CS 111: Digital Image Processing
Fall 2016
Midterm Exam: Nov 23, 2016

Time: 3:30pm-4:50pm
Total Points: 80 points

Name:_____

Number:_____

Pledge: I neither received nor gave any help from or to anyone in this exam.

Signature:_____

Useful Tips

1. For some questions, you may need to use the chromaticity chart provided in the last page of the question paper.
2. All questions are multiple choice questions --- please indicate your answers very clearly. You can circle them or write out the exact choice. If your answer is ambiguous, you are not going to get any points for the answer. **More than one answer can be correct.**
3. Use the blank pages as your worksheet. Put the question number when working out the steps in the worksheet. Also, do your work clearly.This will help us give partial credit. Answer the questions you are most comfortable with first.
4. **Points are indicative of the time in minutes you should spend on the question.**
5. If you need more work sheets, feel free to ask for extra sheets.
6. Staple all your worksheets together with the paper at the end of the exam. If pages of your exam are missing since you took them apart, we are not responsible for putting them together.

Do not enter anything in the table below

Q #	Points	Points Received
1	**9**	
2	**14**	
3	**4**	
4	**9**	
5	**9**	
6	**10**	
7	**7**	
8	**7**	
9	**11**	
Total	**80**	

1) **[3+2+2+1+1=9]** Consider the following questions on geometric transformation.

a. An image undergoes radial distortion that is modeled by a polynomial of degree 2. Hence, a distorted coordinate (x',y') is given by: (a)$x'=c_1x^2+c_2y^2+c_3xy+c_4x+c_5y+c_6$, (b) $y'=d_1x^2+d_2y^2+d_3xy+d_4x+d_5y+d_6$. The minimum number of correspondences required to find the coefficients of the distortion *c's* and *d's* are

i. 6
ii. 5
iii. 4
iv. 3

b. The minimum number of correspondences needed to find the parameters of image rotation are

i. 5
ii. 4
iii. 3
iv. 2

c. You would like to send an image of resolution 1280x1080 to a mobile device with resolution 640x360. The geometric transformation you will apply is

i. Scaling of ½ in X direction and 1/3 in Y direction
ii. Scaling of 2 in X direction and 3 in Y direction
iii. Scaling of 2 in both directions
iv. Scaling of 1/3 in both directions

d. Homogeneous coordinate enables the linear representation of which of the following transformations.

i. Translation
ii. Rotation
iii. Shear
iv. Scaling

e. When translating a line using a linear transformation to get a new line, you need to transform

i. The midpoint of the line
ii. The two end points and the midpoint of the lines
iii. All the points on the line
iv. The two endpoints of the line

2) **[2+3+2+3+2+2=14]** Consider two colors *C1 = (X1, Y1, Z1)* and *C2 = (X2, Y2, Z2)* in the CIE XYZ space. Let their chromaticity coordinates be *(x1, y1)* and *(x2, y2)* respectively.

a. If *C1* is a pure achromatic color, which of the following *are* true.

i. Black lies on the ray connecting the origin to *C1* in XYZ space
ii. White lies on the ray connecting the origin to *C1* in XYZ space
iii. *X1=Y1=Z1*
iv. *(x1, y1) = (1/3, 1/3)*

b. If *C2= (50, 100, 50),* then *(x2, y2)* is given by

i. *(1/4, 1/4)*

ii. *(1/2, 1/2)*
iii. *(1/4, 1/2)*
iv. *(1/2, 1/4)*

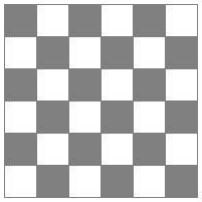
c. The dominant wavelength of *C2* is
   i. *610nm*
   ii. *550nm*
   iii. *515nm*
   iv. *490nm*

d. To create a color of chromaticity coordinates *(7/24,10/24)*, in what proportions should be *C1* and *C2* be mixed?
   i. (1/2,1/2)
   ii. (2/5,3/5)
   iii. (1/4,3/4)
   iv. (3/10, 7/10)

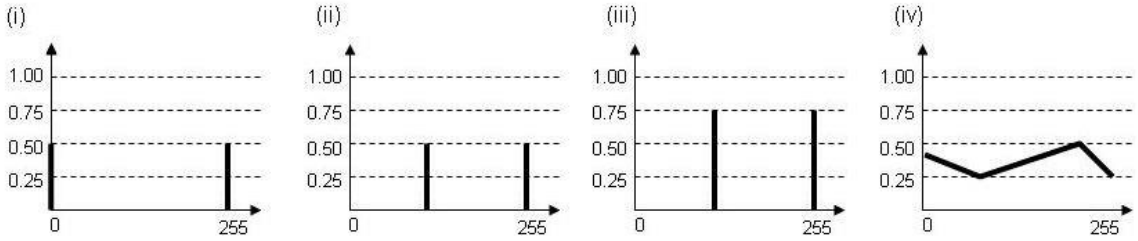
e. The intensity of *C1* required for this mixture is
   i. 400
   ii. 300
   iii. 200
   iv. 100

f. The luminance of *C1* required for this mixture
   i. 133.33
   ii. 100
   iii. 66.67
   iv. 33.33

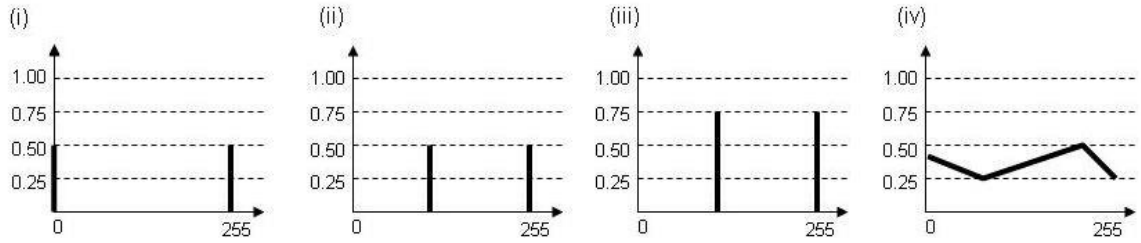
3) **[2+2=4]** Consider the following gray and white checkerboard image.



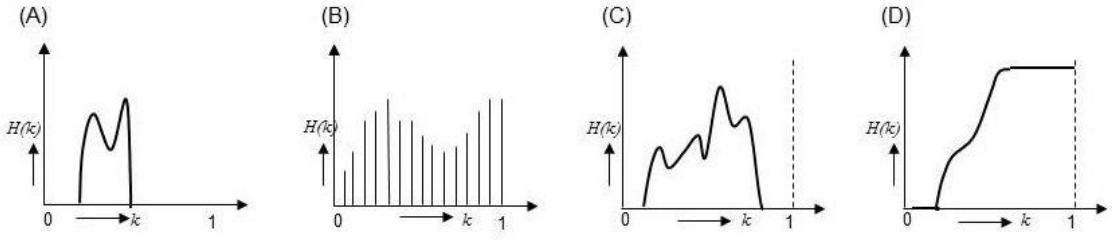
a. Which of the following is the histogram of this image? **ii**



b. What do you expect the histogram to be after global histogram stretching has been applied to this image? **i**



4) **[2+2+2+1+1+1=9]** Let us consider two images with histograms show in (A) and (C) below.



a. Which of the following statements are true?
   i. C has lower contrast than A
   ii. A has lower contrast than C
   iii. Cannot tell if the contrasts of A and C are different

b. If we apply a global histogram stretching to A, the most likely histogram that would result is
   i. D
   ii. C
   iii. B
   iv. A

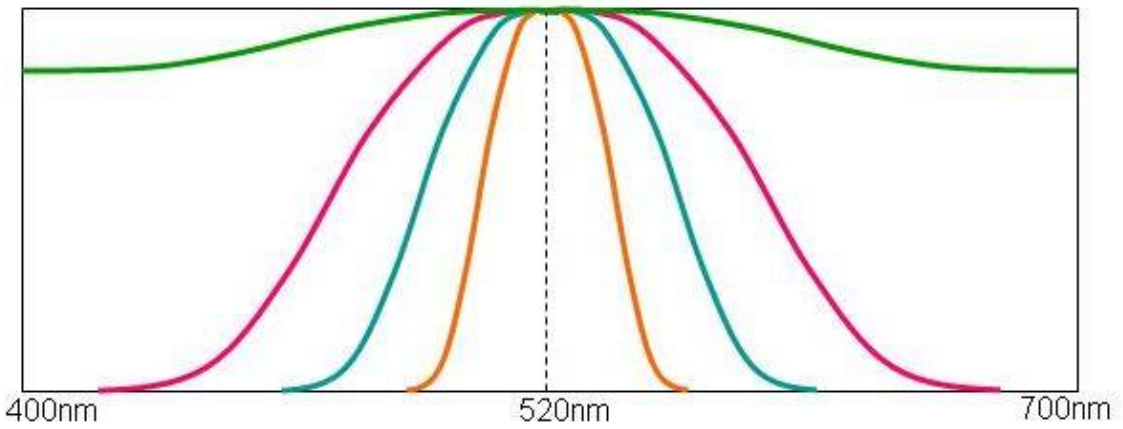
c. If we take a cumulative sum of the histogram of A, the most likely histogram that would result is
   i. D
   ii. C
   iii. B
   iv. A

d. Global histogram stretching can create the following artifacts
   i. Burn and Dodge
   ii. Rainbow effect
   iii. Quantization

e. This happens since global histogram stretching cannot handle
   i. Local contrast variation
   ii. High color resolution
   iii. Non-linear gamma function

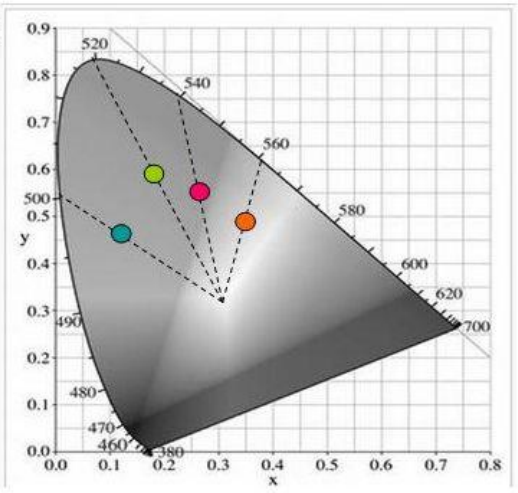
f. This can be alleviated using
   i. Histogram matching
   ii. Histogram equalization
   iii. Adaptive histogram stretching

5) **[3+2+2+2=9]** Consider the following four spectrums, their color not related to their visible colors, but used for visualization.

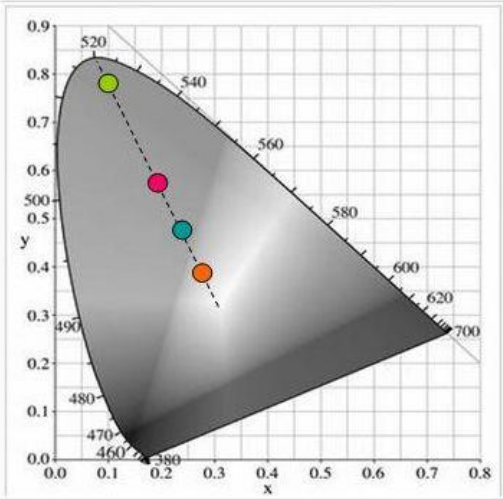


a. Which one of the following is most accurate representation of where these spectrums will fall on the chromaticity chart is given by **iii**

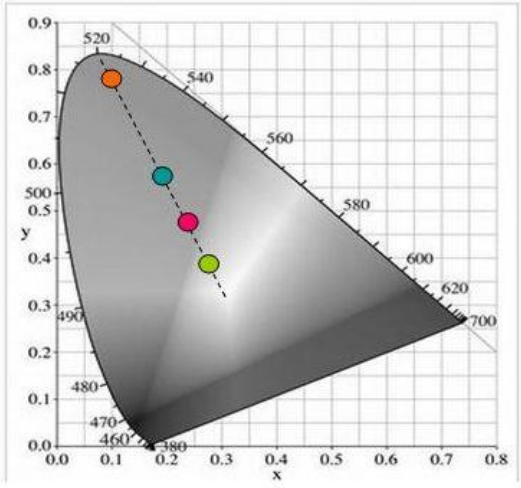
(i)



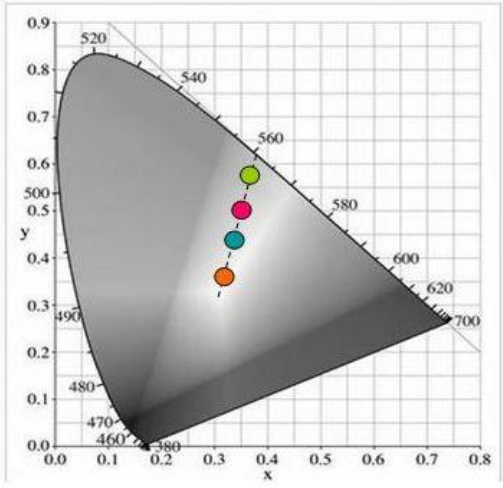
(ii)



(iii)



(iv)



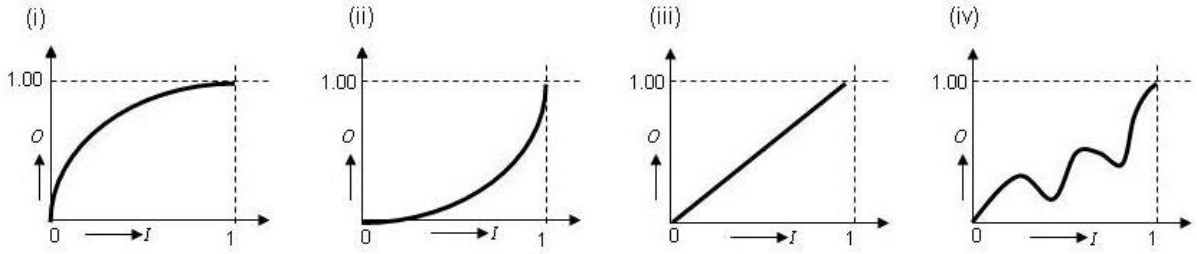
b. The dominant wavelength of all these colors are most likely
- **i.** Entirely different
- **ii.** Clustered together
- **iii.** Same

c. The intensity (X+Y+Z) of these colors are most likely related by the following.
- **i.** Orange < Blue < Pink < Green
- **ii.** Green < Pink < Blue < Orange
- **iii.** Blue < Pink < Orange < Green
- **iv.** Not related at all

d. The most likely position of these colors in the CIE XYZ 3D space is
- **i.** On the same ray from the origin
- **ii.** On two different rays from the origin
- **iii.** On three different rays from the origin
- **iv.** On four different rays from the origin

6) **[2+2+2+2+2=10]** Consider a display with a tone mapping operator of the form $O=I^2$ (where I and O are the input and output levels respectively in normalized scale of *0* to *1*) for all its channels and 8 bits to represent each of its channels.

a. The shape of this operator will be **ii**



b. If the tone mapping operator is made to be $O= I^3$ across all channels, which one or more of the following display quality parameters would change?
- *i.* Contrast
- *ii.* Color Tint
- *iii.* Color Resolution
- *iv.* White Point
- *v.* Brightness

c. If the tone mapping operator is made to be $O= I^3$ for the green channel alone, which one or more of the following display quality parameters would change?
- *i.* Contrast
- *ii.* Color Tint
- *iii.* Color Resolution
- *iv.* White Point
- *v.* Brightness

d. If the tone mapping operator is kept at $O=I^2$, but the number of bits for each channel is increased to 10 bits instead of 8, which one or more of the following display quality parameters would change?
- *i.* Contrast
- *ii.* Color Tint

iii. Color Resolution
iv. White Point
v. Brightness

e. Which of the following display quality parameters would remain unchanged by all of the above operations?
i. Contrast
ii. Color Tint
iii. Color Resolution
iv. White Point
v. Brightness

7) [3+1+1+2=7] Consider dithering with 3 levels of gray to create 33 levels of gray.

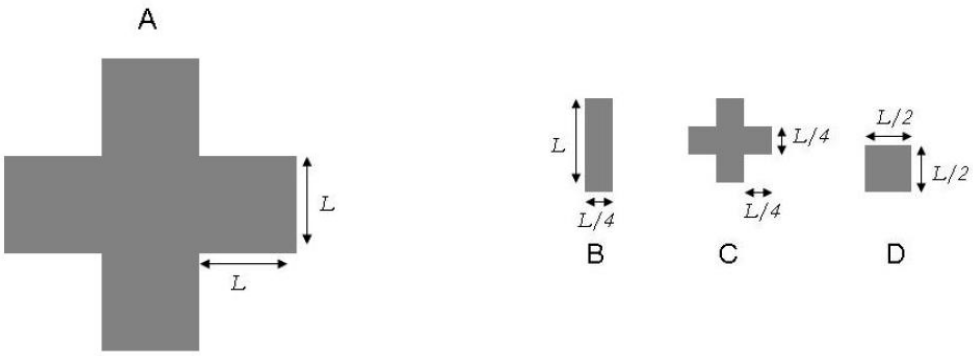
a. The block size of pixels required to achieve this is given by
i. 4x4
ii. 3x3
iii. 2x2

b. Dithering helps us to increase
i. Spatial Resolution
ii. Color Resolution
iii. Temporal Resolution

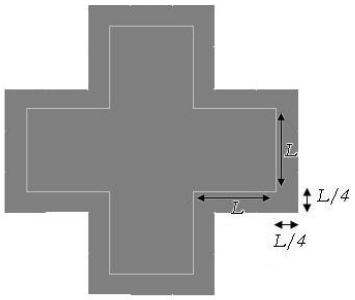
c. Dithering sacrifices
i. Spatial Resolution
ii. Color Resolution
iii. Temporal Resolution

d. Dithering can result in which of the following artifacts
i. Contrast reduction
ii. Quantization
iii. Burn and Dodge

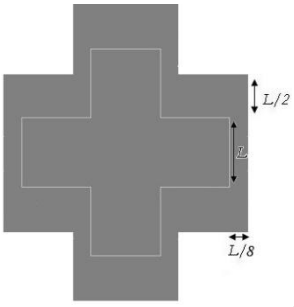
8) [3+2+2=7] Consider the region A and the structuring element B, C and D as follows.



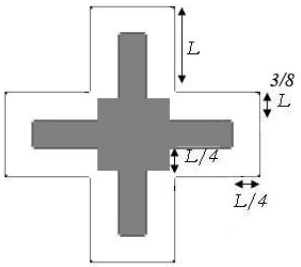
Consider the following six regions – E, F, G, H, I, and J.



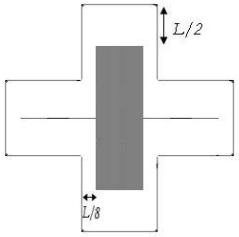
E



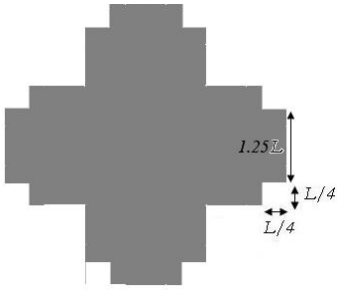
F



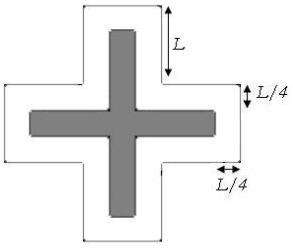
G



H



I



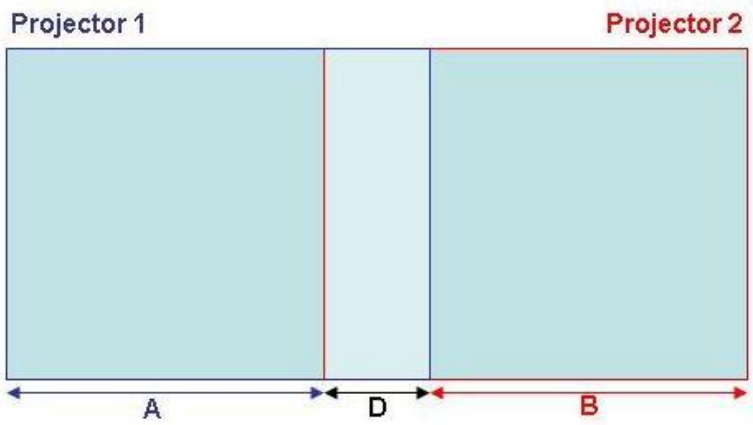
J

a. **[3]** Dilation and erosion of A with B would result in which of the following?
- **i.** F and H
- **ii.** E and H
- **iii.** F and J
- **iv.** E and J

b. **[2]** G is the result of
- **i.** Erosion with B
- **ii.** Erosion with C
- **iii.** Dilation with C
- **iv.** Dilation with D

c. **[2]** Dilation of G with C will have a similar shape as
- **i.** E
- **ii.** F
- **iii.** H
- **iv.** I

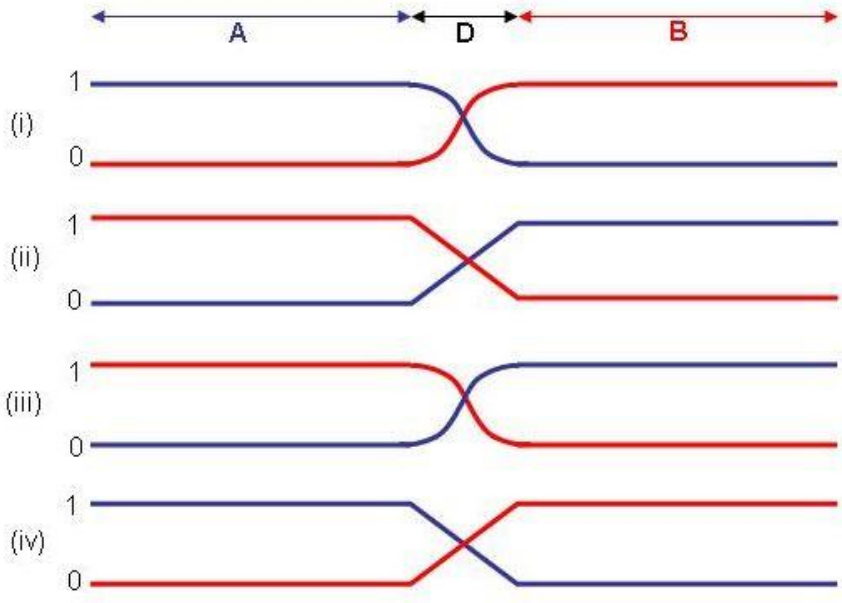
9) **[2+3+1+2+3=11]** Two projectors overlap partially to create a bright overlap region as shown below.



a. We would like to reduce the brightness in the overlap region using a blending operation. The width of the blending function should be

- **i.** A
- **ii.** B
- **iii.** D/2
- **iv.** D

b. Consider a linear blending function. Then, the blending function of the projector 1 (in blue) and projector 2 (in red) are given by



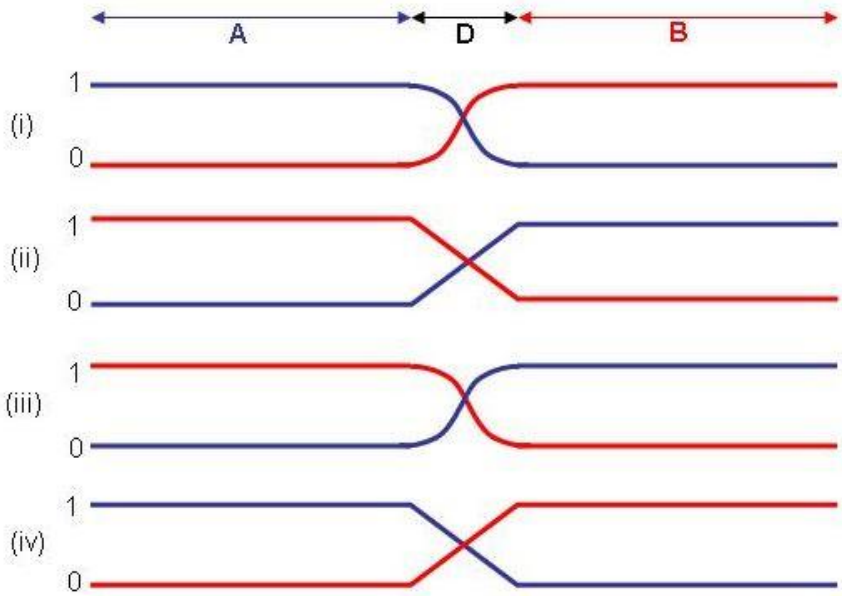
c. Linear blending functions are not

- **i.** Gradient Continuous
- **ii.** Curvature Continuous
- **iii.** Continuous

d. A blending function that can alleviate this problem is

- **i.** Cosine function
- **ii.** Spline function
- **iii.** Step function

e. Such a function in the case of projectors would look like **i**



CHROMATICITY CHART