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C	S	1	1	1	D	I	P

CS 111: Digital Image Processing
Spring 2019
Midterm Exam 2: May 29, 2019

Time: 1 hour, 20 minutes Total Points: 80

Name (in BLOCK LETTERS): **PETER THE ANTEATER**

Seat Assignment: _____

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

Signature: _____

Useful Tips

1. All questions are multiple choice questions. Please indicate your answers clearly. You may circle them or write out the exact choice. If your choice is unclear or ambiguous, you will not receive credit for your answer.
2. **All questions may have more than one correct answer. You must select all the correct answers for full credit.**
3. Use the blank pages as your worksheet. Put the question number when working out the steps in the worksheet. Do your work clearly. This will help in awarding 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. Please ask for extra sheets if you need more.
6. Staple all your worksheets together with the paper when submitting 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.
7. **In the interest of fairness, we will not be answering any queries regarding the exam questions. If you are uncertain about something, clearly state your assumption and solve the question accordingly.**
8. A chromaticity chart is provided for you in the last sheet of the exam.

Do not enter anything in the table below

Q #	Points	Points Received
1)	**9**	
2)	**13**	
3)	**4**	
4)	**9**	
5)	**9**	
6)	**10**	
7)	**6**	
8)	**2**	
9)	**7**	
10)	**11**	
Total	**80**	

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1) [3+2+2+1+1=9] Consider the following questions on geometric transformations:

a. An image undergoes radial distortion that is modeled by a polynomial of degree 2. Hence, a distorted coordinate *(x′,y′)* is given by:

$$x' = c_1x^2 + c_2y^2 + c_3xy + c_4x + c_5y + c_6$$
$$y' = d_1x^2 + d_2y^2 + d_3xy + d_4x + d_5y + d_6$$

The minimum number of correspondences required to find the distortion coefficients i.e. c_i's and d_i's are:

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

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

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

c. To send an image of resolution *1280x1080* to a mobile device with resolution *640x360*, which geometric transformation should be applied?

i. Scaling of 2 in both dimensions
ii. Scaling of 1/3 in both dimensions
iii. **Scaling of ½ in X-dimension and 1/3 in Y-dimension**
iv. Scaling of 2 in X-dimension and 3 in Y-dimension

d. Homogeneous coordinates enable the linear representation of which of the following transformations?

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

e. When applying a linear transformation to a line, what is the least number of points that we need to transform to get the new, transformed line?

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

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2) [2+2+2+3+2+2=13] Consider two colors $C_1 = (X_1, Y_1, Z_1)$ and $C_2 = (X_2, Y_2, Z_2)$ in the CIE-XYZ space. Let their chromaticity coordinates be (x_1, y_1) and (x_2, y_2) respectively.

a. If C_1 is a pure achromatic color, which of the following are true?
   - *i.* **$X_1=Y_1=Z_1$**
   - *ii.* **$(x_1, y_1) = (1/3, 1/3)$**
   - *iii.* **Black lies on the ray connecting the origin to C_1 in XYZ space**
   - *iv.* **White lies on the ray connecting the origin to C_1 in XYZ space**

b. If C_2= *(50,100,50),* then (x_2, y_2) is given by:
   - *i.* (1/2, 1/2)
   - *ii.* **(1/4, 1/2)**
   - *iii.* (1/2, 1/4)

c. The dominant wavelength of C_2 is:
   - *i.* 550nm
   - *ii.* **515nm**
   - *iii.* 490nm
   - *iv.* 610nm

d. To create a color of chromaticity coordinates *(7/24, 10/24),* in what proportions should be C_1 and C_2 be mixed?
   - *i.* (1/4, 3/4)
   - *ii.* (3/10, 7/10)
   - *iii.* **(1/2, 1/2)**
   - *iv.* (2/5, 3/5)

e. The intensity of C_1 required for this mixture is:
   - *i.* **200**
   - *ii.* 300
   - *iii.* 100
   - *iv.* 400

f. The luminance of C_1 required for this mixture is:
   - *i.* **66.67**
   - *ii.* 100
   - *iii.* 33.33
   - *iv.* 133.33

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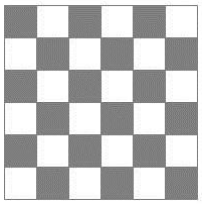
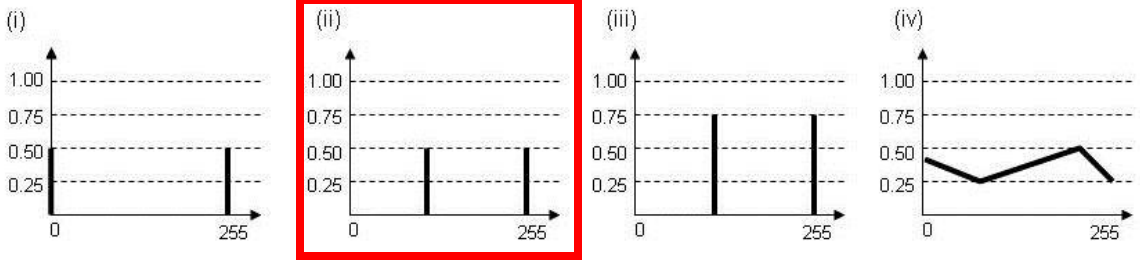
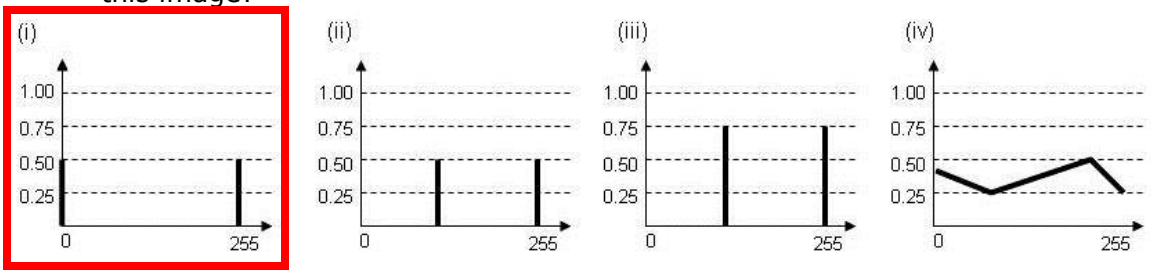
3) [2+2=4] Consider the following gray and white checkerboard image:



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



b. What is the expected histogram after global histogram stretching has been applied to this image?



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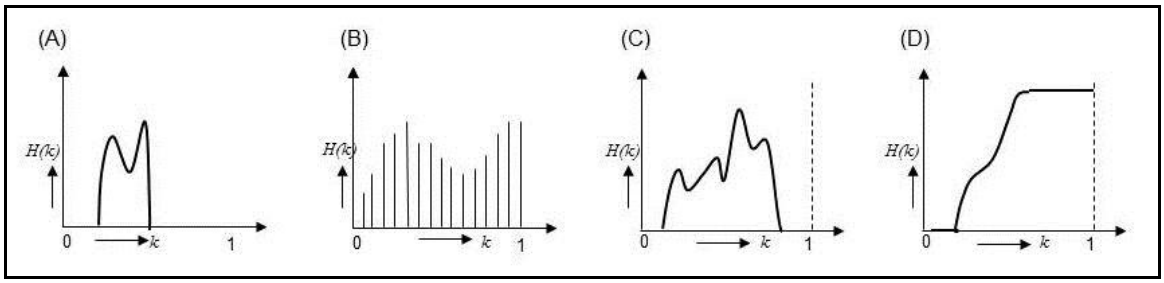
4) [2+2+2+1+1+1=9] Consider two images with histograms show in (A) and (C) below:



a. Which of the following statements are true?
   - *i.* ***A has lower contrast than C***
   - *ii.* *C* has lower contrast than *A*
   - *iii.* Insufficient information to determine whether the contrasts of *A* and *C* are different

b. If global histogram stretching is applied to *A*, the most likely histogram that would result is:
   - *i.* A
   - *ii.* **B**
   - *iii.* C
   - *iv.* D

c. The cumulative sum of A will match which of the above diagrams?
   - *i.* A
   - *ii.* B
   - *iii.* C
   - *iv.* **D**

d. Global histogram stretching can create which of the following artifacts?
   - *i.* Quantization
   - *ii.* **Burn and Dodge**
   - *iii.* Rainbow effect

e. The artifacts due to global histogram stretching occur because it cannot handle:
   - *i.* High color resolution
   - *ii.* **Local contrast variation**
   - *iii.* Non-linear gamma function

f. The artifacts due to global histogram stretching can be alleviated using:
   - *i.* Histogram matching
   - *ii.* **Adaptive histogram stretching**
   - *iii.* Histogram equalization

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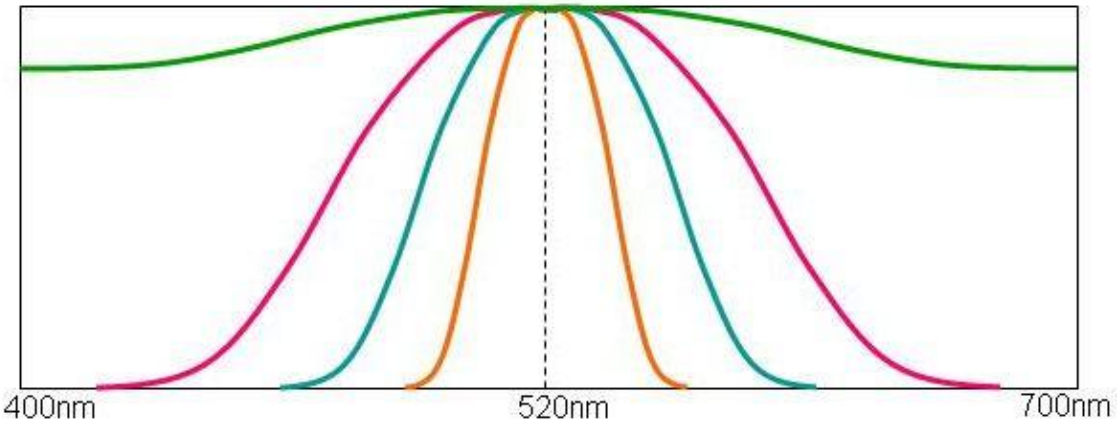
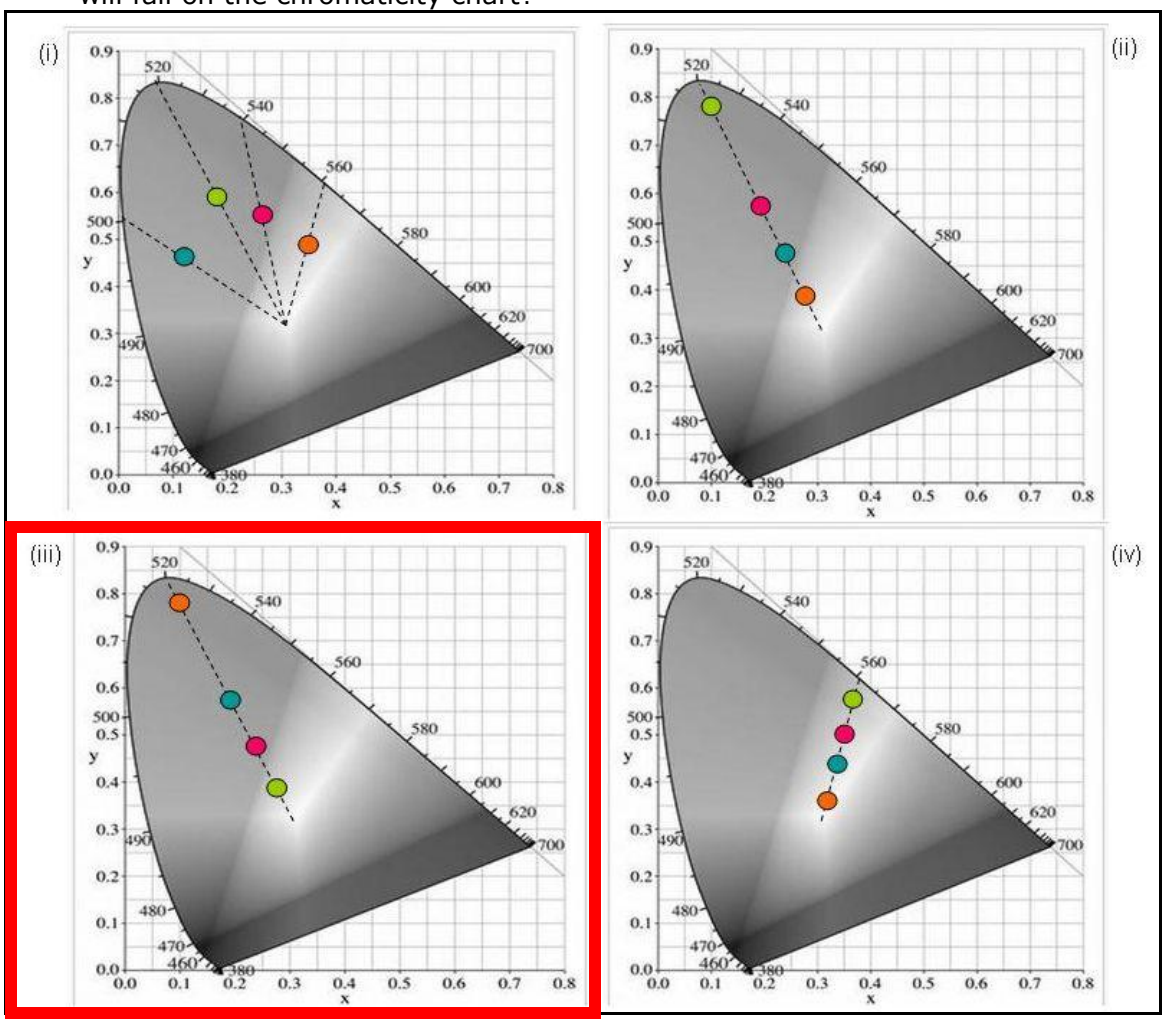
5) [3+2+2+2=9] Consider the following four spectra. Note that their color is not related to their visible colors but are used only for visualization.



a. Which of the following figures is most accurate representation of where these spectra will fall on the chromaticity chart?



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

c. The intensities *(X+Y+Z)* of these colors are most likely related by the following (note that the colors here correspond to graph, not to the physical colors):
   - *i.* Not related at all
   - *ii.* **Orange < Blue < Pink < Green**
   - *iii.* Green < Pink < Blue < Orange
   - *iv.* Blue < Pink < Orange < Green

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 four different rays from the origin**
   - *iii.* On two different rays from the origin
   - *iv.* On three different rays from the origin

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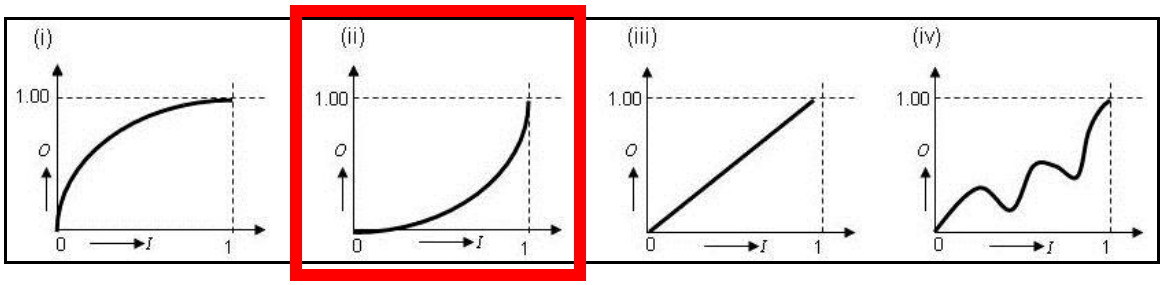
6) [2+2+2+2+2=10] Consider a display with a tone mapping operator of the form $O=I^2$ (where I and O are the input and output levels respectively in normalized scale of 0 to 1) for all image channels with 8 bits used to represent each image channel.

a. The shape of this operator will be:



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

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.* Brightness
   - *ii.* **Contrast**
   - *iii.* Color Resolution
   - *iv.* **White Point**
   - *v.* **Color Tint**

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.* Brightness
   - *ii.* Contrast
   - *iii.* **Color Resolution**
   - *iv.* White Point
   - *v.* Color Tint

e. Which of the following display quality parameters would remain unchanged by all the above operations (mentioned in parts (b) – (d))?
   - *i.* **Brightness**
   - *ii.* Contrast
   - *iii.* Color Resolution
   - *iv.* White Point
   - *v.* Color Tint

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7) [1+1+4=6] Consider the following transformation matrix, which is applied on an image *I* to get a new image *I'*:

$$\begin{bmatrix} 2 & 0.25 \\ 0.75 & 1.5 \end{bmatrix}$$

a. What will the new point *P'* be when the transformation is applied to the point *P(3, 5)*?
   - *i.* (6.5, 8.25)
   - *ii.* **(7.25, 9.75)**
   - *iii.* (10.75, 8.25)
   - *iv.* (8.25, 10.00)

b. Which pixel in *I'* will be affected if we use nearest-neighbor interpolation for *P'*:
   - *i.* (11, 8)
   - *ii.* (6, 8)
   - *iii.* **(7, 10)**
   - *iv.* (8, 10)

c. What are the coefficients of bilinear interpolation for *P'* (along the x and y-axes respectively)?
   - *i.* **x(0.75, 0.25) & y(0.25, 0.75)**
   - *ii.* x(0.75, 0.75) & y(0.25, 0.25)
   - *iii.* x(0.50, 0.50) & y(0.75, 0.25)
   - *iv.* x(0.50, 0.25) & y(0.50, 0.75)

8) [1+1=2] Assume we are blending images together using feathering to form a panorama.

a. What artifact are you likely to see when an object moves through the blended, overlapping regions of the panorama?
   - *i.* Aliasing
   - *ii.* Burns
   - *iii.* **Ghosting**
   - *iv.* Contrast reduction

b. Which of the following is the best technique to get rid of the artifact in (a)?
   - *i.* Alpha blending
   - *ii.* Contrast enhancement
   - *iii.* Pyramid blending
   - *iv.* **Optimal Seam Cut**

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9) [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.* 2x2
   - *ii.* 3x3
   - *iii.* **4x4**
   - *iv.* 5x5

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

c. Dithering sacrifices:
   - *i.* Color Resolution
   - *ii.* **Spatial Resolution**
   - *iii.* Temporal Resolution

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

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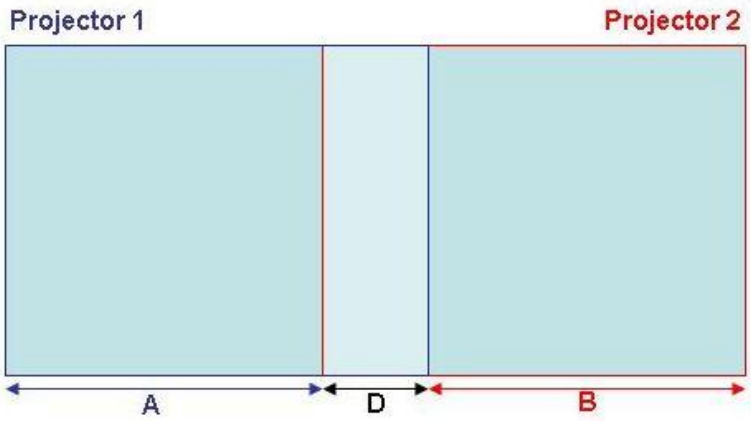
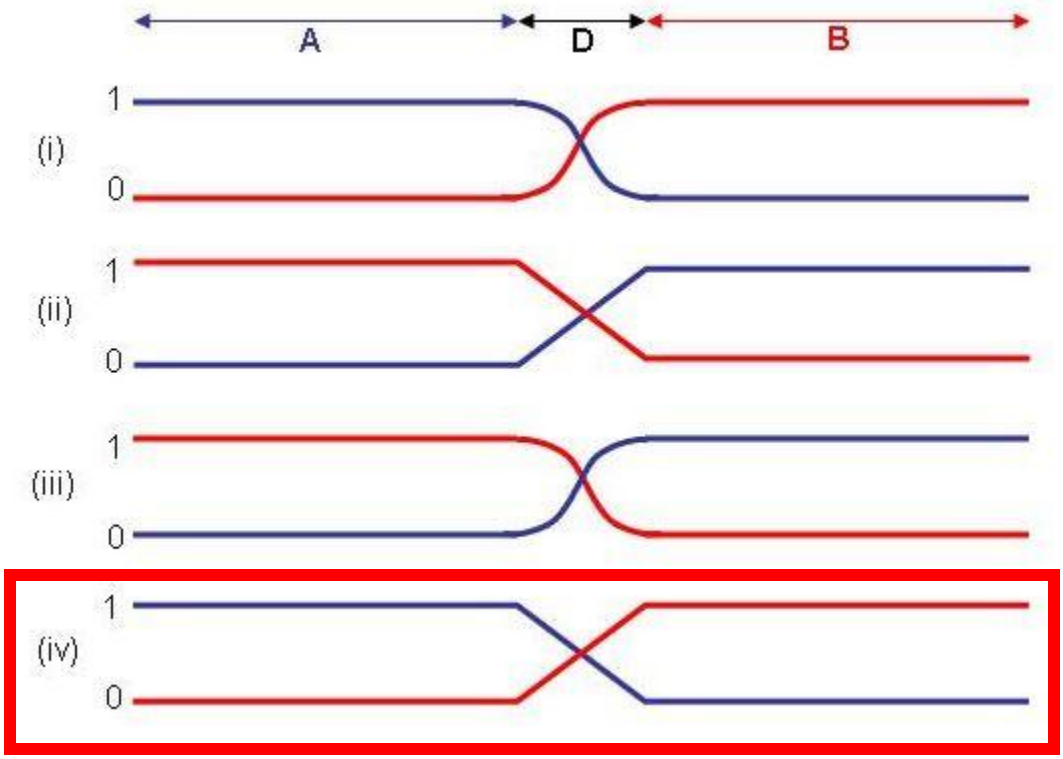
10) [2+3+1+2+3=11] Two projectors overlap partially to create a bright overlap region as shown below:



a. We would like to reduce the brightness in the overlapping region using a blending operation. The width of the blending function should be:
   i. D/2
   ii. **D**
   iii. A
   iv. B

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



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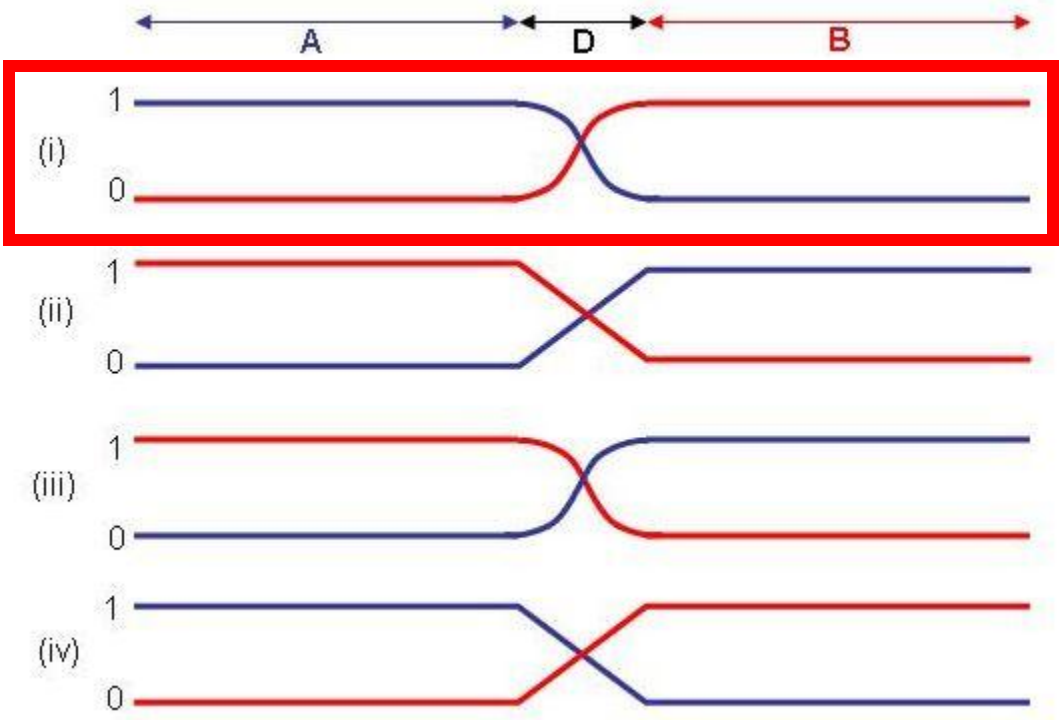
c. Linear blending functions are not:
   - *i.* Continuous
   - *ii.* **Gradient Continuous**
   - *iii.* **Curvature Continuous**

d. A blending function that can alleviate this problem is:
   - *i.* Step function
   - *ii.* **Cosine function**
   - *iii.* **Spline function**

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



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CHROMATICITY CHART