# GUJARAT TECHNOLOGICAL UNIVERSITY

**Program Name: Engineering**

**Level: Diploma**

**Branch: Biomedical Engineering**

**Course / Subject Code: DI01003021**

**Course/Subject Name: Fundamentals of Biomedical Engineering**

| | |
|---|---|
| **w. e. f. Academic Year:** | 2024-25 |
| **Semester:** | 1st |
| **Category of the Course:** | ESC-01 |

| | |
|---|---|
| **Prerequisite:** | Basic knowledge of Physics |
| **Rationale:** | Fundamental of Biomedical Engineering serves as the foundational course for students pursuing a diploma in biomedical engineering. This course is designed to provide students with a comprehensive understanding of the basic principles and concepts that form the basis of biomedical engineering. By studying this course, students will develop a strong foundation in the field, enabling them to apply their knowledge to more advanced courses and real-world applications. By studying the history and evolution of biomedical engineering, students will gain insight into the significant impact this field has had on healthcare and medical technology. Understanding the scope and applications of biomedical engineering will help students appreciate the diverse opportunities available in this rapidly growing field. |

**Course Outcome:**

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

| No | Course Outcomes | RBT Level |
|---|---|---|
| CO-1 | Apply the concept of biomedical engineering and its significance in healthcare | R,U |
| CO-2 | Recognize the importance of man instrumentation system in monitoring physiological parameters and diagnosing medical conditions | R, U |
| CO-3 | Identify suitable biopotential electrodes for Medical Signal Acquisition. | R,U,A |
| CO-4 | Determine appropriate transducers for measurement of various physiological parameters | R,U,A |
| CO-5 | Identify the responsibilities of a biomedical engineer in hospitals and industries | R,U,A |

**Revised Bloom's Taxonomy (RBT)*

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**Teaching and Examination Scheme:**

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

**Course Content:**

| Unit No. | Content | No. of Hours | % of Weightage |
|---|---|---|---|
| 1 | **Introduction to biomedical engineering** | 04 | 14 |
| | 1.1 Introduction:<br>• Biomedical engineering<br>• History and evolution of biomedical engineering<br>1.2.Speciality area of biomedical engineering<br>• Bio instrumentation<br>• clinical engineering<br>• Rehabilitation engineering<br>• Biomaterials<br>• computational biology and bioinformatics<br>• Medical Imaging engineering<br>• Biomechanics<br>1.3.Bio Instrumentation<br>• Diagnostic medical Instrumentation<br>• Therapeutic medical instrumentation<br>• Analytical and optical instrumentation | | |
| 2. | **Measurement and Instrumentation in Healthcare** | 04 | 14 |
| | 2.1 Introduction to measurement systems and bioinstrumentation in the context of healthcare<br>• Man instrumentation system<br>2.2 Basic principles of measurement, including accuracy, precision, and sensitivity<br>2.3 Importance of instrumentation in monitoring physiological | | |

| | | | |
|---|---|---|---|
| | parameters and diagnosing medical conditions<br>2.4 Problems encountered in living system while measurement | | |
| 3 | **Bioelectric signals and electrodes** | 6 | 22 |
| | 3.1. Sources of biomedical signals<br>• Bio electric signals<br>• Bio acoustic signals<br>• Biomechanical signals<br>• Biochemical signals<br>• Bio magnetic signal<br>• Bio optical signals<br>• Bioimpedance signals<br>3.2 Electrode theory: Electrode- electrolyte Interface<br>3.3.Types of Electrodes<br>• Surface Electrodes<br>• Disposable electrodes<br>3.4 Recycling, disposal of used or damaged electrodes safely for an eco-friendly environment. | | |
| 4. | **Transducers in Biomedical Engineering: Principles and Applications** | 10 | 36 |
| | 4.1.Transducers:<br>• Classification of transducers :Active and Passive transducers<br>4.2 Transduction principles<br>• Active transducers: piezoelectric transducers, thermoelectric transducers, and photoelectric (photovoltaic) type transducers.<br>• Passive Transducers: resistive transducers: RTD and Thermistor, inductive transducers: LVDT, capacitive transducers.<br>4.3. Systemic and Skin surface temperatures and Units of temperature measurement. | | |
| 5. | **Biomedical Engineering Applications and Future Trends** | 6 | 14 |
| | 5.1 Role of Biomedical engineer in hospitals<br>5.2 Role of Biomedical engineer in industries<br>5.3. Current trends and future directions<br>• Personalized medicine<br>• Regenerative medicine<br>• Wearable technology | | |

| | | | |
|---|---|---|---|
| | • Artificial intelligence and machine learning based medical technology | | |
| | **Total** | **30** | **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 %** | **43 %** | **17 %** | -- | -- | -- |

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

**References/Suggested Learning Resources:**

**(a) Books:**

1. Biomedical Instrumentation and Measurements by Cromwell Leslie, Fred J. Weibell and Erich A. Pfeiffer ,Goodyear Publishing Co. ,New Delhi, ISBN : 9780876202654
2. Medical Instrumentation application and design by Webster John G., Editor ,4th edition , Wiley ISBN-10: 04716760
3. Fundamental of biomedical engineering by G.S.Sawhney, New Age International publishers,ISBN-13: 978-81-224-2549-9
4. Handbook of Biomedical instrumentation by R.S.Khandpur, Tata MCgraw hill publishing company limited, Delhi, ISBN: 978-0-07-177746-9
5. Biomedical transducers by H. T. Kashipara

**(b) Open-source software and website:**

1. https://nptel.ac.in/
2. https://swayam.gov.in/
3. www.vlab.co.in
4. https://sl-coep.vlabs.ac.in/List%20of%20experiments.html
5. https://sl-coep.vlabs.ac.in/List%20of%20experiments.html

**Suggested Course Practical List: If any**

| Sr. No. | Practical Outcomes (PrOs) | Unit No. | Approx. hours required. |
|---|---|---|---|
| 1 | Identify various biomedical devices based upon the key areas of biomedical engineering | 1 | 2 |
| 2 | Identify and rearrange blocks of man instrument system | 2 | 2 |
| 3 | Study concept of bio potentials | 3 | 2 |
| 4 | Demonstrate different types of ECG,EMG,EEG electrodes | 3 | 2 |
| 5 | Identify the process used to dispose of electrodes. | 3 | 2 |
| 6 | Identify various active and passive sensors/transducers used in biomedical field with their application | 4 | 2 |
| 7 | Test the performance of RTD | 4 | 2 |
| 8 | Test performance of thermistor | 4 | 2 |
| 9 | Test the performance of thermocouple | 4 | 2 |
| 10 | Demonstrate operation of LVDT transducer | 4 | 2 |
| 11 | Test the performance of capacitive transducer | 4 | 2 |
| 12 | Demonstrate operation of strain Gauge transducer | 4 | 2 |
| 13 | Measure body temperature using mercury thermometer | 4 | 1 |
| 14 | Measure body temperature using digital thermometer | 4 | 1 |
| 15 | Demonstrate operation of piezoelectric transducer | 4 | 1 |
| 16 | Measure oxygen saturation using photoelectric transducer | 4 | 1 |
| 17 | Identify current trends in biomedical engineering | 5 | 2 |
| | **Total** | | 30 |

**List of Laboratory/Learning Resources Required:**

1. Classifying Biomedical sensors :
    - Various devices such as
        - Thermistor, thermocouple, RTD, LVDT, capacitive transducer, piezo electric transducer, strain gauge , photoelectric transducer

2. Identifying various electrodes:
    - Types of electrodes used of ECG,EMG,EEG measurement
        - Needle electrodes, micro electrodes, disposable electrodes, suction electrodes
        - Electrode gel
3. Calculating Accuracy, Resolution, and Precision:
    - Standard reference instruments (e.g., calibrated weights, rulers)
    - Calculator or spreadsheet software
4. Man Instrumentation System Block Diagram:
    - Transducers/sensors, amplifier trainer, signal processing board , multimeter
5. Calculating bio potentials :
    - Bio potential amplifier, bio potential electrodes, recording and measuring devices such as Digital storage oscilloscope, recorder and monitoring display.
6. Measurement of temperature
    - Mercury and digital thermometer and sensors

**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, internet-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.

- **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.

a) Make demonstrable models to compare Transducer, Sensor, Actuator and Electrode.
b) Make demonstrable models for various types of instrumentation like diagnostic, therapeutic and analytical instruments.
c) Make a mode showing biopotential generation in human body using LED and other components
d) Build a simple digital thermometer.

**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 and 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.

- Collaborate in groups to create detailed specifications for various biomedical transducers and sensors and devices. Consider accuracy, range, resolution, and environmental factors.
- Form teams and work on small-scale biomedical projects. Apply theoretical knowledge to practical scenarios, such as designing a body temperature control system
- Deliver a seminar on sensors used for biomedical devices.
- Organize a seminar focusing on cutting-edge biomedical technologies. Discuss trends, innovations, and their applications in biomedical industry.
- Conduct a comprehensive market survey to explore available biomedical components (sensors, transducers, devices, electrodes etc.). Analyze their features, costs, and suitability for different applications.
- Prepare portfolios showcasing your biomedical -related work. Include project reports, photographs, and evidence of practical implementation.

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