BIOSIGNAL AND BIOMEDICAL IMAGE PROCESSING
(AEIE 6121)

Time Allotted : 2½ hrs **Full Marks : 60**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 4 (four) from Group B to E, taking one from each group.

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

Group – A

1. Answer any twelve: **12 × 1 = 12**

Choose the correct alternative for the following

(i) Which of the following is an example of Bio-Magnetic signal?
(a) ECG (b) MCG (c) PPG (d) Ultrasonography.

(ii) In ECG, the number of unipolar chest lead is
(a) 3 (b) 4 (c) 5 (d) 6.

(iii) What is the frequency range of the Alpha wave in an EEG signal?
(a) 0.5-4 Hz (b) 4-8 Hz (c) 8-13 Hz (d) 13-50 Hz.

(iv) In N-point DFT of L-point sequence, the value of N to avoid aliasing in frequency spectrum is
(a) $N \neq L$ (b) $N \leq L$ (c) $N \geq L$ (d) $N = L$

(v) The poles of Butterworth transfer function symmetrically lie on a circle in s-plane with angular spacing
(a) $\frac{\pi}{N}$ (b) $\frac{\pi}{2N}$ (c) $\frac{2\pi}{N}$ (d) $\frac{\pi}{N^2}$

(vi) Which technique is used to remove high-frequency noise in image processing?
(a) Median Filtering (b) Gaussian Filtering
(c) Laplacian Filtering (d) Sobel Filtering.

(vii) Which of the following is a commonly used measure of image quality?
(a) Bit rate (b) Signal-to-noise ratio
(c) Compression ratio (d) Sampling rate.

(viii) Canny edge detection algorithm is based on
(a) ideal model (b) step edge
(c) real model (d) smoothing model.

(ix) The disadvantage of lossless data compression technique is
(a) Big reduction in file size (b) Small reduction in file size
(c) No reduction in quality (d) Cannot be used for text data.

(x) Which of the following is required by K-means clustering?
(a) Defined distance metric (b) Number of clusters
(c) Initial guess as to cluster centroids (d) All of the mentioned.

Fill in the blanks with the correct word

(xi) In MRI the nuclear spin of _____ atom is used to produce an image.

(xii) The CT number of water is _____.

(xiii) The filters designed by using finite number of samples of impulse response are called _____.

(xiv) The Histogram Equalization technique is used for _____ enhancement in images.

(xv) Huffman encoding is a _____ type data compression technique.

Group - B

2. (a) What is 'Action potential' and 'Resting Potential' of a cell? *[(CO1)(Remember/LOCQ)]*
(b) Draw a typical ECG waveform over one cardiac cycle indicating the important component waves, their typical durations, and the typical intervals between them. *[(CO1) (Understand/LOCQ)]*
(c) Briefly discuss the sources of noise in EEG waveform. *[(CO2)(Understand/LOCQ)]*

(2+2) + 4 + 4 = 12

3. (a) Explain the working principle of computed tomography using an appropriate diagram. *[(CO2)(Understand/LOCQ)]*
(b) Discuss briefly the MRI working principle. *[(CO2)(Understand/LOCQ)]*
(c) An NMR spectrum is recorded from a sample containing two water locations. The frequency encoding gradient is 1 G/cm along the y-axis. The spectrum contains frequencies of +1000 Hz and -500 Hz relative to the isocenter frequency. What are the locations of the water? *[(CO2)(Solve/IOCQ)]*

4 + 5 + 3 = 12

Group - C

4. (a) Consider the analog signal, $x_a(t) = 6\,cos50\pi t + 3\,sin200\pi t - 3\,cos100\pi t$. Determine the minimum sampling frequency and the sampled version of analog signal at this frequency. *[(CO3)(Apply/IOCQ)]*
(b) Determine whether the signal $x(n) = \cos\frac{\pi}{3}n + \cos\frac{3\pi}{4}n$ is periodic or not. If periodic find the fundamental period. *[(CO3)(Apply/IOCQ)]*
(c) Determine whether the signal $x(n) = \left(\frac{1}{3}\right)^n u(n)$ is energy or power signal *[(CO3)(Apply/IOCQ)]*

4 + 4 + 4 = 12

5. (a) Find the DFT of a sequence $x(n) = \{1,1,0,0\}$. *[(CO3)(Apply/IOCQ)]*

(b) Given the specification $\alpha_p = 1\,dB$, $\alpha_s = 30\,dB$, $\Omega_p = 200\,rad/sec$ and $\Omega_s = 600\,rad/sec$. Determine the order of the filter. *[(CO3)(Apply/IOCQ)]*

(c) Prove that $\Omega_c = \frac{\Omega_p}{\left(10^{0.1\alpha_p}-1\right)^{1/2N}} = \frac{\Omega_s}{\left(10^{0.1\alpha_s}-1\right)^{1/2N}}$. *[(CO3)(Analyze/IOCQ)]*

4 + 3 + 5 = 12

Group - D

6. (a) Define histogram of an image. *[(CO4)(Remember/LOCQ)]*

(b) A 5×5, 3 bits/pixel original image is given by

$$\begin{bmatrix} 4 & 4 & 4 & 4 & 4 \\ 3 & 4 & 5 & 4 & 3 \\ 3 & 5 & 5 & 5 & 3 \\ 3 & 4 & 5 & 4 & 3 \\ 4 & 4 & 4 & 4 & 4 \end{bmatrix}$$

Apply histogram equalization to the image? *[(CO4)(Apply/IOCQ)]*

(c) Explain how we can convert an image to its negative. *[(CO4)(Analyse/IOCQ)]*

2 + 8 + 2 = 12

7. (a) Distinguish between image segmentation based on thresholding with image segmentation based on region-growing techniques. *[(CO4)(Understand/LOCQ)]*

(b) Consider the image segment

$$\begin{bmatrix} 128 & 128 & 128 & 64 & 64 \\ 64 & 64 & 128 & 128 & 128 \\ 32 & 8 & 64 & 128 & 128 \\ 8 & 128 & 128 & 64 & 64 \\ 128 & 64 & 32 & 8 & 64 \end{bmatrix}$$

Based on the histogram, segment the image into two regions. *[(CO4)(Evaluate/HOCQ)]*

(c) Distinguish between statistical and structural approaches to pattern recognition. *[(CO4)(Understand/LOCQ)]*

3 + 6 + 3 = 12

Group - E

8. (a) Write short notes on (any one):
(i) Principal Component Analysis (PCA)
(ii) K-Means clustering algorithm. *[(CO6)(Remember/LOCQ)]*

(b) Cluster the following six data points (with (x, y) representing locations) into three clusters using K-Means clustering algorithm.
D1(1, 10), D2(2, 7), D3(6, 5), D4(3, 9), D5(7, 5), D6(3, 5). *[(CO6)(Solve/IOCQ)]*

5 + 7 = 12

9. (a) Write short notes on (any one):
(i) Compressed sensing
(ii) Lossy data compression. *[(CO5)(Understand/LOCQ)]*

(b) Create an algorithm to compress any one bio-signal using Huffman encoding technique. *[(CO5) (Create/HOCQ)]*

4 + 8 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	39.59	45.83	14.58