CHE-345: Transport Phenomena

Credit Hours: 3-0

Pre-requisites: *CHE-221: Fluid Mechanics-I*

Course Objectives

- To relate and express basics of transport phenomena with the concept of vectors, tensors.
- To setup and solve microscopic momentum, energy and mass for given systems.
- To demonstrate and apply the equations of change for given systems.
- To couple flow hydrodynamics, reaction kinetics and heat transfer to solve complex engineering problems.
- To create ability to define engineering problems, explore solutions. and critically analyze to achieve a practical solution.

Course Contents

i. Introduction to vectors and tensors and their application in fluid flow
ii. Transfer processes: A review of the mechanisms of momentum, energy and mass transport. Balance principles for momentum. Energy, and mass.
iii. Momentum transport: Diffusivity and mechanism of momentum transport. Derivation of equations of continuity and motion (Navier-Stokes) for 1D, 2D and 3D.
iv. Application of Navier-stokes to solve problems related to fluid flow for the 1D as well as 2D case.
v. Energy transport: Thermal conductivity and mechanism of energy transport. Derivation of energy equation microscopic level. Application to heat transfer problems involving conduction, free/forced convection and radiations. Interphase transport in non-isothermal systems,
vi. Case study: Temperature distribution profiles for 1D and 2D case

vii. Mass transport: Diffusivity and mechanism of mass transport. Derivation of species conservation equations for binary and multi-component mixtures.

viii. Cases studies to apply mass transport equations to model species concentration Profiles and changes along the length of the reactor (Convection diffusion equation).

ix. Introduction to transport in turbulent flow: Fluctuations and time-averaged quantities. Time averaged form of the governing equations of momentum, energy and mass transport.

Course Outcomes

After completing this course, student will be able to:

- Fundamental understanding of basic equations that describes momentum, energy and mass transport
- Formulate macroscopic mass, momentum and energy balances and dimensional analysis to solve engineering problems related to fluid flow
- Solve equation of motion, equation of continuity and Navier-Stokes equations to analyze engineering problems related to Newtonian fluid flow in Laminar flow
- Develop and understand the equations of change which describe how the mass, energy, momentum and angular momentum change within the small region
- Determine the velocity, temperature and concentration profiles of different systems
- Numerical and analytical problems solving skills and techniques in the field of mass, energy, momentum and angular momentum
- Use these equations of change to solve the problems of transport phenomena
- Calculate heat transfer coefficients for different systems
- Determine the heat transfer rate for single and composite walls
- Estimate molar/mass flux and concentration profiles for steady-state and unsteady-state molecular diffusion

Recommended Books

- Bennett C.O., Myers J.E. (1983) Momentum, Heat & Mass Transfer, 3rd Edition. McGraw Hill Book Company.
- Bird R. Byron, Stewart Warren E., Lightfoot Edwin N. (2002) Transport Phenomena, 2nd Edition. John Wiley & Sons Inc.

- Brodkey Robert S., Hershey Harry C. (1988) Transport Phenomena – A Unified Approach, McGraw Hill International Editions.
- J.R. Welty, C.E. Wicks, R.E. Wilson, and G.L. Rorer (2008) Fundamentals of Momentum, Heat, and Mass Transfer, 5th Edition. John Wiley & Sons.
- Tosun I. (2007) Modeling in Transport Phenomena: A Conceptual Approach, 2nd Edition. Elsevier.