If you need extra space, use the back of a page, but clearly mark what everything is. We may look at your work to determine partial credit.

Q1: __ / 8
Q2: __ / 8
Q3: __ / 12
Q4: __ / 8
Q5: __ / 6
Q6: __ / 14
Q7: __ / 6
Q8: __ / 12
Q9: __ / 121
Q10: __ / 8
Free points for putting your name on each page: __/6

Total: ___ / 100

Name _____

Question 1 (8 points)

A political candidate is deciding how to dress for a televised debate. They are concerned that issues in how different things will show up on TV will affect their image. Since television is broadcast digitally these days, they need to consider sampling / re-sampling issues.

Consider three different shirts: one with very narrow stripes, one with large dots, and one that is of constant color.

Which will is likely to appear best in the image? Explain your answer in terms of signal processing and sampling theory.

A constant color will not alias (or even be affected by pre-filtering) since it has no high frequencies. Therefore, it is least likely to be affected by transmition.
The dots may be OK, but are not as safe a choice. (see below)

Which shirt will be most likely to show artifacts when imaged digitally? Again, use sampling theory to justify your answer.

The thin stripes have the most high frequency content are likely to be above the Nyquist rate, so they might alias, or at least be filtered out (so the result will look like a more constant color).

The dots may be blurred a little around the edges (as the high frequencies are lost), but since they have substantial mid-frequencies, they should be OK.

Question 2 (8 points)

When doing image resizing, we need to choose a low-pass filter for doing reconstruction. We usually choose filters that more or less approximate an ideal low-pass filter.

Consider two filters, A and B. We want to determine which is a better approximation of the ideal low-pass filter. The test we perform takes an image and scales it up by a factor of 10. (e.g. it takes a 10x10 image and makes a 100x100 image) using each filter. Describe how such a test can tell which filter is the closer approximation to the ideal low-pass filter. You should describe the image that you will use as an input, and what you will look for in the two resulting images.

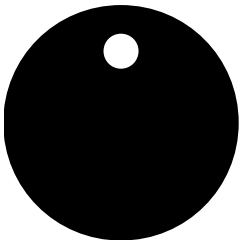
We should pick an image with a sharp change (preferably) between large areas. A better LPF will make the resulting transition appear shaper, although not perfectly sharp (as a spike filter would).

Name _____

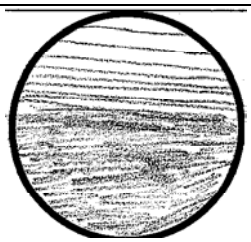
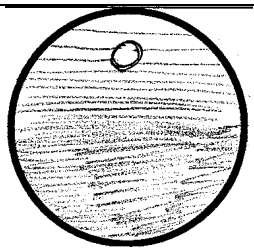
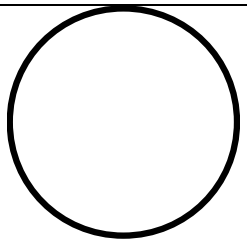
Question 3 (12 points)

A system uses the Phong lighting model (like OpenGL) and does Phong shading (unlike OpenGL). A Sphere is drawn on the Z-axis (so the camera is pointing right at it). A single directionaly light source is placed above the sphere, shining vertically downward. The light is white.

If the sphere is drawn with its material properties as follows: Cs (specular reflectance) = 1, Cd (diffuse reflectance)=0, Ca (ambient reflectance)=0, sh (shininess) = 5 (a high value), the sphere looks like:



Sketch what the sphere would look like if:

 As above, but the spot should be larger and less sharp. (hard to show the latter in a sketch though)	 The sphere is white on top, and gradually gets darker so that the lower part is dark.	 A combination of the two: it should have a spot (as above) and the horizontal gradation (as B)	 It should be white (or like C but brighter all over)
A) As the example, but a very low shininess (sh=.5) (Cd=0,Ca=0 as above)	B) The specular reflectance (Cs)=0 Diffuse reflectance (Cd) = 1 (sh=5,Ca=0 as above)	C) Cs=1, Cd=1, sh=5, Ca=0	D) Cs=1, Cd=1, sh=5, Ca=1

Note: If you're concerned that we will misinterpret your sketch, you can describe the picture in words as well.

Name _____

Question 4 (8 points)

Consider a 3D transformation M (a 4x4 homogeneous coordinate matrix) that is created by composing a rotation and a uniform scale. M maps the unit X vector to (0,1,0), and the unit Y vector to (1,0,0).

Part A: Where does M map the unit Z vector to? 0,0,-1

Part B: What is the amount of the scale used to make M? 1

Hint: You don't want to figure out what the angles of the rotation are. In fact, you might not need to figure out what the transformation is.

Question 5 (6 points)

A student wrote a renderer, but we're not sure if it uses Phong or Gouraud shading. (Assume it correctly implements the Phong lighting model).

All of the models are polygonal (so the triangles use their actual normal vectors), and all the light sources are directional (i.e. rays from the source are parallel).

Are you more likely to see the difference in a large polygon, or in a collection of smaller ones? What surface properties will better show the differences in shading algorithm?

Explain .

You will see the difference most in large polygons that are specular.

Diffuse shading will be the same (since the normal vector and the light direction vectors are constant across the polygons).

The difference will be most obvious when the specular highlight is small relative to the size of the polygon (otherwise, one of the vertices might be at the highlight, so it will be seen). With a larger polygon, it is more likely that the entire highlight might be inside of the area of a triangle, so none of the vertices will see a highlight.

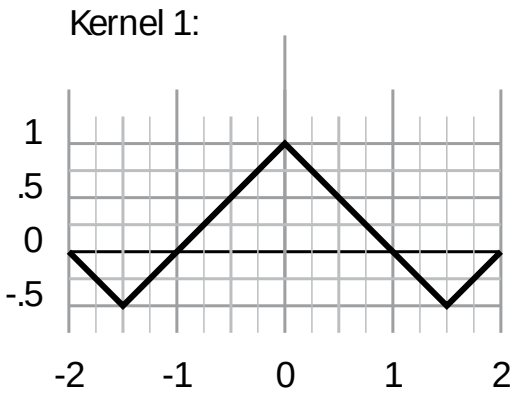
Name _____

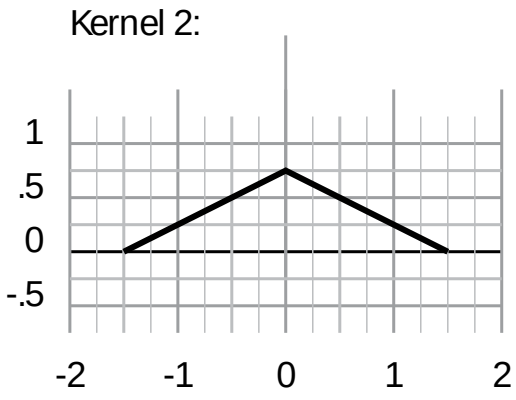
Question 6 (14 points)

Given the following sampled signal:

[0 4 4 8 8 4 0] (the first sample is for t=0, and the second sample is t=1). Assume any sample outside of the range 0-6 is 0.

Here are two reconstruction kernels (the grid units are ¼):





A: If kernel 1 is used to reconstruct the signal, what will the value be at:

t=1.5 -.5 * 0 + .5 * 4 + .5 * 4 + -.5 * 8 = 0

t=3 8 (the kernel is interpolating)

t=4.5 -.5 * 8 + .5 * 8 + .5 * 4 + -.5 * 0 = 2

B: If kernel 2 is used to reconstruct the signal, what will the value be at:

t=1.5 .5 * 4 + .5 * 4 = 4

t=3 .25 * 4 + .75 * 8 + .25 * 8 = 9

t=4.5 .5 * 8 + .5 * 4 = 6

Name _____

Question 7 (6 points)

A vertex (point) is drawn at the origin. It is viewed through a camera that is positioned with the viewing matrix:

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

The object that the vertex is drawn with transformation matrix:

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

This simple projective transform matrix is used:

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

Where does the point appear in screen coordinates?

(give the x,y position)

Apply the modeling matrix (object), to the point 0, and get (3,4,5,1)

Apply the camera matrix to that and get -5/2, 3/2, 8, 1

Apply the projection to that and get 5/2, - 3/2, 1, -8

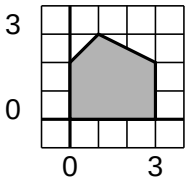
Divide by W to get 5/16, -3/16

Name _____

Question 8 (12 points)

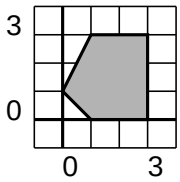
A simple 2D graphics toolkit has the following commands:

Translate x,y	- multiply the current matrix by a translation
Rotate t	- multiply the current matrix by a rotation of t degrees counter clockwise
Scale sx,sy	- multiply the current matrix by a scale
DrawHouse	- draws the following house (note: it is not symmetric)



Note: the transformation commands work like those in OpenGL

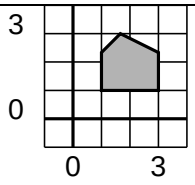
A) Here's an example program and its output. Give a program that does the same thing, but has the transformation commands in reverse order (e.g. fill in the parameters):



Translate 3,0	Rotate _____
Rotate 90	Translate _____
DrawHouse	DrawHouse

Rotate by 90, Translate by 0,-3

B) Give a program that produces the following output (your program should be 2 or 3 lines long). Give a second program that reverses the order of the transformations but does the same thing.



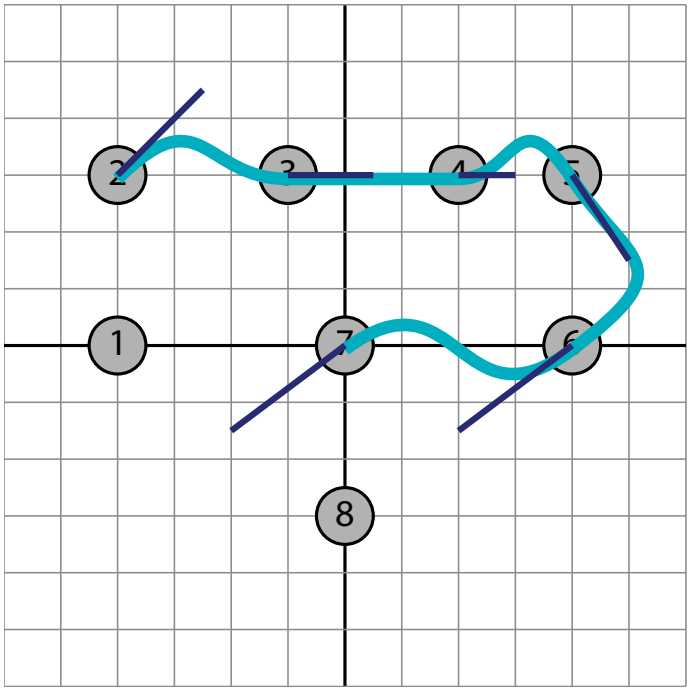
Translate 1,1	Scale 2/3, 2/3
Scale 2/3, 2/3	Translate 3/2, 3/2
DrawHouse	DrawHouse

Name _____

Question 9 (12 points)

Sketch a Camull-Rom (Cardinal Cubic with tension 0 – in class we called this "s=.5") spline through the following 8 points. What is the value of the derivative at point 5?

Please give the numerical values for the derivative at point 5 as well as your sketch. Each square is 1 unit, and the dark lines are the coordinate axes.



The tangent vector at Point 5 is (1, -3/2)

Note: we show the tangent vectors in the sketch to help you see what's going on, that wasn't required

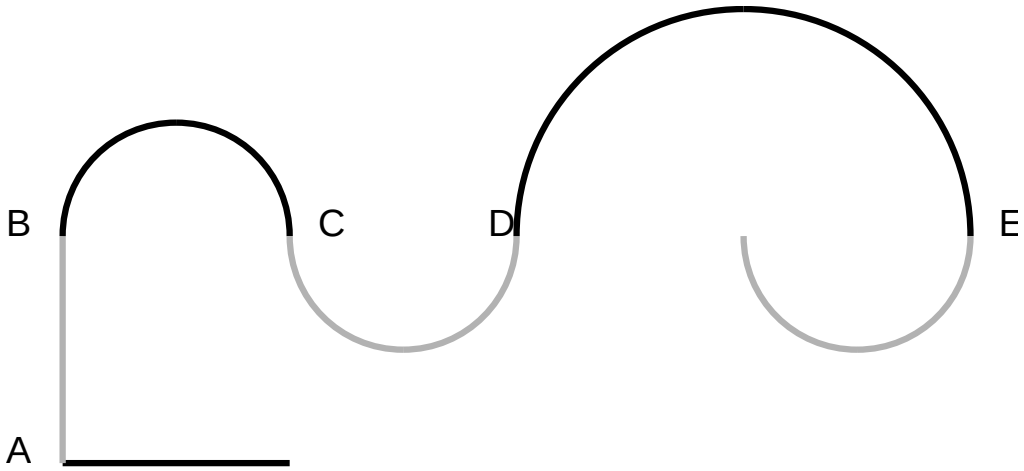
Points for:

- Starting at 2
- Ending at 7
- Each segment has the right wiggles (e.g. 2-3 is above the horizontal, 6-7 is first below then above)

Name _____

Question 10 (8 points)

The following compound curve is made up of semi-circular arcs (some of radius 1, some of radius 2), and two line segments (both of length 2). Each curve segment is unit parameterized, so that any semi-circle or line segment takes the same amount of "time" to traverse. Each curve segment is drawn in a different shade of gray to make it easier to see where one begins and the next begins, and the points at these transitions are labels A-E.



For each point, state the *highest* degree of C continuity and G continuity that the curve has at that point. We've answered the question for point A. For point A, the curve is C(0) (but not C(1)) and G(0) (but not G(1)).

A: C(0) G (0)

B: C(0) G (1) C: C (1) G(1)

D: C(0) G (1) E: C (0) G(infinity) (we'll accept any answer > 1)

Note that while the directions are often the same, the change in radius means a discontinuity in the how fast things go in that direction.