Devi Ahilya University, Indore, India Institute of Engineering & Technology				III Year B.E. (Electronics & Instrumentation Engg.)			
Subject Code & Name	**Instructions Hours per Week**			**Credits**			
EIR5E3	**L**	**T**	**P**	**L**	**T**	**P**	**Total**
Introduction to MEMS	**3**	**1**	**2**	**3**	**1**	**1**	**5**
Duration of Theory Paper: 3 Hours							

Prerequisite: Students should have knowledge of fundamentals of Electrical Engineering, Chemical Engineering, Material Science and Mechanical Engineering. Electronic circuits knowledge.

Rationale: Understand the benefits and consequences of scaling. Understand properties and crystallography of Si. Explain the concept of lithography. Design masks. Understand bulk micromachining. Know the basic methods of surface micromachining. Explain the concept of beams. Understand noise in MEMS. Micro electro mechanical systems (MEMS), devices and technologies. Micro-machining and microfabrication techniques, including planar thin- film processing, silicon etching, wafer bonding, photolithography, deposition and etching. Transduction mechanisms and modeling in different energy domains. Analysis of micromachined capacitive, piezoresistive and thermal sensors/actuators and applications.

Unit 1:

MEMS Roadmaps, Benefits of Miniaturization, faster speed (transistors, micromechanical resonators), lower power consumption (micro-ovens), higher sensitivity (gas sensors).

Unit 2:

Fabrication Process Modules I: oxidation, film deposition, lithography. Fabrication Process Modules II: etching, ion implantation, diffusion.

Unit 3:

Surface Micromachining I: basic polysilicon process flow, release, sacrificial & structural material choices. Surface Micromachining II: 2nd order issues, stiction, residual stress, electroplating, 3D out-of-plane MEMS. Bulk Micromachining: wet etch-based, dissolved wafer process, SOI MEMS, Scream, Hexsil MEMS, sealed cavity deep RIE. Mechanics of Materials for MEMS I: stress, strain, material properties, measurement & characterization of mechanical parameters. quality factor, beam bending

Unit 4 :

Equivalent Circuits I: dynamic mass, stiffness, and damping, example: free-free beam, lumped mass-spring-damper circuit. electromechanical analogies, lossless transducers. capacitive transducers, charge control, voltage control, spring suspended C, parallel-plate capacitive transducer, pull-in, linearization

Unit 5 :

Input modeling, force-to-velocity relationship & circuit, intro. to gyroscopes. output modeling, input-to-output transconductance, complete equivalent circuit. Sensing Circuits I: ideal op amps, velocity sensing, position sensing. Sensing Circuits II: differential position sensing, MEMS/transistor integration. noise sources, noise calculation, min. detectable signal.

Reference Books:

4. Marc Madou, “Fundamentals of Microfabrication”
5. Senturia, “Microsystem Design”
6. Kovacs, “Micromachined Transducers Sourcebook”

Course Outcome:

After learning the course the students should be able to:

4. Understand the benefits and consequences of scaling.
5. Understand properties and crystallography of Si.
6. Explain the concept of lithography.
7. Design masks.
8. Understand bulk micromachining.
9. Know the basic methods of surface micromachining.
10. Explain the concept of beams.
11. Understand noise in MEMS.