CS 559: Computer Graphics - Midterm Exam

October 17, 2002

Name: _____

ID: _____

Login: _____

- You have 1 hour and 10 minutes to complete the exam.
- Before beginning, write your name, ID number and login on the front page, and your login on every page.
- On your desk you may have something to write with, one double-sided piece of paper with anything on it, an optional ruler, and nothing else.
- Do all your work on the pages provided, going to the back side if necessary. If you do use the back, indicate on the front side that there is something on the back.
- If you need to make assumptions in order to answer a question, say what they are. However, all the questions should be unambiguous.

Question 1: ____/4

Question 2: ____/10

Question 3: ____/4

Question 4: ____/3

Question 5: ____/6

Question 6: ____/5

Question 7: ____/2

Question 8: ____/2

Question 9: ____/8

Question 10: ____/4

Question 11: ____/10

Total: ____/58

Question 1: (4 points)

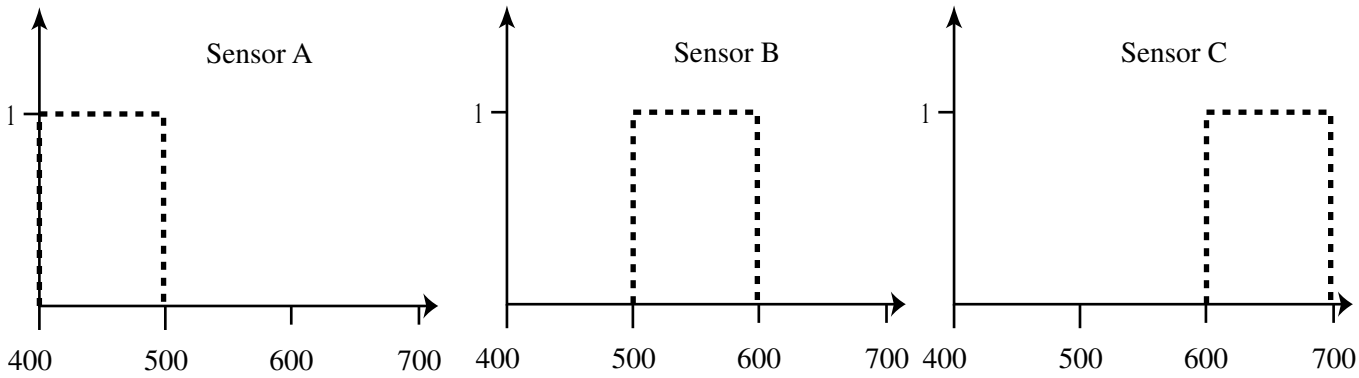
Some monitors accept their RGB input through three separate cables: one for red, one for green and one for blue. You are looking at such a monitor, but the colors are wrong because some cables are not connected to the proper jacks. Even worse, the cables are not labeled, although the jacks are.

a. You have a program that asks the user for a color and then draws a rectangle of that color on the screen. How would you use it to determine the labels for the cables?

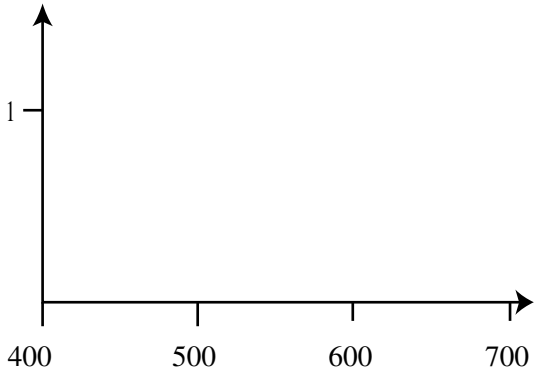
b. Say that you have established that the blue cable is plugged into the red jack, and the red cable is plugged into the blue jack. What color would you see if you tried to display yellow?

Question 2: (10 points)

Consider the three color sensors shown below. Sensor A responds uniformly between 400nm and 500nm. Sensor B responds between 500nm and 600nm. And Sensor C responds between 600nm and 700nm.



a. One the graph below, draw a spectrum that would correspond to white light.



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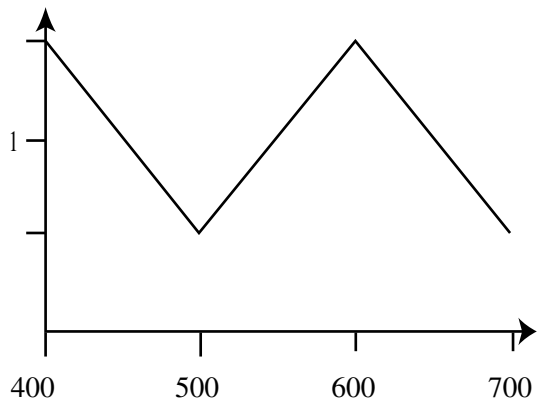
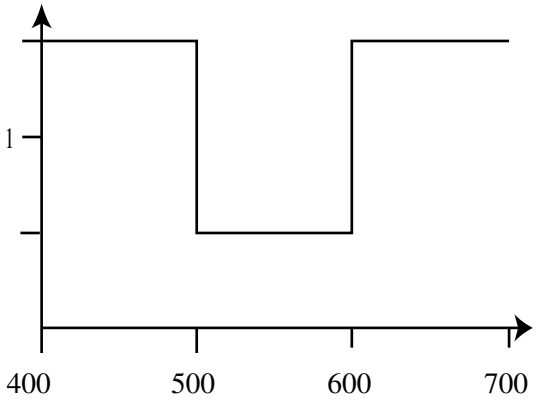
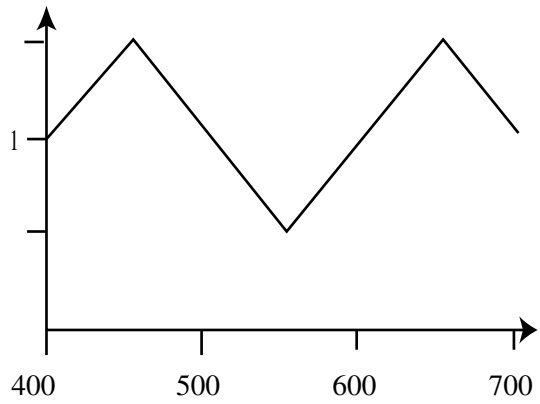
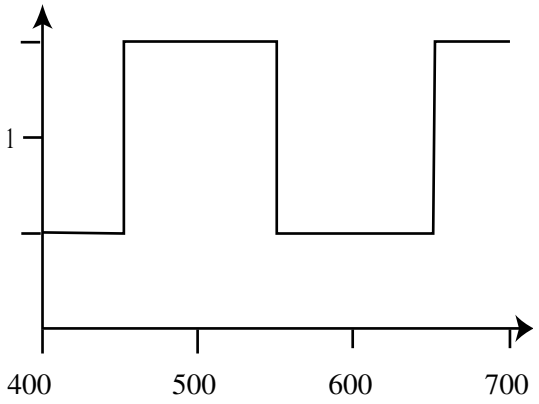
b. Circle the spectra below that give the same response as white light. They are called *metamers* to white.









c. Say I have two colors that are metamers. If I remove one sensor, will they still be metamers with respect to the remaining two sensors?

d. Again, I have two colors that are metamers. If I shift the response curve of one of my sensors, say by 50nm to the left, will the colors still be metamers?

Question 3: (4 points)

A mythical cell phone has a display with 100×100 pixels. 100,000 bits have been allocated for display memory, which must store all the color information about every pixel.

a. How many bits are available for each pixel?

b. Given human visual perception factors, which color component (red, green or blue) would you allocate the most bits to?

c. Write down a formula for the number of bits required to store a 100×100 indexed-color image that uses k bits per pixel to index a color table that stores n bits per color?

Question 4: (3 points)

Temporal coherence is important when rendering animation. An image is temporally coherent if the images displayed from frame to frame only change where the scene itself is actually changing. Of course, an animation display should also be fast.

You are working with an animation display where you must perform dithering. Which dithering algorithm would you use, and why?

Question 5: (6 points)

Consider the problem of taking a digital photograph of striped wallpaper. For each case below, circle the situation that would require a higher sampling frequency.

a. **Narrow stripes** or **wide stripes**?

b. **Close up** or **far** shot?

c. Looking **straight on** or **at an angle**?

Question 6: (5 points)

Consider the image below on the left and the filter matrix on the right. The gray pixels are not part of the image.

0	0	0	1	0	0	0
0	0	0	1	0	0	0
0	0	0	1	0	0	0
1	1	1	1	1	1	1
0	0	0	1	0	0	0
0	0	0	1	0	0	0
0	0	0	1	0	0	0

1	1	1
1	3	1
1	1	1

a. What constant would you multiply the filter by to maintain the brightness of a filtered image?

b. Filter the image above and place the result in the image below. Handle the boundary by extending the edges of the original image outward, as indicated by the gray pixels above. Use symmetry to help you.

Question 7: (2 points)

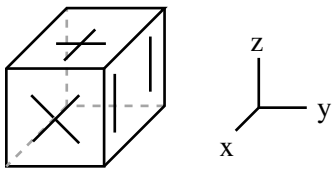
Given a rotation, $\mathbf{R}$, and a translation, $\mathbf{T}$, what is the effect of applying the composition $\mathbf{R}^{-1}\mathbf{T}\mathbf{R}$?

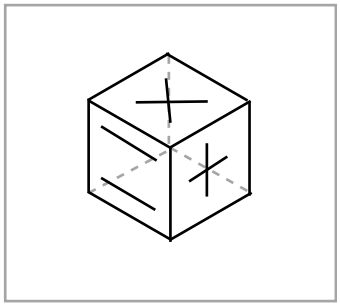
Question 8: (2 points)

What 3D point does the homogeneous coordinate [4 6 2 2] represent?

Question 9: (8 points)

Below on the left is a 3D cube, with marked faces, and a set of axes to indicate the world coordinate system. The origin for the world is at the center of the cube. On the right is a sketch of an image you would like to generate, with the cube appearing such that the back corner is directly behind the front corner, in the orientation indicated.





a. What is the gaze direction?

b. Give a suitable *up* vector.

c. What is the view plane normal vector, **w**, in world coordinates? ($\sqrt{}$ signs are acceptable in your answer.)

d. What vector is to the right in the image plane, **u**?

e. What vector is up in the image plane, **v**?

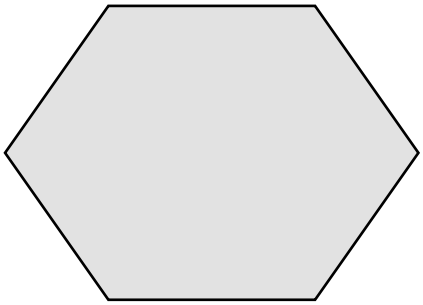
f. I am planning on doing an orthographic projection. How would you describe a suitable location for the eye?

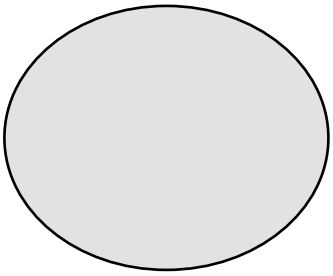
g. Now I plan on doing perspective projection. I want my eye to be 10 units away from the center of the cube. Where should it be?

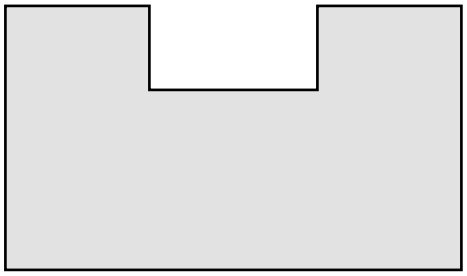
h. If I change the eye distance to 20 units, what will be the effect on the apparent width of the box *in the image.*

Question 10: (4 points)

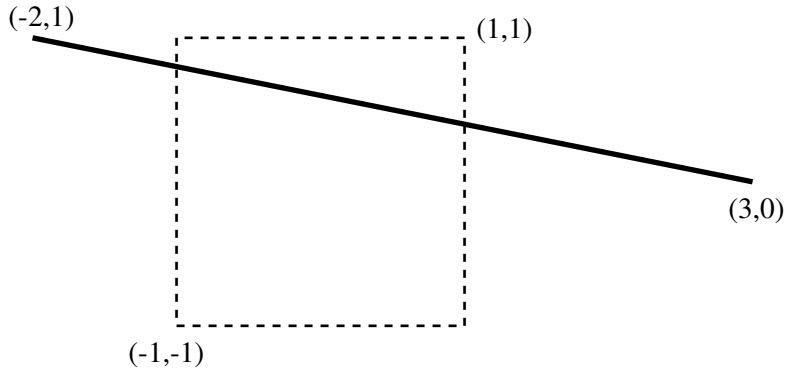
Circle the regions that would be acceptable as **clip regions** for Sutherland-Hodgman clipping. (Dashed continuations indicate infinite lines.)







Question 11: (10 points) This question explores Liang-Barsky clipping. Consider the line segment and clip region shown below.



a. What is the parametric equation of the line? Write it in the form:

$$\begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} a \\ b \end{bmatrix} + t \begin{bmatrix} c \\ d \end{bmatrix}$$

b. What are the four parametric coordinates (the t values) for the intersections of the line with each clip edge? Label them as entering or leaving intersections.

$x = -1$:

$x = 1$:

$y = -1$:

$y = 1$:

c. What are the parametric coordinates of the end-points of the visible segment?

d. What are the (x, y, z) coordinates of the end-points of the visible segment?