GUJARAT TECHNOLOGICAL UNIVERSITY

BIOMEDICAL ENGINEERING (03)

BIOSENSORS & TRANSDUCERS

SUBJECT CODE: 2140306

B.E. 4th SEMESTER

Type Of Course: Core

Prerequisite: Basics Principles of Physics, Human Anatomy & Physiology, Bio – Potentials

Rationale: to impart in students the knowledge of various transduction principles used for physical, chemical & biological parameter sensing along with their biomedical counterparts

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:

Sr. No.	Topics	Teaching Hrs.	Module Weightage
1	BASICS OF SENSING MECHANISMS IN HUMAN BODY Study of biological sensors in human body and their basic mechanism of action - organization of nervous system- Study of various corpuscles like Pacinian - Chemoreceptors, hot and cold receptors, baroreceptors.	4	4%
2	BASICS OF TRANSDUCER AND MEASUREMENT SYSTEM Transducers- sensors: Basics, Classification, Characteristics and Choice, Primary sensing elements. Measurements and generalized measurement system: Static characteristics- accuracy, precision, linearity, hysteresis, threshold; dynamic range, Dynamic Characteristics – response time, damping, calibration, standards and AC/DC bridges.	5	10%
3	MEASUREMENT OF PHYSICAL QUANTITIES: Transducers: Temperature transducers – thermos-resistive transducers, thermoelectric, p-n junction, chemical thermometry, Thermal radiation sensor- detectors pyroelectric thermal sensors. Radiation sensors- introduction, basic characteristics, photodetectors, photomultiplier cells, photoconductive cells, photo- resistive cells, photo-junctions, X-Ray & nuclear radiation sensors- ionization camber, proportional counter, G M counter, scintillation detector, solid state detector. Biomedical applications: body temperature measurement, respiration rate meter, pulse oximeter. Displacement transducers - potentiometric - resistive strain gauges - inductive displacement - capacitive displacement transducer, Opto-Digital encoders. Biomedical applications: goniometer. Pressure transducer- Capacitive, Inductive, strain gauge- principle, properties, types- resistive, rosette, semiconductor, Strain Gage Bridge, Load Cell, Proving Ring, Cantilever Beam, related design problems;	16	40%

	LVDT transducers-principle, equivalent circuit, linearity issues, various secondary coil structure design, design problems; and piezo electric type. Biomedical applications: indirect method - measurement of blood pressure using sphygmomanometer -instrument based on Korotkoff sound, catheter tip transducers - measurement of intracranial pressure - catheter tip - implantable type. Transducers for flow, velocity and torque measurements: transducer for flow measurement - rotameter, venturi tube, hot wire anemometer, time of flight flowmeter, vortex flow meter, electromagnetic flow meter, Fiber-optic transducer. Hall effect transducer, ultrasonic transducer. Biomedical applications: pneumotachometer, Impedance Pneumograph, plethysmograph, sonography- frequency specific probe design for various applications (foetal monitoring, blood flow measurement). Transducer for liquid level measurement: basic principle, various types - ultrasonic, capacitive type & optical transducers. Biomedical applications: liquid level detector		
4	CHEMICAL & BIOLOGICAL SENSORS Chemical Transducers: Transducers for the measurement of ions and dissolved gases. Half-cell potential, Reference electrodes - Hydrogen electrodes - silver-silver chloride electrodes- Calomel electrodes. Measurement of pH- Glass pH electrodes. Measurement of pO2, Measurement of pCO2 -catheter tip electrodes for the measurement of pO2 and pCO2, conductivity measurement transducer. Bio sensors: Ion exchange membrane electrodes- oxygen electrodes- CO2 electrodes enzyme electrode - construction - ISFET for glucose, urea etc. Electrolytic sensors - optical sensor - fiber optic sensors. Microbial sensor, Enzyme immobilization of chemical analyses.	9	30%
5	THIN FLIM SENSORS: introduction, SAW transducer, tactile sensor-grip (capacitive, PZT), gas sensors.	5	8%
6	Smart sensors: introduction, primary sensors, excitation, amplification, filters, converters, compensations, data communication- standards for smart sensor interfacing, automation.	5	8%

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks				
R Level	U Level	A Level	N Level	E Level
20%	35%	25%	10%	10%

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate 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. Sensors And Tranducers, D. Patranabi, Phi Learning Pvt. Ltd., 01-Jan-2003
2. Introduction To Biomedical Equipment Technology, 4/E -Carr Joseph J., Carr Pearson Education India, 01-Sep-2001

3. The Biomedical Engineering Handbook, Second Edition. Ed. Joseph D. Bronzino , Boca Raton: Crc Press Llc, 2000
4. R S Khandpur, Handbook Of Bio Medical Instrumentation , Tata Mcgraw Hill,2004
5. Textbook Of Medical Physiology, Guyton, Elsevier Saunders, 2010
6. Ross And Wilson's Anatomy And Physiology, Churchill Livingstone Elsevier, 2006
7. Medical Instrumentation, Application and Design, Fourth Edition, John G. Webster, John Wiley & Sons, Inc.
8. Biomedical Transducers And Instruments, By Tatsuo Togawa, Toshiyo Tamura, P. Ake Oberg.

Course Outcomes:
After successful completion of the course students should be able to:

1. Present different methods for measuring temperature, pressure, force, flow and other important parameters in determining the circulation-, breathing- and excretory functions.
2. Describe how different measurement techniques are used to determine the vital parameters of diagnostic importance.
3. Provide an engineering approach to develop a biomedical measurement systems

List of Experiments:

1. Study of different transduction principles.
2. To perform displacement measurements using LVDT.
3. To perform force measurements using strain gauge.
4. To study of piezo electric transducer.
5. To study temperature measurements using thermocouple.
6. To study temperature measurements using thermistor
7. To study temperature measurements using RTD.
8. To perform measurement of pressure using silicon pressure sensor.
9. To study of pH measurement.
10. To study different types of electrodes.
11. Simulation of Thermistor, RTD etc. using LabVIEW.

Design based Problems (DP)/Open Ended Problem: Sensor design for given requirements

Major Equipment: Transducer kit and LabVIEW

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.