BIOSIGNAL AND BIOMEDICAL IMAGE PROCESSING
(AEIE 6121)

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) The electrical activity of heart starts at
(a) SA node (b) AV node (c) Bundle of His (d) None of these.

(ii) MCG is an example of a _____ signal.
(a) bio-electric (b) bio-magnetic (c) bio-optical (d) bio-chemical

(iii) In EEG wave the frequency range of Theta wave is
(a) 0.5-4 Hz (b) 0-8 Hz (c) 4-8 Hz (d) 8-13 Hz.

(iv) The most common form of medical imaging, using high-energy radiation to penetrate skin and tissues but not bone is
(a) X-rays (b) CT (c) MRI (d) Ultrasonography.

(v) Naïve Bayes' Classifier refers to
(a) Supervised Learning (b) Unsupervised Learning
(c) Reinforced Learning (d) All of these.

(vi) Dilation followed by erosion is called
(a) Opening (b) Translation (c) Blurring (d) Closing.

(vii) Naïve Bayes' Classifier refers to
(a) Supervised Learning (b) Unsupervised Learning
(c) Reinforced Learning (d) All of these.

(viii) Structuring elements run over image's
(a) Rows (b) Columns (c) Edges (d) Every element.

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

(x) PCA is an example of _____ compression technique.
(a) Time domain based (b) Transform domain based
(c) Parameter extraction based (d) Frequency domain based

Group - B

2. (a) Describe the various stages of the medical instrumentation system using a block diagram. [(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)(Remember/LOCQ)]
   (c) Draw a schematic representation of Einthoven's triangle showing the directions of leads I, II, and III of the ECG signal. [(CO1)(Remember/LOCQ)]

(2 + 3) + 4 + 3 = 12

3. (a) Briefly discuss about the different waveforms present in EEG waveform. [(CO2)(Remember/LOCQ)]
   (b) Briefly discuss the working principle of Ultrasonography. [(CO2)(Remember/LOCQ)]
   (c) A sample contains water at two locations, x = 0 cm and x = 3.0 cm. A one-dimensional magnetic field gradient of 1 G/cm is applied along the x-axis during the acquisition of an FID. What frequencies (relative to the isocenter frequency) are contained in the Fourier transformed spectrum? [(CO2)(Solve/IOCQ)]

4 + 5 + 3 = 12

Group - C

4. (a) The EEG signal in a data acquisition system is contaminated by power line interference noise. What is the issue if the signal is sampled at a sampling frequency of 80 Hz? How to solve this problem? [(CO3)(Analyze/IOCQ)]
   (b) Calculate the circular convolution of the following sequences:
   $x(n) = \{2, 1, 2, -1\}$; $h(n) = \{1, 1\}$
   $\uparrow$ [(CO3)(Analyze/IOCQ)]
   (c) Determine the autocorrelation of the sequence: $x(n) = \{1, -1, 2, 3\}$. [(CO3)(Analyze/IOCQ)]

(3 + 1) + 5 + 3 = 12

5. (a) Apply the 4-point redix-2 DIT-FFT algorithm to find the DFT of the sequence x(n) = {1, 1, 1, 1}. [(CO3)(Apply/IOCQ)]
   (b) Using Matrix method find the DFT of the sequence x(n) = {1, 0, -1, 0}. [(CO3)(Analyze/IOCQ)]

6 + 6 = 12

Group - D

6. (a) What is meant by image enhancement by point processing? Discuss any two methods image enhancement by point processing. [(CO4)(Remember/LOCQ)]
   (b) Distinguish between spatial domain and frequency domain enhancement techniques. [(CO4)(Analyze/IOCQ)]

(2 + 6) + 4 = 12

7. (a) What is image thresholding? Explain about global thresholding.
[(CO4)(Remember/LOCQ)]

(b) Let X is a MRI image data and Y is a structuring element given in the following diagrams.

0	0	0	0	0	0
0	1	1	1	0	0
0	1	1	1	0	0
0	1	1	1	0	0
0	0	0	0	0	0

X

1
0
1

Y

(i) Compute $X \oplus Y$
(ii) Compute $X \ominus Y$.

[(CO4)(Solve/IOCQ)]
(1 + 3) + (4 + 4) = 12

Group - E

8. (a) Discuss the importance of biomedical data compression using appropriate examples.
[(CO5)(Understand/LOCQ)]

(b) Create an algorithm to compress an ECG data using any one lossy data compression technique. [(CO5)(Create/HOCQ)]
5 + 7 = 12

9. (a) Illustrate the flow chart of K-Means algorithm. [(CO6)(Remember/LOCQ)]

(b) Create two clusters from the following data set using the K-means algorithm and the Euclidean distance formula.

Volunteer	Height (cm)	Weight (Kg)
V1	170	80
V2	186	90
V3	164	75
V4	172	76

[(CO6)(Create/HOCQ)]
5 + 7 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	45.83	40.63	13.54

Course Outcome (CO):

1. Understand acquisition, general properties and clinical applications of biomedical signals such as ECG, EEG, EMG, EP and Speech signals.
2. Learn the fundamentals of different modes of 2D and 3D medical imaging, including fluoroscopic, ultrasound imaging, computed tomography and magnetic resonance imaging.

3. Demonstrate advanced knowledge of filtering, transforms and spectral analysis of biomedical signal and image.
4. Apply image processing techniques for enhancement, filtering, segmentation and registration of biomedical images.
5. Gain skill set to compress biomedical signals and images using loss less and lossy compression techniques as well as modern compressed sensing techniques.
6. Perform signal analysis and classification using PCA, ICA, LDA, Bay's classifier, KNN and K-means clustering algorithm.

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