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-Electric signal?
(a) EMG (b) MCG
(c) PPG (d) MRI.

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

(iii) In normal ECG signal the typical P wave duration is
(a) 40-80 ms (b) 40-100 ms
(c) 60-80 ms (d) 60-120 ms.

(iv) 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.

(v) Which medical imaging technique employs a high-energy magnetic field?
(a) X-rays (b) CT
(c) MRI (d) Ultrasonography.

(vi) The complex valued phase factor/ twiddle factor, W_N can be represented as
(a) $e^{\frac{-j2\pi}{N}}$ (b) $e^{-j2\pi N}$
(c) $e^{-j2\pi}$ (d) $e^{-j2\pi kN}$

(vii) In impulse invariant transformation the digital frequency ω for a given analog frequency, Ω is given by
(a) $\omega = \Omega T$ (b) $\omega = \frac{\Omega}{T}$
(c) $\omega = \frac{T}{\Omega}$ (d) $\omega = tan\Omega T$.

(viii) Naïve Bayes' Classifier refers to
(a) Supervised Learning (b) Unsupervised Learning
(c) Reinforced Learning (d) All of (a), (b) & (c).

(ix) Which type of learning algorithm is K-means clustering?
(a) Unsupervised (b) Supervised
(c) Semi-supervised (d) None of (a), (b) & (c).

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

Fill in the blanks with the correct word

(xi) ECG is an example of a ____ signal.

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

(xiii) In ECG the number of augmented unipolar lead is _____.

(xiv) If $x(n) = \{1,0,0,1\}$, the DFT value $X(0)$ is_____.

(xv) Huffman encoding is a _____type data compression technique.

Group - B

2. (a) Explain briefly the depolarization and repolarization process 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) Discuss power line interference and base line wander in an ECG signal using an appropriate diagram. *[(CO1)(Understand/LOCQ)]*

(2 + 2) + 4 + 4 = 12

3. (a) Discuss briefly the MRI working principle. *[(CO2)(Understand/LOCQ)]*

(b) A sample contains water at two locations, x = 1.0 cm and x = 2.0 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)]*

(c) What is the importance and frequency range of different waves in an EEG waveform? *[(CO1)(Understand/LOCQ)]*

5 + 3 + 4 = 12

Group - C

4. (a) Find the DFT of a sequence $x(n) = \{1,2,3,4,4,3,2,1\}$ using DIT algorithm. *[(CO3)(Apply/IOCQ)]*

(b) How many multiplications and additions are required to compute N- point DFT using radix-2 FFT? *[(CO3)(Remember/IOCQ)]*

10 + 2 = 12

5. (a) Find the circular convolution of two sequences $x_1(n) = \{1,2,2,1\}$ and $x_2(n) = \{1,2,3,1\}$ *[(CO3)(Apply/IOCQ)]*

(b) For the analog transfer function $H(s) = \frac{2}{(s+1)(s+2)}$ determine $H(z)$ using impulse invariance method when $T = 1$ sec. *[(CO3)(Apply/IOCQ)]*

6 + 6 = 12

Group - D

6. (a) Explain the contrast enhancement technique. *[(CO4)(Remember/LOCQ)]*

(b) Write a MATLAB code to enhance an image using bit level slicing technique. Preserve the three MSBs and discard the remaining bits of the original image. *[(CO6)(Create/HOCQ)]*

5 + 7 = 12

7. (a) Explain the Histogram equalization process. *[(CO4)(Remember/LOCQ)]*

(b) Write a MATLAB code to enhance and stretch the gray level of the original image in the interval of [210, 300] to [150, 200]. *[(CO4)(Create/HOCQ)]*

5 + 7 = 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 Huffman encoding technique. *[(CO5)(Create/HOCQ)]*

5 + 7 = 12

9. (a) Briefly discuss the K-Means clustering algorithm. *[(CO6)(Remember/LOCQ)]*

(b) Cluster the following eight data points (with (x, y) representing locations) into three clusters using K-Means clustering algorithm.
D1(2, 10), D2(2, 5), D3(8, 4), D4(5, 8), D5(7, 5), D6(6, 4), D7(1, 2), D8(4, 9)
[(CO6)(Solve/IOCQ)]

5 + 7 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	42.71	35.42	21.87

Course Outcome (CO):

After the completion of the course students will be able to:

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.*