GUJARAT TECHNOLOGICAL UNIVERSITY

CHEMICAL ENGINEERING (30)
ADVANCED TRANSPORT PROCESSES
SUBJECT CODE: 2713009
SEMESTER: I

Type of course: Chemical Engineering

Prerequisite: Basics of Fluid Mechanics, Heat Transfer and Mass Transfer Operations

Rationale: Momentum, Heat and Mass Transfer are three basic transport processes in chemical engineering. It is very important to understand mathematical modeling and analogical aspects of chemical process systems where these transport processes occur simultaneously. This subject focuses such typical situations and thereby its complete understanding on axial as well as radial profiles.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P	C	Theory Marks		Practical Marks				
				ESE (E)	PA (M)	PA (V)		PA (I)		
						ESE	OEP	PA	RP	
3	2#	2	5	70	30	20	10	10	10	150

Content:

Sr. No.	Content	Total Hrs	% Weightage
1	**Analogies in Momentum, Heat and Mass Transfer:** Introduction, Reynolds analogy, Prandtl Taylor analogy, Van Karman analogy, Martinelli analogy, Chilton analogy.	9	16
2	**Principles of Momentum & Overall Balances** Newtonian and non-Newtonian Fluid Models, Classification of fluids on the basis of Rheology, General molecular transport equation for momentum transfer, Review of Shell balance method and Equations of changes for fluid flow problems, Time derivatives, The equation of continuity and Navier-Stoke's Equation in different coordinates, and its applications, Flow past different bodies, Turbulent Flow - Equation of changes, Turbulent flow in closed conduits and analysis of different velocity distributions, Boundary layer flow and turbulence.	15	28
3	**Principles of Heat Transfer** Application of Shell balance and Equations of changes for temperature distributions in heat flow problems Heat conduction with various heat sources, Heat conduction with cooling fins, Temperature distribution for fully developed viscous flow, Heat transfer for non-Newtonian fluids, Unsteady state heat transfer in various geometries, Partial freezing model, Chilling & Freezing of biological materials, Heat transfer with phase change	15	28
4	**Principles of MassTransfer** Application of Shell balance method and Equations of changes for mass transfer problems, Diffusivity, mass and molar transport by convection, Concentration distributions for isothermal and non-isothermal mixtures, Multi component systems with more than one independent variable and in turbulent flow convective mass transfer and correlation, interphase mass transfer, Diffusion with chemical reaction, Transport across selectively permeable membrane and porous media	15	28

Reference Books:

1. Bird R.B., Stewart W.E., Lightfoot E.N., Transport Phenomena, 2nd Edition, John Wiley & Sons, 2002
2. James Welty, Charles E. Wicks and Wilson, Gregory L Rorrer, "Fundamentals of Momentum, Heat and Mass transfer", 5th Edition, 2008.
3. Geankoplis C.J., Transport Processes and Separation Process Principles,4th Edition
4. Slattery J.C., Momentum Heat and Mass Transfer in Cintiniua, Mcgraw-Hill.
5. Slattery J.C., Advanced Transport Phenomena, Cambridge University Press.

Course Outcome:

After learning the course the students should be able to:

1. Have an understanding of molecular transport of momentum, heat, and mass.
2. Have an ability to set up and solve shell momentum, heat, and mass balances for one-dimensional steady state problems.
3. Have an ability to set up and solve macroscopic momentum, heat, and mass balances for steady and quasi-steady state problems.
4. Have an intuitive appreciation of the differences in transport processes occurring in laminar and turbulent flows
5. Have an appreciation and some mastery of transient one-dimensional heat conduction problems.
6. Have an appreciation and some facility for solving interphase transport problems which involve friction factors, drag coefficients, heat and mass transfer coefficients.
7. Have an appreciation of the analogies between momentum, heat and mass transport problems.

List of Experiments:

1. Hagen-Poisuille equation for calculation of viscosity and for capillary radii
2. Determination of diffusion coefficient for liquid phase mixture
3. Experiments on gas-liquid-solid contacting equipments
4. Cooling Towers
5. Fluidized beds
6. Bubble cap and sieve tray distillation columns
7. Bubble column and their modification etc.
8. Determination of thermal conductivity of metal rods.
9. Determination of Eflux time for various fluids.
10. Determination of kinematic viscosity of mixture using different viscometer

Open Ended Project:

The practical work at masters must be largely consisting of OEP. In each case a sample set may be provided and the faculty member may be empowered to select appropriate problems for practical work. At the end of semester before submission of marks of PA and term work, the faculty member will upload the three best problems done by the students during the practical hours. The title area of project with practical problem along with the complete details and names of the students and name of the supervisor, branch and name of the college be specified so that this information can be published from GTU website.

Open Ended projects in Advanced Transport Processes may include

- Mathematical Modeling of simultaneous heat and momentum transfer situations such as shell and tube heat exchangers, plate and frame heat exchangers, reverse flow jet loop reactors, bubble columns etc.
- Design and fabrication of equipments for measurement of transport properties such as viscosity, thermal conductivity, diffusivity etc.
- Design calculations of complex problems using various softwares, such as spreadsheets, CHEMCAD, CFD, HYSIS, and ASPEN PLUS etc.

Major Equipments:

1. Hagen-Poisuille apparatus
2. Diffusion Co-efficient apparatus
3. Cooling tower
4. Bubble columns
5. Bubble cap, sieve tray distillation columns
6. Fluidized beds

7. Viscosity measurement (Efflux time) apparatus
8. Ostwald Viscometer
9. Multiphase flow
10. Thermal conductivity of metal rod

List of Open Source Software/learning website:

- NPTEL lecture series
- Literature available on momentum, heat and mass transfer
- MIT Open course lecture on Transport Processes