



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering

Level: Diploma

Branch: Biomedical Engineering

Course / Subject Code: DI03003041

Course/Subject Name: Diagnostic Medical Instrumentation

w. e. f. Academic Year:	2024-25
Semester:	3 rd
Category of the Course:	PCC

Prerequisite:	Basic knowledge of Human Anatomy & Physiology, Fundamentals of Biomedical Engineering , Fundamentals of Medical Electronics
Rationale:	Diagnostic Medical Instruments are pivotal in healthcare, offering essential data for disease diagnosis and monitoring. This course provides a comprehensive exploration of the operational principles and design features of various diagnostic instruments used in biomedical engineering to sense and measure physiological parameters, also with emphasis on current industry applications like IoT, AI, and wearable technologies. Students will gain both theoretical insights and practical experience, empowering them to operate, calibrate and maintain these critical tools. As a cornerstone course for biomedical engineers, it lays the groundwork for advancing medical technology and improving patient care.

Course Outcome:

After Completion of the Course, Student will be able to:

No	Course Outcomes	RBT Level
CO-1	Identify various diagnostic medical instruments and modern health monitoring technologies along with their basic functions.	R, U
CO-2	Demonstrate and Operate different types of equipment used for Cardiac Function Assessment.	U, A
CO-3	Demonstrate and Operate different types of equipment used for Neurological and Muscular Function Assessment.	U, A
CO-4	Demonstrate and Operate different types of equipment used for Respiratory & Sensory Function Assessment.	U, A
CO-5	Apply principles of maintenance, calibration, and e-waste management for diagnostic equipment, incorporating recent trends in IoT and AI-based maintenance technologies.	U, A

**Revised Bloom's Taxonomy (RBT)*



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering

Level: Diploma

Branch: Biomedical Engineering

Course / Subject Code: DI03003041

Course/Subject Name: Diagnostic Medical Instrumentation

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
L	T	PR		C	Theory		Tutorial / Practical	
			ESE (E)		PA(M)	PA (I)	ESE (V)	
3	0	2	4	70	30	20	30	150

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1	Introduction to Diagnostic Medical Instruments and Modalities	7	20
	1.1 Overview of Diagnostic Medical Instrumentation - Definition of diagnostic instrumentation, Basic block diagram of a generalized medical instrumentation system, Classification of diagnostic instruments: Non-invasive and Invasive, , Application Based, Department Based. 1.2 Vital Signs and Basic Diagnostic Tools- physical parameter and related diagnostic instrument. 1.3 Role of IOT and AI/ML in healthcare monitoring system.		
2	Instrumentation for Cardiac Function Assessment	12	20
	2.1 Electrocardiography (ECG) - Working Principle, Block diagram of ECG machine, Lead systems and electrode placement, Overview of Various methods used to calculate Heart rate using ECG. 2.2 Phonocardiography (PCG) - Working principle, Block diagram of PCG machine, Heart sounds, Stethoscope vs PCG. 2.3 Blood Pressure Measurement- Direct BP Measurement, Indirect BP Measurement, Sphygmomanometer: measurement procedure, Automatic BP: Measurement procedure. 2.4 Photoplethysmography (PPG) - Working Principle, Block Diagram of pulse oximetry. 2.5 Recent trends (Wearable/AI/ML/IOT) - Only Listing of recent trends in cardiac function assessment.		
3	Instrumentation for Neurological and Muscular Function Assessment	8	20



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering

Level: Diploma

Branch: Biomedical Engineering

Course / Subject Code: DI03003041

Course/Subject Name: Diagnostic Medical Instrumentation

	3.1 Electroencephalography (EEG) – Working Principle, Block diagram of an EEG system, Electrode placement (10-20 system), Applications 3.2 Electromyography (EMG) – Working Principle, Block diagram of an EMG system, Surface vs. needle EMG, Applications 3.3 Recent trends(Wearable/AI/ML/IOT) – Only Listing of recent trends in Neurological and Muscular Function Assessment		
4	Instrumentation for Respiratory & Sensory Function Assessment	10	20
	4.1 Respiratory Function Assessment- Lung Volume and Capacity Measurement, Spirogram and Spirometry Spirometry Instrument components: flow sensor, turbine, mouthpiece, Apnoea monitor 4.2 Sensory Function Assessment for Ear- Audiometers, Puretone & Speech Audimeters, Hearing Threshold, Masking, 4.3 Sensory Function Assessment for Eye- EOG & ERG working principle and Block diagram. 4.3 Recent trends in Respiratory & Sensory Function Assessment (Wearable/AI/ML/IOT) – Only Listing of recent trends in Respiratory & Sensory (Ear & Eye) Function Assessment		
5	Maintenance & Calibration of Diagnostic medical Equipment.	8	20
	5.1 Maintenance of Diagnostic Equipment: Definition of maintenance and its type: Annual maintenance, Corrective Maintenance, Preventive Maintenance 5.2 Calibration of Diagnostic Equipment, ECG machine calibration 5.3 Recent Trends: IoT-Enabled Predictive Maintenance, AI for Maintenance Scheduling, QR/Barcode & RFID Integration for maintenance.		
	Total	45 Hrs.	100 %

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks (in %)					
R Level	U Level	A Level	N Level	E Level	C Level
40 %	40 %	20 %	--	--	--

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering

Level: Diploma

Branch: Biomedical Engineering

Course / Subject Code: DI03003041

Course/Subject Name: Diagnostic Medical Instrumentation

References/Suggested Learning Resources:

(a) Books:

1. "Handbook of biomedical instrumentation" by R. S. Khandpur, Tata McGraw Hill
2. "Biomedical Instrumentation and Measurements" by Cromwell Leslie, Fred J. Weibell and Erich A. Pfeiffer, Prentice Hall India Learning Private Limited; 2nd edition or latest edition, ISBN-10: 8120306538
3. "Medical Instrumentation Application and Design" by Webster John G., Wiley; 4th edition or latest edition ISBN-10: 0471676004
4. "Introduction to biomedical equipment technology" by Carr Joseph J., Brown J.M, Pearson education Delhi

(b) Open-source software and website:

5. <https://nptel.ac.in/courses/108102191>
6. <https://www.tinkercad.com/circuits>
7. <https://physionet.org/>
8. <https://github.com/PIA-Group/BioSPPy>
9. <https://sourceforge.net/projects/ecgviewer/>
10. <https://sccn.ucsd.edu/eeglab/index.php>
11. https://www.cdc.gov/niosh/spirometry/training/?CDC_AAref_Val=https://www.cdc.gov/niosh/topics/spirometry/training.html
12. <https://www.audacityteam.org/>
13. <https://www.youtube.com/watch?v=T7MKIPYiL48>
14. <https://www.youtube.com/watch?v=yJzbiVUL58Y>
15. <https://www.youtube.com/watch?v=acYMy9b0F2A>
16. <https://www.youtube.com/watch?v=sb2FEMjU2Hs>
17. https://www.youtube.com/watch?v=9siBx_ssiJE

Suggested Course Practical List: If any

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. hours required.
1	Identify and label the blocks of a generalized medical instrumentation system.	1	02
2	Demonstrate basic operation and data interpretation of an IoT-based health monitoring device (e.g., wearable fitness tracker).	1	02
3	Demonstrate electrode placement on an ECG simulator or machine following the standard lead systems.	2	02
4	Record and analyze an ECG waveform using an ECG simulator or machine.	2	02
5	Measure heart rate from the ECG trace using various methods.	2	02



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering

Level: Diploma

Branch: Biomedical Engineering

Course / Subject Code: DI03003041

Course/Subject Name: Diagnostic Medical Instrumentation

6	Demonstrate the use of a stethoscope to identify different heart sounds.	2	02
7	Operate a phonocardiograph and compare its output with stethoscope findings.	2	02
8	Measure blood pressure manually using a sphygmomanometer and digitally using a digital BP monitor.	2	02
9	Demonstrate the working principle of a fingertip pulse oximeter and interpret SpO2 readings.	2	02
10	Identify EEG electrode placement according to the 10-20 system on a mannequin or head model.	3	02
11	Demonstrate the working of an EEG simulator and interpret basic EEG waveforms.	3	02
12	Operate an EMG simulator and record muscle activity signals	3	02
13	Demonstrate the working of spirometer.	4	02
14	Measure respiration rate using respiration trainer kit.	4	02
15	Demonstrate the working of audiometer.	4	02
16	Demonstrate the working of ERG machine.	4	02
17	Demonstrate the working of EOG machine.	4	02
18	Simulate e-waste segregation and management process for damaged biomedical instruments.	5	02
19	Demonstrate IoT-enabled preventive maintenance concepts using sample platforms or simulation tools (if available).	5	02
20	Use QR/barcode/RFID-based asset tracking simulation for equipment maintenance records.	5	02

List of Laboratory/Learning Resources Required:

The major equipment/instruments and software required to develop PrOs are given below, with broad specifications to facilitate their procurement by the administrators/management of the institutes. This will ensure the conduction of practical skills in all institutions across the state properly so that the desired skills are developed in students.

1	ECG Trainer/Module.	Practical 3,4,5
2	EMG Trainer/Module.	Practical 12
3	EEG Trainer/Module.	Practical 10,11
4	Stethoscope	Practical 6
5	PCG Trainer/Module.	Practical 7
6	Pulse Oximeter.	Practical 9
7	Digital Sphygmomanometer + Manual (Mercury/Aneroid)	Practical 8



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering

Level: Diploma

Branch: Biomedical Engineering

Course / Subject Code: DI03003041

Course/Subject Name: Diagnostic Medical Instrumentation

8	Spirometer	Practical 13
9	Audiometer (Pure-tone and Speech)	Practical 15
10	Apnea Monitor Trainer/Module	Practical 14
11	Respiration trainer kit.	Practical 14
12	IoT-enabled Health Monitoring Kit (Arduino/RPi)	Practical 19
13	Wearable fitness tracker (Smart band/ Watch)	Practical 2
14	QR code/Barcode Reader	Practical 20
15	Cathode Ray Oscilloscope: Dual Trace 20MHz, 1 Mega Ω Input Impedance	Microproject
16	Function Generator: 0-2 MHz with Sine, square and triangular output with variable frequency and amplitude.	Microproject
17	Electronic Workbench: 0-30V, 2 Amp Variable DC power supply, Function Generator-2MHz, CRO 0-30MHz or DSO 50MHz minimum Dual channel at least, Digital Multimeter.	Microproject

Suggested Project List:

The projects serve as practical learning experiences for students in the field of Biomedical Engineering. These projects integrate theoretical knowledge with hands-on application, fostering competency development across various Course Outcomes (COs). Below are guidelines for designing and executing projects:

Project Types:

- It can be industry-based, workshop-based, laboratory-based, or field-based.
- Each project should align with specific COs and address real-world challenges.

● CO Integration:

- It should encompass two or more COs.
- Integration involves aligning Program Outcomes (PrOs), Unit Outcomes (UOs), and Assessment and Design Outcomes (ADOs).

● Project Duration:

- Students are encouraged to maintain a dated work diary to document their individual contributions and sufficient engagement time for each project should be allocated by faculty during the course.

● Project Demonstration:

- Before submission, students must give a project demonstration on their project.



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering

Level: Diploma

Branch: Biomedical Engineering

Course / Subject Code: DI03003041

Course/Subject Name: Diagnostic Medical Instrumentation

- The presentation should highlight the project's objectives, methodology, results, and relevance to industry-oriented COs.

- **Seminar Presentation:**

- Before submission, students must give a seminar presentation on their project.
- The presentation should highlight the project's objectives, methodology, results, and relevance to industry-oriented COs.

Following are suggestive projects, and additional ones can be tailored to specific course objectives. Encourage students to explore innovative solutions and apply their engineering skills effectively.

Using topics and sub topics of the syllabus students may develop mini/micro projects based on team/individual basis which concrete their knowledge in developing hardware for different instrumentation part and can work as prototypic models in various societal applications. Following are the suggested list of projects:

1. IoT-Based Patient Health Monitoring System

Develop a system to monitor heart rate, temperature, and SpO₂ with live data display using ESP32 + sensors + cloud (ThingSpeak).

2. ECG Signal Acquisition and Heart Rate Calculation

Build a basic ECG acquisition circuit using AD8232 and calculate heart rate from waveform. Display on LCD.

3. PCG Sound Amplifier Circuit

Design a basic amplifier circuit using op-amps to hear and record heart sounds.

4. Digital Stethoscope with PCG Visualization

Interface a microphone and signal processing circuit to capture heart sounds and display waveform on PC using Audacity.

5. EEG/EMG Signal Viewer (Simulated)

Simulate and visualize EEG/EMG signals using MATLAB/Python libraries (BioSPPy or EEGLAB).

6. Portable Spirometer Using Pressure/Flow Sensor

Create a prototype of a spirometer using sensors to measure lung capacity and analyze waveform.

7. Predictive Maintenance Dashboard for Diagnostic Devices

Simulate predictive alerts for calibration/maintenance using Node-RED and ThingSpeak for connected devices.

8. Hearing Test Audiometer Simulator

Develop a software-based audiometer interface with tone generator, masking, and response capture.

9. 10-20 Electrode Placement Demo Model

Create a physical or virtual model showing EEG electrode placements.

10. Temperature & Heart Rate Logger.

Interface LM35 + MAX30100 sensor to Arduino; store data on SD card.

11. Chart Preparations



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering

Level: Diploma

Branch: Biomedical Engineering

Course / Subject Code: DI03003041

Course/Subject Name: Diagnostic Medical Instrumentation

12. Model Making

Suggested Activities for Students: If any

In addition to classroom and laboratory learning, students are encouraged to engage in co-curricular activities that enhance their understanding and practical skills. These activities can be conducted in groups on breadboard or PCB should be used and it should be documented in 5-page reports. Collecting physical evidence of their work will also contribute to their portfolio, which can be valuable during placement interviews.

Hands-on Circuit Design

- **Objective:** Understand the practical implementation of amplification and filtering circuits.
- **Activity:** Design and build a simple amplifier, filter circuit to perform amplification and filtering of biomedical signals(e.g., ECG Amplifier, EMG Amplifier, EEG Amplifier).

Poster/Chart Making on Classification of Diagnostic Instruments

- **Activity:** Visual understanding of non-invasive, invasive, imaging, and sensor-based systems.
- **Objective:** Improved conceptual clarity through visual learning.

ECG Lead Placement Role Play

- **Activity:** ECG Lead Placement on mannequin or student volunteers.
- **Objective:** Demonstrate correct electrode placement using student volunteers or a mannequin.

BP Measurement Practice

- **Activity:** BP Measurement Practice using sphygmomanometer.
- **Objective:** Hands-on experience with manual BP measurement.

EEG Electrode Placement Demonstration (10–20 System)

- **Activity:** Use a chart or mannequin to locate electrode positions.
- **Objective:** Understand spatial mapping of brain activity.

Hearing Test Simulation

- **Activity:** Use Audiometer simulator software or pure tone generators.
- **Objective:** Develop knowledge of basic auditory testing.

Maintenance Chart for Diagnostic Equipment

- **Activity:** Create an AMS/PMS checklist for a hospital device (ECG, BP monitor, etc.)
- **Objective:** Understand preventive vs breakdown maintenance.

Calibration Demonstration

- **Activity:** Using DMM, Function Generator, CRO and ECG machine, do basic calibration.
- **Objective:** Demonstrate basic calibration methods and importance of accuracy and also understand how errors can affect patient safety.

E-Waste Management Awareness Campaign

- **Activity:** Students create posters or short videos to promote proper disposal of old/damaged medical devices.
- **Objective:** Understand environmental impact of electronic waste.