



# GUJARAT TECHNOLOGICAL UNIVERSITY

**Bachelor of Engineering (Part time)**  
**Subject Code: 2971102**  
**Semester – VII**  
**Subject Name: Biomedical Electronics**

**Type of course:** Program Elective Course

**Prerequisite:** Basic knowledge of Electronics Engineering

**Rationale:** With technological innovations there are many applications of Electronics Engineering in the field of Biomedical. Therefore, the course is designed with the following objectives: (1) to provide an understanding of Biomedical Applications of Electronics, (2) to develop the practical skills necessary to build biomedical applications of electronics.

### Teaching and Examination Scheme:

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

### Content:

Sr. No.	Content	Total Hrs
1	<b>The Human Body and Basic concepts of Medical Instrumentation:</b> Overview Cell Structure, Body Fluids, Major Systems of the Body. Generalized Medical Electronics System, Alternative Operational Modes, Medical Measurement Constraints, Classification Of Biomedical Instruments, Design Criteria, Commercial Medical Instrumentation Development Process	06
2	<b>Fundamentals for bio-signal processing Measurement errors:</b> 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.	06
3	<b>The Origin of Bio-potential Electrical activity of excitable cells:</b> Resting states, Active states, Network equivalent circuit of nerve/ skeletal fiber, propagation of action potential.	03
4	<b>Bio-potential Electrodes:</b> The Electrode-Electrolyte Interface, Polarization, Polarizable and Non-polarizable Electrodes, Electrode Behavior and Circuit Models, The Electrode Skin Interface and Motion Artifact, Body-Surface Recording Electrodes, Internal Electrodes, Electrode	06



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	Arrays, Microelectrodes.	
<b>5</b>	<b>ECG, EEG, Anatomy &amp; physiology:</b> Electro-Conduction System of the Heart, The ECG Waveform. The Standard Lead System, ECG Noises, ECG Amplification and Signal Conditioning Circuits, ECG Readout Devices, ECG machines and their maintenance, ECG machine faults & troubleshooting, Ambulatory (Wearable) ECG Machines, Blood Pressure, characteristics of blood flow, Heart Sound, Pulse and Oxygen saturation measurements, Organization of the Nervous System, the Neuron, Instrumentation for Brain Function Measurement, Electroencephalography: Neuron Membrane Potentials, EEG Electrodes and the 10- 20 System, EEG Amplitude and Frequency Bands, EEG Diagnostic Uses and Sleep Patterns, EEG System Block Diagram	12
<b>6</b>	<b>X-Ray, CT-Scan, Ultrasonic and MRI:</b> Principles and designs of : X-Rays, Ultrasonic Equipment, Computer aided Tomography - Scan, Magnetic Resonance Imaging	06
<b>7</b>	<b>Electrical Safety and Standards :</b> Physiological effects of electricity, Important susceptibility parameters, distribution of electric power, Macro shock hazards, Electrical- Safety codes and standards, basic approaches to protection against shock, power distribution protection, equipment protection	03
<b>8</b>	<b>Active learning assignments:</b> A small group of 2-4 students study any one latest and current topic of research from Biomedical Engineering Journals focusing on any one research paper. They should understand and analyze the latest trends in the area of the selected topic and prepare and present power-point slides, which may include videos, animations, pictures, and graphics for better understanding of the topic. The faculty will guide and help the students in identifying the topic of research.	03
	<b>Total</b>	<b>45</b>

**Suggested Specification table with Marks (Theory): (For BE only)**

<b>Distribution of Theory Marks (100)</b>					
R Level	U Level	A Level	N Level	E Level	C Level
<b>10</b>	<b>30</b>	<b>30</b>	<b>20</b>	<b>5</b>	<b>5</b>

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



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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. Joseph J. Carr and John M. Brown, "Introduction to Biomedical Equipment Technology", Pearson Education.
2. John. G. Webster, "Medical Instrumentation- Application and Design", John Wiley & Sons.
3. R.S. Khandpur,"Handbook of Biomedical Instrumentation", Mc Graw Hill.
4. Leslie Cromwell, Fred J.Weibell, "Biomedical Instrumentation and Measurements", PHI
5. Willis J. Tompkins,"Biomedical Digital Signal Processing", Prentice-Hall of India.
6. Suresh R. Devashahayan,"Signals and Systems in Biomedical Engineering", Kluwer academics/ Plenum publication.

## Course Outcomes:

Sr. No.	CO statement:	Marks % weightage
	At the end of this course, students will be able to:	
CO-1	Understand characterize anatomy and physiology of important physiological system of human body and vital sign medical parameters	30 %
CO-2	Use and analyse electronic instruments for measurement of vital sign medical parameters	40 %
CO-3	Design electronic instruments for measurement of vital sign medical parameters	20 %
CO-4	Implement the electric safety of the medical instruments	10%

## List of Experiments / Assignments:

Various biomedical signal measurement, acquisition, digital-recording, and computer analysis based experiments can be performed depending upon the availability of the equipment

## Suggested List of Practical:

- (1) Acquisition of ECG Signal and understanding ECG lead systems practically
- (2) Analysis of various waveforms (P-Q-R-S-T) and wave boundaries of ECG Signal
- (3) QRS detection using Pan Tompkins Algorithm



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- (4) Acquisition of EEG Signal and understanding EEG lead systems practically
- (5) Analysis of various bands of waves of EEG (alpha, beta, gamma, theta, delta)
- (6) Measurement of Pulse and Oxygen Saturation using Pulse Oximeter
- (7) Study of various parameters of instrumentation amplifiers for amplification of biomedical signals
- (8) Design project for any biomedical application of electronics
- (9) Study of various biomedical images from the online datasets
- (10) Study of various physiological signals from the online datasets
- (11) Any other practical relevant to the course that may be feasible

### **Major Equipment:**

(1) Bio potential and biomedical signal acquisition system, (2) Pulse Oximeter, (3) Instrumentation amplifiers and bio-potential electrodes, (4) Computers with Scilab or Matlab software installed for some practical of signal and image analysis

### **List of Open Source Software / learning website:**

- (1) <https://physionet.org/about/database/> [Visited on 08-08-2020]
- (2) <https://nptel.ac.in/courses/108/105/108105101/> [Visited on 08-08-2020]
- (3) <https://freevidelectures.com/course/3318/ece5030-biomedical-electronics/> [also available on You-Tube [https://www.youtube.com/watch?v=thCFMeB8pHM&list=PLKcjQ\\_UFkrd7zbPHRkDpB7i113wDG\\_Rb3](https://www.youtube.com/watch?v=thCFMeB8pHM&list=PLKcjQ_UFkrd7zbPHRkDpB7i113wDG_Rb3) Visited on 08-08-2020]