CS 447/547: Computer Graphics - Midterm Exam

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- You have 1 hour and 30 minutes to complete the exam.
- Before beginning, write your name and ID number on the front 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 /4

Question 2: 3 /3

Question 3: 0 /2

Question 4: 1 /2

Question 5: 3 /3

Question 6: 2 /2

Question 7: 3 /5

Question 8: 2 /2

Question 9: 3 /3

Question 10: 5 /5

Total: 26 /31

r G B

C M Y

Question 1:

Component video cables for connecting your DVD and television transmit the red, green and blue color channels along separate lines. You have just connected a new cable and you discover that an image of the American flag looks red, magenta and blue. The color blue appears where the flag should be blue, red appears where the flag should be red, and magenta appears where the flag should be white.

a. Is it possible that you have switched two of the color channels when you connected the cables? If so, which color channels might be swapped? If not, why not? (2 points)

~~Yes red + Green Might be swapped~~

~~if the g~~

no, the red part of the flag tells that red cable is correct because the G, B values would be much smaller where red is on the flag

the blue part of the flag tells that the blue cable is correct and the R G values would be much smaller where blue is on the flag

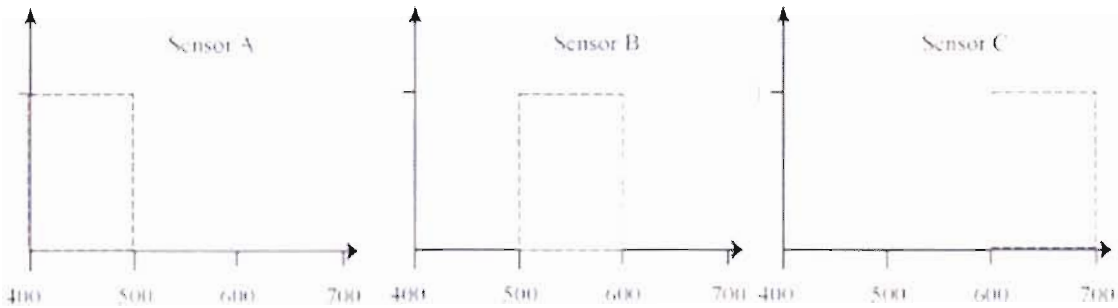
2 cables are correct so there are no switched cables

b. Is it possible that the cable or connector is defective? If so, what is the defect? If not, why not? (2 points)

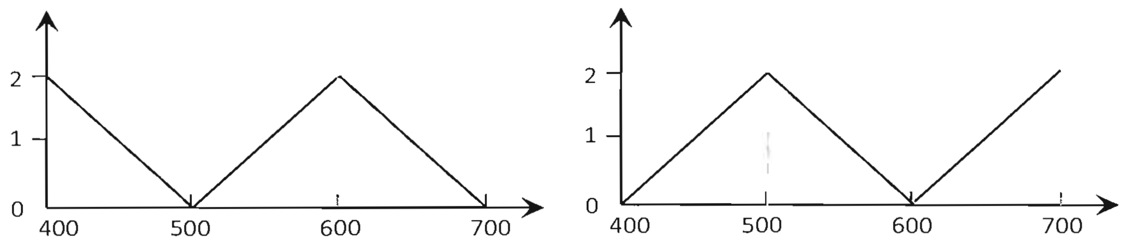
the green cable or connector is defective because the white part is recieving the correct R, B color, but either no green or the wrong value for green, thus displaying magenta

Question 2:

Consider the three color sensor response curves shown below.



a. Will the two spectra below give identical responses, or different responses? (2 points)



$\frac{1}{2} 2 \cdot 100$

100 100 100 100 100 100

Yes they will give the same response

b. Will these two spectra appear as the same color to the above sensors? (1 points)

yes

$\frac{x}{w} = 1 \quad \frac{y}{w} = 4 \quad \frac{z}{w} = 3$

$w = .5$

Question 3:

a. What 3D point does the homogeneous vector [1 4 3 0.5] represent? (1 point)

[.5, 2, 1.5]

b. What is the homogeneous representation for a 3D direction [1 3 4]? (1 point)

[1 3 4 1]

Question 4:

Recall the **over** compositing operation: $c = c_f + (1 - \alpha_f)c_g$.
You are given pre-multiplied RGBA colors $c_f = (0.5, 0, 0, 0.5)$ and $c_g = (0, 0, 0, 1)$.

a. What two RGB colors do these correspond to? (1 point)

c_f r = .5/.5 = 1
g = 0/.5 = 0
b = 0/.5 = 0

c_g r = 0/1
g = 0/1 = black
b = 0/1

c_f = Red
c_g = black

b. What is the RGBA result of c_f **over** c_g? (1 points)

(1, 0, 0)
+ (0x.5, 0x.5 0x.5)
= (1, 0, 0, 1)

Question 5:

a. The *Laplacian* is used to enhance discontinuities. The 3x3 *Laplacian* kernel is:

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

What is the response of this filter to the following 6×6 image? Ignore the boundary pixels that do not have all the pixel values for the filter, such that you get a 4×4 result image. (2 points)

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

0 0 0
1 1 1
1 1 1

-1 4 -1
-1

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

b. We have a 1D low pass filter with kernel $\frac{[1\ 2\ 3\ 2\ 1]}{9}$, what is the kernel for the corresponding 2D filter? (Note, you need to give a 5 by 5 matrix as an answer). (1 point)

$$\begin{matrix} 1 & 2 & 3 & 2 & 1 \\ 2 & 4 & 6 & 4 & 2 \\ 3 & 6 & 9 & 6 & 3 \\ 2 & 4 & 6 & 4 & 2 \\ 1 & & & & \end{matrix}$$

$$\frac{1}{81}\begin{bmatrix} 1 & 2 & 3 & 2 & 1 \\ 2 & 4 & 6 & 4 & 2 \\ 3 & 6 & 9 & 6 & 3 \\ 2 & 4 & 6 & 4 & 2 \\ 1 & 2 & 3 & 2 & 1 \end{bmatrix}$$

(bartlett Filter)

Question 6:

Assume that you are using indexed color with a color table that stores each color using 16 bits. For an image, you use 4 bits per pixel to define color using the color table. Such a scheme might be used in a cell phone years ago.

a. If you only need to display one color in your image, how many possible choices do you have for that color? (1 point)

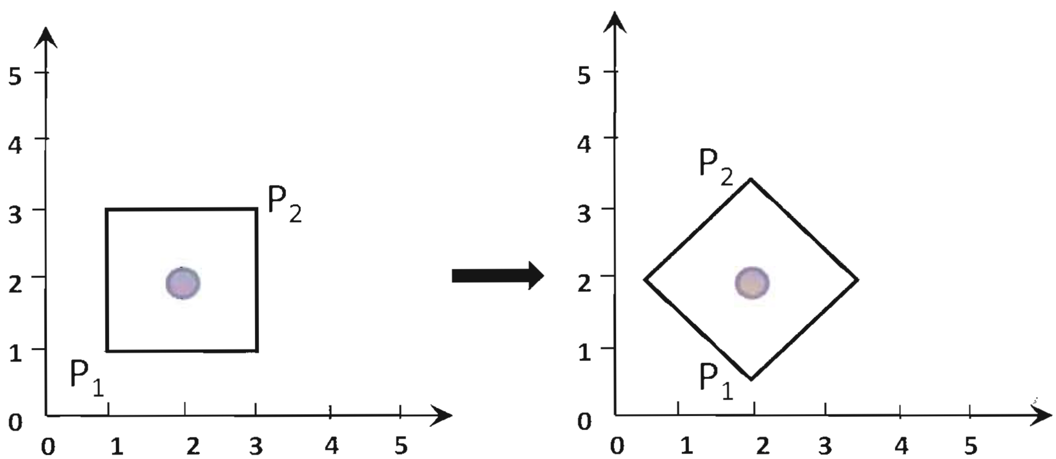
$2^{16} = 65536$

b. How many different colors are available for use in a single image? (1 point)

$2^4 = 16$ colors

Question 7:

In 2D space, we have a square centered at (2, 2). Its bottom-left corner P_1 is at (1, 1) and its top-right corner P_2 is at (3, 3).



a. We rotate this box about its center 45 degrees counter-clockwise as shown in the above figure. What are the coordinates for P_1 and P_2 after rotation? (Hint: there are a few methods to solve this problem. For example, you can finish b and c of this question and then use their result to directly compute the new coordinates for P_1 and P_2. Or, you can work in a new coordinate system whose origin is at (2, 2).) (2 points)

$$\begin{bmatrix} \cos 45 & -\sin 45 \\ \sin 45 & \cos 45 \end{bmatrix} \begin{bmatrix} -1 \\ -1 \end{bmatrix}$$

$x = -\cos 45 + \sin 45 + 2$

$y = -\sin 45 - \cos 45 + 2$

$P_2 x = \cos 45 - \sin 45 + 2 = 2$

$P_2 y \quad \sin 45 + \cos 45 + 2 = 2 + \sqrt{2}$

$P_1 \; x = 2$

$P_1 \; y = 2 - \sqrt{2}$

$P_1 = \begin{bmatrix} 2 \\ 2 - \sqrt{2} \end{bmatrix}$

$P_2 = \begin{bmatrix} 2 \\ 2 + \sqrt{2} \end{bmatrix}$

b. What is the 2D transformation matrix with homogenous coordinates for a rotation about the origin 45 degrees counter-clockwise? (Hint: A 2D transformation matrix with homogenous coordinates is a 3 by 3 matrix) (1 point)

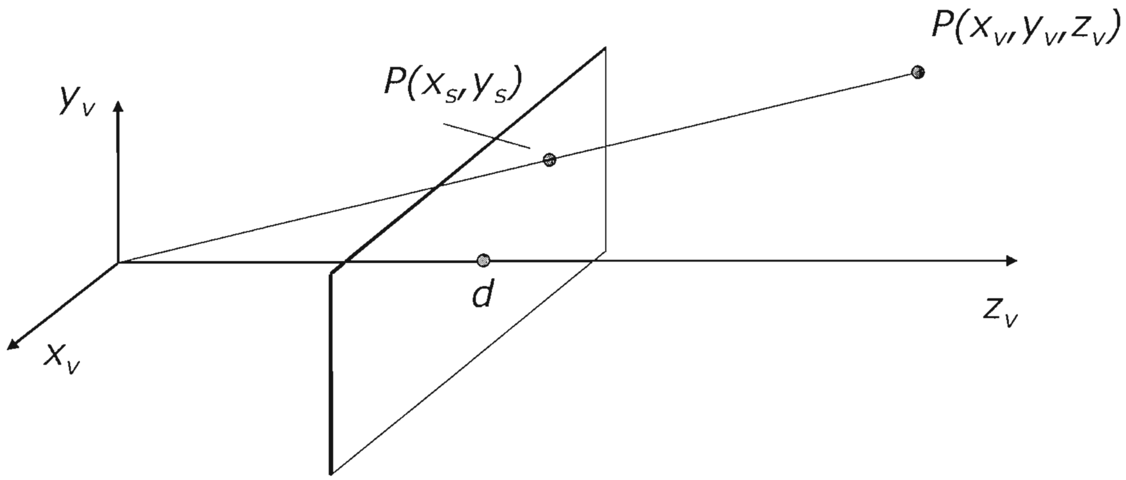
$$\begin{bmatrix} \cos(45^\circ) & -\sin(45^\circ) & 0 \\ \sin(45^\circ) & \cos(45^\circ) & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

c. What is the 2D transformation matrix with homogenous coordinates for a rotation about (2, 2) 45 degrees counter-clockwise? You can verify your answer with (a). (2 points)

$$\begin{bmatrix} \cos(45^\circ) & -\sin 45^\circ & 2 \\ \sin(45^\circ) & \cos 45^\circ & 2 \\ 0 & 0 & 1 \end{bmatrix}$$

Question 8:

We assume a basic perspective projection as illustrated in the following figure.



Here a 3D point P(x_v, y_v, z_v) in the view space is projected onto the image plane P(x_s, y_s).
We know the coordinate of a point in the view space is (100, 20, 20). We also know that it appears at image plane (10, y_s). What is the focal distance d? What is the value of y_s? (2 points)

$$\frac{x_v}{z_v} = \frac{100}{20} = \frac{10}{d}$$

$$100d = 200$$

$$d = 2$$

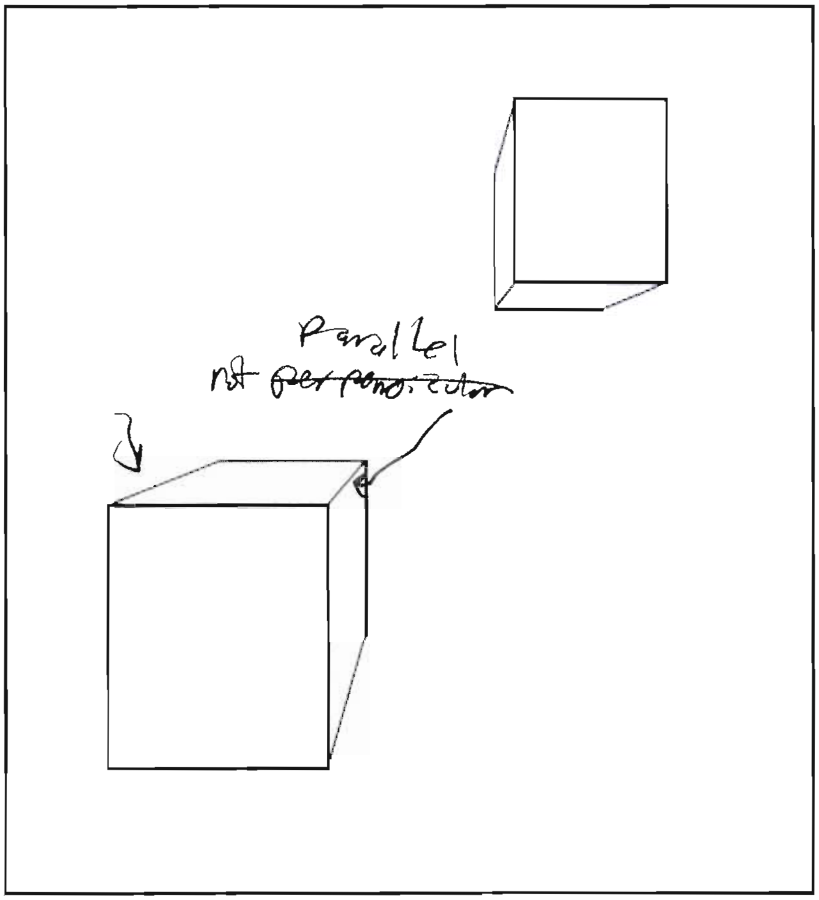
$$d = 2$$
$$y_s = 2$$

$$\frac{y_v}{z_v} = \frac{20}{20} = \frac{y_s}{2}$$

$$y_s = 2$$

Question 9:

The figure below shows the images of two cubes produced by an OpenGL program.



a. Which projection is used to create these images of the cubes? Orthographic or perspective projection? (1 points)

Perspective, the top left & right should be Parallel ~~perpendicular~~ if orthographic

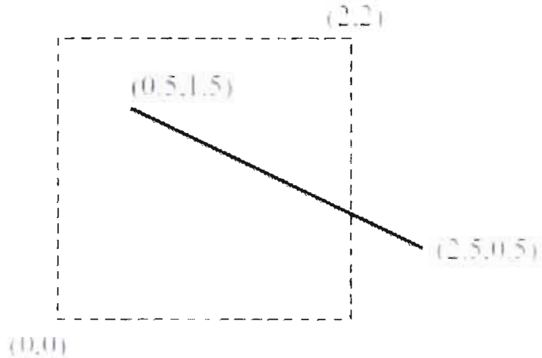
b. Can we tell which cube is bigger in the world coordinate system? If so, which one is bigger? If not, why we cannot tell? (2 points)

Cannot tell because it is perspective projection and the ratios are not preserved.

the distance of the cubes from the camera is unknown, so they cannot be visually compared by size

Question 10:

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 segment? Write it in the form:
$\begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} x_1 \\ y_1 \end{bmatrix} + t \begin{bmatrix} a \\ b \end{bmatrix}$ (1 point)

$$\begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} 0.5 \\ 1.5 \end{bmatrix} + t \begin{bmatrix} 2.5 - .5 \\ 0.5 - 1.5 \end{bmatrix}$$

$$\begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} 0.5 \\ 1.5 \end{bmatrix} + t \begin{bmatrix} 2 \\ -1 \end{bmatrix}$$

b. What are the parametric coordinates of the end-points of the visible segment? (2 points)

$t_1 = 0 \quad \begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} 0.5 \\ 1.5 \end{bmatrix}$

$t_2 = .75 \quad \begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} 2 \\ .75 \end{bmatrix}$

let $t = .75$

$$\begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} .5 \\ 1.5 \end{bmatrix} + .75 \begin{bmatrix} 2 \\ -1 \end{bmatrix} = \begin{bmatrix} 2 \\ .75 \end{bmatrix}$$

c. What are the (x, y) coordinates of the end-points of the visible segment? (2 points)

(0.5, 1.5)

(2, .75)