BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI
FIRST SEMESTER 2020-21
Course Handout (Part II)

Date: 17 August 2020

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
Course Title : Introduction to MEMS
Instructor-in-charge : Prof. Sanket Goel
Teaching Assistants : Mr. Avinash Kothuru, Mr. Sohan Dudala and Ms. Jayapiriya U S
Schedule : Lec (Tues, Thu, Sat: 11 am – 12 nn) || Lab (Mon: 9 am – 11 am & Fri: 1 pm – 3 pm)

1. **Scope and Objective of the Course:**

The course introduces the basic concepts in MEMS (Micro Electromechanical Systems) with a view to address a class of students from science and engineering 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.

2. **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.

3. Course Plan:

#	Learning Objectives	Topic	Lectures	Chap. Sec.
1	Introduction – history, fundamentals, components, landmark interventions, career opportunities, research areas in MEMS		2	Ch. 1(T), Ref (b)
2	To understand MEMS fundamentals and components	Basic Concepts of MEMS Design and Fabrication	2	Ch. 3 Ref (a)
3	To understand basic MEMS governing laws	Scaling Laws – geometry, various forces, fluid mechanics etc	3	Ch. 9(T)
4	To understand Microsensors & Microactuatars	Microsensors & Microactuatars: working principles, design, applications	4	Ch. 2, (T)
5	To understand MEMS fabrication processes	Microfabrication Processes I - lithography	4	Ch. 7 (T), Ch.7 Ref. (a)
6	To understand MEMS fabrication processes	Microfabrication Processes II - soft-lithography, 3D printing	6	Ch. 3(T), Ch 8 7Ref. (a)
7	To understand how MEMS can be harnessed for micromanufactering	Micromanufacturing – fundamental design principles, MEMS integration, applications	4	C8h. 3 (T) Ch. 9 Re9f. (a)

8	To understand Microfluidics	Microfluidics – fundamentals, design parameters, fabrication aspects, characterization, applications	5	Ch. 5 Ref (a), Class Notes
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 for MEMS	MEMS devices used for various Biochemical applications, environmental, mining, monitoring adulteration, Soil parameters etc.	2	Chapter 7 (T)
11	To understand Energy applications in MEMS	MEMS devices used for various Energy applications, Solar, Fuel cells, Supercapacitors etc	2	Ch.8 Ref (b), Class notes
12	To understand Automotive and Defense applications in MEMS	MEMS devices for automobiles, aerospace, defence and military applications	2	Ch.7 Ref (b), Class notes
13	To understand Microsystem design considerations	Microsystem design – integration constraints, industrial applications, troubleshooting	2	Ch.10 Ref. (a)
14	To understand MEMS packaging	MEMS Packaging – function of packaging, requirements, integration aspects, advantages, applications	Self-study	Ch. 11 Ref (a)
		Total	40	

4. **Evaluation Scheme:**

Component	Duration	Weightage		Date &Time	Nature
		%	Marks		
Test 1	30 mins	10	30	September 10 – September 20 (During scheduled class hour)	OB
Test 2	30 mins	15	30	October 09 – October 20 (During scheduled class hour)	OB
Test 3	30 mins	10	30	November 10 – November 20 (During scheduled class hour)	OB
Comprehensive Exam	2 hours.	35	90	To be announced	OB
Quizzes[1]		5	30	During Lecture	OB
Lab[2]		12.5	37.5		
Project[3]		12.5	37.5	To be announced	
Total		**100**	**300**		

5. Lab Experiments

i. Introduction to the software COMSOL and its application in MEMS/Microfluidics.
ii. Simulation of MEMS Sensors/Actuators using COMSOL
iii. Microfluidic simulations using COMSOL: Laminar Flow; Convection diffusion; Conjugate heat transfer.
iv. Development of Micro-device using FDM based 3D printing.
v. Development of electrically conductive polymers using CO2 Laser.
vi. Development of PCB/μ-devices using dry film resist based photolithography.

[1] Total 4 quizzes will be taken and the best 3 will be considered for the final evaluation. No makeup will be allowed for quizzes.
[2] The marks will be based on the lab reports and lab performance
[3] Evaluation: Project Outline - 20%, Project Report - 30%, Presentation and Demo - 50%

vii. Development of Micro-device using poly-di-methyl-siloxane (PDMS) based Soft-lithography.
viii. Development of micro-devices using liquid photoresist based Direct Laser Writing (DLW).
ix. Fundamentals of Clean room and demonstration of Electron Beam Vapour Deposition.
x. Study of Scanning Electron Microscopy

6. **Chamber Consultation Hour:** To be announced in the class.

7. **Make-up Policy:** There will no make-ups unless for genuine reasons. Prior Permission of the Instructor-in-Charge is required to take a make-up for any component.

8.Notices: CMS

9.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.

Instructor-In-Charge