

BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI
SECOND SEMESTER 2022-23
Course Handout (Part II)

Date: 16/01/2023

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. : **ME F423**
Course Title : **Microfluidics and its Applications**
Instructor-in-charge : **Dr. Satish Kumar Dubey**
Instructor : **Satish Kumar Dubey, P. Ramya Priya**

1. Scope and Objective of the Course:

Introduction to microfluidics, scaling in microfluidics, theoretical microfluidics, Philosophy of Computational Fluid Dynamics, Concepts of discretization, fabrication techniques for microfluidic devices, microvalves, micropumps, microflow sensors, microfluidics for life sciences: micromixers, microneedles, microfilters, microseparators, microreactors, modeling and simulation on CAD tool.

2. Text Book:

Fundamentals and applications of microfluidics by Nam-Trung Nguyen and Steven T. Wereley, Artech House, 2002.

Reference Books:

1. Introduction to Microfluidics, by Patrick Tabeling, Oxford University Press, 2005.
2. Theoretical Microfluidics, by Henrik Bruus, Oxford Master Series in Condensed Matter Physics, 2008.
3. Microfluidics Fundamentals, Devices and Applications, Edited by Yujun Song, Daojian Cheng, and Liang Zhao, Wiley 2018.

3. Course Plan:

| # | Learning Objectives | Topic | Lectures | Chap. Sec. |
|---|--|---|----------|-----------------------|
| 1 | Introduction to Microfluidics | Physics at the microscale, role of various intermolecular forces. | 2 | T Ch 1 |
| 2 | Dimensional analysis and scaling laws to understand fluid flow | To understand fluid flow in Microfluidic domain. Navier-Stokes equation and application to obtain certain exact solutions. | 4 | T Ch 2 |
| 3 | Diffusion, mixing and separation of fluids in Microsystems | Analysis of dispersion phenomena, Passive and active mixing, Chaotic mixing, Hydrodynamics of microfluidic systems, bubbles, droplets | 3 | R1 Ch 4 R2 Ch 5 |
| 4 | Electrohydrodynamics of microsystems | Electro-osmosis, Electrophoresis, Dielectrophoresis, Magnetophoresis | 3 | R1 Ch 5 R2 Ch 8-11 |
| 5 | Introduction to flow simulation | Meshing, discretization and simulation using relevant software | 3 | R3 Ch 4 |
| 6 | Introduction to microfabrication techniques | Photolithography- etching – embossing, Soft-lithographic patterning, mask design, surface modification. | 3 | T Ch 3 R1 Ch 7 |
| 7 | Various detection mechanisms in Microfluidics | Electrical, Amperometric, Electrochemical, High-Speed, | 4 | Notes |

| | | | | |
|----|---|---|----|-----------------------------------|
| | | Colorimetric, Fluorescence, Chemiluminescence, Bioluminescence | | |
| 8 | Characterization of Microfluidic Devices | Optical & Electronic Microscope, Profilometers, Scanning Probe Microscopy, Raman Spectroscopy, UV VIS Spectroscopy, Confocal Microscopy | 3 | Notes |
| 9 | Microfluidic Experimental flow characterization and External Flow Control | MicroPIV, Fluorescent microscopy Velocity and Laminar flow measurement and its control | 2 | T Ch 5 |
| 10 | Microfluidics for Internal Flow Control | Microvalves, Micropumps, Micromixers, Microflow Sensors | 2 | T Ch 6, 7, & 8 |
| 11 | Ancillary areas of Microfluidics | Digital Microfluidics, Thermofluidics, Optofluidics, Nanofluidics, Acoustofluidics | 3 | R2, Ch 12, 15, 16, 17 R3, Ch 5 |
| 12 | Application of Microfluidics I Biomedical | Biomedical applications | 4 | Notes |
| 13 | Application of Microfluidics II | Biochemical applications | 4 | Notes |
| | | Total | 40 | |

4. Evaluation Scheme:

| <u>Evaluation Component</u> | Duration (minute) | Weightage (%) | Marks | Date & Time | Nature of Component |
|-----------------------------|--------------------------|----------------------|--------------|---|----------------------------|
| Mid Semester Test | 90 | 25 | 75 | 14/03 11.30 - 1.00PM | CB |
| Lab work and Project | - | 25 | 75 | Evenly spaced throughout the semester | OB |
| Quizes | 25 minutes | 10 | 30 | Evenly spaced throughout the semester during lecture hour | CB |
| Comprehensive Exam | 180 | 40 | 120 | 10/05 AN | CB and OB |

5. Lab Experiments

The list of experiments and complete modalities of operation of the laboratory such as the exact titles of experiments, reports submission and evaluation methodology etc. shall be announced at the beginning of laboratory session by the lab instructors.

| S. No. | Name of Equipment |
|--------|--|
| 1 | Introduction to the software COMSOL and its application in Microfluidics |
| 2 | Simulation of Microfluidic system using COMSOL |
| 3 | Development of Micro-device using FDM based 3D printer. |

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|----|--|
| 4 | Study the customized filament making for FDM 3D printer |
| 5 | Development of Micro-device with the photolithography process using dry film photoresist |
| 6 | Development of Micro-device using poly-di-methyl-siloxane (PDMS) based Soft-lithography |
| 7 | Development of paper Micro-device using solid wax printer |
| 8 | Study of Scanning Electron Microscopy |
| 9 | Understanding of Clean room and Electron Beam Deposition |
| 10 | Understanding of lithography process |
| 11 | Experiment on Droplet microfluidics |
| 12 | Experiment on micro fuel cell |

NOTE:

- 1. Chamber Consultation Hour:** To be announced in the class room.
- 2. Notices:** All notices concerning this course shall be displayed on the CMS Students are advised to visit regularly CMS (institute's web based course management system) for updates on the course matters.
- 3. Make-up Policy:** Make-up shall be given only to the genuine cases with prior intimation. No make-up will be given for the quiz tests.
- 4. Academic Honesty and Integrity Policy:** Academic honesty and integrity are to be maintained by all the students throughout the semester and any type of academic dishonesty is not acceptable.

Instructor-in-charge

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