CS 559: Computer Graphics - Midterm Exam

October 28, 2004

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: ____/4

Question 3: ____/6

Question 4: ____/4

Question 5: ____/6

Question 6: ____/4

Question 7: ____/2

Question 8: ____/8

Question 9: ____/3

Question 10: ____/6

Question 11: ____/5

Total: ____/54

Question 1: (4 points)

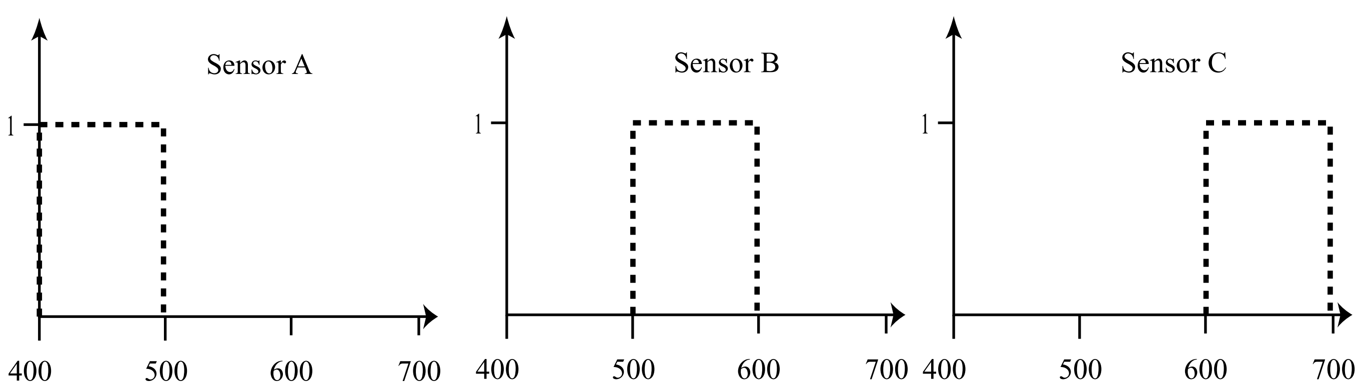
Consider the color with RGB components (0.5, 0.1, 0.1).

a. Give a color that is *less saturated* but otherwise similar. The exact color you give is not important, but the relative amounts of red, green and blue are. It may help to recall the HSV color space to answer this question, but do not convert the color to HSV to answer the question.

b. Give a color that is **brighter** but otherwise similar. Again, the absolute values do not matter but the relationship between red, green and blue is.

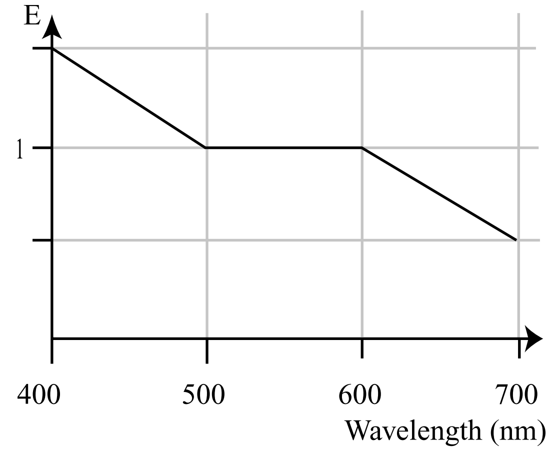
Question 2: (4 points)

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.

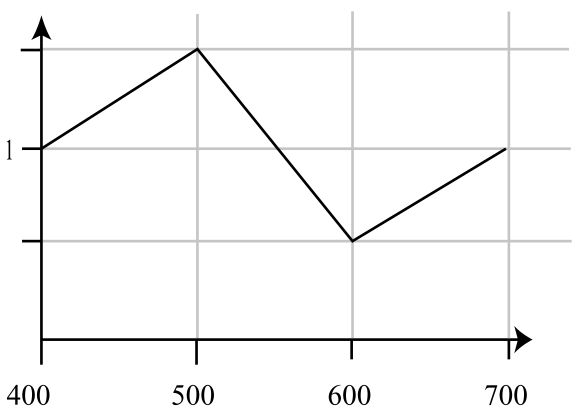


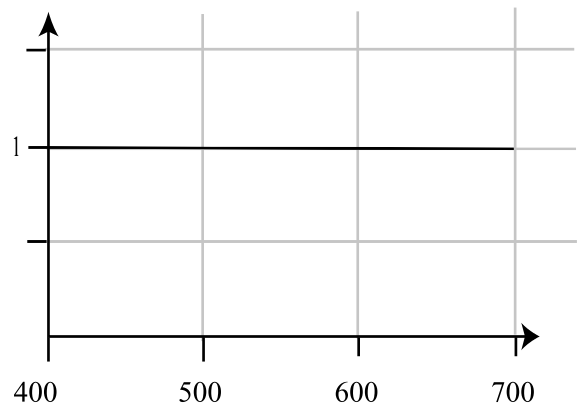
Continued . . .

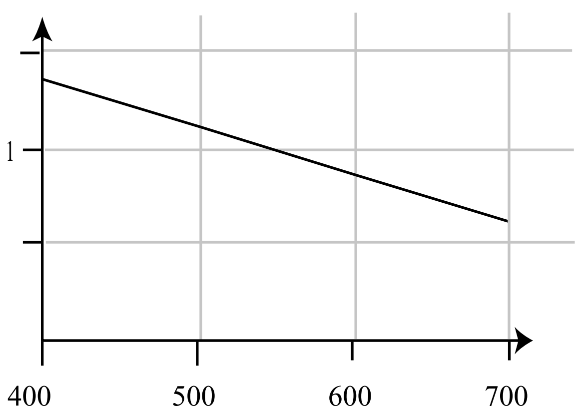
a. This question refers to the following spectrum:

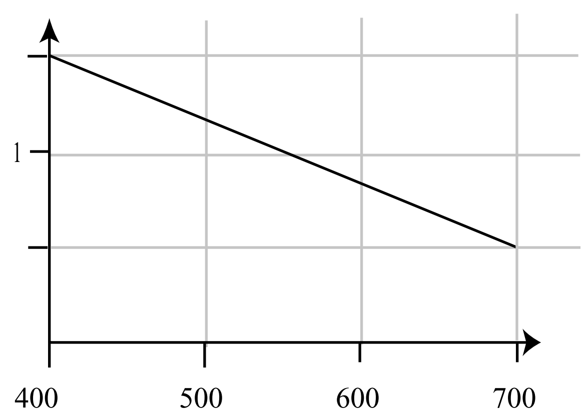


Circle the spectra below that give the same response for all three sensors as the spectrum above. They are called *metamers*.









b. 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: (6 points)

You are asked to apply the **populosity** color quantization algorithm to a video sequence. In video you know the entire contents of every frame before you begin quantizing.

a. What information does the populosity algorithm use to construct its color table when applied to a single image?

b. Why is it a bad idea to apply the populosity algorithm to each frame independently (reconstructing the color table for each frame)?

c. What is a better method for applying populosity to video?

Question 4: (4 points)

Consider the problem of taking a digital photograph of a striped object.

a. Which requires a higher sampling frequency: narrow stripes or wide stripes?

b. Describe a technique employed in secure printing (checks, contracts, and so on) that exploits sampling theory to protect against digital reproduction. What assumptions does the technique rely upon?

Question 5: (6 points)

Consider an image consisting of white rectangles on a black background. This question explores the use of various filters on the image.

a. What is the result (1×5) of applying the 1D filter below (1×4) to the two 1D "images" below?

Filter ⊗ Image = Result

-1	-2	2	1	⊗	0	0	0	0	1	1	1	1	=						
-1	-2	2	1	⊗	1	1	1	1	0	0	0	0	=						

b. Based on part (a), what can you say about the edge finding power of the following 2D filter?

-1	-2	2	1
-1	-2	2	1
-1	-2	2	1
-1	-2	2	1

c. Below is the 2D filter constructed from part (a) using the "standard" method. What type of 2D image features does this filter respond to?

1	2	-2	-1
2	4	-4	-2
-2	-4	4	2
-1	-2	2	1

Question 6: (4 points)

Recall the **over** compositing operation: $c = c_f + (1 - \alpha_f)c_b$.

a. You are given pre-multiplied RGBA colors $c_f = (0.5, 0, 0, 0.5)$ and $c_b = (0, 0, 0, 1)$. What two RGB colors do these correspond to?

b. What is the RGBA result of c_f **over** c_b?

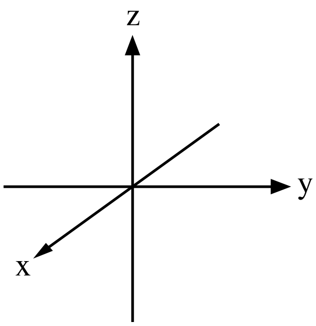
Question 7: (2 points)

What 3D point does the homogeneous vector [1 4 2 0.5] represent?

Question 8: (8 points)

We wish to specify a view that has the image plane centered at the point $(0, 0, 0)$ with the viewer looking along the y axis toward the point $(0, 5, 0)$. The z axis should appear up in the image.

a. Mark the points above and the “up” vector on the diagram.



b. What is the view plane normal vector, **w**, in world coordinates?

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

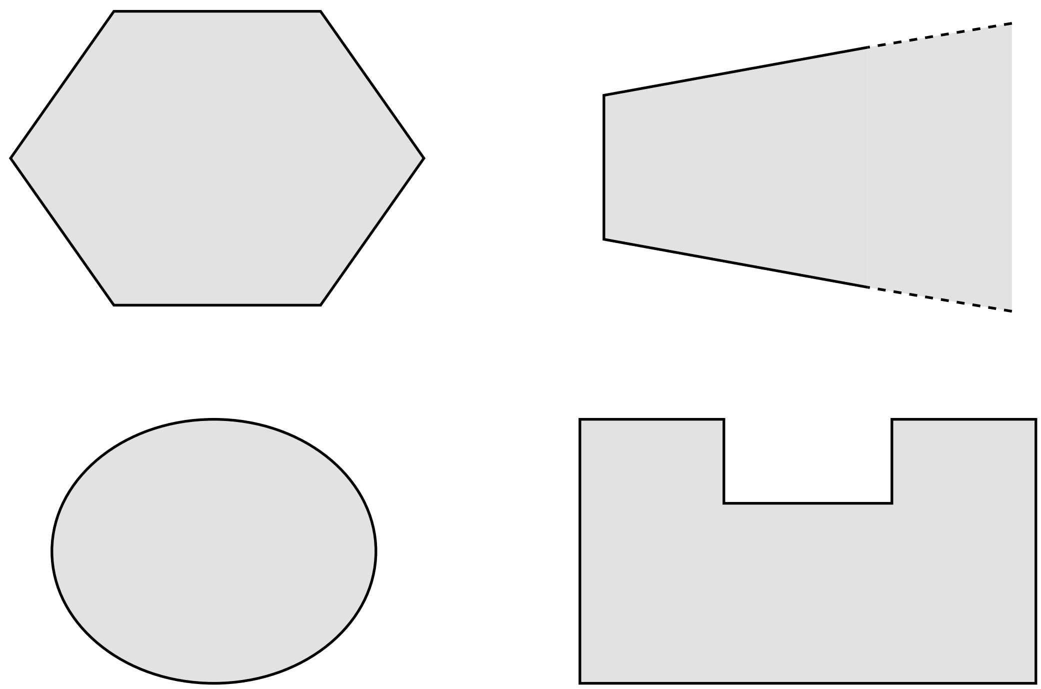
d. What vector is up in the image plane, **v**?

e. In this situation it is possible to transform from world space into view space with a simple rotation. About what axis do we rotate to go from world to view space, and by how much? Recall that in view space, the z axis should point toward the viewer, the x axis should point to the right and the y axis should point up.

f. What is the 4×4 homogeneous transformation matrix that achieves this rotation? (Hint: Test your answer by transforming the **u**, **v** and **w** vectors.)

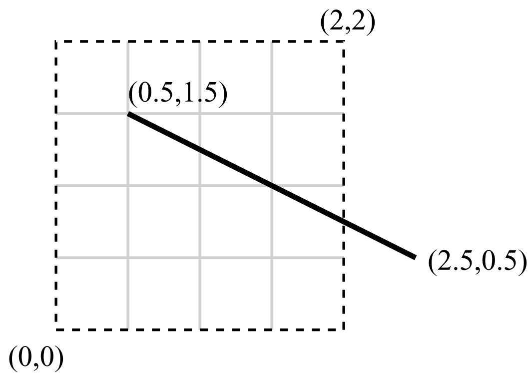
Question 9: (3 points)

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



Question 10: (6 points)

This question explores Liang-Barsky clipping. Consider the 2D line segment and clip region shown below.



a. What is a parametric equation for 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 parametric coordinates of the end-points of the visible segment?

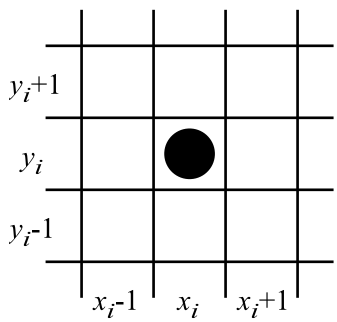
c. What are the (x, y) coordinates of the end-points of the visible segment?

Question 11: (5 points)

You are designing a version of Bresenham's algorithm to use on lines with slopes in the range $(1, \infty)$. Assume you always draw the line starting at the lowest x coordinate and moving toward the highest x coordinate.

a. Will you fill one pixel every row, or one pixel every column?

b. In the image below, assume you have just filled the black pixel at (x_i, y_i). What are the two possible candidates to be the next pixel filled?



c. What are the coordinates of the decision point that you will test to decide between the candidate points when drawing a line?