1. Mention Roll # & Section on each page in the given space only.
2. Complete all the questions in the given space and use space very carefully. ***Spare/extra sheet is not required, complete all steps.***
3. Exam is closed books/notes.
4. Make sure that you have five different pages of the exam booklet (including this covering page)

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1. (a) Define the term *Metamers* in HVS. (b) Name the phenomenon in the *neural system* that helps to create the *Mach Band effect*. (2+2 = 4)

a) Metamers:- Images with different spectral distribution but same RGB values are metamers to each other. They will appear similar to the Human visual system.

b) Lateral Inhibition:-
Lateral Inhibition is the phenomenon in the neural system that helps to create Mach Band effect. It focusses edges to the HVS by functioning as a high pass medium to HVS by using positive and negative factors of weights of edges causing Mach Band Effect. (focus edges to the human eye).

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2. (a) Name the three types of *subjective fidelity* measures. (b) Which type do you think is the best? (3+1 = 4)

Types:-

1) Impairment Test
2) Quality Test
3) Comparison Test

Comparison Test is the best as the subject test evaluates the images side by side. It is more suitable for the people to evaluate images by comparing the results side-by-side and average people can evaluate the image.

3. Find the RGB values for the following *incident photon flux*. Assume that the tristimulus curves are approximated by bandpass filters with a flat response with a gain of 10 using the red green and blue bands: (6)

$$b(\lambda) = 5\lambda$$

$$R = K\int_{400}^{700} R(\lambda)\,b(\lambda)\,d\lambda = K\int_{600}^{700} R(\lambda)\,b(\lambda)\,d\{\lambda\} = K\int_{600}^{700} 10(5\lambda)\,d\lambda$$

$$G = K\int_{400}^{700} G(\lambda)\,b(\lambda)\,d\lambda = K\int_{500}^{600} G(\lambda)\,b(\lambda)\,d\{\lambda\} = K\int_{500}^{600} 10(5\lambda)\,d\lambda$$

$$B = K\int_{400}^{700} B(\lambda)\,b(\lambda)\,d\lambda = K\int_{400}^{500} B(\lambda)\,b(\lambda)\,d\lambda = K\int_{400}^{500} 10(5\lambda)\,d\lambda$$

$$R = K\int_{600}^{700} 50\,\lambda\,d\lambda = K\left\{50\,\frac{\lambda^2}{2}\right\}\Bigg|_{600}^{700} = K\,50\left(\frac{(700)^2}{2} - \frac{(600)^2}{2}\right) = K\,50(245000 - 180000)$$

$$= 50K\int_{600}^{700} \lambda\,d\lambda$$

$$R = 3250000\,K = \boxed{3.25\times10^6\,K}$$

$$G = \int_{500}^{600} 50K\int \lambda\,d\lambda = 50K\left(\frac{\lambda^2}{2}\Bigg|_{500}^{600}\right) = 50K\left(\frac{(600)^2}{2} - \frac{(500)^2}{2}\right) = 2750000K = \boxed{2.75\times10}$$

$$B = 50K\int_{400}^{500} \lambda\,d\lambda = 50K\left(\frac{\lambda^2}{2}\Bigg|_{400}^{500}\right) = 50K\left(\frac{(500)^2}{2} - \frac{(400)^2}{2}\right) = 2250000K = \boxed{2.25\times10^6\,K}$$

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4. Given the following parameters:

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Frame rate is 30 frames/sec.;
gray-level resolution is RGB colors;
spatial resolution is 1024 x 1024.

(5+5 = 10)

Find the following:

i) How much memory (*MegaBytes*) is required to hold *two hours* **color movie**.

ii) How much time (sec) will it take to download the above video through the dialup network with 64 kbps bandwidth?

i

2 hours = $2 \times 3600 = 7200$

for colormovie = $8 \times 3 = 24$

A spatial resolution = 1024×1024 so $M = 10$

Now size = $\dfrac{24 \times 2^{20} \times 30 \times 7200}{1024 \times 1024 \times 8}$ = 648000 MB ~~5184000 MB~~ = $\boxed{6.48 \times 10^5 \text{ MB}}$ $\boxed{\cancel{5.184 \times 10^6 \text{ MB}}}$

ii Bandwidth = 64 Kps = $64 \times 1024 = 65536$

size = $6.48 \times 10^5 \times 1024 \times 1024 \times 8$ = ~~6.794772 48 × 10^11~~
= $5.435817984 \times 10^{12}$ bits

time (s) = $\dfrac{\text{size}}{\text{bandwidth}}$ = $\boxed{\cancel{10368000 s}}$ $\boxed{82944000}$ secs.

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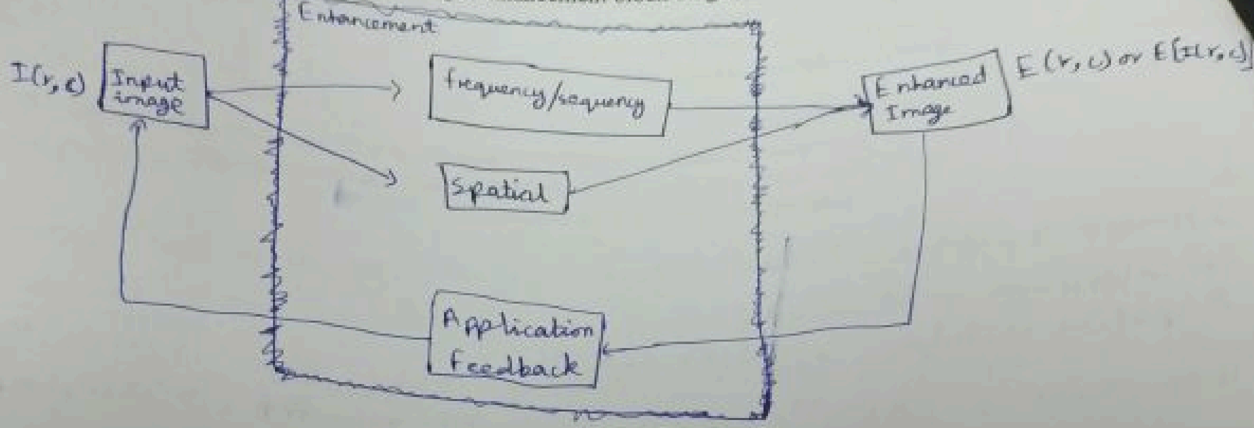
5. Draw the detailed Image Enhancement block diagram. (3)



6. (a) What are the range of visible light wavelengths? (b)What are the types of imaging sensors in the eye? (1+2 = 3)

a The range of visible light wavelengths is from 400nm to 700nm.
R = 700nm-~~600~~, G = 600-500nm and B = 500-400nm.

b There are two types of imaging sensors in the eye that are:

1 Rods: used for scotopic (night) vision. On the order of 100 million. It detects only brightness (not colour).

2 Cones: use for photopic (daylight) vision. On the order of 10 million. It detects colours.

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7. Given the following 4-bit per pixel, 4x4 images, calculate its *root-mean-square error*. (5)

$$\text{Original Image}\begin{bmatrix}11 & 11 & 8 & 7\\ 8 & 7 & 8 & 7\\ 5 & 6 & 5 & 7\\ 11 & 12 & 13 & 14\end{bmatrix} \quad \text{Reconstructed Image}\begin{bmatrix}12 & 12 & 7 & 7\\ 8 & 8 & 8 & 8\\ 6 & 6 & 6 & 6\\ 12 & 12 & 12 & 12\end{bmatrix}$$

Hint: $\sqrt{\frac{1}{\text{matrix size}}\sum\sum(\text{Error})^2}$

First we calculate each error square and then take summation of them and solve for root-mean square error.

error $(0,0) = \hat{I}(0,0) - I(0,0) = 12-11 = 1$ $(E(0,0))^2 = (1)^2 = 1$

error $(0,1) = 12-11 = 1$, $E(0,1)^2 = 1^2 = 1$

error $(0,2) = 7-8 = -1$, $E(0,2)^2 = (-1)^2 = 1$

error $(0,3) = 7-7 = 0$, $E(0,3) = 0$

error $(1,0) = 0$, $E(1,0)^2 = 0$

error $(1,1) = 1$, $E(1,1)^2 = 1$

error $(1,2) = 0$, $E(1,2)^2 = 0$

error $(1,3) = 1$, $E(1,3)^2 = 1$

error $(2,0) = 1$, $E(2,0)^2 = 1$

error $(2,1) = 0$, $E(2,1)^2 = 0$

error $(2,2) = 1$, $E(2,2)^2 = 1$

error $(2,3) = -1$, $E(2,3)^2 = 1$

error $(3,0) = 1$, $E(3,0)^2 = 1$

error $(3,1) = 0$, $E(3,1)^2 = 0$

error $(3,2) = -1$, $E(3,2)^2 = 1$

error $(3,3) = -2$, $E(3,3)^2 = 4$

$$\sum_{r=0}^{3}\sum_{c=0}^{3}[\hat{I}(r,c) - I(r,c)]^2 = 14$$

Now

$$e_{RMS} = \sqrt{\frac{1}{16}(14)} \boxed{= 0.9354}$$