BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI

**SECOND SEMESTER 2019-20**

**Course Handout (Part II)**

Date: 06/01/2020

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**

*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.

1. **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.
8. **Course Plan:**

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| --- | --- | --- | --- | --- |
| **#** | **Learning Objectives** | **Topics to be covered** | **Lectures** | **Chapter in the Text Book** |
| 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 electronics 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 RF 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 |  |

1. **Evaluation Scheme:**

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| --- | --- | --- | --- | --- | --- |
| **Component** | **Duration** | **Weightage** | | **Date &Time** | **Nature of Component** |
| **%** | **Marks** |
| Midterm | 1Hr30m | 20 | 60 | 6/3 1.30 -3.00 PM | Closed Book |
| Comprehensive Exam | 3 Hr. | 30 | 90 | 13 May 2020, FN | Closed Book |
| Quizzes |  | 10 | 30 | During Lecture | Closed Book |
| Lab |  | 20 | 60 |  | Open Book |
| Project |  | 20 | 60 | To be announced | Open Book |
| **Total** |  | **100** | **300** |  |  |

1. **Lab Experiments**
2. Introduction to the software COMSOL and its application in MEMS
3. Simulation of MEMS Actuators using COMSOL
4. Simulation of MEMS Sensors using COMSOL
5. Microfluidic simulations using COMSOL: Laminar Flow; Convection diffusion; Conjugate heat transfer
6. Development of Micro-device using FDM based 3D printer.
7. Study the customized filament making for FDM 3D printer
8. Development of Micro-device with the photolithography process using dry film photoresist
9. Development of Micro-device using poly-di-methyl-siloxane (PDMS) based Soft-lithography
10. Development of paper Micro-device using solid wax printer
11. Development of paper / polymer Micro-device using Xurography

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

1. **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**