Name: _____
CS Login: _____

CS559 Midterm Exam
October 25, 2005

This exam is closed book and closed notes.

You will have the entire class period (until 10:45am) to complete the exam, although the exam is designed to take less 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 $\frac{\sqrt{3}}{2}$ 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.

Question 1	____ / 18 pts
Question 2	____ / 10 pts
Question 3	____ / 10 pts
Question 4	____ / 10 pts
Question 5	____ / 10 pts
Question 6	____ / 22 pts
Question 7	____ / 10 pts
Question 8	____ / 10 pts
Total:	____ / 100 pts

Question 1: 18 pts

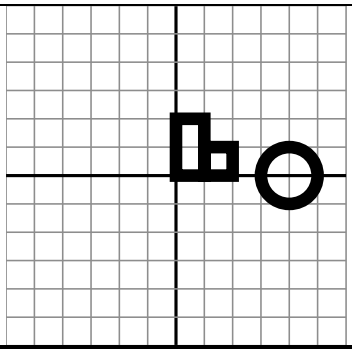
Consider a simple graphics library that uses a post-multiply convention, and provides a matrix stack (similar to OpenGL). Everything is in 2D, but the system uses 3x3 matrices for homogeneous coordinates:

IDENTITY - replaces the top of the stack with the identity matrix
PUSH - pushes a copy of the top of the matrix stack
TRANS(x,y) - translates by x,y
ROT(t) - rotates counter clockwise by t degrees
SCALE(x,y) - scales by x,y
SQUARE - draws a unit square between (0,0) and (1,1)
CIRCLE - draws a unit circle (center at (0,0) radius 1)

Sketch what each program does (Do 3 parts – A, B, and C)

Example

```
IDENTITY
PUSH
SCALE(1,2)
SQUARE
POP
TRANS(1,0)
SQUARE
TRANS(3,0)
CIRCLE
```



A)

```
IDENTITY
PUSH
SCALE(2,2)
TRANS(1,0)
SQUARE
ROT(90)
SQUARE
POP
SQUARE
```

B)

```
IDENTITY
TRANS(1,0)
PUSH
SCALE(2,2)
SQUARE
ROT(90)
TRANS(1,0)
SQAURE
POP
TRANS(2,0)
CIRCLE
```

C)

```
IDENTITY
SCALE(2,3)
TRANS(1,0)
SCALE(1/2,1/3)
CIRCLE
IDENTITY
CIRCLE
TRANS(3,0)
ROT(90)
TRANS(0,3)
SQUARE
```

Question 2: (10 pts)

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:

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

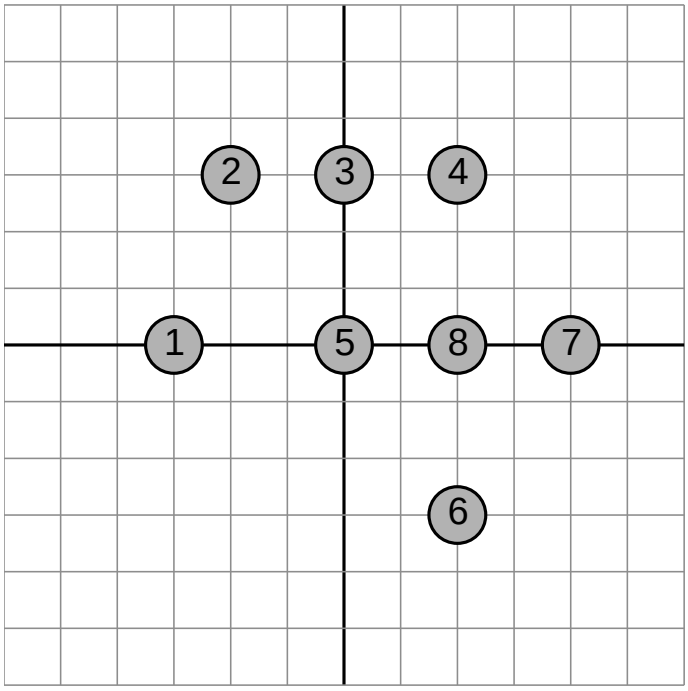
This simple projective transform matrix is used:

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

Where does the point appear in screen coordinates?
(give the x,y position)

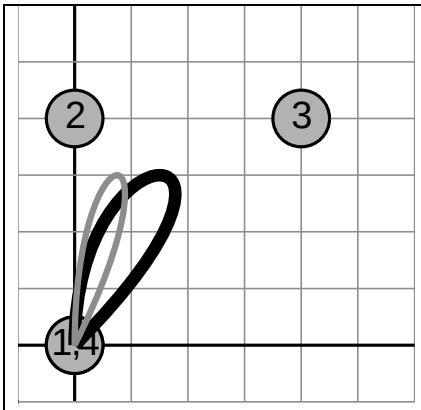
Question 3: (10 pts)

Sketch a Camull-Rom (Cardinal Cubic with tension 0) 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.



Question 4: (10 pts)

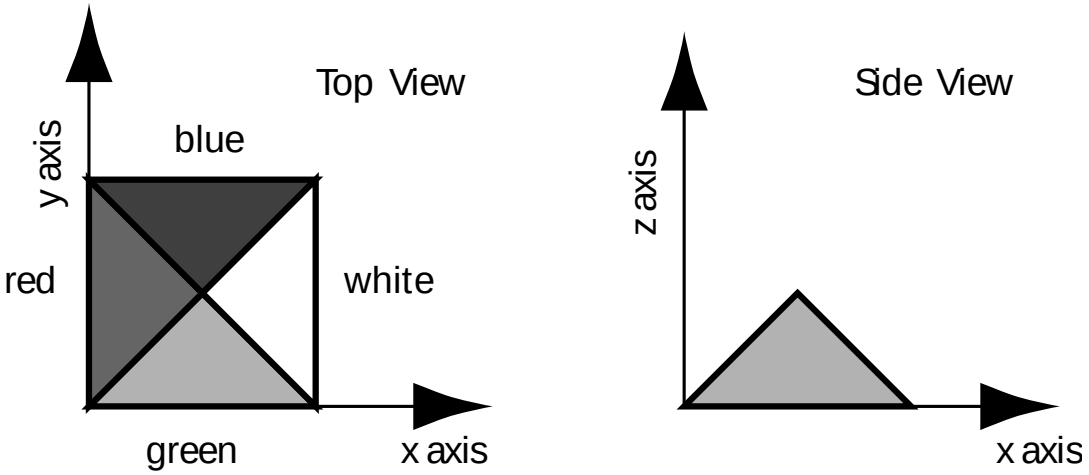
The cubic Bezier Spline shown below has its control points at (0,0), ~~(4,0)~~, (0,4), (4,4), and (0,0). If we cut the curve into two pieces at u=.5, where are the four control points of the first piece (assuming that we divide the original curve into two new cubic Bezier segments)?
Please list the coordinates of the 4 points of the new spline segment.



In the original exam, not only was the position of point 2 given incorrectly (the correct position is (0,4), but the figure was drawn incorrectly (the incorrect curve is shown in gray).

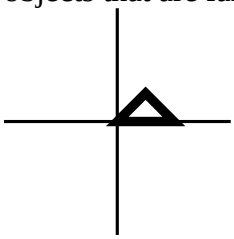
Question 5: (10 pts)

Assume that the x-axis (for the world) points east, the y-axis points north, and the z-axis points up. (this is a right-handed coordinate system)
Imagine a pyramid with a square base placed with its corner at the origin. Each of the triangular sides of the pyramid is painted a different color. The length of a side of the pyamid is 2 units, so the top of the pyramid is at (1,1,1).

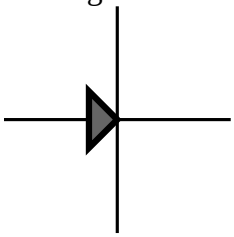


Assume that the film plane or screen is the "normal" xy plane with x going to the right and y going up. The center of the film plane is at the origin, and the viewer sights down the negative Z axis.

5A: Give an orthographic projection matrix (a 4x4 matrix) that gives a view of the white side of the pyramid. Don't worry about depth in the viewing volume other than that objects that are farther away from the viewer should be further along the viewing axis.



5B: Give a Lookfrom/Lookat/VUP (the positions of 2 points and one vector, all in 3D) that specifies a camera that would draw a red triangle pointing to the right, with its tip at the origin.



Question 6: (22 pts)
Multiple Multiple Choice

Select ALL correct answers. There may be more than one correct answer to each Part.

1. Which of the following has infinite depth of field?
    a. A pinhole camera with an infinitesimal aperature
    b. A pinhole camera with a large aperature
    c. A thin-lens with a small aperature
    d. The human eye

2. A Curve that is G(2) (but not G(3))
    a. Is definitely C(0)
    b. Is definitely C(1)
    c. Might be C(1)
    d. Might be C(2)
    e. Might be C(3)

3. The CIE XYZ color system
    a. Can represent any color that a human (with normal color vision) can distinguish
    b. Has primaries that correspond to the three types of cones in humans
    c. Has one primary that is gray

4. A rotation in 3D
    a. Can represent a mirror reflection about any axis
    b. Can always be represented by a rotation around the Z axis, followed by a rotation around the X axis, followed by another rotation about the Z axis
    c. Can be represented by exactly one 3 by 3 matrix

5. Many compressors encode “strings” (pieces of the source material) into “symbols” (pieces of the compressed output). The compressor builds a “codebook” that describes the mapping. Some compression schemes (such as Huffman Coding) send this codebook as part of the encoded output.
   Which of the following is true:
    a. Vector Quantization uses fixed length strings and fixed length symbols.
    b. Huffman coding uses fixed length strings and variable length symbols.
    c. Lempel-Ziv (sometimes known as Ziv-Lempel) uses fixed length strings and variable length symbols.
    d. All lossless compression mechanisms must transmit their codebook.
    e. Only lossless compression transmits the codebooks as part of the compressed output. (e.g. lossy compression does not)

6. Brezenham’s algorithm (or the similar Midpoint algorithm in the book)
    a. Does not require floating point division
    b. May create gaps in lines with very large slopes

Question 7: (10 pts)

Short Answer

1. A continuous signal is to be sampled at 1000 samples per second. An ideal low-pass filter is applied before sampling. Despite this filtering, aliasing occurs. What is the ~~highest~~ lowest possible cutoff frequency for the filter?

2. A computer technician is color blind (missing one type of cone) such that on a correctly connected CRT monitor, yellow looks like white. Most technicians can test to see if all three wires are connected to a monitor by showing a single solid color, but this color blind technician must show two colors. Explain how they do this.

Question 8: (10 pts)

Consider filtering the signal [24 12 12 24 12 12 24 12 12 24 12 12 24 12 12] by convolving it with the kernel [¼ ½ ¼].

If we want the result to have the same length (15 samples) then we must handle the boundaries specially. Two of the ways we discussed to do this are to pad the signal with zeros outside of its domain and to renormalize the kernel when it overlaps a boundary.

Perform the convolution using both of these two methods. You answer should consist of two signals, both 15 samples long.