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SHAMBHUNATH INSTITUTE OF ENGINEERING AND TECHNOLOGY

Subject Code: RCS-082 **Subject: IMAGE PROCESSING**

B.Tech. **SEMESTER-8TH**

FIRST SESSIONAL EXAMINATION, EVEN SEMESTER, (2019-2020)

Branch: COMPUTER SCIENCE & ENGINEERING

Time –1hr 30 min **Maximum Marks – 30**

SECTION – A

1. Attempt all questions in brief. **(1*5 = 5)**

Q N	QUESTION	Marks	CO	BL
a.	**What is Image?** **Ans-**An image is an array, or a matrix, of square pixels (picture elements) arranged in columns and rows.	1	1	1
b.	**What is Color Image Enhancement?** **Ans-**The purpose of image enhancement is to get finer details of an image and highlight the useful information. During poor illumination conditions, the images appear darker or with low contrast. Such low contrast images needs to be enhanced.	1	2	1
c.	**What is Application of DIP?** **Ans-**Industrial inspection/quality control • Surveillance and security • Face recognition• Face recognition • Gesture recognition • Space applications • Medical image analysis • Autonomous vehicles • Virtual reality	1	1	1
d.	**What Is Contrast stretching?** **Ans-**Contrast stretching (often called normalization) is a simple image enhancement technique that attempts to improve the contrast in an image by `stretching' the range of intensity values it contains to span a desired range of values, e.g. the full range of pixel values that the image type concerned allows.	1	2	1
e.	**What is RGB?** **Ans-** RGB (red, green, and blue) refers to a system for representing the colors to be used on a computer display. Red, green, and blue can be combined in various proportions to obtain any color in the visible spectrum. Levels of R, G, and B can each range from 0 to 100 percent of full intensity.	1	1	1

SECTION – B

2. Attempt any TWO of the following. **(2*5 = 10)**

Q N	QUESTION	Marks	CO	BL
a.	**Explain all Steps in Digital image Processing with Suitable Diagram?** **Ans-**	5	1	2

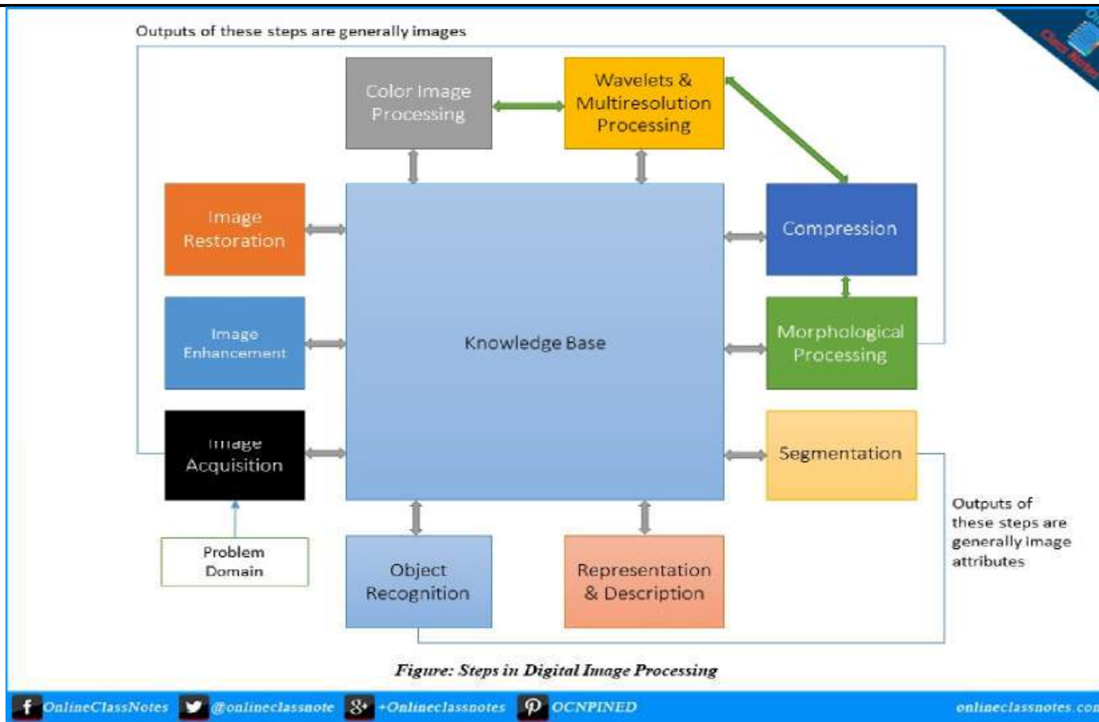


Figure: Steps in Digital Image Processing

b. **Determine the Discrete Fourier transform (DFT) of f(x) = {0, 1, 2, and 1}** | 5 | 1 | 4

Ans-

Section (B)

Ans 2(b) :- $f(x) = \{0, 1, 2, 1\}$

Descrete forier transform

DFT $F[K] = \sum_{x=0}^{N-1} f(x)\, e^{-j2\pi Kx/N}$

here $N = 4$

$x = 0$ to 3

K constant

* for $K = 0$

$F[0] = \sum_{x=0}^{3} f(x)\, e^{-j2\pi Kx/4} = \sum_{x=0}^{3} f(x)\, e^{-j2\pi 0x/4}$

$= \sum_{x=0}^{3} f(x)\, e^{-0}$

$= f(0)e^{-0} + f(1)e^{-0} + f(2)e^{-0} + f(3)e^{-0}$

$= 1\cdot 0 + 1\cdot 1 + 2\cdot 1 + 1\cdot 1$

$F[0] = 4$

* for $K = 1$

$F[1] = \sum_{x=0}^{3} f(x)\, e^{-j2\pi 1\cdot x/4} = \sum_{x=0}^{3} f(x)\, e^{-j\pi x/2}$

$= f(0)e^{-j\pi 0/2} + f(1)e^{-j\pi/2} + f(2)e^{-j\pi 2/2} + f(3)e^{-j\pi 3/2}$

$= f(0)e^{-0} + 1\cdot e^{-j\pi/2} + 2\cdot e^{-j\pi} + 1\cdot e^{-j3\pi/2}$

$= 0\cdot 1 + [\cos\frac{\pi}{2} - j\sin\frac{\pi}{2}] + 2[\cos\pi - j\sin\pi] + [\cos\frac{3\pi}{2} - j\sin\frac{3\pi}{2}]$

$= [0 - j] + 2[-1 - j0] + [0 + j]$

$F[1] = -2$

for $K = 2$

$$F[2] = \sum_{x=0}^{3} f(x)\, e^{-J2\pi K x/4}$$

$$= \sum_{x=0}^{3} f(x)\, e^{-J2\pi 2x/4} = \sum_{x=0}^{3} f(x)\, e^{-J\pi x}$$

$$= f(0)e^{-J\pi 0} + f(1)\, e^{-J\pi} + f(2)\, e^{-J2\pi} + f(3)e^{-J3\pi}$$

$$= 0 \cdot e^{-0} + 1 \cdot e^{-J\pi} + 2 \cdot e^{-J2\pi} + 1 \cdot e^{-J3\pi}$$

$$= 0 + [\cos\pi - J\sin\pi] + 2[\cos 2\pi - J\sin 2\pi] + [\cos 3\pi - J\sin 3\pi]$$

$$= -1 - J\times 0 + 2[1 - J\times 0] + [-1 - J\times 0]$$

$$= -1 - 0 + 2 - 0 - 1 - 0$$

$$F[2] = 0$$

* for $K = 3$

$$F[3] = \sum_{x=0}^{3} f(x)\, e^{-J2\pi 3x/4}$$

$$= \sum_{x=0}^{3} f(x)\, e^{-J3\pi x/2}$$

$$= f(0) \cdot e^{-0} + f(1)\, e^{-J3\pi 1/2} + f(2)\, e^{-J3\pi 2/2} + f(3) e^{-J3\pi 3/2}$$

$$= 0 \cdot e^{-0} + 1 \cdot e^{-J3\pi/2} + 2 \cdot e^{-J3\pi} + f(3) e^{-J9\pi/2}$$

$$= 0 + \left[\cos\frac{3\pi}{2} - J\sin\frac{3\pi}{2}\right] + 2[\cos 3\pi - J\sin 3\pi] + \left[\cos\frac{9\pi}{2} - J\sin\frac{9\pi}{2}\right]$$

$$= 0 + [0 - J\times -1] + 2[-1 - J\times 0] + [0 - J1]$$

$$= 0 + J - 2 - 2J - J$$

$$= -2$$

DFT

$$F[T] = \{4, -2, 0, -2\}$$

c.	**Write a short note on Sampling & Quantization?** **Ans-** To create a digital image, we need to convert the continuous sensed data into digital form. This process includes 2 processes: 1. Sampling: Digitizing the co-ordinate value is called sampling. 2. Quantization: Digitizing the amplitude value is called quantization. To convert a continuous image f(x, y) into digital form, we have to sample the function in both co-ordinates and amplitude**.** The sampling rate determines the spatial resolution of the digitized image, while the quantization level determines the number of grey levels in the digitized image. A magnitude of the sampled image is expre ssed as a digital value in image processing. The transition between continuous values of the image function and its digital equivalent is called quantization. The number of quantization levels should be high enough for human perception of fine shading deta ils in the image. The occurrence of false contours is the main problem in image which has been quantized with insufficient brightness levels.	**5**	**2**	**2**
d.	**Write short notes on?** **(i) Homomorphic Filter** **Ans-** Homomorphic filtering is a generalized technique for signal and image processing, involving a nonlinear mapping to a different domain in which linear filter techniques are applied, followed by mapping back to the original domain. This concept was developed in the 1960s by Thomas Stockham, Alan V. An image as a function can be expressed as the product of illumination and reflectance components as follows: F(x,y) = I(x,y) * R(x,y) (1) Equation (1) cannot be used directly to operate separately on the frequency components of illumination and reflectance because the Fourier transform of the product of two functions is not separable. Instead the function can be represented as a logarithmic function wherein the product of the Fourier transform can be represented as the sum of the illumination and reflectance components as shown below: ln(x,y) = ln(I(x,y)) + ln(R(x,y)) (2) The Fourier transform of equation (2) is Z(u,v) = Fi(u,v) + Fr(u,v) (3) The fourier transformed signal is processed by means of a filter function H(u,v) and the resulting function is invers e fourier transformed. Finally, inverse exponential operation yields an enhanced image. This enhancement approach is termed as homomorphic filtering. The whole operation is expressed as a block diagram below:	**5**	**2**	**2**

F(x,y) G(x,y) ln DFT H(u,v) IDFT exp Implementa tion of Homomorphic filtering Consider an image with 256 x 256 pixels where the pixels have varying intensity. The pattern goes from dark to light as we go from left to right. This is also called a horizontal intensity and it can be visualized by creating a matrix of size 256 with non-uniform illumination. This is the first illumination pattern under investigation.

(ii) Spatial Domain Methods

Ans- Spatial domain refers to the image plane itself and are based on direct manipulation of pixels in an image. Frequency domain processing techniques are based on modifying the Fourier transform of an image. Image enhancement techniques are based on gray level transformation functions . Spatial domain methods .The value of a pixel with coordinates (*x,y*) in the enhan ced image $\hat{F}$ is the result of performing some operation on the pixels in the neighbourhood of (*x,y*) in the input image, *F*.

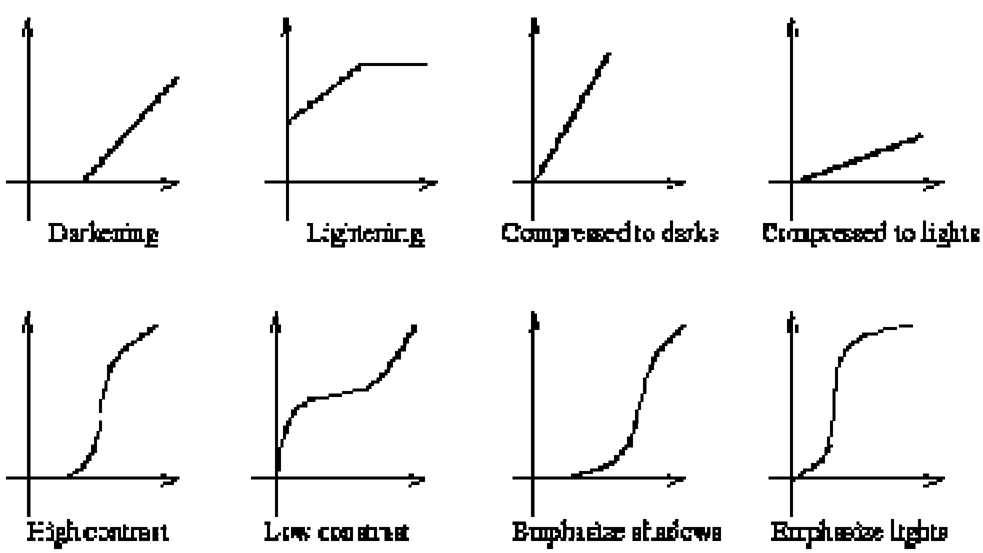
Neighbourhoods can be any shape, but usually they are rectangular.

Grey scale manipulation

The simplest form of operation is when the operator *T* only acts on a 1×1 pixel neighbourhood in the input image, that is $\hat{F}(x, y)$ only depends on the value of *F* at (*x,y*). This is a *grey scale transformation* or mapping. The simplest case is thresholding where the intensity profile is replaced by a step funct ion, active at a chosen threshold value. In this case any pixel with a grey level below the threshold in the input image gets mapped to 0 in the output image. Other pixels are mapped to 255.

Other grey scale transformations are outlined in figure 1 below.

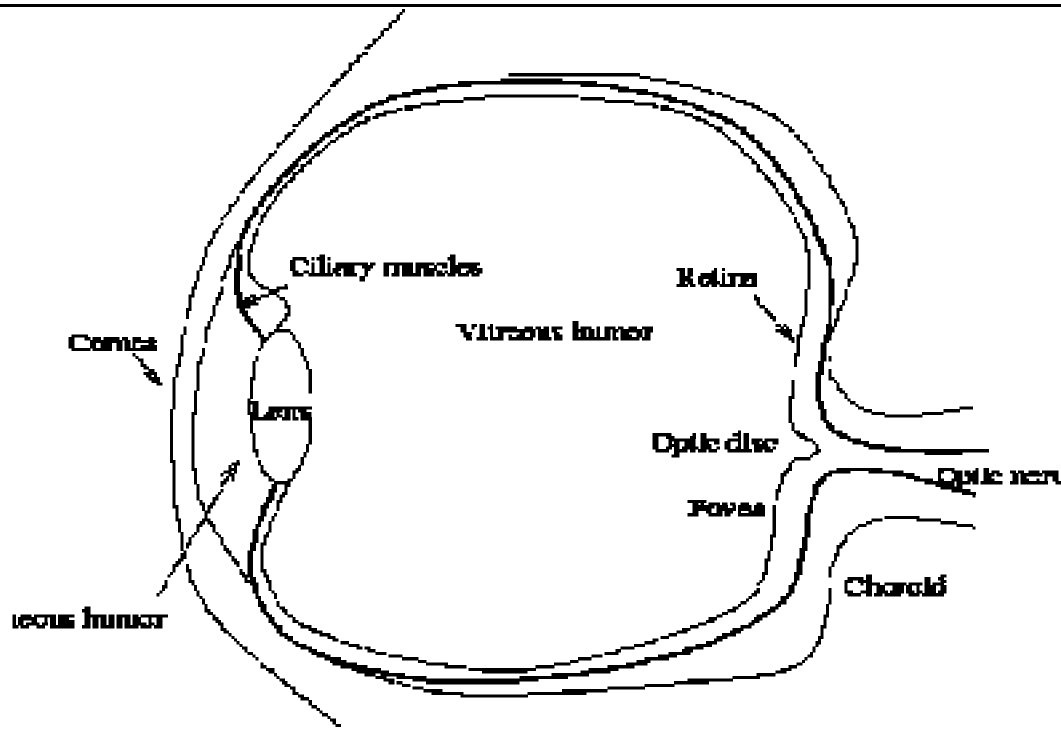
Figure 1: Tone-scale adjustments.



SECTION - C

3. Attempt any ONE part of the following: **(1*5 = 5)**

Q N	QUESTION	Marks	CO	BL
a.	**What is human visual system with suitable diagram also explain image formation in Eye?** **Ans- Image formation in the eye and the camera** Biological vision is the process of using light reflected from the surrounding world as a way of modifying behavior. Generally, with humans, we say that the surrounding environment is *interpreted* by visual input. This usually implies some form of conscious understanding of the 3D world from the 2D projection that it forms on the retina of the eye. However much of our visual computation is carried out unconsciously and often our interpretations can be fallacious. **The eye** Any understanding of the function of the human eye serves as an insight into how machine vision might be solved. Indeed, it was some of the early work by Hubel and Wiesel on the receptive fields in the retina that has led to the fundamental operation of spatial filtering that nowadays dominates so much of early image processing. There are many good references to the function of the eye, although Frisby gives an excellent overview with a computational flavour. The ey e is considered by most neuroscientists as actually part of the brain. It consists of a small spherical globe of about 2cm in diameter, which is free to rotate under the control of 6 extrinsic muscles. Light enters the eye through the transparent *cornea*, passes through the *aqueous humor*, the *lens*, and the *vitreous humor*, where it finally forms an image on the *retina* (see Figure 1). **Figure:** Sketch of a cross-section of the eye (schematic after Nalwa).	**5**	**1**	**1**

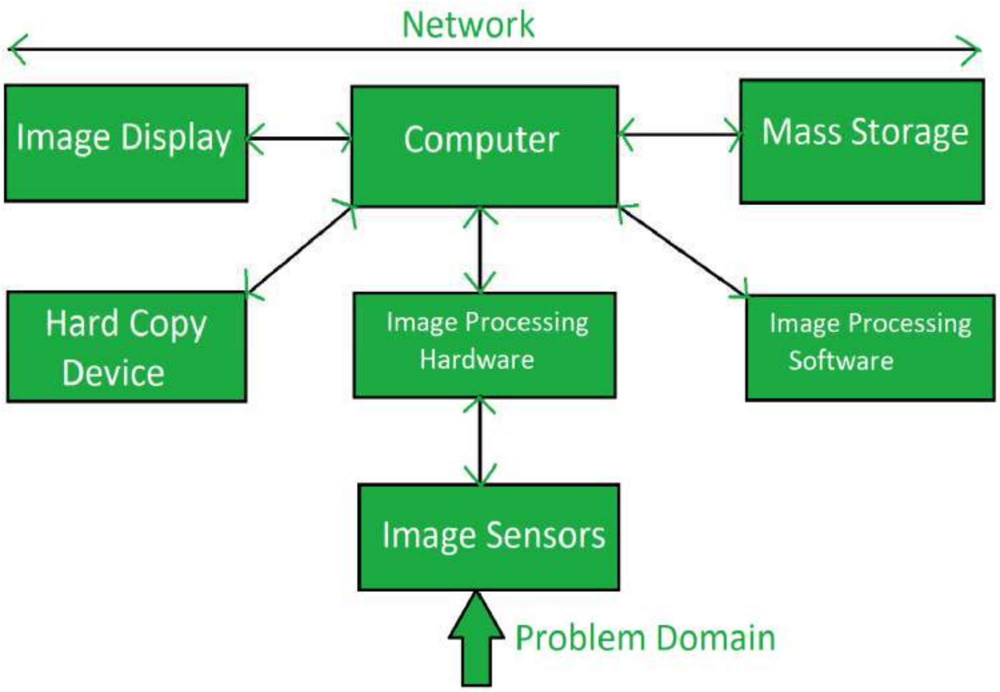


It is the muscular adjustment of the lens, known as *accommodation* that focuses the image directly on the retina. If this adjustment is not correctly accomplished, the viewer suffers from either nearsightedness or farsightedness. Both conditions are easily corrected with optical lenses.

The retina itself is a complex tiling of photoreceptors. These photoreceptors are known as *rods* and *cones*. When these photoreceptors are stimulated by light, they produce electrical signals that are transmitted to the brain via the *optic nerve*. The location of the optic ner ve on the retina obviously prohibits the existence of photoreceptors at this point. This point is known as the *blind spot* and any light that falls upon it is not perceived by the viewer. Most people are unaware of their blind spot, although it is easy to d emonstrate that it exists. And its existence has been known about for many years as it is reputed that the executioners in France during the revolution used to place their victim so that his or her head fell onto the blind spot, thus eliciting a pre-guillotine perception of the poor character without a head.

The rods and cones do not have a continuous physical link to the optic nerve fibers. Rather, they communicate through three distinct layers of cells, via junctions known as *synapses*. These layers of cel ls connect the rods and cones to the *ganglion cells* , which respond to the photo stimulus according to a certain *receptive field*. We can see from Figure 2 that the rods and cones are at the *back* of the retina. Thus the light passes through the various cell layers to these receptive fields, and is then transmitted via various synaptic junctions back towards the optic nerve fiber.

4. Attempt any ONE part of the following: (1*5 = 5)

Q N	QUESTION	Marks	CO	BL
a.	**Explain components of Image processing System with Suitable Diagram?** **Ans-** Image Processing System is the combination of the different elements involved in the digital image processing. Digital image processing is the processing of an image by means of a digital computer. Digital image processing uses different computer algorithms to perform image proc essing on the digital images.  Image Sensors: Image sensors senses the intensity, amplitude, co -ordinates and other features of the images and passes the result to the image processing hardware. It includes the problem domain. Image Processing Hardware: Image processing hardware is the dedicated hardware that is used to process the instructions obtained from the image sensors. It passes the result to general purpose computer. Computer: Computer used in the image processing system is the general purpose c omputer that is used by us in our daily life. Image Processing Software: Image processing software is the software that includes all the mechanisms and algorithms that are used in image processing system.	5	1	2

	Mass Storage: Mass storage stores the pixels of the images during the processing. Hard Copy Device: Once the image is processed then it is stored in the hard copy device. It can be a pen drive or any external ROM device. Image Display: It includes the monitor or display screen that displays the processed images. Network: Network is the connection of all the above elements of the image processing system.			
b.	**Discuss About low pass frequency domain filters & High Pass frequency domain filters?** **Ans- Lowpass filter (smoothing)** A low pass filter is used to pass low-frequency signals. The strength of the signal is reduced and frequencies which are passed is higher than the cut -off frequency. The amount of strength reduced for each frequency depends on the design of the filter. Smoothing is low pass operation in the frequency domain. **1. Ideal Lowpass Filters** The ideal lowpass filter is used to cut off all the high -frequency components of Fourier transformation. Below is the transfer function of an ideal lowpass filter. $H(u,v) = \begin{cases} 1 & \text{if } D(u,v) \leq D0 \\ 0 & \text{if } D(u,v) > D0 \end{cases}$ $D(u,v) = \left[\left(u - \frac{M}{2}\right)^2 + \left(v - \frac{N}{2}\right)^2\right]^{\frac{1}{2}}$ **2. Butterworth Lowpass Filters** Butterworth Lowpass Filter is used to remove high-frequency noise with very minimal loss of signal components.	**5**	**2**	**3**

	$$H(u,v) = \frac{1}{1+\left[\frac{D(u,v)}{D0}\right]^{2n}}$$ **3. Gaussian Lowpass Filters** The transfer function of Gaussian Lowpass filters is ahown below: $$H(u,v) = e^{-D^2(u,v)/2D_0^2} \quad (8)$$ **Highpass filters (sharpening)** A highpass filter is used for passing high frequencies but the strength of the frequency is lower as compared to cut off frequency. Sharpening is a highpass operation in the frequency domain. As lowpass filter, it also has standard forms such as Ideal highpass filter, Butterworth highpass filter, Gaussian highpass filter.			

5. Attempt any ONE part of the following: (1*5 = 5)

Q N	QUESTION	Marks	CO	BL
a.	**Differentiate between ideal, Butterworth, Gaussian filters?** **Ans- Lowpass filter (smoothing)** A low pass filter is used to pass low -frequency signals. The strength of the signal is reduced and frequencies which are passed is higher than the cut -off frequency. The amount of strength reduced for each frequency depends on the design of the filter. Smoothing is low pass operation in the frequency domain. **1. Ideal Lowpass Filters** The ideal lowpass filter is used to cut off all the high -frequency components of Fourier transformation. Below is the transfer function of an ideal lowpass filter. $$H(u,v) = \begin{cases} 1 & if\ D(u,v) \leq D0 \\ 0 & if\ D(u,v) > D0 \end{cases}$$ $$D(u,v) = \left[\left(u-\frac{M}{2}\right)^2 + \left(v-\frac{N}{2}\right)^2\right]^{\frac{1}{2}}$$	5	2	2

2. Butterworth Lowpass Filters

Butterworth Lowpass Filter is used to remove high -frequency noise with very minimal loss of signal components.

$$H(u,v) = \frac{1}{1+\left[\frac{D(u,v)}{D0}\right]^{2n}}$$

3. Gaussian Lowpass Filters

The transfer function of Gaussian Lowpass filters is ahown below:

$$H(u,v) = e^{-D^2(u,v)/2D_0^2} \quad (8)$$

Highpass filters (sharpening)

A highpass filter is used for passing high frequencies but the strength of the frequency is lower as compared to cut off frequency. Sharpening is a highpass operation in the frequency domain. As lowpass filter, it also has standard forms such as Ideal highpass filter, Butterworth highpass filter, Gaussian highpass filter.

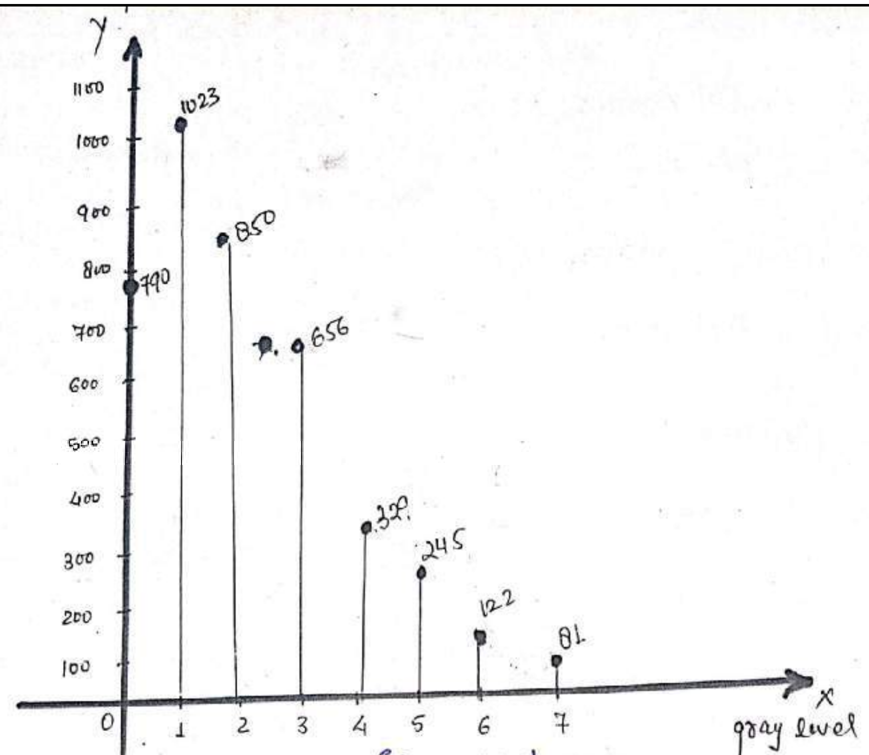
b. **Equalize the Given histogram?** **5** **2** **4**

Gray	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Pixels	**790**	**1023**	**850**	**656**	**329**	**245**	**122**	**81**

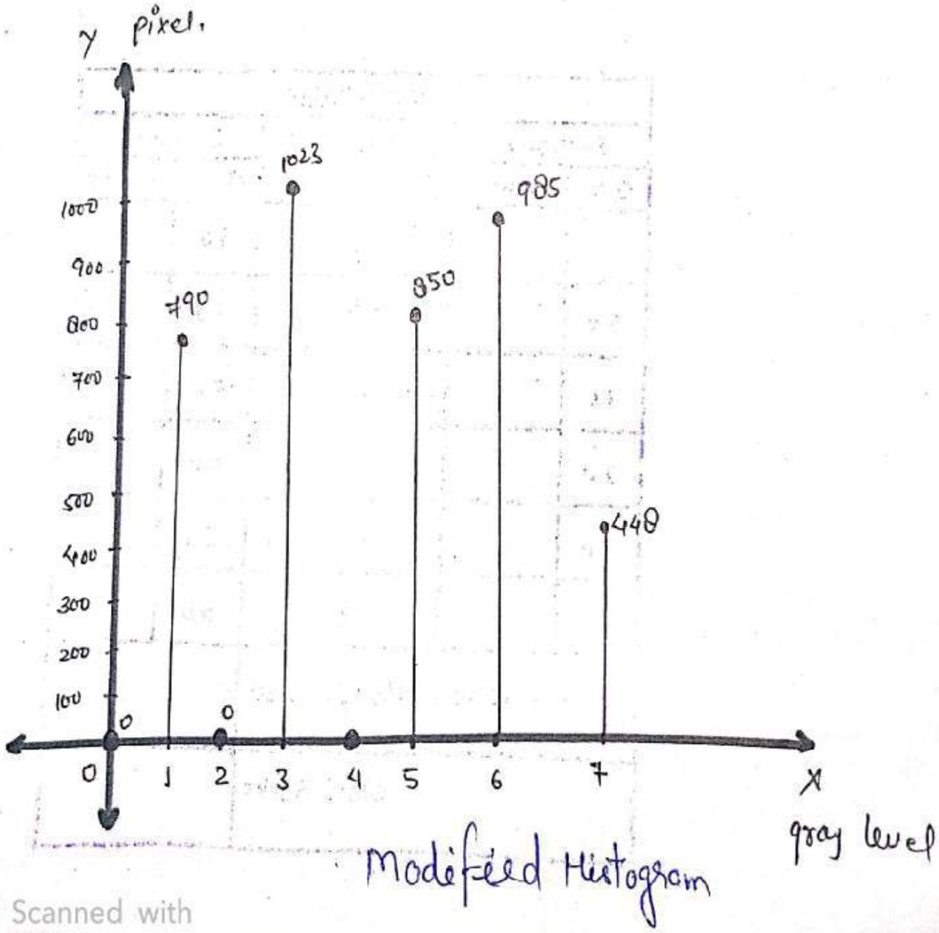
Ans-

Gray	pixel	PDF	CF (S_k)	$(L-1)S_k$ $7 \times S_k$	New Roundoff
0	790	$790/4096 = 0.19$	0.19	~~1.19~~ (1.33)	~~0~~ 1
1	1023	0.25	0.44	~~2.44~~ (3.08)	~~1~~ 3
2	850	0.21	0.65	~~4.65~~ (4.55)	5
3	656	0.16	0.81	~~5.81~~ (5.67)	6
4	329	0.08	0.89	~~5.89~~ (6.23)	6
5	245	0.06	0.95	~~6.95~~ (6.65)	7
6	122	0.03	0.98	~~6.98~~ (6.86)	7
7	81	0.02	1.00	~~8~~ (7)	7
	Σpixel = 4096				

Old gray level	New gray level	pixel (New)
0	1	0
1	3	790
2	5	0
3	6	1023
4	6	0
5	7	850
6	7	985
7	7	448



Given Histogram



Modified Histogram