Approval: 9th Senate Meeting

Course Number: ME 507

Course Name: Micro and Nanoscale Fluid Mechanics

Credits: 3-0-0-3

Prerequisites: ME-210: Fluid Mechanics, IC-142: Engineering Thermodynamics, ME-303: Heat Transfer

Intended for: UG/PG

Distribution: Elective

Semester: Odd/Even

Preamble: As the size of modern devices goes down to micro-nanoscale, the fundamental hypotheses adopted in macroscale fluid mechanics is not applicable in such small scales. The objectives of this course are: to identify dominant forces and their effects in micro scale fluid systems that are different from those in the macro scales; to understand the fundamentals of micro fluidic phenomena; to discuss various microfluidic applications in research and commercial levels; and to explore new possible microfluidic applications in the emerging fields.

Course Outline: This course aims to introduce unique transport phenomena and major applications of micro and nanofluidics to undergraduate and graduate students. Objective of this course is to describe the underlying physics of fluid flow transport processes at micro/nanoscale and to introduce the contemporary experimental and theoretical tools used to understand them. Topics to be covered in this course include overview of microfluidics, scaling laws, violation limit of the Navier-Stokes equations, surface force, surface tension, electrowetting, electrokinetics, dielectrophoresis and fabrication techniques.

Course Modules:

1. Introduction – Overview, physics of miniaturization, scaling laws and continuum model, engineering applications of micro/fluidics (4 contact hours).

2. Microscale fluid mechanics – Navier Stokes equations, energy and species transport equations, constitutive relations, surface tension, Young-Laplace equation, velocity and stress boundary conditions at interfaces, exact solutions, flow regimes, inter-molecular forces, kinetic theory of gases, slip theory, Low Re flows, High Pe flows, Couette flow, Poiseuille flow, Stokes drag on a sphere, time-dependent flows, Hydraulic circuit analysis (16 contact hours)

3. Electrokinetics – Electrostatics and electro hydrodynamics fundamentals, electro-osmosis, electrophoresis, Dielectrophoresis, electro-capillarity and electrowetting effects (10 contact hours)

4. Microfabrication techniques – Micromachining of Silicon and Polymeric chips, Chemical etching and bonding, electron beam lithography, soft lithography, micromachining, casting, injection molding (8 contact hours)

5. Introduction to Nanofluidics – Unidirectional transport in nanochannels, transport through nanostructures with interfaces, molecular dynamics simulations, nanofluidic energy conversion (4 contact hours)

Reference Books

1. P. Tabeling, *Introduction to Micro Fluidics,* Oxford 2005.
2. B. Kirby, *Micro and Nanoscale Fluid Mechanics: Transport in Microfluidic devices*, Cambridge Univ. Press, 2010.
3. N.T. Nguyen, S. Wereley, *Fundamentals and applications of Microfluidics,* Artech House, 2002.
4. Marc. J. Madou, *Fundamentals of Microfabrication*, 2nd edition, CRC Press, 2002.
5. S. Colin, *Microfluidics,* John Wiley & Sons, 2009.
6. H. Bruss, *Theoretical Microfluidics,* Oxford 2008.