GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering
Level: UG
Subject Code : BE04003021
Subject Name : Biomedical Sensors & Transducers

WEF Academic Year:	2024-2025
Semester:	4
Category of the Course:	Professional Core Course

Prerequisite:	Physics, DFW, Basic Electrical Engineering, Basic Electronics, Advanced Electronics.
Rationale:	Biomedical Sensors & Transducers is a core pillar of Biomedical Engineering, providing the foundational principles and working of Biomedical Sensors & Transducers for the measurement of Biomedical variables.

Course Outcome:

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

No	Course Outcomes	RBT Level*
01	Demonstrate an understanding of Sensor, Transducer, Actuator, their characteristics and measurement system.	RM/UN
02	Demonstrate working of different Resistive transducers and Apply them in Biomedical applications.	RM/UN/AP
03	Demonstrate working of different Temperature transducers and Apply them in Biomedical applications.	RM/UN/AP
04	Demonstrate working of different Inductive & Capacitive transducers and Apply them in Biomedical applications.	RM/UN/AP
05	Demonstrate working of different Piezoelectric, Photoelectric, Flow transducers & Biosensors and Apply them in Biomedical applications.	RM/UN/AP

*RM: Remember, UN: Understand, AP: Apply, AN: Analyze, EL: Evaluate, CR: Create

Teaching and Examination Scheme:

Teaching-Learning Scheme (in Hours per Semester)					Total Credits = TH/30	Assessment Pattern and Marks					Total Marks
						Theory		Tutorial/Practical			
L	T	P	PBL*	TH		ESE (E)	PA (M)	PA/ (I)	PBL (I)	ESE (V)	
45	0	30	45	120	04	70	30	20	30	50	200

*** Problem Based Learning (PBL) aims to accommodate learning beyond syllabus as per clause 9.4 of NBA manual.**

Course Content:

Sr. No.	Course Content	No. of Hours	% of Weightage
1	**Basics of Sensors & Transducers:** General Structure of the measurement system, Measurement & Measurand, Sensor, Transducer & Actuator, Classification of Transducer, Basics of different Transduction principles, Selection criteria for Transducer/Sensor, Characteristics of Transducer: Static Characteristics, Dynamic Characteristics, Accuracy, Precision, Types of error, Types of Transducers & their Biomedical applications.	**6**	**15**
2	**Resistive Transducers:** Basic Principle, Potentiometer, Resistance Pressure Transducer, Resistive Position Transducer, Strain Gauges: Introduction, Types, Wire strain gauges: Unbonded, Bonded, Arrangement of Wire Strain Gauges, Foil Strain Gauge, Semiconductor Strain Gauge, Load cell. Biomedical Applications.	**9**	**20**
3	**Temperature Transducers:** Introduction, Resistance Temperature Detector (RTD), Platinum Thin Film Sensors, Resistance Thermometer, Thermistors & Types, Thermocouple & Types, Semiconductor Diode Temperature Sensor, IC Type Sensor, Pyrometers, Basic Principle, Types: Total Radiation Pyrometer (TRP), Infrared Pyrometers, Optical Pyrometer. Biomedical Applications.	**10**	**20**
4	**Inductive Transducer:** Basic Principle, Change in Self Inductance with Numbers of Turns, Change in Self Inductance with Change in Permeability, Variable Reluctance Type Transducer, Differential Output Transducers, Linear Variable Differential Transducer/Transformer (LVDT), Rotational Variable Differential Transducer (RVDT), Basic Pressure Inductive Transducer. **Capacitive Transducer:** Basic Principle, Types, Construction, and Working. Biomedical Applications.	**10**	**20**
5	**Piezoelectric Transducer:** Basic Principle, Construction and working. **Photoelectric Transducers:** Basic principle, Photo Multiplier Tube, Photo Conductive Cells, Photo-voltaic Cell, Semiconductor Photo-diode, Photo-transistor. **Flow Measurement:** Magnetic Flowmeter, Ultrasonic Flow meter, Turbine Flowmeter.	**10**	**25**

	Biosensors: Basic principle of Biosensor, main components of Biosensor, **Basics of Smart sensors.** Biomedical Applications.		
	Total	**45**	**100**

Reference Book:

1. Electronic Instrumentation, H S Kalsi, Tata McGraw Hill Education Private Limited.
2. Principles of Medical Electronics and Biomedical Instrumentation, C Raja Rao & S K Guha, Universities Press.
3. Handbook of Biomedical Instrumentation, R S Khandpur, MC Graw Hill Education, 3rd Ed.
4. Biomedical Transducers, H T Kashipara, Akshat Publication.
5. Principles of Measurement and Transduction of Biomedical variables, Vera Button, Academic Press.
6. Biomedical Sensors and Measurement, Ping Wang, Qingjun Liu, Springer.
7. Biomedical Transducers & Instruments, By Tatsuo Togawa, Toshiyo Tamura, P. Ake Oberg., CRC Press.

Suggested Course Practical List:

1. To study Biomedical transducers and their characteristics.
2. To study Strain measurement using strain gauges and cantilever assembly.
3. To study the working of the Load Cell.
4. To study the Characteristics of the K-type thermocouple sensor.
5. To study the Characteristics of a Thermistor.
6. To study the Characteristics of RTD.
7. To study the Characteristics of the IC Temperature Sensor.
8. To study the working of the LVDT.
9. To study the Characteristics of a Photovoltaic cell.
10. To study the Characteristics of PIN Photodiode.
11. To study the Characteristics of the Phototransistor.
12. To study the Flow Transducers.

List of Laboratory/Learning Resources Required:

1. Transducer Kit/Lab
2. Virtual Laboratory-Sensors Modeling & Simulation Lab (https://sl-coep.vlabs.ac.in/Introduction.html)
3. NPTEL/ MOOC Swayam course

- **Activities suggested under Problem Based Learning:**

Sr. No.	Name of the activity	No. of hours per activity	Evaluation Criteria
1.	Industry/Research laboratory visit	Visit=5h, Report preparation = 5h Total = 10h	Based on report submitted. Report should contain observations and calculations Based on industry/lab data.
2.	Technical video-based learning related to the subject	Duration of video = 5h Report preparation=5h Total= 10h	Report/presentation based on the video learning outcomes.
3.	Assignment writing. Numerical based assignment is preferable.	5 assignments of 2h each. Total= 10h	Based on the assignment submitted.
4.	Problem-solving/Virtual Lab or any Other relevant software	5 small Virtual Lab-based assignments of 2h each. Total = 10h	Based on the Virtual Lab performance submitted.
5.	Self-learning online course	Minimum duration of the course should be 10h.	Examination-based assessment at the end of the course. Based on the certificate produced.
6.	Complex problem solving	Maximum 2problem. Study of the problem and solution finding. Total= 10h	Based on the depth of the Solution submitted.
7	Videos on Industrial safety aspects based on the subject	Duration of video = 5h Report preparation =5h Total= 10h	Based on the quiz/report submitted
8	Discussion on research paper Based on the relevant subject	5 research paper =20 h	Summarize the research paper and the Evaluation of critical parameters
9.	Poster/chart/PowerPoint preparation on technical topics	Duration=6h	Based on the poster/chart Preparation and presentation skills

10	Working/non-working model on technical topics	Working=12h Non-working=8 h	Based on inter-department/ external evaluation
11	Industrial exposure for 2-3 days to observe and provide tentative solutions on society/environment/health/any other issue	Duration=15h for industrial exposure Problem identification and tentative solution = 10 h Total = 20 h	Based on the evaluation of critical problems and solutions
12	Group Discussion on emerging/trending technical topics based on subject	Duration=1h each	Based on performance in group discussion, technical depth, knowledge etc.
13.	Real world case studies-based learning	Duration of data collection/study = 5h Report preparation=5h Total= 10h	Based on in-depth study, technical depth, data collected, fact finding, etc.
14.	Application/Software development	Duration=10h	Depending on the complexity of the Application/Software
15	Online Technical Quizzes/Simulations	Multiple quizzes summing up to 10h	Based on quiz scores and reflection report after each quiz.
16	Patent Search and Innovation Gap Identification	10h(Search + Report)	Based on number of relevant patents analyzed and Identification of innovation scope.

Note:

- All the suggested activity should be related to the subject.
- Subject coordinator shall identify activities from above list as per the subject needs, they also declare list of activities wise hours, evaluation scheme and rubrics to students at the start of semester.
- The number of hours is suggestive. Faculty can sub-divide the number of hours based on the activity. However, total number of hours is fixed.
- All records pertaining to the evaluation and assessment of self-learning activities must be properly maintained and preserved at the institute level. These records should be made available to the university upon request.
- Institutes are encouraged to utilize digital platforms, such as Microsoft Teams, for effective record-keeping and to ensure transparency in the evaluation and assessment of self-learning activities.

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