Visual Perception: Midterm Exam
Total Points: 100

PLEDGE: I have not given/received any assistance to/from anybody in this exam.

Signature: _____ Date: _____

Name : _____

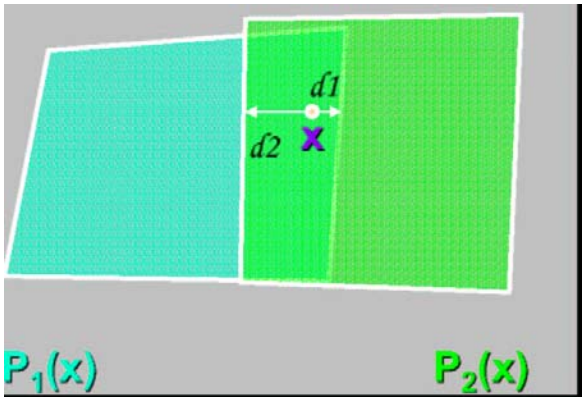
1. Explain why windows in a house, when viewed from the inside, appear transparent during the daylight hours, but act like mirrors at night. **[4]**

2. The sky on earth looks blue, but the same sky on moon looks black. Why? **[4]**

3. The color of the runway lights in airports is blue, and not red. Why? **[4]**

4. Explain how our perception of the Mach band would change if we had lateral excitation instead of lateral inhibition. **[4]**

5. Cataracts are tissues that develop clouding the eye's lenses. Cataracts mostly happen in the old age. But there are also cased of juvenile cataracts that occur in babies and often are existent from birth. In 1960s, when the art of cataract removal was perfected, several old people were operated and cured. However, operations performed on a bunch of young men who had juvenile cataracts, did not cure them. Why? **[3]**



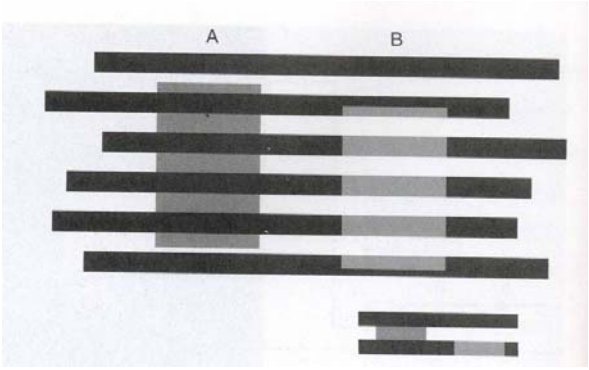
6. The image on the left shows a display made of two projectors P_1 and P_2. At any pixel x, the contribution of the two projectors at this pixel are expressed by $P_1(x)$ and $P_2(x)$ respectively. To remove the high brightness in the overlap region, the intensity at any pixel x in this region is blended using the functions $A_1(x)$ and $A_2(x)$ from projector P_1 and P_2 respectively such that $A_1(x) + A_2(x) = 1$ and the combined intensity at pixel x from the two projectors is given by $A_1(x)P_1(x) + A_2(x)P_2(x)$.

Two types of function can be used.

(1) In the first, A_1 and A_2 are assigned as follows.
$A_1(x) = d1/(d1+d2)$
$A_2(x) = d2/(d1+d2)$

(2) In the second, A_1 and A_2 are assigned as follows
$A_1(x) = cos(d1/(d1+d2)*90)$
$A_2(x) = cos(d2/(d1+d2)*90)$

Which of these functions would look perceptually better? Why? **[5]**



7. In the image on the left, the gray rectangle on the right looks lighter than the rectangle on the left. But they are actually the same gray. Can you explain this by lateral inhibition? **[4]**

8. We know that edge detection can be performed by the eye in different resolutions. Do you think that the illumination and the reflectance edges will show up in different resolutions? Justify your answer. **[5]**

9. A person was presented an annular ring of luminance of 100cd/m^2 with a circular inset of luminance 50cd/m^2. In an adjacent region, he was presented with a circular inset of 150cd/m^2 and asked to adjust the luminance of the annular ring surrounding it so that it creates similar perception as that of the former pair. What luminance do you expect him to adjust to? **[4]**

10. A sinusoidal grating has a mean of 100cd/m^2 and contrast (defined by the range of the luminance in the grating) of 50cd/m^2. It is projected on a screen of width 20 inch with resolution of 50pixels/inch. The number of cycles of the grating made over the whole screen is 10. What is the distance from the screen where the user should be place so that this grating subtends 3cycles per degree of the eye? **[5]**

11. A two month old was being very jittery and crying. The room is lit by a whitish tube light. In order to pacify him, the mother puts on a very bright yellowish table lamp. The kid suddenly finds renewed interest in everything around him and stops crying. What perceptual phenomenon can explain this behavior of the kid? **[5]**

12. You have your framed graduation certificate hanging on the wall. When you view if from a distance of 12 or more feet, you cannot see the letters clearly. As you approach the frame, slowly the letters become clearer and clearer. However, if you are within an inch or two, you find that the letters have again become blurred. Can you explain this with CSF? **[4]**

13. You are going on a train. The track is lined by electric poles placed regularly along the track so that it is just a few feet away when you look out of the window. When the train just starts you can make out these poles clearly as they keep moving away from you. As the train increases speed, slowly the poles become blurred as they move away from you. Can you explain this phenomenon with CSF? **[5]**

14. In a movie auditorium, the projection system is used with mean luminance of 12-22 foot Lamberts for refresh rates of 48 Hz. However, it is said that a refresh rate

has to be increased to 60 Hz for higher luminance projection system. Explain this with CSF. **[5]**

15. Assume a gray scale projector which shows no spatial variation in luminance. The contrast of the projector is defined by the ratio of the maximum and the minimum luminance that can be projected by the projector. For an ideal projector, no light is projected for black and hence infinite contrast can be achieved. However, in this practical projector, black offset is present. What is the effect of this black offset on the contrast of the projector? Based on CSF, which range of intensities (low range, high range or mid range) will be more adversely affected perceptually by the presence of this black offset and why? **[2+4=6]**

16. Let the maximum spatial frequency detected by a human at luminance L be *30 cycles/degree* of the angle subtended on the human eye. Nyquist sampling condition says that to generate a spatial pattern of a certain frequency f on a display, at least $2f$ number of pixels are required. From this find out the minimum display resolution needed for a person at a distance d, so that he can see all the different spatial frequencies he is sensitive to. Plot the r with respect to d to find how the minimum required resolution changes with the distance of the observer. **[4+4=8]**

17. An audio signal of bandwidth 200 MHz, centered at 700 MHz is being transmitted. There are several kinds of noise in the system. It is found that if the noise has a bandwidth of 140 MHz and is also centered at 700 MHz, a noise of large amplitude large amplitude can be tolerated without being audible. However, as the frequency at which the noise is centered reduces or increases, the noise becomes more and more audible. This phenomenon in audio is analogous to which visual phenomenon? How does that explain these phenomena? If the frequency at which the noise is centered reduces or increase, the noise can still be made inaudible, but this time by reducing its amplitude significantly. What phenomenon describes the noise being inaudible in this case? If both the noise and the signal are centered at 300MHz, it is found that the bandwidth of the noise needs to be reduced to 100 MHz to be inaudible. What does this tell you? **[3+2+2=7]**

18. We have n devices. The gamut of the device i, $1 \leq i \leq n$, is denoted by Gi. To perform gamut matching, a common gamut G_c which is the intersection of all G_is has to be found. And then every G_i should be transformed to the common gamut G_c. In what kind of situations do you think this method of matching colors across devices will be impossible? Even if it is possible, what kind of image degradation would you expect from gamut matching? **[5]**

19. Let us consider a linear display with no spatial variation in color and no black offset. The chromaticity coordinates of the red, green and blue channel of this display are given by *(0.5, 0.4)*, *(0.2, 0.6)* and *(0.1, 0.2)* respectively. The maximum luminances of the red, green and blue channel are *100*, *200* and

$80cd/m^2$ respectively. Generate the matrix that converts the RGB coordinates for this device to the XYZ coordinates. What is the XYZ coordinates of the color generated by the RGB input (0.5, 0.75, 0.2) on this device? **[5+2=7]**

20. Let a projector coordinate system be defined by *(s,t)* with origin *(0,0)* at the center of the projector. The projector shows a symmetric fall-off in the maximum luminance for each channel from the center to the fringes. The fall off is inversely proportional to the square of the distance of *(s,t)* from the center of the projector. The black offset does not vary spatially and is defined by the XYZ vector (X_B, Y_B, Z_B). Each channel has a quadratic input transfer function. If the color with maximum luminance for red, green and blue channel at the center of the projector is defined by the vectors (X_r, Y_r, Z_r) , (X_g, Y_g, Z_g) and (X_b, Y_b, Z_b), what would be the equation defining XYZ coordinates of the color for any input (i_r, i_g, i_b) at any pixel *(s,t)* of the projector. **[7]**