GUJARAT TECHNOLOGICAL UNIVERSITY

INSTRUMENTATION & CONTROL ENGINEERING (17)
BIO-POTENTIAL INSTRUMENTATION
SUBJECT CODE: 2161712
B.E. 6th SEMESTER

Type of course: Core Engineering

Prerequisite: Knowledge of sensor/ transducers, op-amp based circuit, simulation know- how on Matlab or other software

Rationale: The biopotentials like ECG, EEG, EMG, etc. are vital signs considered for preliminary diagnostic tools for patient health condition. This course describes the principles, applications, and design process of the medical instruments used for bioptential measurement. The course covers the topic from the origin of biopotnetials, through electrodes, to the special amplifier design requirement and electric safety in hospitals.

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)	
					PA	ALA	ESE	OEP		
4	0	2	6	70	20	10	20	10	20	150

Content:

S. N.	Content	Total Hrs	% Weightage
1	**The Human Body: An Overview** Cell structure, Body fluids, Major systems of the body	**3**	6
2	**Basic concepts of Medical Instrumentation** Generalized medical instrumentation system, operational modes, medical measurement constraints, classification of biomedical instruments, interfering and modifying inputs, compensation techniques, Design criteria, commercial medical instrumentation development process	**3**	6
3	**Fundamentals for bio-signal processing** **Measurement errors** - Types & analysis **Noise -** Types, SNR, Noise factor, figure and temperature, Noise in cascade amplifiers, Noise reduction strategies **Sensor -** Types, error sources, Tactics and signals processing for improved sensing, Matching sensors to circuit **Bioelectric Amplifiers -** Op-amp ideal properties, Instrumentation amplifiers, Isolation amplifiers, Chopper stabilized amplifiers, Input guarding	**6**	12
4	**The Origin of Bio-potential** Electrical activity of excitable cells- Resting states, Nernst equation, G-H-K	**6**	12

	equation, Active states, Network equivalent circuit of nerve/ skeletal fiber, propagation of action potential Volume conductor fields		
5	**Bio-potential Electrodes** The electrode-electrolyte interface, Polarization, Polarizable and nonpolarizable electrodes, Electrode behaviour and circuit models, The electrode skin interface and Motion artifact, Body-surface recording electrodes, Internal electrodes, Electrode arrays, Microelectrodes, Electrodes for electric stimulation of tissue	**10**	19
6	**Electrocardiography** Anatomy & physiology of heart, electro-conduction system of the heart, The ECG waveform &Wigger's diagram, Heart problems The standard lead system, other ECG signals, ECG Noises, ECG amplification and signal conditioning circuits, ECG readout devices, ECG machines and maintenance of it, ECG faults & troubleshooting	**10**	19
7	**The Human nervous system & Brain function measurement** Organization of the nervous system, the neuron, structure and function of the central nervous system, Peripheral nervous system, Autonomic nervous system **Instrumentation for brain function measurement** Cerebral angiography, cranial x-rays, brain scans, ultrasonic equipment **Electroencephalography:** Neuron membrane potentials, EEG electrodes and the 1-20 system, EEG amplitude and frequency bands, EEG diagnostic uses and sleep patterns, EEG system block diagram, Preamplifiers and EEG system specifications, Visual and auditory evoked potential recordings, EEG telemetry, Typical EEG system artifacts, faults, troubleshooting, and maintenance	**10**	19
8	**Electrical Safety** Physiological effects of electricity, Important susceptibility parameters, distribution of electric power, Macroshock hazards, Microshock hazards, Electrical- Safety codes and standards	**4**	7

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
14	**14**	**14**	**14**	**14**	**0**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Introduction to Biomedical Equipment Technology by Josheph J. Carr and John M. Brown, Pearson Education.
2. Medical Instrumentation- Application and Design by John. G. Webster, John Wiley & Sons.

3. Biomedical Digital Signal Processing by Willis J. Tompkins, Prentice-Hall of India.
4. Biomedical Signal analysis- A Case Study Approach by Rangraj M. Rangayyan, Wiley India.
5. Signals and Systems in Biomedical Engineering by Suresh R. Devashahayan, Kluwer academics/ Plenum publication.
6. Introduction to Biomedical Equipment Technology by Josheph J. Carr and John M. Brown, Pearson Education.
7. Medical Instrumentation- Application and Design by John. G. Webster, John Wiley & Sons.
8. Biomedical Instrumentation and Measurements by Leslie Cromwell, Fred J. Weibell, and Erich A. Pfeiffer, Prentice-Hall of India.

Course Outcome:

After learning the course the students should be able to:

CO1. characterize anatomy and physiology of important physiological system of human body.
CO2. analyze and design of medical instruments by evaluating medical parameter measurement constraint.
CO3. analyze important vital sign parameters to evaluate certain disease conditions

List of Experiments:

1. Study of typical medical and physiological parameters along with their measurement range, frequency and standard sensor or method.
2. Study of Physiological system of human body.
3. Implementation of various Bio-electric amplifiers.
4. Implementation of Filter for noise removal in medical parameter measurements using software or hardware.

5. Implementation of Multiplexer, ADC & DAC.

6. Implementation of semiconductor based sensor ICs.

a. Temperature sensor IC- TMP 102, LM 35
b. Pressure Sensor IC- Smartec SPD015G
c. Light sensor OPT 101

7. Study of ECG measurement system : - (i) study of electrodes, patient cable and monitors (ii) Study of ECG simulation software (iii) demonstration of wireless ECG system (lead-I measurement only).

8. Measurement of Blood pressure using i).sphygmomanometer ii) Pressure gauge

9. Visit report of I.C.U of hospital / micro biology laboratories

10. Course Project - A product report of any bio-medical instrument/ device/ system.

Design based Problems (DP)/Open Ended Problem:

1. Design ECG front end (monitoring grade only) using instrumentation amplifier/ operational amplifiers.
2. Propose a remote patient monitoring system.
3. Simulate generation of action potential phenomena using MatLab or Scilab.
4. Simulate various filters/ algorithm to remove noise from ECG/EEG, etc using MatLab or SciLab.

Major Equipment:

Computers, simulation software, ECG measurement system, Blood pressure measurement system, etc.

List of Open Source Software/learning website:

http://nptel.ac.in/video.php?subjectId=108105064

http://coep.vlab.co.in/?sub=25&brch=78 – online biomedical and signal processing laboratory

http://www.physionet.org/physiobank/database/mitdb/ - for patient ECG data

ACTIVE LEARNING ASSIGNMENTS: Preparation of power-point slides, which include videos, animations, pictures, graphics for better understanding theory and practical work – The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus to be covered. The power-point slides should be put up on the web-site of the College/ Institute, along with the names of the students of the group, the name of the faculty, Department and College on the first slide. The best three works should submit to GTU.