Roll No.												

PRESIDENCY UNIVERSITY

BENGALURU

Mid - Term Examinations – March 2026

Date: 13- 03-2026 **Time:**11.45am to 01.15pm

School: SOE	**Program:** B. Tech. in ECE	
Course Code: ECE3035	**Course Name:** Biomedical Signal Processing	
Semester: VI	**Max Marks:** 50	**Weightage:** 25%

CO - Levels	CO1	CO2	CO3	CO4	CO5
Marks	26	24			

Instructions:

(i) Read all questions carefully and answer accordingly.
(ii) Do not write anything on the question paper other than roll number.

Part A

Answer ALL the Questions. Each question carries 2 marks. **5Q x 2M=10M**

1	Explain the purpose of the Wilson Central Terminal (WCT) in a 12-lead ECG system.	2 Marks	L2	CO2
2	Name two sources of noise commonly encountered in EEG signal acquisition and briefly explain how each can affect the recording.	2 Marks	L1	CO2
3	List the typical amplitude and frequency ranges for a diagnostic-quality Electrooculogram (EOG) signal.	2 Marks	L1	CO1
4	Explain why biomedical signals are classified as “power signals” rather than “energy signals” in signal processing terms.	2 Marks	L2	CO1
5	Describe the term “causality” in the context of recorded physiological signals. Why are all recorded biosignals considered causal?	2 Marks	L2	CO1

Part B

Answer the Questions. **Total Marks 40M**

6.	**a.**	A 5-second epoch of an EEG signal from an occipital (back of the head) electrode, recorded from a relaxed subject with eyes closed, is analyzed. The calculated power spectral density (PSD) shows the following average power in four standard frequency bands: $\text{Delta}(\delta) : 1 - 4 \text{ Hz} \rightarrow 25\ \mu\text{V}^2$ $\text{Theta}(\theta) : 4 - 8 \text{ Hz} \rightarrow 30\ \mu\text{V}^2$ $\text{Alpha}(\alpha) : 8 - 13 \text{ Hz} \rightarrow 80\ \mu\text{V}^2$ $\text{Beta}(\beta) : 13 - 30 \text{ Hz} \rightarrow 25\ \mu\text{V}^2$ Calculate: i) The Total Power (P_{total}) in the 1–30 Hz range. ii) The Relative Power for each band (as a percentage of the total power). iii) Based on the relative power distribution, identify the dominant rhythm observed. What common physiological state does this pattern suggest?	**10 Marks**	**L3**	**CO2**
	b.	A surface EMG signal is recorded from the biceps muscle during a controlled arm flexion exercise. The recorded raw signal (in mV) over 10 samples (sampling frequency = 2 KHz) is: Raw EMG Data: $x[n] = [0.02, -0.05, 0.03, -0.70, 1.50, -1.30, 0.85, -0.40, 0.10, -0.01]\ \text{mV}$ i) Calculate the rectified EMG signal $y[n] = \mid x[n] \mid$. ii) Apply a 3-point moving average filter to the rectified signal to obtain the envelope $z[n]$. The moving average is defined as: $z[n] = (y[n-1] + y[n] + y[n+1])/3$ iii) If the muscle activation threshold is set at 0.45 mV in the envelope domain, determine at which sample number the muscle activation begins.	**10 Marks**	**L3**	**CO2**
		Or			
7.	**a.**	A patient is monitored using an invasive arterial catheter. The pressure transducer outputs a voltage signal calibrated such that 1 mV = 10 mmHg. The recorded signal for one cardiac cycle is shown below (in mV): • Time t_1: Signal = 1.5 mV, Time t_2: Signal = 13.0 mV, Time t_3: Signal = 6.5 mV Given that t_1 corresponds to the end of diastole, t_2 corresponds to the systolic peak, and t_3 corresponds to the dicrotic notch. Calculate: i) The patient's Systolic Blood Pressure (SBP) in mmHg.	**10 Marks**	**L3**	**CO2**

		ii) The patient's Diastolic Blood Pressure (DBP) in mmHg. iii) The Pulse Pressure (PP). **iv)** The Mean Arterial Pressure (MAP) using the standard approximation formula.			
	b.	In a 12-lead ECG, the net QRS voltages measured in Lead I and Lead aVF are +10 mm and +8 mm, respectively. Calculate: i) The mean electrical QRS axis (in degrees) using the quadrant method. **ii)** Categorize the calculated axis as Normal, Left Axis Deviation, Right Axis Deviation, or Extreme Axis Deviation.	**10 Marks**	**L3**	**CO2**

8.	**a.**	In a 12-lead ECG setup, the following instantaneous potentials (in mV) are measured at the electrodes: $R_A = +0.2$ mV $L_A = +0.4$ mV $L_L = +0.9$ mV $R_L = 0.0$ mV (ground) Chest electrodes: $V_1 = +0.3$ mV $V_2 = +0.5$ mV $V_3 = +0.7$ mV $V_4 = +0.8$ mV $V_5 = +0.9$ mV $V_6 = +0.6$ mV i) Calculate the three bipolar limb leads: Lead I, Lead II, Lead III. ii) Compute the Wilson Central Terminal (WCT) voltage. iii) Determine the three augmented limb leads: aVR, aVL, aVF. iv) Calculate the six precordial (chest) leads: $V_1, V_2, V_3, V_4, V_5, V_6$. v) Verify Einthoven's Law using your calculated values.	**10 Marks**	**L3**	**CO1**
	b.	A healthy human neuron at rest has the following ionic concentrations: • Intracellular Potassium ion concentration, $[K^+]_i = 140$ mM • Extracellular Potassium ion concentration, $[K^+]_o = 3.5$ mM The universal gas constant, $R = 8.314\ \mathrm{J \cdot mol^{-1} \cdot K^{-1}}$ The Faraday constant, $F = 96,485\ \mathrm{C \cdot mol^{-1}}$ Normal human body temperature, $T = 37°\mathrm{C}$ Calculate:	**10 Marks**	**L3**	**CO1**

		i) The Nernst Potential for Potassium ions (E_K) for this neuron at body temperature. ii) If during a metabolic disturbance, the extracellular K^+ concentration rises to 8 mM, what will be the new E_K? Comment on what this change means for the cell's excitability.			
Or					
9.	**a.**	During a routine clinical examination, a patient's 12-lead electrocardiogram (ECG) is recorded. The tracing clearly shows a series of regular, well-defined QRS complexes. By measuring the time between two consecutive R-peaks — known as the R-R interval — the cardiac cycle length is determined to be 0.85 seconds. i) Calculate the patient's heart rate in beats per minute (BPM) using the standard physiological formula. ii) Explain the physiological significance of the R-R interval and the relationship between cycle length and heart rate. iii) Interpret the calculated heart rate with reference to the normal adult resting range and briefly discuss one clinical condition that could result in a similar heart rate.	**10 Marks**	**L3**	**CO1**
	b.	In a 12-lead ECG setup, the following instantaneous potentials (in mV) are measured at the electrodes: $R_A = +0.3 \text{ mV}, L_A = +0.7 \text{ mV}, L_L = +1.2 \text{ mV}, R_L = 0.0 \text{ mV (ground)}$ Chest electrodes: $V_1 = +0.4 \text{ mV}, V_2 = +0.6 \text{ mV}, V_3 = +0.8 \text{ mV}, V_4 = +1.0 \text{ mV}, V_5 = +1.1 \text{ mV}, V_6 = +0.9 \text{ mV}$ i) Calculate the three bipolar limb leads: Lead I, Lead II, Lead III. ii) Compute the Wilson Central Terminal (WCT) voltage. iii) Determine the three augmented limb leads: aVR, aVL, aVF. iv) Calculate the six precordial (chest) leads: $V_1, V_2, V_3, V_4, V_5, V_6$. v) Verify Einthoven's Law using your calculated values.	**10 Marks**	**L3**	**CO1**