



GUJARAT TECHNOLOGICAL UNIVERSITY

Master of Engineering

Subject Code: 3723017

Semester – II

Subject Name: Advanced Transport Phenomena

Type of course: Core Course III

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 course focuses such typical situations and thereby its complete understanding on axial as well as radial profiles.

Teaching and Examination Scheme:

Teaching Scheme			Credits C	Examination Marks				Total Marks
L	T	P		Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	2	4	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs
1	Analogies in Momentum, Heat and Mass Transfer: Introduction, Reynolds analogy, Prandtl Taylor analogy, Van Karman analogy, Martinelli analogy, Chilton analogy.	09
2	Principles of Momentum Transport: Molecular and convective momentum transport, Molecular theory of viscosity in gases and liquids. Shell momentum balances and equation of changes: Navier-Stoke's equation and its applications, Velocity distributions in laminar flow, creeping flow around a sphere. Time dependent flow of laminar Newtonian fluids: Unsteady Laminar Flow between two parallel plates. Turbulent flow: Reynolds stress, Time-Smoothed Equations of Change for Incompressible Fluids and Velocity distributions, Boundary layer flow.	15
3	Principles of Energy Transport: Molecular and convective energy transport, Theory of thermal conductivity in solids, gases and liquids, Shell energy balances, Heat conduction with various heat sources, Equation of changes in non-isothermal systems and its applications to solve steady state forced and free convection and viscous heat generation problem, Unsteady state heat conduction, temperature distributions in laminar tube flow and laminar forced convection near heated flat plate. Temperature distributions in turbulent flow: time smoothed equation of changes and time smoothed temperature profile near wall. Temperature distribution in boundary layer.	15
4	Principles of Mass Transport: Molecular and convective mass transport, Theory of binary and multicomponent diffusion in gases and liquids, Shell mass balances and concentration distribution in laminar flow, diffusion in falling liquid film, diffusion in three component gas system, equation of changes for multicomponent systems, Use of the Equations of Changes to solve Simultaneous heat and mass transport and concentration profile in a tubular reactor principles of unsteady state diffusion.	15



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Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
7	14	14	14	14	7

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

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., Advanced Transport Phenomena, Cambridge University Press.

Course Outcomes: At the end of the course, the students will be able to

Sr. No.	CO statement	Marks % weightage
CO-1	Understand the mechanism of momentum, heat and mass transport for steady and unsteady flow.	20
CO-2	Perform momentum, energy and mass balances for a given system at macroscopic and microscopic scale.	25
CO-3	Solve the governing equations to obtain velocity, temperature and concentration profiles.	25
CO-4	Model the momentum, heat and mass transport under turbulent conditions.	15
CO-5	Develop analogies among momentum, energy and mass transport.	15

List of Experiments:

1. Hagen-Poiseuille 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 Efflux time for various fluids.
10. Determination of kinematic viscosity of mixture using different viscometer

Major Equipments:

1. Hagen-Poiseuille 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



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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