



Birla Institute of Technology & Science, Pilani
Hyderabad Campus

SECOND SEMESTER 2023-2024

Course Handout Part II

Date: 09-01-2024

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 F417
Course Title	: Microfluidics and its applications
Instructor-in-Charge	: Meenakshi V
Co-Instructor	: Aravinda N Raghavan

Scope and Objective of the Course:

Microfluidics is about manipulating fluids in miniaturized systems at the micro / nano liter scale. This subject is now one of the frontiers in interdisciplinary research that has many applications; for example, in developing novel health care devices. An important advancement that has propelled research in this area is the ability to build micron scale structures using various techniques: soft-lithography, photolithography, Laser engraving, 3D printing, etc. In this course, a student will learn the physics behind microfluidic devices through lectures, computer simulations, lab work and by reading research articles.

Here is a glimpse of the topics that will be covered in this course: Dimensional analysis and scaling laws to understand the forces that are significant at microscale, Navier-Stokes equation, Convection-Diffusion equation, simulation of fluid flow in micro-channels, diffusion, mixing and separation of microfluids, controlling flows – pumps and valves, micro fabrication, principle behind microfluidics-enabled technologies such as ink-jet technology, lab-on-a-chip (paper) devices. Students will have the opportunity to conduct a project on a chosen topic by performing an experiment in microfluidics and the corresponding numerical simulation after hands on training in microfabrication.

Learning outcomes

- A. Dimensional and scaling analysis of fluid flow.
- B. Fabricating micron / nano scale structures using various techniques: soft-lithography, photolithography, Laser engraving.
- C. Analyzing microfluidic flow using COMSOL - computer simulation.
- D. Surveying the various applications of microfluidics.
- E. Reading Research Articles to understand important and current developments.



Text Book:

Micro- and Nanoscale Fluid Mechanics by Brian J Kirby, Cambridge University Press, 2010.

Reference Books:

A Brief Introduction to Fluid Mechanics, by Donald F Young, Bruce R Munson, Theodore H Okishii and Wade W Huebsch, John Wiley & Sons, 2011.

Theoretical Microfluidics, by Henrik Bruus, Oxford Master Series in Condensed Matter Physics, 2008.

Fundamentals of Microfabrication, by Marc J Madou, Taylor & Francis, 2017.

Computational Fluid Dynamics, by John D Anderson (Jr), McGraw Hill, 1995.

Lecture No.	Topics to be covered	Chapter
1-2	Introduction to microfluidics – Physics at the microscale, role of various intermolecular forces.	Chapter 1 (Henrik Bruus)
3-6	Buckingham Π theorem, Dimensional analysis and scaling laws to understand fluid flow.	Appendix E (Textbook) Chapter 7 (Donald Young et al)
7-13	Navier-Stokes equation and application to obtain certain exact solutions.	1.1-1.4, Chapter 2, 4.1 (Textbook)
14-18	Diffusion, mixing and separation of fluids in Microsystems - Analysis of dispersion phenomena, Passive and active mixing, Chaotic mixing.	Chapter 4 (Textbook)
19 -24	Finite Difference and Finite Element Methods, Introduction to flow simulation using computers - Meshing, discretization and simulation using COMSOL multiphysics software	Chapter 4 (Anderson) and Lecture Notes
25-30	Introduction to microfabrication techniques - Photolithography- etching – embossing, Soft-lithographic patterning, mask design, Laser Engraving, Paper microfluidics	Chapter 1 (Madou) and Lecture Notes
30-35	Experimental flow characterization – Micro Particle Image Velocimetry, Fluorescent microscopy	Research Articles
35-40	Applications of microfluidics - Micropumps and microvalves, Lab-on-a-chip devices, micromixers	Research Articles
41	Conclusion	

Evaluation Scheme

Component	Duration	Weightage (%)	Date & Time	Nature of Component
Mid-semester exam	90 min	25%	12/03 - 9.30 - 11.00AM	Closed Book
Lab - Hands on training on microfabrication		10%		Experimental work
Lab Project work and Presentation		20%		Experimental Work (Lab)
Simulation and Demonstration		10%		CAD Lab
Comprehensive exam	3 hours	35%	08/05 FN	Closed Book

Chamber Consultation Hour: To be announced in class.

Notices: All notices concerning this course will be displayed in CANVAS.

Make-up Policy: No makeup will be provided for any lab / simulation component. For mid-semester and comprehensive exam, make-up will be granted only for genuine health issues (with supporting document) and with prior permission.

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

