BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI
SECOND SEMESTER 2019-20
Course Handout (Part II)

Date: 12/12/2019

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**
Instructor **: Prof. Sanket Goel and Dr. Satish Kumar Dubey**

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, Microrobotics and Microsensors 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	2	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	3	Ch. 7 (T), Ch.7 Ref. (a)
6	To understand MEMS fabrication processes	Microfabrication Processes II - soft-lithography, 3D printing	4	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 COMSOL based MEMS modelling	Modeling in MEMS – COMSOL fundamentals, design principles, examples	5	Ch. 4, 5, 6 (T)

9	To understand meteorological applications for MEMS	Meteorology in MEMS – fundamentals of Meteorology, need for MEMS, recent applications	1	Class-notes
10	To understand electronic components in MEMS	Electronics in MEMS – integration of IC, embedded systems with MEMS devices, with few design principles and examples	2	Chapter 7 (T)
11	To RF components in MEMS	RF MEMS – Components, Biasing, Packaging, Microfabrication, Reliability, Applications	2	Ch.8 Ref (b), Class notes
12	To Optical components in MEMS	Optical MEMS – need for optical MEMS, Components, Biasing, Integrated optics, Reliability, Applications	2	Ch.7 Ref (b), Class notes
13	To understand Microfluidics	Microfluidics – fundamentals, design parameters, fabrication aspects, characterization, applications	4	Ch. 5 Ref (a), Class Notes
14	To understand Microsystem design considerations	Microsystem design – integration constraints, industrial applications, troubleshooting	3	Ch.10 Ref. (a)
15	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	Remarks
		%	Marks		
Midterm	1Hr30m	20	60		Closed Book
Comprehensive Exam	3 Hr.	30	90	13 May 2020, AN	Closed Book
Quizzes[1]		10	30	During Lecture	Closed Book
Lab[2]		20	60		Open Book
Project[3]		20	60	To be announced	Open Book
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.
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

Instructor-In-Charge

[1] Total 8 quizzes will be taken and the best 6 will be considered for the final evaluation
[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%