

SECOND SEMESTER 2023-24 | Course Handout Part II

Date: 09-01- 2024

In addition to Part I (General Handout for all courses appended to the time table) this portion gives further specific details regarding the course.

*Course No.* : BITS F415 / ME 423 (3 1 4)

*Course Title* : Introduction to MEMS

*Instructor-in-charge* : Prof. Sanket Goel (<https://www.bits-pilani.ac.in/Hyderabad/sgoel/Profile>)

*Teaching Assistants* : Mr. Pavar Sai Kumar and Mr. Abhishek Kumar

*Discipline Elective FD* : ECE, EEE, EEI, ChemE, MechE, ManufE; Minor (Robotics and Automation)

*Discipline Elective HD* : Communication, Embedded System, Microelectronics, Electronics & Control, Design, Mechanical, Thermal

*Lab website* : <https://mmne.bits-hyderabad.ac.in/>

**Scope and Objectives:** The course includes basic concepts in MEMS (Micro Electromechanical Systems) with a view to address students all the disciplines. The discussion on topics like MEMS design, Microfabrication, Microfluidics, Microsensors and Diverse applications have been structured in the course plan. The objective of the course is to equip the students from various aspects and with basic knowledge of the area of MEMS.

**Text Book:**

Tai-Ran Hsu, *MEMS and Micro systems Design and Manufacture*, Tata McGraw Hill, 2002

**Reference Books:**

1. G.K. Ananthsuresh et al,’Micro and Smart Systems’, Wiley, India, 2010.
2. Nitaigour P. Mahalik, *MEMS*, Tata McGraw Hill, 2007
3. Marc Madou, *Fundamentals of Microfabrication*, CRC Press, 2002.
4. Chang Liu, *Foundation of MEMS*, Pearson Education Inc., NJ, 2006
5. Nadim Maluf, *Introduction to Microelectromechanical Systems Engineering*, Artech House, 2000.
6. Stephen D. Senturia, *Microsystem Design*, Kluwer Academic Publishers, 2001
7. Gad- el-Hak, *Introduction to MEMS*, CRC Press, 2010.

**Course Plan:**

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| --- | --- | --- | --- | --- | --- | --- | --- |
| **#** | **Learning Objectives** | | **Topic** | | | **Lectures** | **Reference** |
| 1 | Introduction – history, fundamentals, components, landmark interventions, career opportunities, research areas in MEMS | | | | | 2 | Ch. 1 & 2 (T),  Class notes |
| 2 | To understand  fundamentals components | MEMS  and | Working principles of various micro sensors  and actuators in microsystems., Scaling Laws in MEMS | | | 2 | Ch. 3 & 6 (T),  Class notes |
| 3 | To understand basic MEMS Engineering & Science | | Engineering Science for MEMS, Materials for MEMS | | | 2 | Ch. 7(T),  Class notes |
| 4 | To understand the  Environment to do the MEMS Fabrication process | | Clean Environment, Clean User, Clean Process | | | 2 | Class notes |
| 5 | To understand fabrication processes | MEMS | Microfabrication Processes I - lithography | | | 4 | Ch. 8 (T),  Class notes |
| 6 | To understand fabrication processes | MEMS | Microfabrication Processes II lithography, 3D printing | - | soft- | 5 | Ch. 8 (T),  Class notes |
| 7 | To understand how to characterize MEMS devices | | SEM, TEM, Raman, Confocal, XRD, UV-VIS- IR | | | 4 | Class notes |
| 8 | To understand Microfluidics | | Microfluidics – fundamentals, parameters, fabrication  characterization, applications |  | design aspects, | 5 | Class notes |

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| --- | --- | --- | --- | --- |
| 9 | To understand Biomedical applications for MEMS | MEMS devices used for various Biomedical  applications, such as biosensing, medical devices, diagnostics etc | 2 | Class notes |
| 10 | To understand Biochemical applications | MEMS devices used for various Biochemical applications, environmental, mining, monitoring adulteration, Soil parameters etc. | 2 | Class notes |
| 11 | To understand Energy applications | MEMS devices for Energy applications - Solar, Fuel cells, Supercapacitors | 2 | Class notes |
| 12 | To understand Automotive and Defense applications | MEMS devices for automobiles, aerospace, defence and military applications | 2 | Class notes |
| 13 | To understand Microsystem design considerations | Integration constraints, industrial applications, troubleshooting | 2 | Ch. 10(T) |
| 14 | To understand MEMS packaging | Function of packaging, requirements, integration, advantages, applications | Self-study | Ch. 11(T) |
|  |  | Total | 36 |  |

**Evaluation Scheme:**

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| --- | --- | --- | --- | --- | --- |
| **Component** | **Duration** | **Weightage** | | **Date &Time** | **Remarks**[**1**](#_bookmark0) |
| **%** | **Marks** |
| MidSem Exam | 1 hr 30 mins | 25 | 75 | 15/03 - 4.00 - 5.30PM | OB |
| Comprehensive Exam | 3 hrs | 40 | 120 | 17/05 AN | CB |
| Quizzes[2](#_bookmark1) |  | 10 | 30 | TBD | CB |
| Lab[3](#_bookmark2) |  | 10 | 30 | Weekly | OB |
| Lab Quiz | 30 mins | 5 | 15 | TBD | CB |
| Project[4](#_bookmark3) |  | 10 | 30 | TBA | OB |
| **Total** |  | **100** | **300** |  |  |

**Lab Experiments**

1. Introduction Session
2. Introduction to the software COMSOL and its application in MEMS/Microfluidics.
3. Simulation of MEMS Sensors/Actuators using COMSOL
4. Microfluidic simulations using COMSOL: Laminar Flow; Convection diffusion; Conjugate heat transfer.
5. Development of PCB/μ-devices using dry film resist based photolithography.
6. Development of Micro-device using FDM based 3D printing.
7. Development of electrically conductive polymers using CO2 Laser.
8. Development of micro-devices using Direct Laser Writing (DLW) & Soft Lithography.
9. Fundamentals of Cleanroom and demonstration of Electron Beam Vapour Deposition.
10. Characterization I: Study of Scanning Electron Microscopy, Four Probe, Tensiometer, etc.
11. Case Study: IoT in MEMS & Point of Care Devices
12. Project Lab – I
13. Project Lab - II

**Consultation Hour:** As per mutual convenience via Google-Meet.

**Notices:** will be posted on Google Classroom

**Make-up Policy:** Prior permission of IC is required for make-up. No make-up allowed for quizzes and lab quiz.

**Academic Honesty and Integrity Policy:** Academic honesty and integrity are to be maintained by all the students throughout the semester and no type of academic dishonesty is acceptable.

***Please contact the Instructor In-Charge for any questions***

1 For open book exam, only hand-written notes (notebooks/well bound sheets), textbooks, and reference books will be allowed.

2 Total 4 quizzes will be taken and the best 3 will be considered for the final evaluation. No makeup will be allowed for quizzes.

3 The marks will be based on the lab reports and lab performance

4 Evaluation: Project Outline - 20%, Project Report - 30%, Presentation and Demo - 50%