Birla Institute of Technology & Science, Pilani
Hyderabad Campus

FIRST SEMESTER 2023-24 | Course Handout Part II

Date: 11 August 2023

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)
Instructor : Prof. Satish Kumar Dubey (https://www.bits-pilani.ac.in/hyderabad/satishkdubey/Profile)
Teaching Assistants : Mr. Pavar Sai Kumar and Mr. Abhishek Kumar
Schedule : Lecture [Mon, Wed, Fri, 9-950 am (J-220)] || Lab [Wed & Thu, 2-4 pm (J-204 and others)]
Google Classroom : https://classroom.google.com/u/1/c/NTgxMzQ1NjgyNDIy
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:

#	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 MEMS fundamentals and components	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 MEMS fabrication processes	Microfabrication Processes I - lithography	4	Ch. 8 (T), Class notes
6	To understand MEMS fabrication processes	Microfabrication Processes II - soft-lithography, 3D printing	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, design	5	Class notes

		parameters, fabrication aspects, characterization, applications		
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:

Component	Duration	Weightage		Date &Time	Remarks[1]
		%	Marks		
MidSem Exam	1 hr 30 mins	25	75	09/10 - 11.30 - 1.00PM	CB
Comprehensive Exam	3 hrs	40	120	06/12 AN	OB
Quizzes[2]		10	30	TBD	CB
Lab[3]		10	30	Weekly	OB
Lab Quiz	30 mins	5	15	TBD	CB
Project[4]		10	30	TBA	OB
Total		**100**	**300**		

Lab Experiments

i. Introduction Session
ii. Introduction to the software COMSOL and its application in MEMS/Microfluidics.
iii. Simulation of MEMS Sensors/Actuators using COMSOL
iv. Microfluidic simulations using COMSOL: Laminar Flow; Convection diffusion; Conjugate heat transfer.
v. Development of PCB/μ-devices using dry film resist based photolithography.
vi. Development of Micro-device using FDM based 3D printing.
vii. Development of electrically conductive polymers using CO2 Laser.
viii. Development of micro-devices using Direct Laser Writing (DLW) & Soft Lithography.
ix. Fundamentals of Cleanroom and demonstration of Electron Beam Vapour Deposition.
x. Characterization I: Study of Scanning Electron Microscopy, Four Probe, Tensiometer, etc.
xi. Case Study: IoT in MEMS & Point of Care Devices
xii. Project Lab – I
xiii. 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.

[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%

Please contact the Instructor In-Charge for any questions