TRANSPORT PHENOMENA

Course Code: 13CH2103

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PREREQUISITES: The student should have knowledge of how to formulate differential equations relating to mass, momentum and heat transfer.

Course Educational Objectives: This course introduces the student the following aspects.

1. Present the fundamental equations.
2. Understand the analogy between momentum, mass and energy transport.
3. Concept of shell balances.
4. Equation of change for isothermal and non-isothermal systems and multi-component mixtures.

Course Outcomes: After completion of this course the student would be able to

1. Apply the fundamental equations to solve various chemical engineering problems.
2. Develop expressions for velocity, temperature and concentration profiles using shell balances.
3. Apply equations of change to solve flow problems.

Introduction:

Review of mathematics: Scalars, Vectors, Tensors, divergence, relation between rectangular coordinates and cylindrical coordinates, relation between rectangular coordinates and spherical coordinates, partial derivative, substantial derivative, total derivative, line integral, surface integral, integral theorems, frames of reference (Eulerian and Lagrangian).

UNIT-I

The equations of change for isothermal flow: Equations of continuity, equation of motion, the equation of mechanical energy, application of Navier-Stokes equation to solve problems like falling film, flow in a tube, shape and surface of a rotating fluid.

Velocity distribution with more than one independent variable like flow over a plate set in motion, unsteady flow between plates, and laminar flow over a flat plate.

UNIT-II

The equations of change for non-isothermal flow: Equations of energy, the energy equation in curvilinear coordinates, use of equations of change to set up steady state heat transfer problems, steady state forced and free convection, flow with viscous dissipation, free convection heat transfer over a vertical plate.

Temperature distribution with more than one independent variable: heating of a semi infinite slab and finite slab, cooling of a sphere in contact with a fluid, laminar tube flow with constant heat flux at the wall.

UNIT-III

The equations of change for multi component systems: The equations of continuity for a binary mixture, the equation of continuity of a in curvilinear coordinates, the multicomponent equations of change in terms of the flows, the multicomponent fluxes in terms of the transport properties, use of equations of change to setup diffusion problems and solve like simultaneous heat and mass transfer, concentration profile in a tubular reactor, catalytic oxidation of CO.

UNIT-IV

Setting up and solving problems like: Diffusion with heterogeneous reaction, gas absorption with chemical reaction, diffusion in a falling film, diffusion and reaction in a spherical catalyst particle.

UNIT-V

Turbulent flow: Introduction, fluctuations and time smoothened equations for velocity, time smoothing of equation of change, Reynolds stresses.

TEXTBOOK:

1. Bird R.B, Stewart W.E and Lightfoot E.N., *"Transport Phenomena"* Wiley international Edition, New York, 2002.

REFERENCE:

1. Welty J.R, Wicks C.E, Wilson R.E, *"Fundamental of Momentum, Heat and Mass Transfer"*, 4th Edition, John Wiley, 2009.

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