



# GUJARAT TECHNOLOGICAL UNIVERSITY

**Master of Engineering**

**Subject Code: 3733106**

**Semester – III**

**BioMEMS**

**Type of course:** Program elective V

**Prerequisite:** Material science, Biomaterials and Implants, Chemistry, Mechanics of solids.

**Rationale:** During the last several decades, micro-system research mainly addressed electromechanical systems and in recent years, the focus has shifted to Bio-Microelectromechanical Systems (BioMEMS). This shift is driven primarily by the potential applications of the micro-systems to chemistry, biology and medicine. In fact, a combination of BioMEMS and microsystems has made possible the realization of physical systems at scales and dimensions similar to biological entities such as bacterial and mammalian cells, viruses, spores, etc., and this has resulted in the development of a variety of diagnostic and therapeutic applications, intelligent biochips and sensors. BioMEMS today finds many applications within the chemical, health-care, biotechnological and manufacturing industries and this has necessitated a considerable shift in the focus of engineering education.

### Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P		Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	0	3	70	30	00	00	100

### Content:

Sr. No.	Content	Total Hrs
1	<b>Introduction:</b> Introduction to BioMEMS, Application Areas, Evolution of Systems Based on Size, Intersection of Science and Engineering, Commercialization, Potential, and Market	3
2	<b>Substrate Materials Used in BioMEMS Devices:</b> Metals, Glasses and Ceramics, Silicon and Silicon-Based Surfaces, Polymers, Biopolymers,	3
3	<b>Biomolecules and Complex Biological Entities: Structure and Properties:</b> Amino Acids, Polypeptides and Proteins, Lipids, Nucleotides and Nucleic Acids, Carbohydrates, Enzymes, Cells, Bacteria and Viruses.	5
4	<b>Engineering of Bioactive Surfaces:</b> Introduction, Plasma Treatment and Plasma-Mediated Surface Modification, Surface Modifications Mediated by Self-Assembled Monolayers (SAMs), Langmuir-Blodgett and Layer-by-Layer Assembly, Bio smart Hydrogels, Immobilization and Detection of Biomolecules by Using Gold Nanoparticles: Case Studies, Biomimetic Surface Engineering., Attachment of Proteins to Surfaces, Surface Modification of Biomaterials for Tissue Engineering Applications, Temperature-Responsive Intelligent Interfaces.	6
5	<b>Methods of Study and Characterization of Surface-Modified Substrates:</b> Contact Angle, Atomic Force Microscopy (AFM), X-Ray Photoelectron Spectroscopy, Confocal	7



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	Fluorescence Microscopy, Attenuated Total Reflection (Internal Reflection) Infrared Spectroscopy, Mechanical Methods: Use of Micro- and Nanocantilevers for Characterization of Surfaces, Simulation for characterization.	
6	<b>Fabrication of BioMEMS Devices:</b> Basic Microfabrication Processes, Micromachining, Soft Micromachining, Microfabrication Techniques for Biodegradable Polymers, Nanofabrication Methods, Simulation for design.	6
7	<b>Introduction to Microfluidics:</b> Fluid Physics at the Microscale, Methods for Enhancing Diffusive Mixing between Two Laminar Flows, Controlling Flow and Transport in Microfluidic Channels, Modeling Microchannel Flow, Experimental Methods, and Simulation for characterization.	6
8	<b>Life Science Applications:</b> Introduction to Microarrays, Microarrays Based on DNA, Polymerase Chain Reaction (PCR), Protein Microarrays, Cell and Tissue-Based Assays on a Chip, Microreactors, Micro Total Analysis Systems ( $\mu$ TAS) and Lab-on-a-Chip (LOC), Lab-on-a-Chip, Microcantilever BioMEMS.	6

### Suggested Specification table with Marks (Theory):

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

**Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create 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. BioMEMS science and engineering perspective, Simona Badilescu, Muthukumaran Packirisamy, CRC Press, International Standard Book Number-13: 978-1-4398-9116-2 (eBook - PDF).
2. BioMEMS, Gerald A. Urban, ISBN 10 0-387-28732-9 (e-book), Springer.
3. MICROSYSTEMS, Stephen D. Senturia, ISBN 978-1-4757-3534-5 (eBook), Springer Science.
4. BioMEMS and Biomedical Nanotechnology, Volume III, Therapeutic Micro/Nanotechnology, Mauro Ferrari, Tejal Desai, Sangeeta Bhatia, ISBN-10: 0-387-25565-6, springer.
5. Introduction to BioMEMS, Albert Folch, CRC Press, International Standard Book Number-13: 978-1-4665-0938-2 (eBook - PDF).

### Course Outcomes: After the learning, students will able

Sr. No.	CO statement	Marks % weightage



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CO-1	To understand basic educational foundation in micro-systems engineering emphasizing Biomedical micro-devices	20%
CO-2	To learn basic biological/ biochemical concepts and techniques which are necessary for understanding of diagnostics and therapeutics	20%
CO-3	To learn about fundamental micro-fabrication/ microelectronic processing technologies	20%
CO-4	To understand applications of BioMEMS in Microfluidic technology.	20%
CO-5	To understand the various life science applications of MEMS technology.	20%

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

**Software:** COMSOL, CoventorWare, Ansys, SIMULIA, Intellisense, MEMS Plus, AutoCAD,

### Websites:

1. <https://nanohub.org/resources/180/share>
2. [https://onlinecourses.nptel.ac.in/noc19\\_me38/preview](https://onlinecourses.nptel.ac.in/noc19_me38/preview)
3. <https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-777j-design-and-fabrication-of-microelectromechanical-devices-spring-2007/lecture-notes/>
4. <https://nptel.ac.in/courses/117105082/>
5. <https://www.digimat.in/>
6. <https://www.class-central.com/report/swayam-moocs-course-list/>