(2½ Hours)

[Total Marks: 60]

N. B.: (1) **All** questions are **compulsory**.
(2) Make **suitable assumptions** wherever necessary and **state the assumptions** made.
(3) Answers to the **same question** must be **written together**.
(4) Numbers to the **right** indicate **marks**.
(5) Draw **neat labelled diagrams** wherever **necessary**.
(6) Use of **Non-programmable** calculators is **allowed**.

I	**Choose the correct alternative and rewrite the entire sentence with the correct alternative. (30)**			
1.	Digitizing the coordinate values of a continuous image is called______________ .			
	a.	Compression	**b.**	Sampling
	c.	Segmentation	**d.**	Quantization
Answer Key : b				
2.	Which of the following is the principle energy source for images?			
	a.	electrical spectrum	**b.**	electro magnetic spectrum
	c.	electro spectrum	**d.**	magnetic spectrum
Answer Key : b				
3.	A ____________ process is characterized by the fact that its inputs generally are images, but its outputs are attributes extracted from those images.			
	a.	Low-level	**b.**	Last level
	c.	High level	**d.**	Mid level
Answer Key : d				
4.	_________________ are used for modeling and visualization, which are generated by computer.			
	a.	X-rays Images	**b.**	Vector Images
	c.	Synthetic images	**d.**	Ultraviolet Images
Answer Key : c				
5.	____________ is process which based on Visible red light.			
	a.	Vegetation discrimination	**b.**	Mineral mapping
	c.	Soil moisture	**d.**	Water penetration
Answer Key : a				
6.	______________ simply yields the value of the function f (t) at the location of the impulse.			
	a.	Rotation	**b.**	Scaling
	c.	Shifting	**d.**	Correlation
Answer Key : c				
7.	Fourier transform pair denoted as f (t)⇔ F(m) where the double arrow indicates that the expression on the left is obtained by taking the ______________ of the expression on the right.			
	a.	Forward Fourier Transform	**b.**	Inverse Fourier Transform
	c.	Power Law Transform	**d.**	Convolution
Answer Key : b				

8.	____________ is the property of two functions that involves flipping rotating by 180°one function about its origin and sliding it past the other.			
	a.	Separability	**b.**	Laplacian
	c.	Distribution	**d.**	Convolution
Answer Key : d				
9.	Continuous functions have to be converted into a sequence of discrete values before they can be processed in a computer which requires _________________.			
	a.	Sampling and Quantization	**b.**	Compression
	c.	Interpolation	**d.**	Correlation
Answer Key : a				
10.	Filters are instrumental in recovering the original function from its samples, filters used for the such purpose are also called _______________.			
	a.	Notch filter	**b.**	Statistical filter
	c.	Homomorphic filter	**d.**	Reconstruction filters
Answer Key : d				
11.	In orthonormal basis the __________ have same length as original vector			
	a.	Vector subset	**b.**	pixel representation
	c.	coordinates representation	**d.**	scalar quantities
Answer Key : c				
12.	What is Heisenberg's uncertainty principle?			
	a.	Set of points function in image where time and frequency is zero	**b.**	Set of points function in image where time and frequency is Uncertain
	c.	Set of points function in image where time and frequency is Constant	**d.**	Set of points function in image where time and frequency is non zero
Answer Key : b				
13.	discrete Hartley transform, discrete cosine transform, and discrete sine transform, All three transforms avoid the computational complexity of ________			
	a.	Complex Numbers	**b.**	Real Numbers
	c.	Maximum Numbers	**d.**	Odd Numbers
Answer Key : a				
14.	Walsh-Hadamard transforms (WHTs) are _________ transformations			
	a.	sinusoidal	**b.**	circular
	c.	non-sinusoidal	**d.**	centrifugal
Answer Key : c				
15.	What is Walsh function ?			
	a.	basic function with 0 to 1 range of pixels	**b.**	a linear combination of N X N Matrix basis functions
	c.	a linear combination of circular basis functions	**d.**	a linear combination of rectangular basis functions
Answer Key : d				
16.	What is use of digital image watermarking?			
	a.	copy protection	**b.**	image transmission
	c.	image compression	**d.**	image modification
Answer Key : a				

17.	To expand the boundary of an object in binary images the appropriate operation is _______________				
	a.	Erosion	**b.**	Dilation	
	c.	Opening	**d.**	Closing	
Answer Key : b					
18.	In region growing technique ____________ is the starting pixel.				
	a.	original pixel	**b.**	seed pixel	
	c.	base pixel	**d.**	center pixel	
Answer Key : b					
19.	Which of the following second order operator is most sensitive to noise in edge filtering?				
	a.	Sobel operator	**b.**	Prewitt operator	
	c.	Laplacian operator	**d.**	Laplacian of Gaussian operator	
Answer Key : c					
20.	When we apply High pass filter in an image, we can approximate___________.				
	a.	Background	**b.**	Texture	
	c.	Object	**d.**	Boundary	
Answer Key : c					
21.	On which properties, Gray level image segmentation is based on:				
	a.	Discontinuity and similarity	**b.**	continuity and similarity	
	c.	only similarity	**d.**	only continuity	
Answer Key : a					
22.	Pick the correct example of clustering method				
	a.	Level Set Methods	**b.**	Neural Network Segmentation	
	c.	Graph Partitioning Methods	**d.**	Watershed Transformation	
Answer Key : a					
23.	Similarity approach of segmentation depends on__________				
	a.	low frequencies	**b.**	smooth changes	
	c.	abrupt changes	**d.**	contrast	
Answer Key : a					
24.	What is the opening operation in morphology?				
	a.	structured filling of image region boundary pixels	**b.**	image pattern matching and marking	
	c.	structured erosion using image pattern matching	**d.**	structured removal of image region boundary pixels	
Answer Key : d					
25.	Points on the inside and outside of the boundary are _________ because there are no discontinuities in intensity in those regions.				
	a.	white	**b.**	blank	
	c.	black	**d.**	one	
Answer Key : c					
26.	A point(1,1) in the cartesian system is represented in slope-intercept space(m,c) as,				
	a.	m= - c + 1	**b.**	m= c + 1	
	c.	m= c - 1	**d.**	m= - c - 1	
Answer Key : a					

27.	What is accepting or rejecting certain frequency components in an image called as ?				
	a.	Histogram equalization	**b.**	contrast stretching	
	c.	filtering	**d.**	band pass filtering	
Answer Key : c					
28.	In image enhancement -reduced dataset contains only ____________ of the pixels found in the original scene.				
	a.	half(50%)	**b.**	full(100)	
	c.	one fourth (25%)	**d.**	one third(75%)	
Answer Key : c					
29.	Digital image magnification is usually performed for_____________				
	a.	enlarge or match the scale of an image	**b.**	reduce and match the scale of an image	
	c.	reduce and match the contrast of an image	**d.**	enlarge or match the contrast of an image	
Answer Key : a					
30.	Nearest-neighbor, bilinear interpolation, or cubic convolution are used as _____________				
	a.	searching algorithm	**b.**	resampling algorithm	
	c.	analysis algorithm	**d.**	plotting algorithm	
Answer Key : b					

II	**Attempt *<u>any one</u>* of the following:**	**6**

a Elaborate the digital image processing and its scope? Discuss basic technical process.

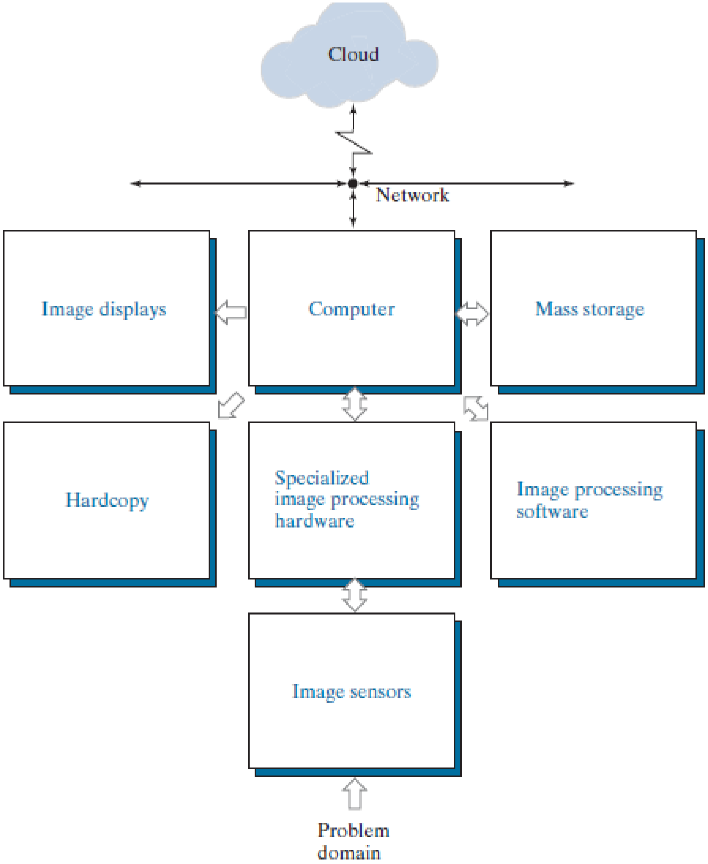
Ans:

1. An image may be defined as a two-dimensional function, f (x, y), where x and y are spatial (plane) coordinates, and the amplitude of f at any pair of coordinates (x, y)is called the intensity or gray level of the image at that point. When x, y, and the intensity values of f are all finite, discrete quantities, we call the image a digital image.
2. The field of digital image processing refers to processing digital images by means of a digital computer. a digital image is composed of a finite number of elements, each of which has a particular location and value. These elements are called picture elements, image elements, pels, and pixels.
3. Pixel is the term used most widely to denote the elements of a digital image.
4. Vision is the most advanced of our senses, so it is not surprising that images play the single most important role in human perception. However, unlike humans, who are limited to the visual band of the electromagnetic (EM) spectrum, imaging machines cover almost the entire EM spectrum, ranging from gamma to radio waves.

5. They can operate on images generated by sources that humans are not accustomed to associating with images. These include ultrasound, electron microscopy, and computer-generated images. Thus, digital image processing encompasses a wide and varied field of applications.

b Explain the components of digital image processing with labelled diagram?

Ans:



Explanation of each block with correct exposure.

1. Image displays
2. Mass storage
3. Image processing software
4. Image sensors

c Explain image acquisition methods in brief? Elaborate its types?

Ans:

Most of the images in which we are interested are generated by the combination of an “illumination” source and the reflection or absorption of energy from that source by the elements of the “scene” being imaged. We enclose illumination and scene in quotes to emphasize the fact that they are considerably more general than the familiar situation in which a visible light source illuminates a familiar 3-D scene.

- Illumination:

The illumination may originate from a source of electromagnetic energy such as a radar, infrared, or X-ray system. But, as noted earlier, it could originate from less traditional sources, such as ultrasound or even a computer-generated illumination pattern.

- Scene:

The scene elements could be familiar objects, but they can just as easily be molecules, buried rock formations, or a human brain. Depending on the nature of the source, illumination energy is reflected from, or transmitted through, objects.

IMAGE ACQUISITION USING A SINGLE SENSING ELEMENT:

- A familiar sensor of this type is the photodiode, which is constructed of silicon materials and whose output is a voltage proportional to light intensity. Using a filter in front of a sensor improves its selectivity. For example, an optical green-transmission filter favors light in the green band of the color spectrum.
- As a consequence, the sensor output would be stronger for green light than for other visible light components. In order to generate a 2-D image using a single sensing element, there has to be relative displacements in both the x- and y-directions between the sensor and the area to be imaged.

IMAGE ACQUISITION USING SENSOR STRIPS:

- A geometry used more frequently than single sensors is an in-line sensor strip, as The strip provides imaging elements in one direction.
- Motion perpendicular to the strip provides imaging in the other direction his arrangement is used in most flat bed scanners. Sensing devices with 4000 or more in-line sensors are possible.
- In-line sensors are used routinely in airborne imaging applications, in which the imaging system is mounted on an aircraft that flies at a constant altitude and speed over the geographical area to be imaged.
- One dimensional imaging sensor strips that respond to various bands of the electromagnetic spectrum are mounted perpendicular to the direction of flight.
- An imaging strip gives one line of an image at a time, and the motion of the strip relative to the scene completes the other dimension of a 2-D image. Lenses or other focusing schemes are used to project the area to be scanned onto the sensors.

2	**Attempt *any one* of the following:**	**6**

a Explain sampling theorem? Describe the Fourier transform of sampled function.

Ans:

The Sampling theorem:

1. The sampling theorem specifies the minimum-sampling rate at which a continuous-time signal needs to be uniformly sampled so that the original signal can be completely recovered or reconstructed by these samples alone. This is usually referred to as Shannon's sampling theorem in the literature.
2. Sampling theorem: If a continuous time signal contains no frequency components higher than Whz, then it can be completely determined by uniform samples taken at a rate fs samples per second where

$$f_s \geq 2W$$

or, in term of the sampling period

$$T \leq 1/2W$$

3. A signal with no frequency component above a certain maximum frequency is known as a bandlimited signal. Figure 2.4 shows two typical bandlimited signal spectra: one low-pass and one band-pass.

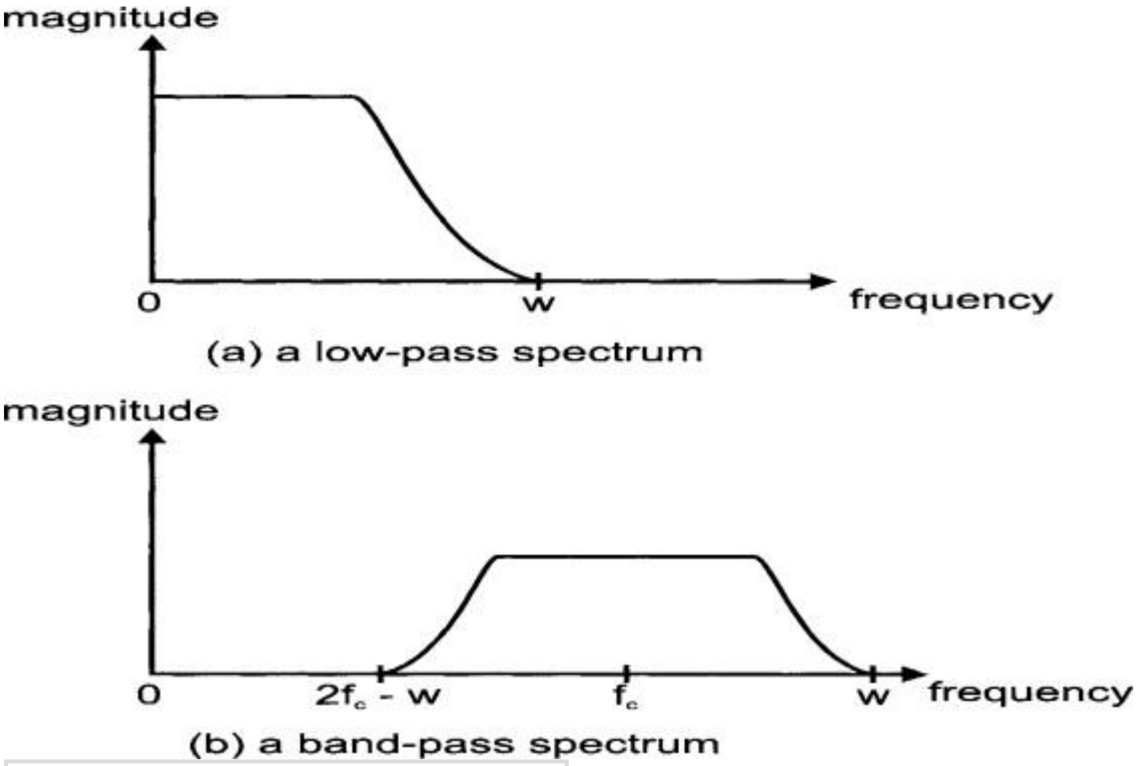
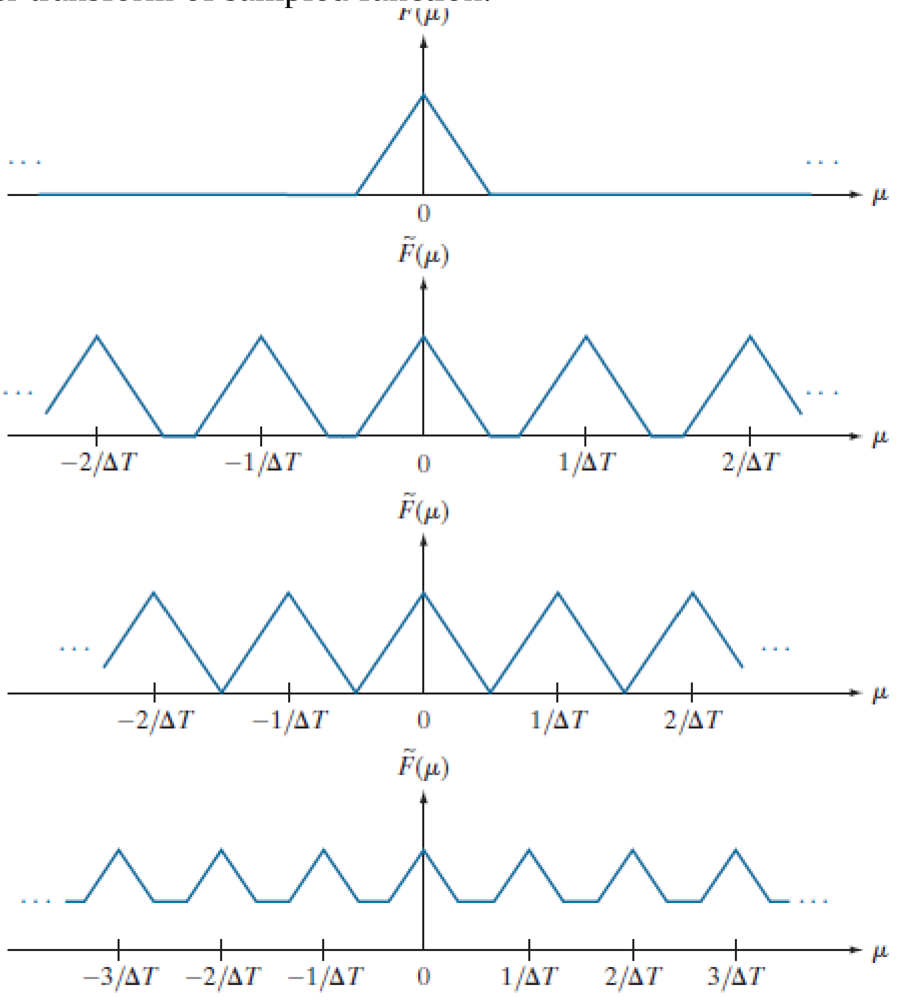


Figure 2.4. Two bandlimited spectra

4. The minimum sampling rate allowed by the sampling theorem (fs = 2W) is called the Nyquist rate.

Fourier transform of sampled function:



1. A higher value of _T would cause the periods in _F (m) to merge; a lower value would provide a clean separation between the periods.
2. We can recover *f* (*t*) from its samples if we can isolate a single copy of *F*(m) from the periodic sequence of copies of this function contained in _F (m), the transform of the sampled function *f*_(*t*).
3. _F(m) is a *continuous*, *periodic* function with period 1 _*T*. Therefore, all we need is one complete period to characterize the entire transform. In other words, we can recover *f* (*t*) from that single period by taking its inverse Fourier transform.
4. Extracting from _F (m) a single period that is equal to *F*(m) is possible if the separation between copies is sufficient . In terms of sufficient separation is guaranteed if 1 /2 delta *T* > m_{max} or

$$\frac{1}{\Delta T} > 2\mu_{max}$$

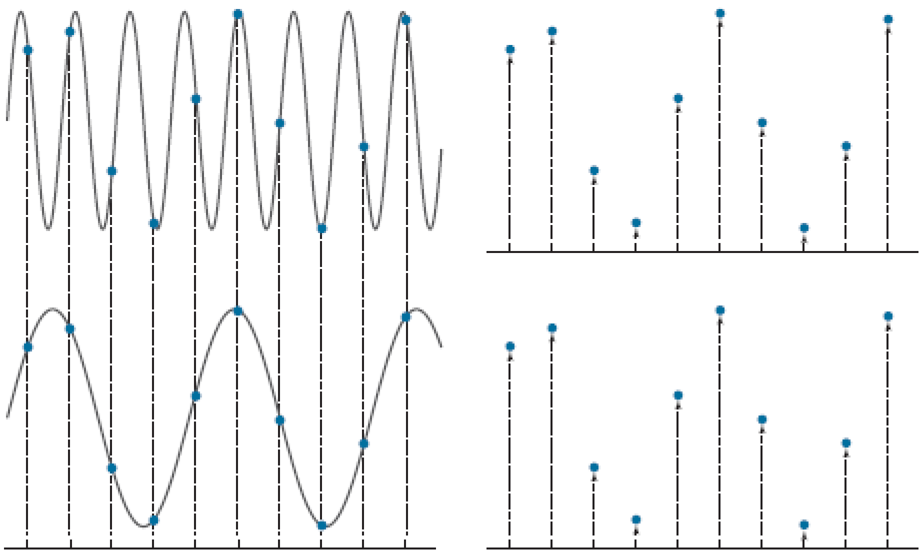
5. This equation indicates that a continuous, band-limited function can be recovered completely from a set of its samples if the samples are acquired at a rate exceedingly twice the highest frequency content of the function. This exceptionally important result is known as the sampling theorem.

b Explain the concept of Aliasing in image processing?

Ans:

1. The foundation of aliasing phenomena as it relates to sampling is that we
2. can describe a digitized function only by the values of its samples. This means that it is possible for two (or more) totally different continuous functions to coincide at the values of their respective samples, but we would have no way of knowing the characteristics of the functions between those samples. Two completely different sine functions sampled at the same rate.
3. Two continuous functions having the characteristics just described are called an aliased pair, and such pairs are indistinguishable after sampling. Note that the reason these functions are aliased is because we used a sampling rate that is too coarse. That is, the functions were under-sampled.
4. It is intuitively obvious that if sampling were refined, more and more of the differences between the two continuous functions would be revealed in the sampled signals.
5. Aliasing is always present in sampled signals. This is because, even if the original sampled function is band-limited, infinite frequency components are introduced the moment we limit the duration of the function. f (t), to a finite interval, say [0,T]. We can do this by multiplying f (t) by the function,

$$h(t) = \begin{cases} 1 & 0 \le t \le T \\ 0 & \text{otherwise} \end{cases}$$



c Explain Gaussian Low pass filter transfer function with diagram?

Ans:

Gaussian lowpass filter (GLPF) transfer functions have the form,

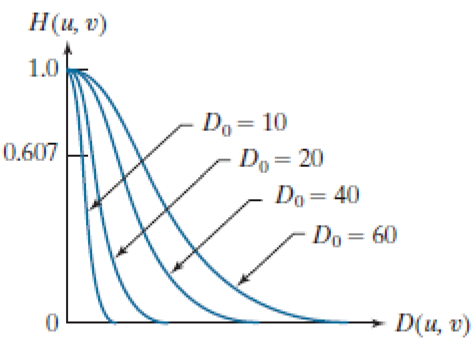
$$H(u,v) = e^{-D^2(u,v)/2\sigma^2}$$

where, as D(u,v) is the distance from the center of the P ×Q frequency rectangle to any point, (u,v), contained by the rectangle.

Unlike our earlier expressions for Gaussian functions, we do not use a multiplying constant here in order to be consistent with the filters discussed in this and later sections, whose highest value is 1. As before, s is a measure of spread about the center. By letting s = D0 , we can express the Gaussian transfer function in the same notation as other functions,

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

where D0 is the cutoff frequency. When D(u,v) = D , 0 the GLPF transfer function is down to 0.607 of its maximum value of 1.0.



3		**Attempt *<u>any one</u>* of the following:**	**6**

a Describe color model in brief? List and explain its type.

Ans:

1. The purpose of a color model (also called a color space or color system) is to facilitate the specification of colors in some standard way. In essence, a color model is a specification of (1) a coordinate system, and (2) a subspace within that system, such that each color in the model is represented by a single point contained in that subspace.
2. Most color models in use today are oriented either toward hardware (such as for color monitors and printers) or toward applications, where color manipulation isa goal (the creation of color graphics for animation is an example of the latter).
3. In terms of digital image processing, the hardware-oriented models most commonly used in practice are the RGB (red, green, blue) model for color monitors and a broad class of color video cameras; the CMY (cyan, magenta, yellow) and CMYK (cyan, magenta, yellow, black) models for color printing; and the HSI (hue, saturation,intensity) model, which corresponds closely with the way humans describe and interpret color.
4. The HSI model also has the advantage that it decouples the color and gray-scale information in an image, making it suitable for many of the gray-scale techniques . There are numerous color models in use today.
5. This is a reflection of the fact that color science is a broad field that encompasses many areas of application. It is tempting to dwell on some of these models here, simply because they are interesting and useful.
6. The RGB model:In the RGB model, each color appears in its primary spectral components of red,green, and blue. This model is based on a Cartesian coordinate system. The color .subspace of interest is the cube
7. The CMY And CMYK Color Models:Most devices that deposit colored pigments on paper, such as color printers and copiers, require CMY data input or perform an RGB to CMY conversion internally.This conversion is performed using the simple operation
8. The HSI Color Model:When humans view a color object, we describe it by its hue, saturation, and brightness. Recall from the discussion in Section 6.1 that hue is a color attribute that describes a

pure color (pure yellow, orange, or red), whereas saturation gives a measure of the degree to which a pure color is diluted by white light. brightness is a subjective descriptor that is practically impossible to measure. It embodies the achromatic notion of intensity and is one of the key factors in describing color sensation.

9. We do know that intensity (gray level) is a most useful descriptor of achromatic images. This quantity definitely is measurable and easily interpretable. The model we are about to present, called the HSI (hue, saturation, intensity) color model, decouples the intensity component from the color-carrying information (hue and saturation) in a color image.

b Explain Walsh-Hadamard transforms (WHTs) in brief?

Ans:

Walsh-Hadamard transforms (WHTs) are non-sinusoidal transformations that decompose a function into a linear combination of rectangular basis functions, called Walsh functions, of value +1 and −1. The ordering of the basis functions within a Walsh-Hadamard transformation matrix determines the variant of the transform that is being computed. For Hadamard ordering (also called natural ordering), the transformation matrix is obtained by substituting the inverse transformation kernal.

$$s(x,u) = \frac{1}{\sqrt{N}}(-1)^{\sum_{i=0}^{n-1} b_i(x) b_i(u)}$$

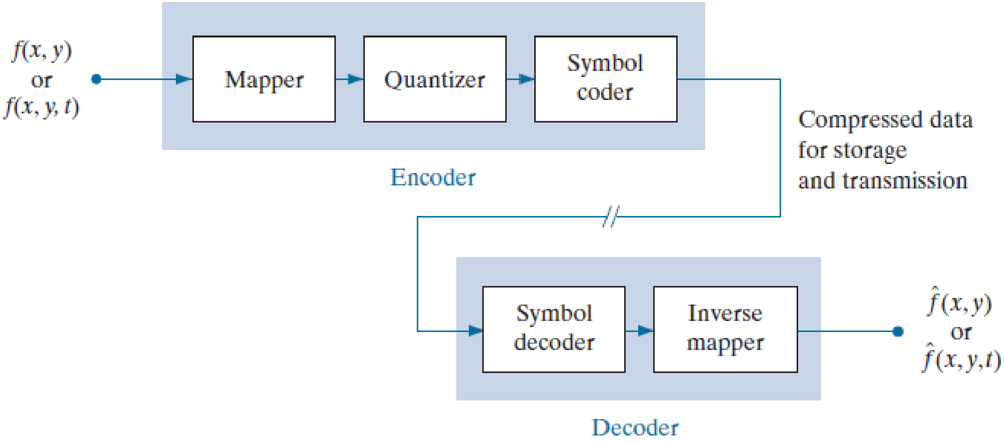
into Eqs.1 where the summation in the exponent of Eq.2 is performed in modulo 2 arithmetic, N = 2n, and b z k( ) is the kth bit in the binary representation of z. For example, if n = 3 and z = 6 (110 in binary), b z 0 ( ) = 0, b z 1( ) = 1,and b z 2 ( ) = 1. If N = 2, the resulting Hadamard-ordered transformation matrix is,

$$\mathbf{A}_W = \frac{1}{\sqrt{2}}\begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}$$

where the matrix on the right (without the scalar multiplier) is called a Hadamard matrix of order 2. Letting H_N denote the Hadamard matrix of order N, a simple recursive relationship for generating Hadamard-ordered transformation matrices is,

$$\mathbf{H}_{2N} = \begin{bmatrix} \mathbf{H}_N & \mathbf{H}_N \\ \mathbf{H}_N & -\mathbf{H}_N \end{bmatrix}$$

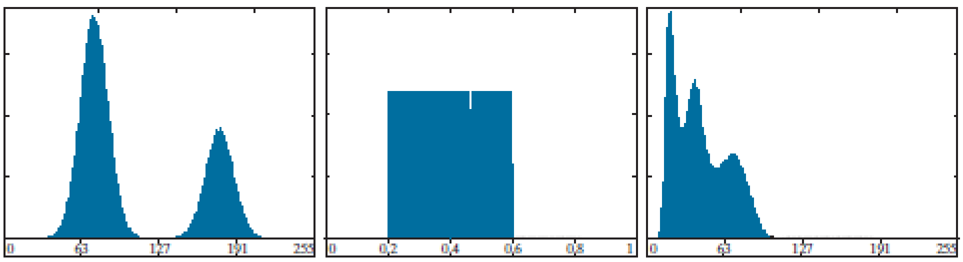
The number of sign changes along a row of a Hadamard matrix is known as the

		sequency of the row. Like frequency, sequency measures the rate of change of a function, and like the sinusoidal basis functions of the Fourier transform, every Walsh function has a unique sequency. Since the elements of a Hadamard matrix are derived from inverse kernal values, the sequency concept applies to basis functions s(x,u) for u = 0,1,…,N − 1 as well. For instance, the sequencies of the H4 basis vectors in eq. are 0, 3, 1, 2; the sequencies of the H8 basis vectors in Eq. are 0, 7, 3, 4, 1, 6, 2, and 5. This arrangement of sequencies is the defining characteristic of a Hadamard-ordered Walsh-Hadamard transform.	
	c	Explain the image compression model? Ans: Explanation of each block.  • Mapper • Quantizer • Symbol coder • Symbol decoder • Inverse mapper	
4	**Attempt *<u>any one</u>* of the following:**		**6**
	a	Write a note on Morphological Smoothing? Ans: 1. Because opening suppresses bright details smaller than the specified SE while leaving dark details relatively unaffected, and closing generally has the opposite effect,these two operations are used often in combination as morphological filters for image smoothing and noise removal.	

		2. Consider Fig. which shows an image of the Cygnus Loop supernova taken in the X-ray band (see Fig. 1.7 for details about this image). For purposes of the present discussion, suppose that the central light region is the object of interest, and that the smaller components are noise. 3. Our objective is to remove the noise. Figure (b) shows the result of opening the original image with a flat disk of radius 1, then closing the opening with an SE of the same size. Figures (c) and (d) show the results of the same operation using SEs of radii 3 and 5, respectively. 4. As expected, this sequence shows progressive removal of small components as a function of SE size. In the last result, we see that the noise has been almost eliminated. The noise components on the lower right side of the image could not be removed completely because their sizes are larger than the other image elements that were successfully removed. 5. A procedure used sometimes is to perform alternating sequential filtering, in which the opening–closing sequence starts with the original image, but subsequent steps perform the opening and closing on the results of the previous step. 6. This type of filtering is useful in automated image analysis, in which results at each step are compared against a specified metric.	
	b	Write a note on segmentation methods for point, line and edge detection? Ans: 1. segmentation methods that are based on detecting sharp, local changes in intensity. 2. The three types of image characteristics in which we are interested are isolated points, lines, and edges. 3. Edge pixels are pixels at which the intensity of an image changes abruptly, and edges (or edge segments) are sets of connected edge pixels. 4. Edge detectors are local image processing tools designed to detect edge pixels. 5. A line may be viewed as a (typically) thin edge segment in which the intensity of the background on either side of the line is either much higher or much lower than the intensity of the line pixels. 6. The lines give rise to so-called "roof edges." 7. An isolated point may be viewed as a foreground (background) pixel surrounded by background (foreground) pixels.	
	c	Explain the role of noise in image thresholding?	

Ans:

- The simple synthetic image in Fig.is free of noise, so its histogram consists of two “spike” modes.
- Segmenting this image into two regions is a trivial task: we just select a threshold anywhere between the two modes.
- Figure shows the original image corrupted by Gaussian noise of zero mean and a standard deviation of 10 intensity levels.
- The modes are broader now but their separation is enough so that the depth of the valley between them is sufficient to make the modes easy to separate.
- A threshold placed midway between the two peaks would do the job. Figure shows the result of corrupting the image with Gaussian noise of zero mean and a standard deviation of 50 intensity levels.
- As the histogram in Fig. shows, the situation is much more serious now, as there is no way to differentiate between the two modes.
- Without additional processing (such as the methods discussed later in this section) we have little hope of finding a suitable threshold for segmenting this image.



5	**Attempt *any one* of the following:**	6

a Describe the boundary following algorithm?

Ans:

We assume that we are working with binary images in which object and background points are labeled 1 and 0,respectively; and that images are padded with a border of 0’s to eliminate the possibility of an object merging with the image border. For clarity, we limit the discussion to single regions.

The approach is extended to multiple, disjoint regions by processing the regions individually.

The following algorithm traces the boundary of a 1-valued region, R, in a binary image.

1. Let the starting point, b0 , be the uppermost-leftmost point† in the image that is labeled 1. Denote by c0 the west neighbor of b0 [see

Fig. 11.1(b)]. Clearly, c0 is always a background point. Examine the 8-neighbors of b0, starting at c0 and proceeding in a clockwise direction.

2. Let b1 denote the first neighbor encountered whose value is 1, and let c1 be the (background) point immediately preceding b1 in the sequence. Store the locations of b0 for use in Step 5.
3. Let b = b0 and c = c0.
4. Let the 8-neighbors of b, starting at c and proceeding in a clockwise direction, be denoted by n1,n2 ,…, n8. Find the first neighbor labeled 1 and denote it by nk .
5. Let b nk = and c nk = –1.5. Repeat Steps 3 and 4 until b = b0. The sequence of b points found when the algorithm stops is the set of ordered boundary points.

b Explain a chain code representation(Freeman chain code) in brief?

Ans:

- A chain code representation is based on 4- or 8-connectivity of the segments.
- The direction of each segment is coded by using a numbering scheme. A boundary code formed as a sequence of such directional numbers is referred to as a Freeman chain code.
- Digital images usually are acquired and processed in a grid format with equal spacing in the x- and y-directions, so a chain code could be generated by following a boundary a clockwise direction and assigning a direction to the segments connecting every pair of pixels.
- This level of detail generally is not used for two principal reasons:
- The resulting chain would be quite long and
- Any small disturbances along the boundary due to noise or imperfect segmentation would cause changes in the code that may not be related to the principal shape features of the boundary.
- An approach used to address these problems is to resample the boundary by selecting a larger grid spacing, then as the boundary is traversed, a boundary point is assigned to a node of the coarser grid, depending on the proximity of the original boundary point to that node,
- The resampled boundary obtained in this way can be represented by a 4- or 8-code. the coarser boundary points represented by an 8-directional chain code. It is a simple matter to convert from an 8-code to a 4-code and vice versa

c Explain SIFT algorithm with steps?

Ans:

As the material in the preceding sections shows, SIFT is a complex procedure consisting of many parts and empirically determined constants. The following is a step by-step summary of the method.

1. Construct the scale space. This is done using the procedure outlined in the parameters that need to be specified are s, s, (k is computed from s), and the number of octaves. Suggested values are s = 1 6 . , s = 2, and three octaves.
2. Obtain the initial keypoints. Compute the difference of Gaussians, D(x, y,s), from the smoothed images in scale space, as explained in
3. Find the extrema in each D(x, y,s) image using the method explained these are the initial keypoints.
4. Improve the accuracy of the location of the key points. Interpolate the values of D(x, y,s) via a Taylor expansion.
5. The improved key point locations are given by 4. Delete unsuitable key points.
6. Eliminate key points that have low contrast and/or are poorly localized.
7. This is done by evaluating D from Step 3 at the improved locations, using all key points whose values of D are lower than a threshold are deleted.
8. A suggested threshold value is 0.03. Key points associated with edges are deleted also, A value of 10 is suggested for r.
9. Compute key point orientations. Use eq.to compute the magnitude and orientation of each key point using the histogram-based procedure discussed in connection with these equations.
10. Compute key point descriptors. Use the method summarized in Fig. 11.62 to compute a feature (descriptor) vector for each key point. If a region of size 16 × 16 around each key point is used, the result will be a 128-dimensional feature vector for each key point.