Birla Institute of Technology & Science, Pilani
Hyderabad Campus

SECOND SEMESTER 2023-2024
Course Handout Part II

20-12-2023

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	:	**Advance Transport Phenomena**
Instructor-in-Charge	:	**Dr. Nandini Bhandaru**

Scope and Objective of the Course:

Transport phenomena is one of the basic subjects of chemical engineering and includes the 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 advanced 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 will also be covered.

Textbooks:

T1. Bird, Stewart and Lightfoot, ‘Transport Phenomena’, John Wiley & Sons, 2002, 2nd edition.

T2. Joel Plawsky, “Transport Phenomena Fundamentals”, CRC Press, 2010, 2nd edition.

T3. William M. Deen, “Analysis of Transport Phenomena”, Oxford University Press, Indian Edition, 2008.

Reference books

R1. L. Gary Leal, “Advanced Transport Phenomena”, Cambridge University Press, 2007.

R2. Ronald G. Larson, “The structure and rheology of complex fluids”, Oxford University Press, USA, 1999.

R3. Michael Rubinstein and Ralph H. Colby, “Polymer Physics”, Oxford University Press, Oxford, 2003.

R4. John C. Slattery, “Advanced Transport Phenomena”, Cambridge University Press, 1999.

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Course Plan:

Lecture No.	Learning Objectives	Topics to be covered	Chapter in the Text Book
1-2	Review of Shell Momentum balances, 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 (T3)
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 (T3)
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, Temperature Distribution for Turbulent Flow in Tubes and jets	Ch-13 (T1)
18-20	Equations of Change for	Multicomponent equations of	Ch 19 (T1)

	Multicomponent Systems	change, multicomponent fluxes, use of the equations of change for mixtures	Ch 11 (T3)
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	Fundamentals of rheology, types of complex fluids, origins of Non-Newtonian behavior Non-Newtonian viscosity and generalized Newtonian models,	Ch 8 (T1) Ch 1, 3 (R2)
27-29	Behavior of polymeric melts	elasticity and linear viscoelastic models, unentangled and entangled polymer melts	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,	Ch 14, 22 (T1)
36-37	Energy transport by radiation	Definition of transfer coefficients in two phases, Effects of interfacial forces on heat and mass transfer 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)

Evaluation Scheme:

Component	Duration	Weightage (%)	Date & Time	Nature of Component
Midsem Test	90 min	25		CB
Surprise quizzes (min 5)	TBA	15		OB
Assignment/ Seminar	TBA	10		OB
Project	TBA	15		OB
Comprehensive Exam	3 hours	35		OB (15%)/CB (20%)

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

Notices: To be posted on CMS.

Make-up Policy: Granted for genuine cases only with valid justification and proof. *Prior permission of IC is compulsory.*

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.

Nandini Bhandaru
INSTRUCTOR-IN-CHARGE
CHE G552

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