Please read over the entire exam before starting.

This exam is closed book and closed notes.

The exam is designed to not need a calculator. If you feel as if you need one, you are probably making things more difficult than they should be.

Leave your answers in fractional / radical form: we would prefer to see ¼ than .25, or $\sqrt{2}$ than 1.414…

If you feel a question is ambiguous, state the assumptions that you make to make it unambiguous. Chances are, if you feel a question is ambiguous, you aren't understanding something.

Please answer in the space provided. If you need more space, answer on the back of the page, but put a note to remind us to look there.

1 ____ / 8 pts

2 ____ / 12 pts __ (6) __ (2) __ (2) __ (2)

3 ____ / 11 pts __ (7) __ (4)

4 ____ / 18 pts

5 ____ / 13 pts __ (5) __ (4) __ (4)

6 ____ / 15 pts __ (5) __ (5) __ (5)

____ / 75 pts

QUESTION 1:

A Quadratic Curve segment has f(0)=1, f'(0)=1, f''(0)=1 (that is, when the parameter is 0, the value, first, and second derivatives are all equal to one).

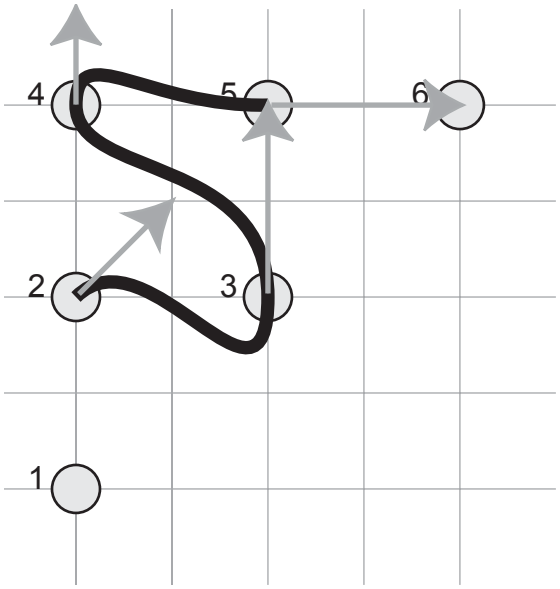
What is the value of f(1)?

f(u) = a1 + a2 u + a3 u^2 **f(0) = 1 -> a1 + 0 + 0 = 1 -> a1 = 1**
f'(u) = a2 + 2 * a3 u **f'(0) = 1 -> a2 + 0 = 1 -> a2 = 1**
f''(u) = 2 * a3 **f''(0) = 1 -> 2*a3 = 1 -> a3 = ½**

f(1) = 1 + 1*1 + ½ * 1 = 2 ½

QUESTION 2:

Sketch a Catmull-Rom Curve (a cardinal cubic with tension 0) through the following 6 points, and answer the questions about it:



Note: the grid is unit size (the spacing between grid lines is 1)

2B: What is the derivative at point 3?

0,2

2C: What is the derivative at point 5?

2,0

2D: What is the highest order continuity of the curve at point 3?

***C*(1)**

2E: What is the highest order continuity of the curve at the point halfway between 3 and 4?

infinite

Question 3:

Students were asked to halve 1D images (downsample by a factor of 2). Some students used the uniform average filter [1/3 1/3 1/3], while others used the binomial filter [¼ ½ ¼].

The test signal was 12 cycles of a square wave of amplitude 12:

[12 0 12 0 12 0 12 0 12 0 12 0]

Question 3A:
What results would a student who used the average filter get if they implemented everything correctly?

Either [4 8 8 8 8 8 4] or [4 4 4 4 4 4 0]

Note: getting the ends wasn't important – noticing that the middle could be very different was!

Question 3B:
What results would a student who used the binomial filter get if they implemented everything correctly?

Either [3 6 6 6 6 6 3] or [6 6 6 6 6 6 0]

Note: getting the ends was not important, but getting the middle (all 6s) was

Question 4: Multiple-Multiple Choice

Please circle the number for ALL of the correct answers for each question. There may be more than one.

A. Which of the following can be done without division (except divisions by powers of two that can be done as shifts)?

1. drawing a line

2. drawing a circle

3. converting from homogeneous to Cartesian coordinates

4. filling a triangle with a constant color

5. Floyd-Steinberg error diffusion

B. Which of the following can be done by a linear transformation in homogeneous coordinates, but **not** by a linear transformation in regular coordinates

1. rotation
2. non-uniform scaling

3. translation

4. orthographic projection

5. perspective projection

C. Which of the following are reasons why you might prefer perspective transformations over orthographic transformations

1. **objects that are further away get smaller**
2. farther objects occlude nearer objects
3. **near plane clipping is important for more reasons**

D. If your red photoreceptors fail, which colors would you NOT be able to distinguish on a CRT monitor

1. yellow and green

2. red and blue
3. green and cyan

4. cyan and gray

5. magenta and gray

Question 5:

Short answer: concise answers will be rewarded. One or two sentences should do the trick.

Question 5A:

A robot designer creates a synthetic monkey with a vision system that is similar to a new world monkey in that it has two types of photo receptors. The designer makes one type of photoreceptor sensitive only to green light, and the other type only sensitive to red light.

The robot passes its tests for identifying bananas in pictures presented on the CRT screen of the designers computer, but cannot find bananas in the jungle. Explain why this happened.

The CRT monitor makes yellow by adding red and green and faking out a biological eye (whose red and green receptors overlap at yellow). Because the robot's receptors are sensitive ONLY to green and red, the real yellow light would not excite either of them.

Question 5B:

A student claims that their implementation of simple thresholding (picking the nearest color value) gives the same answers as Floyd-Steinberg error diffusion for turning greyscale images into black and white. What kinds of images did the student test this theory on?

Black and White images

Question 5C:

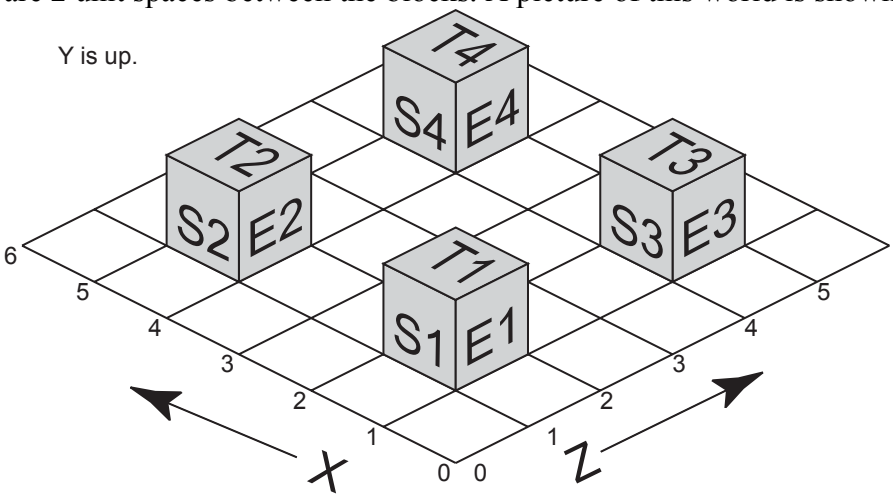
Explain why the frequency content of images would affect the choice between using Floyd-Steinberg error diffusion and ordered dithering

(either answer would be sufficient)
If the image does not contain high frequencies, ordered dithering might be acceptable.

The potential for error accumulation in FS happens on LF images (since errors can get pushed off the edges). If there's enough frequency content in an image, there will probably be errors in both directions, so FS would be OK

Question 6:

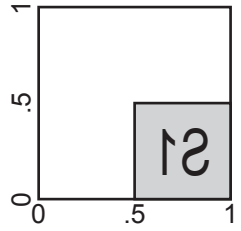
Consider a world with 4 blocks (numbered 1 to 4 in it). Each face of the blocks has the letter (N,S,E,W,T,B) for which side it is on (North, South, East, West, Top, Bottom). The blocks are unit size (each edge has length one). All blocks are placed on the ground (y=0). The first block is placed one unit away from the origin (its corner is at 1,0,1), and there are 2 unit spaces between the blocks. A picture of this world is shown:



Consider viewing this world with an orthographic camera. The camera's film plane is the XY plane (Z=0), and is the unit square (between 0 and 1 in X and Y – note: it is NOT centered at the origin). The viewing direction is down the negative Z axis.

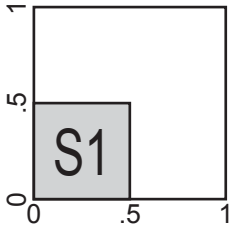
Provide the viewing matrix (4x4) that generates the following views:

Example:

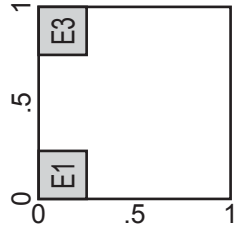


1/2	0	0	0
0	1/2	0	0
0	0	-1	0
0	0	0	1

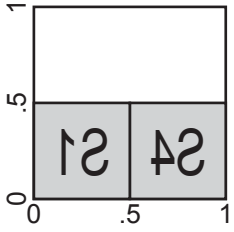
6A:



6B:



6C:



6A:

-1/2	0	0	1
0	½	0	0
0	0	-1	0
0	0	0	1

how? X=2 -> X=0, X=1 -> X=.5 – solve 2x2 linear system if need be

6B:

0	¼	0	¼
0	0	¼	-¼
-1	0	0	0
0	0	0	1

how? Think about what happens to each axis:
+Z axis -> +Y axis, scale by ¼, shift by -¼ (put block at origin)
+Y axis -> +X axis, scale by -¼, shift (need to flip around ¼)
+X axis -> -Z axis (scale doesn't matter)

6C:
this one was hard! However, at least one person got it

½	0	-1/3	-1/6
0	½	0	0
0	0	-1	0
0	0	0	1

first, the Y and Z are simple – they are just like the example
second, consider all of the facts that we know about the Xs. (since Ys don't matter, only consider X, Z and W)
X,Z,W -> X' 1 1 1 -> 0,
2 1 1 -> .5
4 4 1 -> .5
5 4 1 -> 1
we know that the x component must be ½ since the cubes are scaled in the x direction even though they are parallel to the x axis (constant Z).
so plugging that into those 4 equations gives:
1 1 -> -.5
1 1 -> -.5
4 4 -> -1.5
4 4 -> -1.5
which we can solve for the W and Z components