Computer Graphics — Brian Curless
CSE 591 — Autumn 1999

Homework 1

Assigned: Tuesday, October 12, 1999
Due: Tuesday, October 26, 1999

DIRECTIONS

Please provide short written answers to the questions in the space provided. If you require extra space, you may staple additional pages to the back of your assignment. Feel free to talk over the problems with classmates, but please answer the questions on your own.

NAME: ________________________________

Problem 1 True or False (justify your answers)

(a) Our peripheral vision has low acuity, because we have relatively few cones in the periphery.

(b) Two spectra that are metamers have identical coordinates in CIE color space.

(c) For every monochromatic color A, there exists a complementary monochromatic color A, such that some mixture of A and A makes white.

(d) Two colors with identical coordinates in CIE color space have the same spectra.

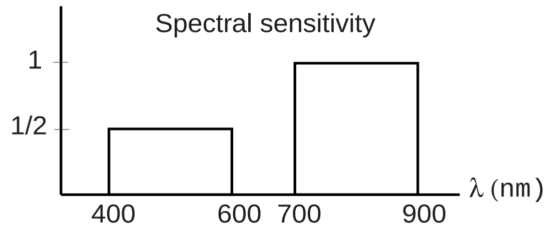
(e) The color gamut of a printed page can change depending on whether it is viewed in florescent lighting or natural sunlight.

(f) A mean filter with small support will sharpen an image.

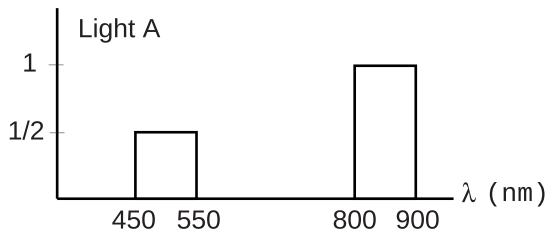
(g) The red electron gun in a color monitor fires electrons with energies that are closer to the infrared portion of the spectrum than the ultraviolet.

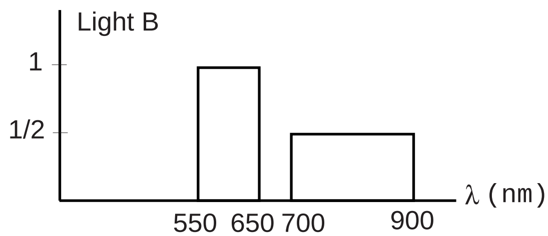
Problem 2 In a modified color matching experiment, we have one test light and two sets of primaries. The first set of primaries has spectra $a(\lambda)$, $b(\lambda)$, and $c(\lambda)$ and we can control their power settings to be e_a, e_b, and e_c. Similarly, the second set of primaries has spectra $d(\lambda)$, $e(\lambda)$, and $f(\lambda)$ and we can control their power settings to be e_d, e_e, and e_f. If we adjust the first set of primaries to match the test light, we should be able to figure out how to adjust the second set of primaries to match the same test light. Using the vector and matrix notation from class, construct a matrix equation that tells us how to compute e_d, e_e, and e_f given e_a, e_b, and e_c.

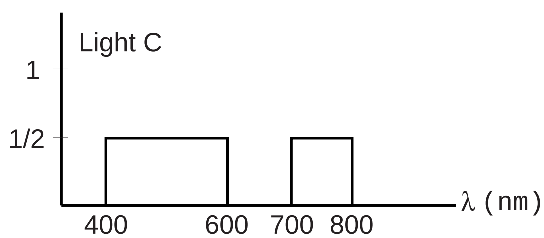
Problem 3 A recently discovered breed of pot-bellied pig has two types of cones, labeled A and B, with spectral sensitivities as shown below:



(a) We perform the color matching experiment with this rather intelligent pig using the three lights shown below. Determine which, if any of these lights, are metamers for the pig. Show your work.

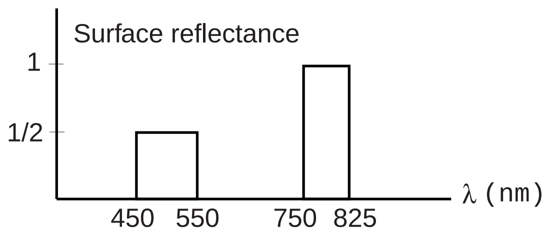






Problem 3, continued.

(b) We now repeat the experiment by shining the lights from (a) onto a piece of paper with surface reflectance show below. Determine under which, if any, of the lights the surface will yield subtractive metamers for the pig. Show your work.



Problem 4 The American standard video system calls for a total of 525 horizontal lines. However only 483 of these 525 lines are actually visible because a time equivalent to 42 lines is required to reposition the electron beam from the bottom of the screen back to the top. For the duration of this "vertical retrace" period, the electron beam is made invisible or "blanked."

(a) The American standard video system also calls for a "viewing aspect ratio" of 4:3; that is, the visible viewing area is three-quarters as high as it is wide. How many pixels are on each scan line, assuming square pixels?

(b) To avoid flicker, the whole screen needs to be refreshed at 60hz. How much time does this allow for each scan line?

(c) When the electron beam reaches the right edge of the screen after each scan line is drawn, it is made invisible and rapidly returned to the left edge. This "horizontal retrace" period generally requires 17% of the time allowed for one scan line. How much time does this leave for accessing and displaying each pixel?

Problem 4, continued.

In order to allow more time for transmitting and displaying each pixel, the American broadcast television standard uses an "interlaced" type of refresh, in which each video frame is broken into two "fields," each containing one-half of the picture. The two fields are "interlaced" in the sense that each field contains every other scan line: all odd-numbered scan lines are displayed in the first field, and all even-numbered scan lines are displayed in the second.

The purpose of an interlaced scan is to place some new information in all areas of the screen at a high enough rate to avoid flicker, while allowing the hardware more time for accessing and displaying each pixel.

(d) If the video controller displays each field in $1/60^{th}$ of a second, what is the overall frame rate for displaying the entire screen?

(e) Assuming no additional vertical retrace time is required for painting the two fields, how much time is available for drawing each pixel?

(f) An interlaced refresh works well as long as adjacent scan lines display similar information. In which parts, if any, of the following images would you expect to see flicker on an interlaced display (and mention why):

- A single horizontal white line on a black background?

- A single vertical white line on a black background?

- A checkerboard of black and white, where each black or white square is 8 x 8 pixels?

- A checkerboard of black and white, where each black or white square is a single pixel?

Problem 5

(a) Convolution filtering can modify images in a variety of ways. Describe the expected effect of filtering an image using the following convolution kernel. Justify your answer.

$$\begin{bmatrix} -1 & -3 & -1 \\ -3 & 16 & -3 \\ -1 & -3 & -1 \end{bmatrix}$$

(b) Some image I(i,j) is given as an array of greyscale values, each between 0 and 1. If we filter this image with the convolution kernel in part (b), we get a new image I'(i,j). What are the maximum and minimum values the filtered image I'(i,j) can take on at a particular pixel?

Problem 5 - continued.

(c) Why might the following convolution kernel be a good choice for smoothing images taken from interlaced video?

$$\frac{1}{38}\begin{bmatrix} 1 & 1 & 1 \\ 8 & 16 & 8 \\ 1 & 1 & 1 \end{bmatrix}$$

(e) Suppose you had a digital photograph where the camera was moving downward at the exact instant the picture was taken. That is, everything in the image is blurred a little bit vertically, but not horizontally. Devise a convolution operator to sharpen this image. Note that a general "sharpen" filter would work, but for this special case, it can be done better.