GUJARAT TECHNOLOGICAL UNIVERSITY

ELECTRONICS & COMMUNICATION (EMBEDDED SYSTEM) (54)

BIOMEDICAL INSTRUMENTATION AND SIGNAL PROCESSING

SUBJECT CODE: 2725408

SEMESTER: II

Type of course: Biomedical Instrumentation, Biomedical Signal Processing

Prerequisite: Fundamental knowledge of Instrumentation and digital signal processing

Rationale: Students are introduced to the physiological system of human in terms of various bioelectrical signals like ECG, EEG, EMG etc. The Biomedical instrumentation part covers study of various electrodes and transducers and acquisition of these signals. The signal processing part focuses various signal processing and filtering techniques for noise and artifacts removal from the acquired biomedical signals.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P	C	Theory Marks		Practical Marks				
				ESE (E)	PA (M)	ESE (V)		PA (I)		
						ESE	OEP	PA	RP	
3	0	2#	4	70	30	20	10	10	10	150

Course Content:

Sr. No.	Content	Hours	%Weightage
1	**Introduction to Biomedical Instrumentation System:** Overview of Bioinstrumentation, Biomedical Simulators, Biomedical organizations and Standards; Sources of Bioelectric Potential and Electrodes- Resting and Action potential, Propagation of action potential, The bioelectric potentials: ECG, EEG, EMG, ERG, EOG, EGG; Digital Biosignals, Types of Noise	**05**	**10**
2	**Biomedical Electrodes, Sensors and Transducers:** Electrode Theory, Goldman and Nernst Equations, Ag-AgCl Reference Electrode; Surface electrodes, Needle electrodes, microelectrodes; Classifications and Characteristics of Sensors and Transducers, Pressure, Flow, Temperature and Optical transducers	**05**	**10**
3	**Instrumentation in Diagnostic Cardiology:** The Heart and cardiovascular system, The Electrocardiogram (ECG), ECG leads, Vectorcardiography, Normal and abnormal ECGs, Block diagram of ECG machine (Electrocardiograph); Blood pressure, Heart sounds, Defibrillators and Pacemakers – Theory and circuits, Types of defibrillators and pacemakers	**08**	**20**
4	**Electroencephalography and EMG Instrumentation:** The Anatomy of the Nervous system, The organization of the Brain and its measurement, The Electroencephalogram (EEG) - EEG electrodes, machines and measurements; EMG Machines and Neuromuscular measurements	**10**	**25**
5	**Artifacts and Noise in Medical Instrumentation:** Examples of noise in	**08**	**20**

	medical instrumentation and biomedical signals – baseline wander, powerline interference, electrode motion artifacts etc, Noise reduction with digital signal processing; QRS complex detection in ECG- Pan Tompkins Algorithm		
6	**Modern Medical Imaging and Instrumentation Systems:** Ultrasound and Ultrasonic imaging system – Ultrasound Doppler and flow detector, Echocardiogram; Physics of X-rays and X-ray machines, X-ray images and data, Computer Tomography (CT) – Principles and scans; Magnetic resonance imaging (MRI) Positron Emission Tomography (PET)	**06**	**15**
	Total	**42**	**100**

Reference Books:

1. Biomedical Instrumentation S. Chatterjee and Aubert Miller Cengage Learning
2. Biomedical Instrumentation and Measurements Lesli Cromwell, F J Weibell, Erich Pfeiffer PHI
3. Handbook of Biomedical Instrumentation R S Khandpur TMH
4. Biomedical Digital Signal Processing Willis J Tompkins PHI

Course Outcome:

1. Need for Biomedical Instrumentation
2. Electrodes, Sensors and Transducers for biomedical signal acquisition
3. ECG, EEG and EMG recording techniques and their instrumentation
4. Signal processing and filtering techniques for noise and artifact removal
5. Modern medical imaging modalities and instruments

List of Experiments:

1. To study the different type of Electrodes used in Biomedical Instrumentation.
2. To study the ECG Machine and record the ECG. To study different waves of ECG in its different lead configuration.
3. To study EEG/EMG simulators.
4. To study sphygmomanometer. To perform the blood pressure measurement using sphygmomanometer and stethoscope.
5. To study pacemakers/defibrillators. To design the pacemaker/defibrillator circuits.
6. Introduction to filter design and analysis (FDA) tool of Matlab.
   Design a minimum order Lowpass and Highpass IIR/FIR filters with appropriate cut-off frequencies.
7. Load and plot an ECG signal '100.txt' and '203.txt'. Remove the low frequency noise (baseline wander) and high frequency noise from these signals and display the clean ECG signals.
8. Design a notch filter and use the same to remove the powerline noise (50/60 Hz) from ECG signal. Plot the power spectrums of the input and filtered signal.
9. Introduction to SPTool of Matlab. Plot the power spectra of various signals using different methods.
10. Develop an algorithm (Pan-Tompkins) for detecting the QRS-complex of an ECG signal and estimate the heart rate.

Design based Problems (DP)/Open Ended Problem:

1. Interface ECG electrodes with existing biomedical experimental kit like BIOPAC and acquire as well as record the signals for long duration.
2. Interface EEG electrodes for several channels with existing biomedical experimental kit like BIOPAC and acquire as well as record the delta, theta, alpha, beta and gamma signals for long duration.
3. Configure a Data acquisition card for acquiring biomedical signal along with Low Pass Filter and High Pass Filter action.
4. Using FDA tools of MATLAB design FIR and IIR filter with coefficients for ECG and EEG signal measurement. Test the designed filter in simulated environment.
5. From a recorded ECG signal, identify QRS complex with the help of time domain as well as frequency domain approaches in MATLAB.

Major Equipment:

i. Biopac MP36 system
ii. Personal Computer

C. List of Software:

MATLAB

Learning website:

www.nptel.ac.in

www.physionet.org

Review Presentation (RP): The concerned faculty member shall provide the list of peer reviewed Journals and Tier-I and Tier-II Conferences relating to the subject (or relating to the area of thesis for seminar) to the students in the beginning of the semester. The same list will be uploaded on GTU website during the first two weeks of the start of the semester. Every student or a group of students shall critically study 2 papers, integrate the details and make presentation in the last two weeks of the semester. The GTU marks entry portal will allow entry of marks only after uploading of the best 3 presentations. A unique id number will be generated only after uploading the presentations. Thereafter the entry of marks will be allowed. The best 3 presentations of each college will be uploaded on GTU website