Teaching Scheme and Syllabus

For

Bachelor of Technology

In

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Minor in Chemical Engineering

Department of Chemical Engineering

Sardar Vallabhbhai National Institute of Technology

Minor in Chemical Engineering

Sr. No.	Semester	Subject	Code	Scheme	Credit	Notional hours of Learning (Approx.)
1.	IV	FLUID AND PARTICLE MECHANICS	CH210	3-1-0	4	60
2.	V	HEAT TRANSFER OPERATIONS	CH211	3-1-0	4	60
3.	VI	MASS TRANSFER OPERATIONS	CH212	3-1-0	4	60
4.	VII	CHEMICAL REACTION ENGINEERING	CH213	3-1-0	4	60
5.	VII	MINI PROJECT	CH214	0-0-4	2	60

Subject Code: CH210

L	T	P	C
3	1	0	4

1. Course Outcomes:

At the end of the course, the students will be able to

CO1	Predict the velocity profile and flow behaviour in various types of systems.
CO2	Calculate pressure loss and power requirement in different types of flow systems.
CO3	Compare and select appropriate types of fluid moving machineries for fluid transport.
CO4	Analyze and estimate the effects of different types of forces on fluid particle interactions in unit operations.
CO5	Predict behavior of fluid solid system based on the process variables.
CO6	Calculate efficiency and the size of the unit operations based on the desirable performance.

2. Syllabus:

INTRODUCTION	**(02 Hours)**
Definition of Unit Operations, Definition and basic concepts of fluid, Properties of fluids, Stress, Deformation, Dimensional analysis, Overview of different operations practiced in industry, some real Industrial examples.	
FLUID STATICS AND ITS APPLICATIONS	**(04 Hours)**
Nature of fluids: Incompressible and compressible fluids, Pressure concepts, Hydrostatic equilibrium in gravitational and centrifugal field, Manometers, Inclined manometer, Continuous gravity decanter and centrifugal decanter.	
BASIC EQUATIONS OF FLUID FLOW AND THEIR APPLICATIONS	**(06 Hours)**
Stream line and stream tubes, Average velocity, Mass velocity, Continuity equation, Momentum balance, Navier-Stokes equations, Bernoulli's equation.	
FLUID FLOW MEASUREMENTS	**(03 Hours)**
Fluid flow measurement: Venturi meter, Orifice meter, Rotameter, Pitot tubes, etc.	
FLUID MOVING MACHINERIES	**(05 Hours)**
Transportation and metering of fluids, Pipe, fitting and valves, Construction, working and characteristic features of various types of pumps, compressors, blowers and fans.	
PARTICLE CHARACTERIZATION	**(04 Hours)**
Particle size measurements, Describing the Size & shape of a Single Particle, Description of Populations of Particles, Conversion between Distributions, Bulk properties measurement, characterization of powder flowability & powder compaction, Sieving and other methods of size measurements: Sieve analysis.	
SIZE REDUCTION	**(03 Hours)**
Size reduction of solids, Mechanism of size reduction, Energy for size reduction, Laws of Crushers, Model Predicting Energy Requirement and Product Size Distribution, Types & Classification of size reduction equipment, Types of Milling Circuit: Open and closed-circuit grinding.	

FLUID FLOW THROUGH A PACKED BED OF PARTICLES & THEORY OF FILTRATION	**(06 Hours)**
Estimation of packed bed parameters, Prediction of pressure drop using Kozeny-Carman Equation, Ergun's equation.	
FLUIDIZATION OF SOLIDS	**(05 Hours)**
Estimation of fluidized bed parameters, Prediction of pressure drop and minimum fluidization velocity using Ergun's equation, Geldart's powder classification. Types of fluidization.	
PHYSICAL SEPARATORS	**(07 Hours)**
Filters, Cyclones, Electrostatic Precipitator, Fabric filters, Centrifugal Separators.	
Tutorial problems based on the topics covered during the theory classes.	**(15 Hours)**
(Total Contact Time: 45 Hours + 15 Hours = 60 Hours)	

3. Books Recommended:

1.	White F. M., "Fluid Mechanics",7th Ed., McGraw Hill, 2011.
2.	McCabe W.L., Smith J.C., Harriott P., "Unit Operations of Chemical Engineering", 6th & 7th Eds., McGraw-Hill, New York, 2001 & 2005.
3.	Coulson J.M., Richardson J.F., "Chemical Engineering", Vol. 2, 5th Ed., Elsevier, New Delhi, 2002.
4.	Martin Rhodes, "Introduction to Particle Technology", 2nd Edition, John Wiley & Sons, 2008.
5.	Batchelor G. K., An Introduction to Fluid Dynamics, Cambridge Univ Press, 1967.

Subject Code: CH211

L	T	P	C
3	1	0	4

1. **Course Outcomes:**

At the end of the course, the students will be able to

CO1	Explain conduction, convection and radiation principles and applications.
CO2	Mathematically model heat transfer problems
CO3	Estimate heat transfer coefficient for convection.
CO4	Identify the type of heat transfer model that needs to be applied.
CO5	Analyze the performance of heat exchangers.
CO6	Select evaporator for industrial applications.

2. **Syllabus:**

INTRODUCTION	**(02 Hours)**
Modes of heat transfer: conduction, convection and radiation, Mechanism and applications.	
CONDUCTION	**(06 Hours)**
General conduction equation in Cartesian coordinate, Steady state conduction through Plane, Cylindrical and Spherical walls, Steady state conduction with heat generation, Transient heat conduction and Lumped heat capacity analysis.	
EXTENDED SURFACES	**(04 Hours)**
Different types of fins, Temperature profile and heat transfer of fins, effectiveness and fin efficiency.	
FORCED CONVECTION	**(08 Hours)**
Hydrodynamic and thermal and boundary layer, Internal and external forced convection in laminar and turbulent flow, Flow in circular and non-circular tubes, Cylinder in cross flow, Flow across banks of tubes, Convection correlations.	
NATURAL CONVECTION	**(04 Hours)**
Physical considerations, Laminar and turbulent free convection on a vertical surface, Empirical correlations, Free convection within parallel plate channels and encloser, Combined free and forced convection.	
BOILING AND CONDENSATION	**(06 Hours)**
Boiling modes, Pool boiling, Pool boiling correlation, Forced convection boiling, Laminar and turbulent film condensation on a vertical surface, Film condensation of radial systems, Condensation in horizontal tubes, Dropwise condensation.	
HEAT EXCHANGERS	**(06 Hours)**
Heat Exchanger Types: Double pipe heat exchanger, Shell-and-tube heat exchanger, Spiral and Plate heat exchanger, Extended surface heat exchanger and Compact heat exchanger, Overall heat transfer coefficient, Heat exchanger analysis: LMTD Method and Effectiveness-NTU method, LMTD correction factor, Fouling factor, Heat exchanger design and performance calculations.	

EVAPORATION AND CRYSTALIZATION	(05 Hours)
Different types of evaporators, Single effect and Multi-effect evaporators, Material and Heat balance in single and multi-effect evaporators. Equilibrium in crystallization, operation and equipment.	
RADIATION	**(04 Hours)**
Fundamental concepts, Radiation heat fluxes, Blackbody radiation, Emission from real surfaces, Absorption, reflection, and transmission by real surfaces, Kirchhoff's law, View factor, Blackbody radiation exchange, Radiation exchange between opaque, diffuse, gray surfaces in an enclosure.	
Tutorial problems based on the topics covered during the theory classes.	**(15 Hours)**
(Total Contact Time: 45 Hours + 15 Hours = 60 Hours)	

3. Books Recommended:

1.	Hollman, J. P., Heat Transfer – Basic Approach, 10th Edition, McGraw-Hill Pub., 2010.
2.	Incropera, F.P., DeWitt, D.P., Bergman T.L., Lavine A.S., Incropera's Principles of Heat and Mass Transfer, Global Edition, Wiley India Edition, 2019.
3.	Geankoplis C. J., Transport Processes and Separation Process Principles, Pearson, 4th Edition 2012.
4.	Suryanarayana, N. V., Engineering Heat Transfer, 2nd Edition, Penram International Publishing (I) Private Ltd., Mumbai, 2015.
5.	Kern, D. Q., Process Heat Transfer, McGraw-Hill Int. Edition, New York, 1997.

Subject Code: CH212

L	T	P	C
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1. Course Outcomes:

CO1	Explain the scope of mass transfer operations in chemical industries.
CO2	Determine diffusivity and flux for compounds present in gas and liquid systems.
CO3	Analyze the mechanism of mass transfer in various systems related to chemical engineering and estimate the mass transfer coefficient.
CO4	Estimate the number of stages using graphical methods for distillation.
CO5	Estimate the number of stages using graphical and analytical methods for absorption and adsorption.

2. Syllabus:

INTRODUCTION	**(02 Hours)**
Introduction to Mass Transfer Operation: Classification & method.	
DIFFUSION AND MASS TRANSFER	**(06 Hours)**
Molecular diffusion in fluids, Steady state diffusion (both gases & liquids), Diffusivity of liquids & gases.	
MASS TRANFER COEFFICIENTS	**(06 Hours)**
Mass Transfer co-efficient in laminar & turbulent flow, Mass, Heat and Momentum Transfer analogies.	
INTER PHASE MASS TRANSFER	**(06 Hours)**
Equilibrium, Diffusion between phases, Material balance, Stages and efficiency.	
EQUIPMENT FOR GAS-LIQUID OPERATIONS	**(02 Hours)**
Sparged and agitated vessels, Venturi scrubber, Wetted wall towers, Tray and packed towers, Mass transfer coefficients for packed towers, Hydrodynamic considerations.	
DISTILLATION	**(12 Hours)**
VLE data, Flash, differential and continuous distillation, McCabe-Thiele and Ponchon-Savarit method, Distillation in a packed column, Azeotropic and Extractive distillation.	
ABSORPTION	**(06 Hours)**
Equilibrium, Material balance for single component transfer, Multi-stage and packed tower operation, Graphical and analytical methods for tray/stage determination, Non-isothermal operation.	
ADSORPTION	**(05 Hours)**
Adsorption equilibria, Stage-wise and continuous operations, Graphical and analytical methods for tray/ stage determination, Equipments for adsorption.	

Tutorial problems based on the topics covered during the theory classes.	(15 Hours)
	(Total Contact Time: 45 Hours + 15 Hours = 60 Hours)

3. Bools Recommended:

1.	Treybal R.E., “Mass Transfer Operations”, 3rd Ed., McGraw-Hill, Singapore, 2017.
2.	Dutta, B. K., “Principles of Mass Transfer and Separation Process” PHI Learning Pvt Ltd., New Delhi, 2006.
3.	McCabe W.L., Smith J.C., Harriott P., "Unit Operations of Chemical Engineering", 7th Eds., McGraw-Hill, New York, 2022.
4.	Coulson J.M., Richardson J.F., Chhabra R. P., Shankar V., “Coulson and Richardson’s Chemical Engineering: Heat and Mass Transfer: Fundamentals and Applications”, Vol. 1B, 7th Ed., IChemE, Butterworth-Heinemann, 2017.
5.	Foust, A. S., Wenzel, A. L., Clump, C. W., Maus, L., Andersen, L. B. “Principles of Unit Operations”, 2nd Ed., John Wiley & Sons, Singapore, 2008.

Subject Code: CH213

L	T	P	C
3	1	0	4

1. Course Outcomes:

CO1	Discuss the kinetics of homogeneous reactions and applications.
CO2	Solve kinetics, constant volume, and variable volume batch reactor problems.
CO3	Analyze the performance of CSTR and PFR.
CO4	Estimate heat of reaction from thermodynamics and product distribution.
CO5	Illustrate advanced concepts in heterogeneous catalysis.
CO6	Correlate safe operations with process catalyst systems.

2. Syllabus:

INTRODUCTION	**(02 Hours)**
Chemical kinetics, Classification of reactions, Variables affecting the rate of reaction, Reaction rate.	
KINETICS OF HOMOGENEOUS REACTIONS	**(06 Hours)**
Concentration dependent term and temperature dependent terms of rate equation, Single and multiple reactions, Elementary and non-elementary reactions, Molecularity and order of reaction, Rate constant, Representation of reaction rate, Kinetic models, Temperature dependency from Arrhenius' law, Thermodynamics, Various theories, Activation energy, Searching for the reaction mechanism.	
INTERPRETATION OF BATCH REACTOR DATA	**(10 Hours)**
Constant volume batch reactor, Variable volume batch reactor, Integral method and differential method of analysis of kinetic data, Temperature and reaction rate.	
INTRODUCTION TO REACTOR DESIGN	**(03 Hours)**
Types of reactors, PFR, CSTR etc., Material & energy balances single ideal reactor, Space time and space-velocity, Holding time, Introduction of non-ideal flow .	
TEMPERATURE & PRESSURE EFFECTS	**(05 Hours)**
Single & multiple reactions, Heats of reaction from thermodynamics, Product distribution.	
CATALYTIC REACTORS	**(10 Hours)**
Kinetics, External and internal diffusional resistances, Effects of heat generation/absorption, Effectiveness factors, Fixed bed, Fluid bed, Trickle bed, Slurry reactors, LHHW models, Method of initial rates.	
CATALYSIS, ZEOLITE CATALYSIS, ENVIRONMENTAL CATALYSIS	**(09 Hours)**
Typical catalysts used in chemical processes, Catalyst characterizations, Catalyst deactivation and regeneration, Temperature progression, Moving bed reactors, Metal recovery from the spent catalysts, Nano catalysis, Synthesis, Applications in refining and petrochemical processes, Rise of acidity, Modifications, Shape selectivity.	

Tutorial problems based on the topics covered during the theory classes.	**(15 Hours)**
(Total Contact Time: 45 Hours + 15 Hours = 60 Hours)	

3. Books Recommended:

1.	Fogler H.S., "Elements of Chemical Reaction Engineering", 4th Ed., Prentice Hall, NJ, 2006.
2.	Levenspiel O., "Chemical Reaction Engineering", 3rd Ed., John Wiley & Sons, Singapore, 1999.
3.	Smith J. M., "Chemical Engineering Kinetics", 3rd Ed., McGraw Hill, N Y, 1981.
4.	Davis M.E., Davis R.J., "Fundamentals of Chemical Reaction Engineering", McGraw-Hill, New York,2003.
5.	Froment G.F., Bischoff K.B., "Chemical Reactor Analysis and Design", 2nd Ed., John Wiley & Sons, Singapore, 1990.