Course code	Course Name	L-T-P-Credits	Year of Introduction
CH401	TRANSPORT PHENOMENA IN PROCESSES	3-1-0-4	2016

Prerequisite: Nil

Course Objectives

- To impart the knowledge in transport of momentum, heat and mass transport and provide insight into the dependence of temperature and pressure on the transport coefficients.
- To derive simple shell balances to formulate basic conservation equations of transport processes for solving selected engineering problems which can be solved analytically.
- To give basic axioms of conservations namely conservation of momentum, energy and mass.

Syllabus

Introduction to transport phenomena, Basics of Vector and tensor calculus, Mechanisms of momentum transport, Shell momentum balances, 1-D problems on velocity distribution in laminar flow, Equations of change for isothermal systems, Applications of equations of change to solve 1-D problems on velocity distribution in laminar flow. Mechanisms of energy transport, Shell energy balances, 1-D problems on temperature distribution in solids and in laminar flow, equations of change for non-isothermal systems, Applications of equations of change to solve 1-D problems on temperature distribution in solids and in laminar flow. Mechanisms of mass transport, Shell mass balances, Applications of shell mass balances to solve 1-D problems on concentration distributions in solids and in laminar flow, Equations of change for multi-component systems, 1-D problems on concentration distributions in solids and in laminar flow, Methods of solution of momentum, heat and mass transfer problems with more than one independent variable.

Expected Outcomes.

At the end of the semester, the student will be able to:

i. Apply the governing equations of transport of momentum, heat and mass transport in solving engineering problems
ii. Analyse the dependence of temperature and pressure on the transport coefficients.
iii. Derive simple shell balances to formulate basic conservation equations of transport processes and obtain analytical solutions of selected simple engineering problems.
iv. Interpret the basic axioms of conservations namely conservation of momentum, energy and mass and obtain analytical solutions of selected simple engineering problems.

Text Book

- Bird R.B., Stewart W.C and Lightfoot F.N, *Transport phenomena*, John Wiley & Sons.

References:

1. **Theodore L**, *Transport Phenomena for Engineers* by, International text book Company, U.S.A
2. **Geankoplis**, *Transport processes and unit operations*, 3rd, , PHI, 1997.
3. **Welty, Wicks and Wilson,** Fundamentals of Heat, Momentum and Mass Transfer, John Wiley.
4. **John C Slattery,** *Momentum, Energy and Mass transfer in continua*, McGraw Hill, Co.

5. **Robert S. Brodkey and Harry C Hersing,** *Transport Phenomena a Unified approach,* McGraw Hill Book Co.
6. **Bennet C U** and **Myers J E,** *Momentum, Heat and Mass Transfer,* Tata McGraw Hill Publishing Co.

Course Plan

Module	Contents	Hours	Sem. exam marks
I	Viscosity and the mechanisms of momentum transfer: Newton's law of viscosity, molecular momentum transport, generalization of Newton's law of viscosity, pressure and temperature dependence of viscosity of gases and liquids, prediction of viscosity of gases: Rigid sphere model and rigorous models, prediction of transport coefficients of liquids. Numerical problems Shell momentum balances and velocity distributions in laminar flow: shell momentum balances and boundary conditions, flow of a falling film along a flat surface and on the surface of cylinders, flow of a Newtonian fluid in between two slits formed by two flat plates, flow through a circular tube, flow through annulus, and flow of two adjacent immiscible fluids. Flow of a Bingham fluid through a cylinder- Buckingham-Reiner Equation.	12	20%
II	General transport equation for momentum, derivation of continuity equation, Analysis of equation of motion in rectangular coordinates, Navier Stoke's equation and Euler equation with significance of each terms, transport equation in curvilinear coordinates, application of transport equations to solve steady flow problems:- flow through a tube, tangential annular flow, rotating liquid, cone and plate viscometer. Velocity distributions in turbulent flow: comparisons of laminar and turbulent flows, time-smoothed equations of change for incompressible fluids, and the time- smoothed velocity profile near a wall.	10	20%
FIRST INTERNAL EXAMINATION			
II	**Energy Transport:** Thermal conductivity and the mechanism of energy transport- prediction of thermal conductivity of gases, effect of temperature and pressure on thermal conductivity of gases, relationship between thermal conductivity and viscosity of gases. Thermal conductivity of solids, relationship between thermal and electrical conductivity of solids, Numerical problems. Shell energy balance:- Boundary conditions, application of shell balances to heat conduction problems with electric, nuclear and viscous heat sources and other similar heat conduction problems, use of shell heat balances in variable thermal conductivity systems to derive temperature and heat flux profiles, fixed bed flow reactor, cooling fins with insulated	10	15%

	tip condition, heat transfer by free between two vertical plates and forced convection for flow through pipes with heat transfer at constant wall heat flux.		
IV	Equations of energy in rectangular coordinates, energy equations in curvilinear coordinates, application to steady state heat transfer problems:- tangential flow in annulus with viscous heat generation, free convection from vertical plate, flow of non-isothermal film and transpiration cooling.	8	15%
SECOND INTERNAL EXAMINATION			
V	**Diffusivity and the Mechanism of Mass Transport**: Definition of concentrations, velocities and mass/molar fluxes, Interrelationship between fluxes. Fick's law of diffusion, kinetic theory of diffusion in gases at low density, theory of ordinary diffusion in liquids. Prediction of diffusivity of gases	8	15%
VI	Analogies between heat, mass and momentum transfer, Derivation of equation of continuity for binary mixtures in rectangular coordinates in mass and molar units, general study of equation of continuity in curvilinear coordinates (derivation not desired). Application to combined heat and mass transfer, thermal and pressure diffusion. Solution of mass transport problems for binary systems with analytical solutions.	8	15%
END SEMESTER EXAM			

Question Paper Pattern:

Maximum Marks : 100 Exam Duration: 3 Hours

Part A: There shall be **Three questions** uniformly covering Modules 1 and 2, each carrying 20 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 20 marks for all the subdivisions put together.

(2 x 20= 40 Marks)

Part B: There shall be **Three questions** uniformly covering Modules 3 and 4, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together.

(2 x15= 30 Marks)

Part C: There shall be **Three questions** uniformly covering Modules 5 and 6, each carrying 15 marks, of which the student has to answer any **Two questions**. At the most 4 subdivisions can be there in one main question with a total of 15 marks for all the subdivisions put together.

(2 x15= 30 Marks)