BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE- PILANI,
HYDERABAD CAMPUS
SECOND SEMESTER 2022-2023

Date: 12/01/2023

In addition to Part I (General Handout for all courses appended to the Time Table), this portion gives further specific details regarding the course.

Course No. **: CHE G552**
Course Title **: Advanced Transport Phenomena**
Instructor-in-Charge **: Dr. Balaji Krishnamurthy/Dr. Nandini Bandaru**

1. Scope & Objective

Transport phenomena is one of the basic subjects of chemical engineering and includes study of fluid dynamics, heat and mass transfer. The governing equations for the aforementioned transport processes are analogous in nature as the underlying molecular mechanisms are very closely related. The objective of this course is to cover advance topics in this area like the transport of momentum, heat and mass in turbulent flow, creeping flows, flow through porous media, flow over flat plates and curved surfaces, interphase transport, etc. A balanced overview and fundamental equations for transport processes would be provided along with illustrations regarding solving relevant problems. Further, some special cases which are frequently encountered would also be covered. The non-exam portion of the course will be for 40%. This will include projects, assignments and suprize quizzes.

2. Course Description: Viscosity, thermal conductivity and diffusivity, Shell momentum and energy balance, equations of change for isothermal and non-isothermal systems, Concentration distribution in solids and laminar flows, momentum, thermal and concentration boundary layers near walls, origin of turbulence, length scales in turbulent flows, Reynolds (RANS) equations, estimates of Reynolds stress (k-epsilon and k-omega type models), turbulent shear flow near a wall, turbulent flow in pipes and channels, turbulent heat transfer, Introduction to large eddy simulations models, rheology and material functions, non-Newtonian viscosity and generalized Newtonian models, Linear and non-linear visco-elasticity, radiation heat transfer, multi-component systems, Coupled heat and mass transfer, evaporation, boiling and condensation, chemical reactions, Special topics: Flow through porous media, compressible flows, multiphase flow, Transport phenomena in biochemical systems.

3. Text Books

1. Bird, Stewart and Lightfoot, 'Transport Phenomena', John Wiley & Sons, 2002, 2nd edition
2. Joel Plawsky, "Transport Phenomena Fundamentals", CRC Press, 2010, 2nd edition

4. Reference Books

1. L. Gary Leal, "Advanced Transport Phenomena", Cambridge University Press, 2007

2. Ronald G. Larson, “The structure and rheology of complex fluids”, Oxford University Press, USA, (1999)
3. Michael Rubinstein and Ralph H. Colby, “Polymer Physics”, Oxford University Press, Oxford, (2003)
4. William M. Deen, “Analysis of Transport Phenomena”, Oxford University Press, Indian Edition, 2008
5. John C. Slattery, “Advanced Transport Phenomena”, Cambridge University Press, 1999

5. Course Plan:

Lecture	Learning Objectives	Topics to be covered	Chapter
1-2	Review of Shell Momentum Balance Equations of change for isothermal systems	Shell Momentum Balances and Boundary Conditions, The Equations of Change in Terms of the Substantial Derivative, Use of the Equations of change to Solve Flow Problems	Ch. 1-3 (T1)
3-4	Review of Shell Energy balances, Equations of change for non-isothermal systems	Shell Energy Balances and boundary conditions, Free and forced convection, Use of the Equations of Change to Solve Steady-State Problems	Ch-9-11 (T1)
5-6	Review of Concentration Distributions in Solids and in Laminar Flow	Shell mass balances, Boundary conditions, Diffusion through a stagnant gas film, with a chemical reaction, Diffusion and chemical reaction inside a porous catalyst	Ch-18 (T1)
7-9	Convective Transport on a flat plate, Convective Transport over systems with curvature	Laminar hydrodynamic, thermal and mass transfer boundary layers, flow over cylinders, spheres, turbulent boundary layers	Ch 12-14 (T2)
10-12	Creeping Flow – Two-Dimensional and Axisymmetric Problems, Thin gap approximation-lubrication problem	Nondimensionalization and the Creeping-Flow Equations, Two-Dimensional Creeping Flows, Axisymmetric Creeping Flows, Basic Equations of Lubrication Theory	Ch 5-7 (R4)
13-15	Velocity Distributions in Turbulent Flow	Time-Smoothed Equations of Change for Incompressible Fluids, The Time-Smoothed Velocity Profile near a Wall, Empirical Expressions for the Turbulent Momentum Flux, Turbulent flow in pipes and channels, Eddy diffusivity models	Ch. 5 (T1) Ch 13 (R4)
15-17	Temperature distributions in Turbulent flow	Time-Smoothed Equations of Change for Incompressible Nonisothermal Flow, The Time-Smoothed Temperature Profile near a Wall, Empirical Expressions for the Turbulent Heat Flux,	Ch-13 (T1)

		Temperature Distribution for Turbulent Flow in Tubes and jets	
18-20	Equations of Change for Multicomponent Systems	Multicomponent equations of change, multicomponent fluxes, use of the equations of change for mixtures	Ch 19 (T1) Ch 11 (R4)
21-23	Concentration Distributions in Turbulent Flow	Time-smoothing of the equation of continuity, Enhancement of mass transfer by a first-order reaction in turbulent flow, Turbulent mixing and turbulent flow with second-order reaction	Ch 21 (T1)
24-26	Rheology of complex fluids, Linear and non-linear viscoelasticity Behavior of polymeric melts	Fundamentals of rheology, types of complex fluids, origins of Non-Newtonian behavior Non-Newtonian viscosity and generalized Newtonian models, elasticity and linear viscoelastic models, unentangled and entangled polymer melts	Ch 1, 3 (R2) Ch (R4)
27-29			Ch 8 (T1) Ch 8-9 (R3)
30-31	Coupled heat and mass transfer	Coupled diffusion and reaction, coupled heat and momentum transport	Ch 5 (T2)
32-35	Interphase transport in non-isothermal systems and mixtures	Heat Transfer Coefficients for Forced Convection, Free and Mixed Convection, Heat Transfer Coefficients for Condensation of Pure Vapors on Solid Surfaces, Definition of transfer coefficients in two phases, Effects of interfacial forces on heat and mass transfer	Ch 14, 22 (T1)
36-37	Energy transport by radiation	Absorption and emission at solid surfaces, Planck's distribution law, Wien's displacement law, and the Stefan-Boltzmann law, Radiation between non-black bodies at different temperatures	Ch 16 (T1) Ch 15 (T2)
38-39	Special topics: Flow through porous media, multiphase flow, Hydrodynamic Stability	Heat and mass transfer using extended surfaces, diffusion and reaction in catalyst pellets Multidimensional effects, potential functions and fields	Ch 8-9 (T2) Ch 12 (R1)

5. Evaluation Scheme:

S.No.	Component	Duration	Weightage	Date and Time	Nature of the Component
1	Mid	90 min	25%	15/03 2.00-3.30PM	CB
2	Projects		20%		OB
3	Surprise quizzes		10%		OB
4	Comprehensive	3 h	35%	13/05 FN	CB - 10% OB - 30%

6. Chamber Consultation Hour: To be announced in the class.

7. Notices: All notices concerning this course will be uploaded on Moodle.

8. Make-up Policy: Make-up is granted only for genuine cases with valid justification and prior permission of Instructor-in-charge.

9.Academic Honesty and Integrity Policy: Academic honesty and integrity are to be maintained by all the students throughout the semester and no type of academic dishonesty is acceptable

Instruction-in-Charge
CHE G552