DIGITAL IMAGE PROCESSING
(AEIE 4242)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) At what points, a continuous image is digitized?
(a) Sampling (b) Vertex (c) Contour (d) Random.

(ii) Which characteristics are taken together in chromaticity?
(a) Hue and Saturation (b) Hue and Brightness
(c) Saturation, Hue, and Brightness (d) Saturation and Brightness.

(iii) Intensity slicing is called
(a) density slicing (b) image slicing
(c) color slicing (d) region slicing.

(iv) What are the names of the various colour image processing categories?
(a) Pseudo-color and Multi-color processing
(b) Half-color and pseudo-color processing
(c) Full-color and pseudo-color processing
(d) Half-color and full-color processing.

(v) Which of the following is the first and foremost step in Image Processing?
(a) Image acquisition (b) Segmentation
(c) Image enhancement (d) Image restoration.

(vi) What are the characteristics that are used to distinguish one color from the other?
(a) Brightness, Hue and Saturation (b) Hue, Brightness and Intensity
(c) Saturation, Hue (d) Brightness, Saturation and Intensity.

(vii) Which of the following filter's responses is based on the pixels ranking?
(a) Sharpening filters (b) Nonlinear smoothing filters
(c) Geometric mean filter (d) Linear smoothing filters.

(viii) What is the name of area of the triangle in C.I. E. chromatic diagram that shows a typical range of colors produced by RGB monitors?
(a) Color gamut (b) Tricolor
(c) Color game (d) Chromatic colors.

(ix) Thresholding is the example of
(a) continuity (b) similarity
(c) recognition (d) discontinuity.

(x) Bayes approach to pattern recognition fits into the category of
(a) structural approach (b) statistical approach
(c) neural-network approach (d) template matching.

Group- B

2. (a) Compute the 2D DFT of the 4 × 4 grayscale image given below

$$f[m,n] = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 \end{bmatrix}$$

[(CO2)(Apply/IOCQ)]

(b) Compute the 2D Haar transform of the signal $f(m,n) = \begin{bmatrix} 4 & -1 \\ 2 & 3 \end{bmatrix}$.
[(CO2)(Apply/IOCQ)]

(c) What is the advantage of Walsh transform over Fourier Transform?
[(CO2)(Remember/LOCQ)]

5 + 5 + 2 = 12

3. (a) Prove that if an image $f(m,n), 0 \le m < M-1 \; and \; 0 \le n < N-1$ is multiplied by the checkerboard pattern $(-1)^{m+n}$ then its DFT is centred at $\left(\frac{M}{2}, \frac{N}{2}\right)$.
[(CO2)(Analyse/IOCQ)]

(b) An image matrix is given by $f(m,n) = \begin{vmatrix} 1 & 1 & 2 & 1 \\ 2 & 1 & 1 & 2 \\ 1 & 3 & 2 & 1 \\ 2 & 1 & 2 & 1 \end{vmatrix}$. Find the 2D Hadamard transform for this image. [(CO2)(Apply/IOCQ)]

7 + 5 = 12

Group - C

4. (a) If all the pixels in an image are shuffled, will there be any change in the histogram? Justify your answer. [(CO3)(Understand/LOCQ)]

(b) Filter the following image using 3 × 3 neighbourhood averaging by assuming pixel replication.

$$\begin{vmatrix} 1 & 2 & 3 & 2 \\ 4 & 2 & 5 & 1 \\ 1 & 2 & 6 & 3 \\ 2 & 6 & 4 & 7 \end{vmatrix}$$

[(CO3)(Apply/IOCQ)]

(c) What is the effect of mean filtering to an image? [(CO3)(Remember/LOCQ)]

3 + 7 + 2 = 12

5. (a) Using the following image segment, justify the statement — "median filter is an effective tool to minimize salt and pepper noise".

$$\begin{bmatrix} 18 & 22 & 33 & 25 & 32 & 24 \\ 34 & \boxed{128} & \boxed{24} & \boxed{172} & \boxed{26} & 23 \\ 22 & 19 & 32 & 31 & 28 & 26 \end{bmatrix}$$

[(CO3)(Justify/HOCQ)]

(b) Find all the 4-bit-plane images for the following 3 × 3 image.

$$\begin{vmatrix} 13 & 15 & 11 \\ 14 & 10 & 9 \\ 2 & 4 & 8 \end{vmatrix}$$

[(CO3)(Apply/IOCQ)]

(c) What is the use of a closing operation? [(CO3)(Understand/LOCQ)]

6 + 4 + 2 = 12

Group - D

6. (a) Explain the three different types data redundancy based on which an image compression is performed. What are lossless and lossy compressions of image? [(CO4)(Understand/LOCQ)]

(b) Explain the 'fidelity criterion' for lossy image compression. [(CO4)(Analyse/IOCQ)]

(c) For the image shown below, compute the degree of compression that can be achieved using Huffman coding of pixel values.

$$\begin{vmatrix} 3 & 3 & 3 & 2 \\ 2 & 3 & 3 & 3 \\ 3 & 2 & 2 & 2 \\ 2 & 1 & 1 & 0 \end{vmatrix}$$

[(CO4)(Evaluate/HOCQ)]

(3 + 1) + 2 + 6 = 12

7. (a) List the reasons why image compression is important. [(CO4)(Remember/LOCQ)]

(b) Consider an image strip of size 50 × 100. The image consists of five vertical stripes. The gray levels of the stripes from left to right are 128, 64, 32, 16 and 8. The corresponding widths of the stripes are 35, 30, 20, 10 and 5 pixels, respectively. If this stripe image is coded by Huffman coding, evaluate its efficiency. [(CO4)(Evaluate/HOCQ)]

2 + 10 = 12

Group - E

8. (a) Describe the region growing technique for image segmentation and mention the problems associated with it. [(CO5)(Understand/LOCQ)]

(b) What is meant by object description? Explain 4-chain code descriptor with example. [(CO5)(Understand/LOCQ)]

(c) What is an edge? Describe Laplacian edge detector.

[(CO5)(Understand/LOCQ)]

4 + 4 + 4 = 12

9. (a) Explain Sobel, Roberts, Prewitt operators for edge detection.

[(CO5)(Analyse/IOCQ)]

(b) Define skew, kurtosis and entropy as features of an image.

[(CO6)(Remember/LOCQ)]

(c) What is the main difference between cluster-analysis and classification?

[(CO6)(Understand/LOCQ)]

6 + 3 + 3 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	34.37	42.71	22.92

Course Outcome (CO):

After the completion of the course students will be able to

1. Understand how gray level and colour images are formed, sampled, quantized and represented digitally and processed by discrete, linear, time-invariant systems.
2. Apply transformation algorithms such as DFT, DCT, Walsh, Hadamard, Haar, KLT and Wavelet transform to any given image.
3. Perform image enhancement, restoration and morphological operations on images.
4. Compress a given image by applying lossy and loss less image coding techniques.
5. Evaluate the methodologies of image segmentation, representation and description.
6. Learn feature extraction techniques for image analysis and recognition.

*LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question