Department of Chemical Engineering

Birla Institute of Technology, Mesra, Ranchi - 835215 (India)

Institute Vision

To become a Globally Recognized Academic Institution in consonance with the social, economic and ecological environment, striving continuously for excellence in education, research and technological service to the National needs.

Institute Mission

- To educate students at Undergraduate, Post Graduate Doctoral and Post-Doctoral levels to perform challenging engineering and managerial jobs in industry.
- To provide excellent research and development facilities to take up Ph.D. programmes and research projects.
- To develop effective teaching and learning skills and state of art research potential of the faculty.
- To build national capabilities in technology, education and research in emerging areas.
- To provide excellent technological services to satisfy the requirements of the industry and overall academic needs of society.

Department Vision

To be a centre of excellence for the provision of effective teaching/learning, skill development and research in the areas of chemical engineering and allied areas through the application of chemical engineering principles.

Department Mission

1) To educate and prepare graduate engineers with critical thinking skills in the areas of chemical engineering & polymer science and engineering, who will be the leaders in industry, academia and administrative services both at national and international levels.

2) To inculcate a fundamental knowledge base in undergraduate students which enable them to carry out post-graduate study, do innovative interdisciplinary doctoral research and to be engaged in long-life learning.

3) To train students in addressing the challenges in chemical, petrochemical, polymer and allied industries by developing sustainable and eco-friendly technologies.

Program Educational Objectives (PEO) for BE- Chemical Engineering

1. To understand and apply working knowledge of chemical engineering principles in independent research and development
2. To implement the inter-perceptional skills of individuals in technical profession
3. To update technical know-how by self- learning besides learning a great deal by associating with professional bodies and alumni
4. To develop an ability to succeed in the graduate competitive examinations and pursue higher studies in chemical engineering or lateral disciplines

Program Outcomes (PO)

Engineering Graduates will be able to:

1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

2. Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

Programme Specific Objectives

PSO 1

To develop students' understanding of the core scientific, mathematical and engineering principles conceive and design processes to produce, transform and transport materials (chemical products) — beginning with experimentation in the laboratory and followed by implementation of technologies in full-scale production.

PSO 2

To prepare students for professional work in development, design, modelling, simulation, optimization and operation of chemical products and processes.

PSO 3

With due emphasis on interdisciplinary and industrial collaboration, students are prepared for employment in such industries as chemical, petroleum, electrochemical, biochemical, semiconductor, nuclear, aerospace, plastics, food processing, environmental control etc.

PSO 4

Prepare students with high scholastic attainment to enter graduate programs leading to advanced degrees in chemical engineering or in related professional, scientific, and engineering fields.

COURSE INFORMATION SHEET: CL 201 Thermodynamics

Course code	CL201
Course title	Thermodynamics
Pre-requisite(s)	
Co- requisite(s)	
Credits	L: 3 T: 1 P: 0
Class schedule per week	4
Class	B. Tech.
Semester / Level	III / Second
Branch	Chemical Engineering
Name of Teacher	

Course Objectives

This course enables the students:

1.	To apply knowledge of the laws of thermodynamics to solve physical and chemical problems encountered in chemical and biochemical industries.
2.	To analyze and interpret data, to identify, formulate, and solve engineering problems.
3.	To use the techniques, skills, and modern engineering tools necessary for engineering practice.

Course Outcomes

After the completion of this course, students will be able to:

CO201.1	***Apply*** the laws of thermodynamics on closed and open systems.
CO201.2	***Evaluate*** the properties of real gases.
CO201.3	***Solve*** problems involving various thermodynamic cycles.
CO201.4	***Evaluate*** the thermodynamic properties (Such as Partial molar properties, Fugacity coefficients, activity coefficients etc.) of pure fluid and fluid mixtures.
C0201.5	***Predict*** equilibrium composition of mixtures under phase and chemical-reaction equilibria.

Syllabus

Module 1: Introduction and Basic Concepts
First law of thermodynamics, Energy balance for closed systems, Mass and Energy balances for open systems, Volumetric properties of pure fluids, Virial equations of state, Cubic equations of state, Theorem of corresponding states, Acentric factor, generalized correlations for gases and liquids, Statements of the second law, Heat engines, Carnot cycle, Refrigerator and Heat pump, Third law of thermodynamics, Microscopic interpretation of entropy. [8L]

Module 2: Thermodynamic Relations and Thermodynamic Properties of Fluids
Euler relation, Gibbs-Duhem relation, Legendre transformation, Helmholtz free energy, Gibbs free energy, Maxwell relations, Gibbs energy as a generating function, Joule-Kelvin Effect, Bridgman table,

Clausius/Clapeyron equation, Antoine equation, Residual properties, Thermodynamic properties of real gases using tables and diagrams: Edmister chart, Lee-Kesler data. [8L]

Module 3: Vapor-Liquid Equilibrium in Mixtures
Introduction to Vapor-Liquid Equilibrium, Vapor-Liquid Equilibrium in ideal mixtures, Dew point and bubble point temperatures/Pressures, VLE from K-value correlations (Flash calculations), Low-Pressure Vapor-Liquid equilibrium in non-ideal mixtures, EOS, SRK. [8L]

Module 4: Thermodynamics of Multicomponent Mixtures
Fundamental Property Relation, The Chemical Potential and Phase Equilibria, Partial Properties, The Ideal-Gas Mixture Model, Fugacity and Fugacity Coefficient (Pure Species and Species in Solution), The Ideal-Solution Model, Excess Properties, The Excess Gibbs Energy and the Activity Coefficient, Models for the Excess Gibbs Energy (Margules equation, Redlich-Kister equation, van Laar equation, Wilson equation, NRTL model and UNIQUAC equation) SRK, PR. [8L]

Module 5: Chemical Reaction Equilibria
The reaction coordinate, Application of Equilibrium Criteria to Chemical Reactions, The standard Gibbs Energy Change and the Equilibrium Constant, Effect of Temperature on the Equilibrium Constant, Evaluation of Equilibrium Constants, Relation of equilibrium constants to composition, Equilibrium Conversions for single Reactions, Phase Rule and Duhem's Theorem for Reacting Systems, Multi-reaction equilibria. [8L]

Text books:

1. Introduction to Chemical Engineering Thermodynamics: J.M. Smith, H.C. Van ness, and M.M. Abbot. 7th Edition, McGraw-Hill's Chemical Engineering Series.
2. Chemical, Biochemical and Engineering Thermodynamics: Stanley I. Sandler. Fourth Edition, John Wiley & Sons, Inc.
3. Chemical Engineering Thermodynamics: Y V C Rao, University Press.

Reference books:

1. Molecular Thermodynamics of Fluid-Phase Equilibria: J.M. Prausnitz, R.N. Lichtenthaler, E G de Azevedo. 3rd Edition, Prentice Hall International Series in the Physical and Chemical Engineering Sciences.
2. Engineering and Chemical Thermodynamics: Milo D. Koretsky. 2nd Edition, John Wiley & Sons, Inc.
3. Using Aspen Plus in Thermodynamics Instruction: Stanley I. Sandler, John Wiley & Sons, Inc.

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

Introduction to molecular/statistical thermodynamics.

POs met through Topics beyond syllabus/Advanced topics/Design
PO2, PO3 and PO4

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
End Sem Examination Marks	50
Quiz	10+10
Teachers Assessment	5

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination Marks	Y	Y	Y	N	N
End Sem Examination Marks	Y	Y	Y	Y	Y
Quiz	Y	Y	Y	Y	Y

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												PSOs			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
1	3	3	3	2	2	2	2	0	1	2	0	3	3	3	3	3
2	3	2	1	2	3	0	1	0	1	2	0	3	3	3	3	3
3	3	1	1	1	1	0	0	0	1	1	0	1	3	3	3	3
4	3	3	2	2	3	1	2	0	1	2	0	3	3	3	3	3
5	3	3	1	2	3	2	2	0	1	2	0	3	3	3	3	3

3= High, 2 = Medium, 1 = Low

Mapping Between COs and Course Delivery (CD) methods		
CD	**Course Delivery methods**	**Course Outcome**
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, CO2, CO3, CO4, CO5
CD2	Tutorials/Assignments	CO1, CO2, CO3, CO4, CO5
CD3	Seminars	
CD4	Mini projects/Projects	CO2, CO3, CO5
CD5	Laboratory experiments/teaching aids	
CD6	Industrial/guest lectures	
CD7	Industrial visits/in-plant training	
CD8	Self- learning such as use of NPTEL materials and internets	CO1, CO2, CO3, CO4, CO5
CD9	Simulation	

Lecture wise Lesson Planning Details.

Week No.	Lect. No.	Tentative Date	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Actual Content covered	Methodology used	Remarks by faculty if any
1	1			First Law of thermodynamics, Mass/Energy balance for open/closed systems	TX1, TX2, TX3	CO1			
	2			Volumertric properties of fluids, Virial EOS	TX1, TX2, TX3	CO2			
	3			Cubic EOS, Theorem corresponding states, Acentric factor, correlation for gases-liquids	TX1, TX2, TX3	CO2			
	4			Solve numerical problems based on L1 to L3	TX1, TX2, TX3				
2	5			Second law of TD, heat engines	TX1, TX2, TX3	CO1, CO3			
	6			carnot cycle, refrigeration, heat pump	TX1, TX2, TX3	CO3			
	7			Third law of TD, Microscopic interpretation of entropy	TX1, TX2, TX3	CO1			
	8			Solve numerical problems based on L4 to L6	TX1, TX2, TX3				
3	9			Euler relation, Gibbs-Duhem relation, Legendre transformation	TX1, TX2, TX3	CO4			
	10			Helmholtz free energy, Gibbs free energy, Maxwell relations, Gibbs energy as a generating function	TX1, TX2, TX3	CO4			
	11			Joule-Kelvin Effect, Bridgman table	TX1, TX2, TX3	CO4			
	12			Solve numerical problems based on L7 to L9					
4	13			Clausius/Clapeyron equation, Antoine equation.	TX1, TX2, TX3	CO4			
	14			Residual properties	TX1, TX2, TX3	CO4			
	15			Thermodynamic properties of real gases using tables and diagrams: Edmister chart, Lee-Kesler data	TX1, TX2, TX3	CO4			
	16			Solve numerical problems based on L10 to L12					
5	17			Introduction to VLE	TX1, TX2, TX3	CO4,			

						CO5			
	18			VLE in ideal mixtures	TX1, TX2, TX3	CO4, CO5			
	19			Dew point and bubble point temperatures/Pressures, VLE from K-value correlations	TX1, TX2, TX3	CO4, CO5			
	20			Solve numerical problems based on L13 to L15					
6	21			Flash calculations	TX1, TX2, TX3	CO4, CO5			
	22			Flash Calculations	TX1, TX2, TX3	CO4, CO5			
	23			Low-Pressure VLE in non-ideal mixtures.	TX1, TX2, TX3	CO4, CO5			
	24			Solve numerical problems based on L16 to L18					
7	25			Fundamental Property Relation, The Chemical Potential and Phase Equilibria	TX1, TX2, TX3	CO4			
	26			Partial Properties, The Ideal-Gas Mixture Model	TX1, TX2, TX3	CO4			
	27			Fugacity and Fugacity Coefficient (Pure Species and Species in Solution)	TX1, TX2, TX3	CO4			
	28			Solve numerical problems based on L19 to L21					
8	29			The Ideal-Solution Model, Excess Properties, The Excess Gibbs Energy , Activity Coefficient	TX1, TX2, TX3	CO4			
	30			Models for the Excess Gibbs Energy (Margules equation, Redlich-Kister equation,	TX1, TX2, TX3	CO4			
	31			van Laar equation, Wilson equation, NRTL model and UNIQUAC equation).	TX1, TX2, TX3	CO4			
	32			Solve numerical problems based on L22 to L24					
9	33			The reaction coordinate, Application of Equilibrium Criteria to Chemical Reactions	TX1, TX2, TX3	CO5			
	34			The standard Gibbs Energy Change and the Equilibrium Constant	TX1, TX2, TX3	CO5			
	35			Effect of Temperature on the Equilibrium	TX1, TX2, TX3	CO5			

				Constant, Evaluation of Equilibrium Constants					
	36			Solve numerical problems based on L25 to L27					
10	37			Relation of equilibrium constants to composition, Equilibrium Conversions for single Reactions	TX1, TX2, TX3	CO5			
	38			Phase Rule and Duhem's Theorem for Reacting Systems	TX1, TX2, TX3	CO5			
	39			Multi-reaction equilibria.	TX1, TX2, TX3	CO5			
	40			Solve numerical problems based on L28 to L30					

COURSE INFORMATION SHEET: CL 203 Fluid Mechanics

Course code: CL203
Course title: Fluid Mechanics
Pre-requisite(s):
Co- requisite(s):
Credits: L: 3 T:0 P: 0
Class schedule per week: 03
Class: B. Tech
Semester / Level: III / Second
Branch: Chemical
Course Objectives

This course enables the students:

1.	To develop an appreciation for the properties of Newtonian fluids.
2.	To apply concepts of mass and momentum conservation to fluid flows and analytically solve a variety of simplified problems.
3.	To understand the dynamics of fluid flows and the governing non-dimensional parameters.

Course Outcomes
After the completion of this course, students will be able to:

CO203.1	Describe fluid pressure, its measurement and calculate forces on submerged bodies.
CO203.2	Understand the flow visualization, boundary layer and momentum correction factor, state the Newton's law of viscosity and Reynolds number. Analyze fluid flow problems with the application of the continuity and momentum equation.
CO203.3	Examine energy losses in pipe transitions and evaluate pressure drop in pipe flow using Hagen-Poiseuille's equation and Bernoulli's principle for laminar flow.
CO2034	Understand the concept of drag, lift, streamlining, equivalent diameter, sphericity, determine minimum fluidization velocity in fluidized bed and Compute pressure drop in fixed bed, packed bed and fluidized system.
CO203.5	Analyze the general equation for internal flow meters and Determine and analyze the performance aspects of fluid machinery.

Syllabus:

Module 1:

Fluid Statics: Basic equation of fluid statics; pressure variation in a static field; pressure measuring devices–manometer, U-tube, inclined tube, well, diaphragm, hydraulic systems – force on submerged bodies (straight, inclined), pressure centre. **[8L]**

Module 2:

Fluid flow phenomena: Fluid as a continuum, Terminologies of fluid flow, velocity – local, average, maximum, flow rate – mass, volumetric, velocity field; dimensionality of flow; flow visualization – streamline, path line, streak line, stress field; viscosity; Newtonian fluid; Non-Newtonian fluid; Reynolds number-its significance, laminar, transition and turbulent flows: Prandtl boundary layer, compressible and incompressible. Momentum equation for integral control volume, momentum correction factor. **[8L]**

Module 3:

Internal incompressible viscous flow: Introduction; flow of incompressible fluid in circular pipe; laminar flow for Newtonian fluid; Hagen-Poiseullie equation; flow of Non-Newtonian fluid, introduction to turbulent flow in a pipe; energy consideration in pipe flow, relation between average and maximum velocity, Bernoulli's equation–kinetic energy correction factor; head loss; friction factor; major and minor losses, Pipe fittings and valves. **[8L]**

Module 4:

Flow past of immersed bodies: Introduction; concept of drag and lift; variation of drag coefficient with Reynolds number; streamlining; packed bed; concept of equivalent diameter and sphericity; Ergun equation, Fluidization: Introduction; different types of fluidization; fluidized bed assembly; governing equation; industrial use. Agitation and mixing of liquids: agitated vessel, blending & mixing, suspension of solid particles. Dispersion operation. Turbine Design/scale up, Flow number, Power Requirement. **[8L]**

Module 5:

Flow measurement: Introduction; general equation for internal flow meters; Orifice meter; Venturimeter; concept of area meters: rotameter; Local velocity measurement: Pitot tube. Fluid moving machines: Introduction; Basic classification of pumps, Mechanical pump: Centrifugal and Positive displacement pumps (rotary, piston, plunger, diaphragm pumps); pump specification; basic characteristics curves for centrifugal pumps; fan, blower and compressor. **[8L]**

Text books:

1. McCabe, W.L., Smith J.C., and Harriot, P., "Unit Operations in Chemical Engineering", McGraw-Hill, Inc.

2. Coulson, J.M. and Richardson, J.F., "Chemical Engineering, Volume I", Pergamon Press.

3. Geankoplis, C.J., "Transport Processes and Unit Operations", Prentice-Hall Inc.

Reference books:

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
End Sem Examination Marks	50
Quiz	10+10
Teachers Assessment	5

Assessment Components	CO1	CO2	CO3	CO4	CO5	CO6	CO7	CO8
Mid Sem Examination Marks	Y	Y	Y	Y				
End Sem Examination Marks	Y	Y	Y	Y	Y	Y	Y	Y
Quiz	Y	Y	Y	Y	Y	Y	Y	Y

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												PSOs			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
1	3	3	2	2	2	2	2	2	3	3	1	2	3	3	2	2
2	3	3	2	2	2	2	2	2	3	3	1	2	3	3	2	2
3	3	3	2	2	2	2	2	2	3	3	1	2	3	3	2	2
4	3	3	3	2	2	2	2	2	3	3	1	2	3	3	2	2
5	3	3	3	2	2	2	2	2	3	3	1	2	3	3	2	2

3= High, 2 = Medium, 1 = Low

Mapping Between COs and Course Delivery (CD) methods		
CD	**Course Delivery methods**	**Course Outcome**
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, CO2, CO3, CO4, CO5, CO6, CO7, CO8
CD2	Tutorials/Assignments	CO1, CO2, CO3, CO4, CO5, CO6, CO7, CO8
CD3	Seminars	
CD4	Mini projects/Projects	
CD5	Laboratory experiments/teaching aids	
CD6	Industrial/guest lectures	
CD7	Industrial visits/in-plant training	
CD8	Self- learning such as use of NPTEL materials and internets	CO1, CO2, CO3, CO4, CO5, CO6, CO7, CO8
CD9	Simulation	

Lecture wise Lesson planning Details.

Week No.	Lect. No.	Tentative Date	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Actual Content covered	Methodology used	Remarks by faculty if any
	L1			Fluid Statics: Basic equation of fluid statics;	T1	1,2		PPT Digi Class/Chalk -Board	
	L2			pressure variation in a static field;	T1	1,2		PPT Digi Class/Chalk -Board	
	L3			pressure measuring devices-manometer, U-tube, inclined tube, well, diaphragm,	T1	1,2		PPT Digi Class/Chalk -Board	
	L4			, hydraulic systems – force on submerged bodies (straight, inclined),pressure centre.	T1	1,2		PPT Digi Class/Chalk -Board	
	L6			Fluid flow phenomena: Fluid as a continuum	T1	1,2		PPT Digi Class/Chalk -Board	
	L7			Terminologies of fluid flow, velocity – local, average, maximum, flow rate – mass, volumetric, velocity field; dimensionality of flow	T1	1,2		PPT Digi Class/Chalk -Board	
	L8			flow visualization – streamline, path line, streak line,	T1	1,2		PPT Digi Class/Chalk -Board	
	L9-11			Newtonian fluid; Non-Newtonian fluid; Reynolds number-its significance, laminar, transition and turbulent flows: Prandtl boundary layer,	T1	1,2,3		PPT Digi Class/Chalk -Board	

	L12 -14			compressible and incompressible. Momentum equation for integral control volume, momentum correction factor.	T1	1,2,3		PPT Digi Class/Chalk -Board	
	L15 -17			Internal incompressible viscous flow: Introduction; flow of incompressible fluid in circular pipe; laminar flow for Newtonian fluid; Hagen-Poiseullie equation; flow of Non-Newtonian fluid,	T1	1,2,3		PPT Digi Class/Chalk -Board	
	L18 -19			introduction to turbulent flow in a pipe; energy consideration in pipe flow, relation between average and maximum velocity,	T1	1,2,3		PPT Digi Class/Chalk -Board	
	L20 -21			Bernoulli’s equation–kinetic energy correction factor; head loss; friction factor; major and minor losses,	T1	1,2,3		PPT Digi Class/Chalk -Board	
	L22			Pipe fittings and valves	T1	1,2,3		PPT Digi Class/Chalk -Board	
	L23 -24			Flow past of immersed bodies: Introduction; concept of drag and lift; variation of drag coefficient with Reynolds number; streamlining;	T1	1,2,3		PPT Digi Class/Chalk -Board	
	L24 -26			packed bed; concept of equivalent diameter and sphericity; Ergun equation, Fluidization: Introduction; different types of fluidization; fluidized bed assembly; governing equation; industrial use.	T1	1,2,3		PPT Digi Class/Chalk -Board	
	L27 -28			Agitation and mixing of liquids: agitated vessel, blending & mixing,	T1	1,2,3		PPT Digi Class/Chalk -Board	
	L29 -30			suspension of solid particles. Dispersion operation. Turbine Design/scale up, Flow number, Power Requirement.	T1	1,2,3		PPT Digi Class/Chalk -Board	

	L31 L32 -33			Flow measurement: Introduction; general equation for internal flow meters; Orifice meter; Venturimeter; concept of area meters: rotameter;	T1	1,2,3		PPT Digi Class/Chalk -Board	
	L34			Local velocity measurement: Pitot tube.	T1	1,2,3		PPT Digi Class/Chalk -Board	
	L35 -40			Fluid moving machines: Introduction; Basic classification of pumps, Mechanical pump: Centrifugal and Positive displacement pumps (rotary, piston, plunger, diaphragm pumps); pump specification; basic characteristics curves for centrifugal pumps; fan, blower and compressor.	T1	1,2,3		PPT Digi Class/Chalk -Board	

COURSE INFORMATION SHEET: CL204 Chemical Process Calculations

Course code:	CL204
Course title:	Chemical Process Calculations
Pre-requisite(s):	
Co- requisite(s):	
Credits:	L: 2 T: 1 P: 0
Class schedule per week:	3 hrs
Class:	B. Tech
Semester / Level:	III / Second
Branch:	Chemical Engineering
Name of Teacher:	

Course Objectives

This course enables the students:

1.	To use basic, applied chemistry/ thermodynamics for material balance calculations for different unit operations and unit processes.
2.	To use basic, applied chemistry/ thermodynamics for energy balance calculations for different unit operations and unit processes.
3.	To develop the systematic problem solving skills.

Course Outcomes

After the completion of this course, students will be able to:

CO204.1	Apply the concept of dimension and unit conversion to check dimensional consistency of balanced equation and understand the specific terms used in process calculation.
CO204.2	Solve problems related to ideal and real gas and solution.
CO204.3	Solve material balance problems without chemical reactions.
CO204.4	Solve material balance problems with chemical reactions.
CO204.5	Solve energy balance problems of various unit processes.

Syllabus

Module I: Introduction to Stoichiometry:

Units and Dimensions: Conversion of Equations, Systems of Units, Dimensional Homogeneity and Dimensionless Quantities, Buckingham Pi-theorem for Dimensional Analysis, Introduction to Chemical Engineering Calculations: Basis, Mole Fraction and Mole Percent, Mass Fraction and Mass Percent, Concentration of different forms, Conversion from one form to another, Stoichiometric and composition relations, Excess & Limiting reactants, Degree of completion, Conversion, Selectivity and Yield. [8L]

Module II: Gas Calculations, Humidity & Saturation:

Gas laws-Ideal gas law, Dalton's Law, Amagat's Law, and Average molecular weight of gaseous mixtures. Vapour pressure, partial pressure, Vapour pressures of miscible, immiscible liquids and solutions. Real-gas relationships, Roult's Law, Henry's law, Antoine's Equation, Clausius Clapeyron Equation. PVT calculations using ideal and real gas relationships, Relative Humidity and percent saturation; Dew point, Dry and Wet bulb temperatures; Use of humidity charts for engineering calculations. [8L]

Module III: Material Balance without Chemical Reaction:

Unit Operations & Process Variables, Degree of Freedom Analysis, Application of material balances to single and multiple unit operations without chemical reactions involving distillation column, absorption column, evaporators, driers, crystallizer, liquid-liquid and liquid-solid extraction units, Unsteady state material balances. [8L]

Module IV: Material Balance with Chemical Reaction:

Material balances with Single Reaction & Multiple Reactions applicable to single and multiple unit operations, Recycle, purge, bypass in batch, stage wise and continuous operations in systems with or without chemical reaction. Material balances in combustion, gas-synthesis, acid-alkali production reactions. [8L]

Module V: Energy Balance:

Heat capacity of solids, liquids, gases and solutions, use of mean heat capacity in heat calculations, problems involving sensible and latent heats, Evaluation of enthalpy, Standard heat of reaction, heat of formation, combustion, solution mixing etc., Calculation of standard heat of reaction, Hess Law, Energy balance for systems with and without chemical reaction, Unsteady state energy balances. [8L]

Text books:

1. Haugen, P.A. Watson, K.M., Ragatz R.A Chemical Process Principles Part - I
2. Himmelblau, D.M Basic Principles and Calculation in chemical engineering, Prentice Hall
3. Bhatt B.L.Vora, S.M Stoichiometry, Tata McGraw Hill Publishing Co. Ltd., New Delhi

Reference books:

1. Felder, R. M.; Rousseau, R. W., "Elementary Principles of Chemical Processes", Third Edition, John Wiley & Sons, 2000
2. Venkataramani, V., Anantharaman, N., Begum, K. M. Meera Sheriffa, "Process Calculations", Second Edition, Prentice Hall of India.
3. Sikdar, D. C., "Chemical Process Calculations", Prentice Hall of India

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus
Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
End Sem Examination Marks	50
Quiz	10+10
Teachers Assessment	5

Assessment Components	CO1	CO2	CO3	CO4
Mid Sem Examination Marks	Y	Y		
End Sem Examination Marks	Y	Y	Y	Y
Quiz	Y	Y	Y	Y

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												PSOs			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
1	3	3	0	0	2	0	0	0	1	0	0	3	3	0	1	2
2	3	3	2	1	1	1	0	0	1	1	0	3	3	0	1	2
3	3	3	0	1	1	2	2	2	2	2	2	3	3	3	2	2
4	3	3	2	0	1	2	2	2	2	2	2	3	3	3	2	2
5	3	3	2	0	1	2	2	2	2	2	2	3	3	3	2	2

3= High, 2 = Medium, 1 = Low

Mapping Between COs and Course Delivery (CD) methods		
CD	**Course Delivery methods**	**Course Outcome**
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, CO2, CO3, CO4

CD2	Tutorials/Assignments	CO1, CO2, CO3, CO4
CD3	Seminars	
CD4	Mini projects/Projects	
CD5	Laboratory experiments/teaching aids	
CD6	Industrial/guest lectures	
CD7	Industrial visits/in-plant training	
CD8	Self- learning such as use of NPTEL materials and internets	CO1, CO2, CO3, CO4
CD9	Simulation	

Lecture wise Lesson planning Details.

Week No.	Lect. No.	Tentative Date	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Actual Content covered	Methodology used	Remarks by faculty if any
1	L1		1	Units and Dimensions: Conversion of Equations, Systems of Units, Dimensional Homogeneity and Dimensionless Quantities,	T1, T2, T3, R1, R2, R3	1		PPT	
	L2		1	Buckingham Pi-theorem for Dimensional Analysis	T1, R2	1		PPT, Chalk -Board	
	L3		1	Introduction to Chemical Engineering Calculations: Basis, Mole Fraction and Mole Percent, Mass Fraction and Mass Percent	T1, T2, T3, R1, R2, R3	2, 3, 4, 5		PPT, Chalk -Board	
2	L4		1	Concentration of different forms, Conversion from one form to another,	T1, T2, T3	2, 3, 4, 5		PPT, Chalk -Board	
	L5		1	Stoichiometric and composition relations	T1, R2	2, 3, 4, 5		PPT, Chalk -Board	
	L6		1	Excess & Limiting reactants	T1, R2	2, 4, 5		Chalk -Board	
3	L7		1	Degree of completion, Conversion, Selectivity and Yield	T1, R2	2, 4, 5		Chalk -Board	
	L8		1	Tutorial				Assignment	
	L9		2	Gas laws-Ideal gas law, Dalton’s Law, Amagat’s Law, and Average molecular weight of gaseous mixtures.	T1, R2	2		PPT	
4	L10		2	Vapour pressures of miscible, immiscible liquids and solutions.	T1, R2	2		PPT, Chalk -Board	
	L11		2	Real-gas relationships, Roult’s Law, Henry’s law,	T1, R2	2		PPT, Chalk -Board	
	L12		2	Antoine’s Equation, Clausius Clapeyron Equation.	T1, R1	2		PPT, Chalk -Board	
5	L13		2	PVT calculations using ideal and real gas relationships,	T1, R2	2		Chalk -Board	
	L14		2	Relative Humidity and percent saturation; Dew point, Dry	T1, R2	3		PPT, Chalk	

				and Wet bulb temperatures;				-Board	
	L15		2	Use of humidity charts for engineering calculations	T1, R2	3		PPT, Chalk -Board	
6	L16		2	Tutorial				Assignment	
	L17		3	Unit Operations & Process Variables, Degree of Freedom Analysis,	T1, R2	4, 5		PPT, Chalk -Board	
	L18		3	Application of material balances to single unit operations – Distillation and Absorbtion columns	T1, T2, T3, R1, R2, R3	4, 5		PPT, Chalk -Board	
7	L19		3	Application of material balances to single unit operations – Evaporators & Driers	T1, T2, T3, R1, R2, R3	4, 5		PPT, Chalk -Board	
	L20		3	Application of material balances to single unit operations –crystallizer, liquid-liquid and liquid-solid extraction units,	T1, T2, T3, R1, R2, R3	4, 5		PPT, Chalk -Board	
	L21		3	Application of material balances to Multiple Unit operations	T1, T2, T3, R1, R2, R3	4, 5		PPT, Chalk -Board	
8	L22		3	Application of material balances to Multiple Unit operations	T1, T2, T3, R1, R2, R3	4, 5		PPT, Chalk -Board	
	L23		3	Unsteady state material balances	T1, T2, T3, R1, R2, R3	4, 5		PPT, Chalk -Board	
	L24		3	Tutorial				Assignment	
9	L25		4	Material balances with Single Reaction & Multiple Reactions applicable to single unit operations,	T1, T2, T3, R1, R2, R3	4, 5		PPT, Chalk -Board	
	L26		4	Material balances with Single Reaction & Multiple Reactions applicable to multiple unit operations,	T1, T2, T3, R1, R2, R3	4, 5		PPT, Chalk -Board	
	L27		4	Material balances applied to unit operations with Recycle, purge, bypass in batch, stage wise and continuous operations in systems with or without chemical reaction.	T1, T2, T3, R1, R2, R3	4, 5		PPT, Chalk -Board	

101	L28		4	Material balances applied to unit operations with Recycle, purge, bypass in batch, stage wise and continuous operations in systems with or without chemical reaction.	T1, T2, T3, R1, R2, R3	4, 5		PPT, Chalk -Board	
	L29		4	Material balances in combustion, Excess air calculations,	T1, T2, T3, R1, R2, R3	4, 5		Chalk -Board	
	L30		4	Material balances in combustion, Excess air calculations,	T1, T2, T3, R1, R2, R3	4, 5		Chalk -Board	
11	L31		4	Material balances in gas-synthesis, acid-alkali production reactions.	T1, T2, T3, R1, R2, R3	4, 5		Chalk -Board	
	L32		4	Tutorial				Assignment	
	L33		5	Heat capacity of solids, liquids, gases and solutions, use of mean heat capacity in heat calculations,	T2, R1	5		PPT	
12	L34		5	problems involving sensible and latent heats,	T2, R1	5		Chalk -Board	
	L35		5	Evaluation of enthalpy, Standard heat of reaction,	T2, R1	5		PPT, Chalk -Board	
	L36		5	heat of formation, combustion, solution mixing etc.,	T2, R1	5		PPT, Chalk -Board	
13	L37		5	Calculation of standard heat of reaction, Hess Law,	T1, T2, R1	5		Chalk -Board	
	L38		5	Energy balance for systems with and without chemical reaction,	T1, T2, T3, R1, R2, R3	4, 5		PPT, Chalk -Board	
	L39		5	Unsteady state energy balances	T1, T2, T3, R1, R2, R3	4, 5		PPT, Chalk -Board	
14	L40		5	Tutorial				Assignment	

COURSE INFORMATION SHEET: CL 205 Mechanical Operations

Course code: **CL 205**
Course title: **Mechanical Operations**
Pre-requisite(s):-
Co- requisite(s):-
Credits: L:3 T:0 P:0
Class schedule per week: **3**
Class: B. Tech
Semester / Level: **III / Second**
Branch: **Chemical Engineering**
Name of Teacher:

Course Objectives

This course enables the students:

1.	To understand particulate solid characterization and storage and transportation of solids
2.	To understand principles of size reduction and equipment for size reduction
3.	To understand solid-liquid, liquid-liquid, gas-solid and solid-solid Mechanical separation

Course Outcomes

After the completion of this course, students will have:

CO205.1	Knowledge of particle size analysis, solid storage and transportation properties like frictional properties.
CO205.2	Knowledge of size reduction machineries for various industries and calculate power requirement.
CO205.3	Knowledge to design Gravity and Centrifugal settling processes for various applications, including pollution control in industry.
CO205.4	Knowledge of filtration equipment for different chemical industries, and designing of filtration process
CO205.5	Knowledge of solid-solid and gas-solid separation techniques for various applications including coal, mineral beneficiation environmental pollution control

Syllabus:

Module 1:
Characterization of solid particles: Particle Shape. Particle size analysis Differential and cumulative analysis. **Properties of particulate masses:** Bulk density, coefficient of Internal Friction, Storage of solids, Pressure distribution in hopper. Janssen Equation. **Transportation of Solids**: Studies on performance and operation of different conveyors eg. Belt, Screw, Apron, Flight etc. and elevators. [8L]

Module 2:

Size Reduction: Rittinger_s law, Kick_s law, Bond_s law, Work index, Types of comminuting equipment – Jaw Crushers, Gyratory Crusher, Roll crushers; Grinders-hammer Mill, Ball Mill, Rod Mill etc. Dry and wet griding, open and closed circuit. Simulation of Milling operation grinding rate function, breakage function. [8L]

Module 3:

Solid Liquid separation : Gravity Settling process – Clarifiers and Thickeners, Flocculation Design of Gravity Thickner,**. Centrifugal Settling:** principle, Centrifuges for solid liquid and liquid liquid separation. [8L]

Module 4:
Filtration: Theory of solid-liquid filtration, principle of filtration, constant pressure and constant rate filtration, compressible and incompressible cakes, Filter aids, Equipment of liquid solid filtration, Batch and continuous pressure filters. Theory of centrifugal filtration, Equipment for centrifugal filtration. [8L]

Module 5:

Solid Solid Separation : Industrial Screening equipment :Screen effectiveness and Capacity.**Wet Classification:** Differential settling, Liquid cyclones,Drag, Rake and Spiral, Bowl, Hydroseparator, Hydaulic classifiers, Tabling, Jigging, Froth floatation, Dense media separation etc.Magnetic separation, Electrostating Separation. **Gas-solid separation:** Settling chambers, centrifugal settling, Cyclones, ESP, Scrubbers, Filters. [8L]

Suggested Books:

1. McCabe, W.L., Smith J.C., and Harriot, P., “Unit Operations Chemical Engineering”, McGraw-Hill, Inc.

2. Coulson, J.M. and Richardson, J.F., “Chemical Engineering, VolumeI”, Pergamon Press.

3. Geankoplis, C.J., “Transport Processes and Unit Operations”, Prentice-Hall Inc.

Gaps in the syllabus (to meet Industry/Profession requirements) : Visit to industries like Coal Washeries, Mineral processing like HINDALCO

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design :

POs met through Topics beyond syllabus/Advanced topics/Design

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
End Sem Examination Marks	50
Quiz	10+10
Teachers Assessment	5

Assessment Components	CO1	CO2	CO3	CO4	CO5	CO6	CO7
Mid Sem Examination Marks	Y	Y	Y	Y			
End Sem Examination Marks	Y	Y	Y	Y	Y	Y	Y
Quiz	Y	Y	Y	Y	Y	Y	Y

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												PSOs			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
1	3	3	3	2	3	2	2	1	1	1	1	1	3	3	3	3
2	3	3	3	2	3	2	2	1	1	1	1	1	3	3	3	3
3	3	3	3	2	3	2	2	1	1	1	1	1	3	3	3	3
4	3	3	3	2	3	2	2	1	1	1	1	1	3	3	3	3
5	3	3	3	2	3	1	1	1	1	1	1	1	3	3	3	3

3= High, 2 = Medium, 1 = Low

Mapping Between COs and Course Delivery (CD) methods		
CD	**Course Delivery methods**	**Course Outcome**
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, CO2, CO3, CO4, CO5, CO6, CO7

CD2	Tutorials/Assignments	CO1, CO2, CO3, CO4, CO5, CO6, CO7
CD3	Seminars	
CD4	Mini projects/Projects	
CD5	Laboratory experiments/teaching aids	
CD6	Industrial/guest lectures	
CD7	Industrial visits/in-plant training	
CD8	Self- learning such as use of NPTEL materials and internets	CO1, CO2, CO3, CO4, CO5, CO6, CO7
CD9	Simulation	

Lecture wise Lesson planning Details.

Week No.	Lect. No.	Tentative Date	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Actual Content covered	Methodology used	Remarks by faculty if any
1	L1		1	Introduction of Mechanical operation in Chemical Engineering Industry.Particle Shape. Particle size analysis.	T1, T3	1, 2		PPT Digi Class/Chock -Board	
1	L2		1	Differential and cumulative analysis	T1, T3			Do	
1	L3		1	Bulk density, coefficient of Internal Friction.	T1, T3			Do	
2	L4		1	Storage of solids, Pressure distribution in hopper.	T1, T3			Do	
2	L5		1	Janssen Equation	T1, T3			Do	
2	L6		1	Introduction to studies on performance and operation of different conveyors.	T1, T3			Do	
3	L7		1	Belt, Screw, Apron- conveyors.	T1, T3			Do	
3	L8		1	Flight etc. and elevators- conveyors.	T1, T3			Do	
3	L1		2	Introduction class for Size Reduction Rittinger_s law.	T1, T3			Do	

4	L2		2	Kick_s law, Bond_s law.	T1, T3			Do	
4	L3		2	Work index, Types of comminuting equipment.	T1, T3			Do	
4	L4		2	Jaw Crushers, Gyratory Crusher, Roll crushers.	T1, T3			Do	
5	L5		2	Grinders-hammer Mill, Ball Mill, Rod Mill.	T1, T3			Do	
5	L6		2	Dry and wet griding,	T1, T3			Do	
5	L7		2	Open and closed circuit.	T1, T3			Do	
6	L8		2	Simulation of Milling operation grinding rate function, breakage function.	T1, T3			Do	
6	L1		3	Introduction class for Solid Liquid separation	T1, T3			Do	
6	L2		3	Introduction class for Gravity Settling Process	T1, T3			Do	
7	L3		3	Gravity Settling – Clarifiers	T1, T3			Do	
7	L4		3	Gravity Settling –Thickeners.	T1, T3			Do	
7	L5		3	Flocculation	T1, T3			Do	
8	L6		3	Design of Gravity Thickner,.	T1, T3			Do	
8	L7		3	Principle of Centrifuges for solid-liquid separation.	T1, T3			Do	
8	L8		3	Principle of liquid-liquid separation.	T1, T3			Do	

9	L1		4	Introduction class for Filtration.	T1, T3			Do	
9	L2		4	Theory of solid-liquid filtration, principle of filtration. Constant pressure filtration	T1, T3			Do	
9	L3		4	Constant rate filtration, compressible and incompressible cakes, Filter aids.	T1, T3			Do	
10	L4		4	Equipment of liquid solid filtration.	T1, T3			Do	
10	L5		4	Batch and continuous pressure filters.	T1, T3			Do	
10	L6		4	Theory of centrifugal filtration.	T1, T3			Do	
11	L7		4	Introduction to Equipment for centrifugal filtration.	T1, T3			Do	
11	L8		4	Different equipment of filtration.	T1, T3			Do	
11	L1		5	Industrial Screening equipment :Screen effectiveness and Capacity.	T1, T2			Do	
12	L2		5	Wet Classification: Differential settling, Liquid cyclones,Drag, Rake and Spiral,	T1, T2			Do	
12	L3		5	Wet Classification :Bowl, Hydroseparator	T1, T2			Do	
12	L4		5	Hydaulic classifiers, Tabling, Jigging, Froth floatation,	T1, T2			Do	
13	L5		5	Dense media separation etc.Magnetic separation,	T1, T2			Do	

				Electrostating Separation.					
13	L6		5	Gas-solid separation: Settling chambers, centrifugal settling.	T1, T2			Do	
13	L7		5	Cyclones, ESP,	T1, T2			Do	
14	L8		5	Scrubbers, Filters.	T1, T2			Do	

COURSE INFORMATION SHEET: CL 206

Course code: **CL206**
Course title: **Chemical Principles for Chemical Engineers**

Pre-requisite(s):
Co- requisite(s):
Credits: L:02 T:00 P:00
Class schedule per week: **02**
Class: **B. Tech.**
Semester / Level: **III / Second**
Branch: **Chemical Engineering**
Name of Teacher:

Course Objectives

This course enables the students:

1.	Explain: Describe the reaction mechanism of common organic transformations
2.	Illustrate: Illustrate Schrodinger wave equation and partition functions
3.	Analysis: Find the relation between entropy and probability

Course Outcomes

After the completion of this course, students will be:

CO206.1	Define: Describe the reaction mechanism of common organic transformations
CO206.2	Illustrate: Demonstrate collision state theory and transition state theory
CO206.3	Application: Apply transition state theory for common organic reactions
CO206.4	Synthesize: Develop suitable model for microbial growth kinetics
CO206.5	Evaluate: Compare the properties of polymer synthesized by different techniques

Syllabus

MODULE– I

Introduction to organic reactions involving substitution, addition, elimination, oxidation, reduction, cyclization and ring openings. Synthesis of commonly used industrial chemicals. [9L]

MODULE- II

Fundamentals of Statistical Thermodynamics, Wave Mechanics, Schrodinger wave equation, Models in Statistical Thermodynamics, F-D Statistics, Partition function and application to monoatomic gas, Principles of equipartition of energy and statistics of a photon gas, Application of partition function and relation between entropy and probability. [8L]

MODULE- III

Integrated rate laws. Experimental methods in chemical kinetics. Elementary reactions and reaction mechanism. Temperature dependence of reaction rates. Complex reactions. Theories of reaction rates-Collision theory. Transition state theory. Potential energy surfaces (PES). Free energy and EMF. [9L]

MODULE– IV

Introduction to biotechnology. Prokaryotic and Eukaryotic cells. Metabolism I Kinetics. Mechanism II Kerb cycle. Anaerobic oxidation and fermentation. Growth kinetics for different biological systems. Microbial growth kinetics. Product recovery from over expressed cells. [7L]

MODULE– V

Principles of condensation polymerization, kinetics, chain length regulation and control of molecular weight, Principles of addition polymerization. Principles of ionic polymerization. Principles co-ordination polymerization. Polymer supported catalyst. [7L]

Text Books:

1. M. B. Smith, Organic Synthesis. F. A. Carey and R. J Sundberg, Advanced Organic Chemistry,
2. Introduction to Polymer Science and Chemistry. M. Chandra. Copyright © 2006 by Taylor & Francis Group, LLC. CRC Press, New York
3. A Bejan, Advanced Engineering Thermodynamics, 3rd edition, John Wiley and Sons, 2006.
4. Basic Biotechnology edited by Colin Ratledge, Bjorn Kristiansen, 3rd edition, Cambridge University Press,2006

Reference books:

1. Fundamentals of Polymer Science: Kumar Anil & Gupta R.K. Mc Graw Hill, 1998.
2. The Element of Polymer Science & Engineering: Rudin.
3. I.K. Puri and K. Annamalai, Advanced Engineering Thermodynamics, CRC Press, 2001.
4. Biological science fundamentals and systematics - Volume II edited by Alessandro Minelli , Eloss Publishers, UK, 2009.

Gaps in the syllabus (to meet Industry/Profession requirements):

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

POs met through Topics beyond syllabus/Advanced topics/Design:

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
End Sem Examination Marks	50
Quiz	10+10
Teachers Assessment	5

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination Marks	Y	N	Y	N	Y
End Sem Examination Marks	Y	Y	Y	Y	Y
Quiz	Y	Y	Y	Y	Y

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												PSOs			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO206.1	3	3	3	1	2	2	2	3	2	2	0	1	3	2	1	1
CO206.2	3	3	3	1	2	2	2	3	2	2	0	1	3	2	1	1
CO206.3	3	3	3	1	1	2	2	3	2	2	0	1	3	2	1	1
CO206.4	3	3	3	2	1	2	2	3	2	2	0	1	3	2	1	1
CO206.5	3	3	3	2	1	2	2	3	2	2	0	1	3	2	1	1

3= High, 2 = Medium, 1 = Low

Mapping Between COs and Course Delivery (CD) methods		
CD	**Course Delivery methods**	**Course Outcome**
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, CO2, CO3, CO4, CO5
CD2	Tutorials/Assignments	CO3, CO5
CD3	Seminars	CO2
CD4	Mini projects/Projects	
CD5	Laboratory experiments/teaching aids	
CD6	Industrial/guest lectures	
CD7	Industrial visits/in-plant training	

Lecture wise Lesson planning Details.

Week No.	Lect. No.	Tentative Date	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Actual Content covered	Methodology used	Remarks by faculty if any
1	L1		1	Introduction to organic reactions		1, 2		PPT Digi Class /Chalk-Board	
1	L2		1	Substitution reactions					
1	L3		1	Addition reactions					
2	L4		1	Elimination reactions					
2	L5		1	Oxidation reactions					
2	L6			Reduction reactions					
3	L7			Cyclization reactions					
3	L8			Ring openings reactions					
3	L9			Synthesis of commonly used industrial chemicals					
4	L10			Fundamentals of Statistical Thermodynamics					
4	L11			Wave Mechanics					
4	L12			Schrondinger wave equation					
5	L13			Models in Statistical Thermodynamics					
5	L14			F-D Statistics					
5	L15			Partition function and application to monoatomic gas					
6	L16			Principles of equipartition of energy and statistics of a photon gas					
6	L17			Application of partition function and relation between entropy and probability					
6	L18			Integrated rate laws					
7	L19			Experimental methods in chemical kinetics					

7	L20			Elementary reactions and reaction mechanism					
7	L21			Temperature dependence of reaction rates					
8	L22			Complex reactions					
Mid									
Mid									
Mid									
9	L23			Theories of reaction rates- Collision theory					
9	L24			Transition state theory					
9	L25			Potential energy surfaces (PES)					
10	L26			Free energy and EMF					
10	L27			Introduction to biotechnology					
10	L28			Prokaryotic and Eukaryotic cells					
11	L29			Metabolism I Kinetics					
11	L30			Mechanism II Kerb cycle					
11	L31			Anaerobic oxidation and fermentation					
12	L32			Growth kinetics for different biological systems					
12	L33			Product recovery from over expressed cells					
12	L34			Principles of condensation polymerization					
13	L35			Kinetics, chain length regulation and control, molecular weight					
13	L36			Principles of addition polymerization					
13	L37			Principles of ionic polymerization					
14	L38			Principles of co-ordination polymerization					
14	L39			Different polymerization methods					
14	L40			Polymer supported catalyst					

COURSE INFORMATION SHEET : CL 207 Process Technology and Economics - I

Course code	CL207
Course title	Process Technology and Economics - I
Pre-requisite(s)	Thermodynamics CL201, Chemical Process Calculations CL204
Co- requisite(s)	Mass Transfer Operation CL 209, Heat Transfer Operation CL208.
Credits	L: 3 T: 0 P: 0
Class schedule per week	3
Class	B. E.
Semester / Level	IV / Second
Branch	Chemical Engineering
Name of Teacher	

Course Objectives

This course enables the students:

1.	To understand the various processes involved in chemical industries for the production of inorganic and organic chemicals.
2.	To understand economic principles as applied in Chemical Engineering.
3.	To identify and solve engineering problems during production.

Course Outcomes

After the completion of this course, students will be able to:

CO207.1	Explain important process industries with manufacturing processes.
CO207.2	Illustrate the different unit operations and unit processes in a given process flow diagram.
CO207.3	Explain the effect of various process parameters on manufacturing processes.
CO207.4	Estimate and understand various financial terms.
CO207.5	Evaluate and analyze the concept of depreciation and profitability measure.

Syllabus

Module 1:

Sulfuric acid: Properties of sulfuric acid, Hydrates of sulfuric acid, Usage, Contact process, Catalysts, Contact process equipment's, Materials of construction, DCDA process. Phosphorous Industries: Phosphate rock, Superphosphates, Manufacturing of Phosphoric acid (Wet-Process and Electric-Furnace), Phosphates (Sodium phosphates, Pyrophosphates, Calcium Phosphates), manufacturing of diammonium phosphate. **8L**

Module 2:

Chlor-alkali industries: Manufacture of Soda Ash, Caustic Soda and Chlorine. Bleaching Powder, Calcium Hypochlorite, Sodium Hypochlorite. Manufacture of chlorine caustic soda, Mercury cathode and membrane process, hydrochloric acid.

Pulp and Paper Industries: Manufacture of pulp (Kraft pulping and Sulfite pulping), Manufacture of paper. **8L**

Module 3:

Nitrogen industries: Manufacturing of Ammonia; ammonium nitrate, ammonium sulphate; Manufacturing of Urea and Nitric acid.
Fertilizer Industries: Manufacturing of Single Superphosphate (SSP), Triple Superphosphate (TSP) and ammonium phosphate.
Mixed fertilizers: NPK – Manufacturing process and details of major equipments. **8L**

Module 4:

Process design development, preliminary design concepts, flowsheet development. Cost estimation of investment and production. Break-even analysis. Interest and Investment costs: Simple interest, Compound interest, Nominal and Effective interest rates, Continuous interest, Annuities. **8L**

Module 5:

Profitability measures: Rate of return on investment, Present worth and discounted cash flow, Payback period, Capitalized Costs. Depreciation: Types of depreciation, Salvage Value, Present Value, Book Value, Market Value, Replacement Value. Methods for determining depreciation: Straight line method, Declining-balance or Fixed percentage method, Sum-of-the-years-digits method, Sinking-fund Method, Accelerated cost recovery system, Modified accelerated cost recovery system. **8L**

Text books:

1. Dryden's Outlines of Chemical Technology, M. Gopala Rao, M. Sittig, 3rd Edition, East West Press.
2. Shreve's Chemical Process Industries, George T. Austin, 5th Edition, Tata McGraw Hill Edition.
3. Plant Design and Economics for Chemical Engineers, Max S. Peters, K. D. Timmerhaus, 4th Edition, McGraw-Hill Inc.
4. Process Engineering Economics, James Riley Couper, Marcel Dekker Inc.

Reference books:

1. Coulson & Richardson's Chemical Engineering Design, R K Sinnott, Vol. 6., Fourth Edition, Elsevier.
2. Encyclopedia of Chemical Technology, Kirk-Othmer, 5th Edition.

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
End Sem Examination Marks	50
Quiz	10+10
Teachers Assessment	5

Assessment Components	CO1	CO2	CO3	CO4
Mid Sem Examination Marks	Y	Y	Y	
End Sem Examination Marks	Y	Y	Y	Y
Quiz	Y	Y	Y	Y

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												PSOs			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO207.1	3	2	2	1	1	2	3	2	1	2	2	2	3	1	3	3
CO207.2	3	2	2	1	1	2	3	1	1	2	2	2	3	1	3	3
CO207.3	3	2	2	1	1	2	3	1	1	2	2	2	3	1	3	3
CO207.4	2	2	1	1	1	1	1	1	1	2	3	2	1	1	1	3
CO207.5	2	2	1	1	1	1	1	1	1	2	3	2	1	1	1	3

3= High, 2 = Medium, 1 = Low

Mapping Between COs and Course Delivery (CD) methods		
CD	**Course Delivery methods**	**Course Outcome**
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, CO2, CO3, CO4
CD2	Tutorials/Assignments	CO1, CO2, CO3, CO4
CD3	Seminars	
CD4	Mini projects/Projects	CO3, CO4
CD5	Laboratory experiments/teaching aids	

CD6	Industrial/guest lectures	
CD7	Industrial visits/in-plant training	CO1, CO2, CO3, CO4
CD8	Self- learning such as use of NPTEL materials and internets	CO1, CO2, CO3, CO4
CD9	Simulation	

Lecture wise Lesson Planning Details.

Week No	Lect. No.	Tentative Date	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Actual Content covered	Methodology used	Remarks by faculty if any
1	L 1			Properties of sulfuric acid, Hydrates of sulfuric acid, Usage	T 1 T 2	CO 1		CD 1	
1	L 2			Contact process, Catalysts	T 1 T 2	CO 1 CO 2		CD 1	
1	L 3			Contact Process Equipment's, Materials of construction,.	T 1 T 2	CO 1 CO 2		CD 1	
2	L 4			DCDA process	T 1 T 2	CO 1 CO 2		CD 1	
2	L 5 L 6			Phosphate rock, Superphosphates, Manufacturing of Phosphoric acid (Wet-Process and Electric-Furnace),	T 1 T 2	CO 1 CO 2		CD 1	
3	L 7 L 8			Phosphates (Sodium phosphates, Pyrophosphates, Calcium Phosphates), manufacturing of diammonium phosphate.	T 1 T 2	CO 1 CO 2		CD 1	
4 5	L 9 L10 L11			Manufacture of Soda Ash, Caustic Soda and Chlorine	T 1 T 2	CO 1 CO 2		CD 1	
5 6	L 12 L 13			Bleaching Powder, Calcium Hypochlorite, Sodium Hypochlorite.	T 1 T 2	CO 1 CO 2		CD 1	
6	L 14 L 15			Manufacture of chlorine caustic soda, Mercury cathode and membrane process.	T 1 T 2	CO 1 CO 2		CD 1	
7	L 16 L 17			Pulp and Paper Industries: Manufacture of pulp (Kraft pulping and Sulfite pulping), Manufacture of paper.	T 1 T 2	CO 1 CO 2		CD 1	
7 8	L 18 L 19			Manufacturing of Ammonia; ammonium nitrate, ammonium sulphate;	T 1 T 2	CO 1 CO 2		CD 1	
8	L 20 L 21			Manufacturing of Urea and Nitric acid.	T 1 T 2	CO 1 CO 2		CD 1	
9	L 22 L 23			Manufacturing of Single Superphosphate (SSP), Triple Superphosphate (TSP) and ammonium phosphate.	T 1 T 2	CO 1 CO 2		CD 1	

9	L 24			Mixed fertilizers: NPK – Manufacturing process and details of major equipments.	T 1 T 2	CO 1 CO 2		CD 1	
10	L 25 L 26			Simple Interest, Ordinary and Exact Simple Interest	T 3 T 4	CO 3		CD 1 CD 2	
10	L 27			Compound Interest	T 3 T 4	CO 3		CD 1 CD 2	
11	L 28 L 29			Nominal and Effective Interest Rates, Continuous Interest	T 3 T 4	CO 3		CD 1 CD 2	
11	L 30			Present Worth and Discount	T 3 T 4	CO 3		CD 1 CD 2	
12	L 31 L 32			Annuities, Perpetuities and Capitalized Costs.	T 3 T 4	CO 3		CD 1 CD 2	
13 14	L 33 L 34 L 35			Types of depreciation, Salvage Value, Present Value, Book Value, Market Value, Replacement Value.	T 3 T 4	CO 3 CO 4 CO 5		CD 1 CD 2	
14 15	L 36 L 37 L 38			Methods for determining depreciation: Straight line method, Declining-Balance or Fixed Percentage Method, Sum-of-the-Years-Digits Method, Sinking-Fund Method	T 3 T 4	CO 3 CO 4 CO 5		CD 1 CD 2	
15 16	L 39 L 40			Accelerated cost recovery system, Modified accelerated cost recovery system.	T 3 T 4	CO 3 CO 4 CO 5		CD 1 CD 2	

COURSE INFORMATION SHEET: CL 208 Heat Transfer Operations

Course code: CL208
Course title: Heat Transfer Operations
Pre-requisite(s):
Co- requisite(s):
Credits: L: 3 T: 1 P: 0
Class schedule per week: 4 hrs
Class: B. Tech
Semester / Level: IV / Second
Branch: Chemical Engineering
Name of Teacher:

Course Objectives

This course enables the students:

1.	To understand the fundamentals of heat transfer mechanisms in fluids and solids and their applications in various heat transfer equipment's in process industries.
2.	Understanding the heat exchangers: working principles and basic geometries.
3.	To design heat exchangers and evaporators and analyze their performance.

Course Outcomes

After the completion of this course, students will be able to:

CO208.1	Understand and Solve heat transfer by conduction in solids for steady state and transient conditions.
CO208.2	Explain and solve heat transfer by forced and natural convection.
CO208.3	Discuss and solve heat transfer by radiation.
CO208.4	Determine heat transfer in boiling, condensation and evaporators.
CO208.5	Analyze the performance of heat exchange equipments.

Syllabus

Module I

Basic Concepts: Modes of heat transfer, conduction, convection and radiation, analogy between heat flow and electrical flow. **Conduction:** One dimensional steady state heat conduction, the Fourier heat conduction equation, conduction through plane wall, conduction through cylindrical wall, spherical wall, conduction through composite slab, cylinder and sphere, critical radius of insulation, **Extended surfaces:** heat transfer from a fin, fin effectiveness and efficiency, Introduction to unsteady state heat conduction. **[8L]**

Module II

Convection: Natural and forced convection, the convective heat transfer coefficient. **Forced Convection:** Correlation equations for heat transfer in laminar and turbulent flows in a Circular tube and duct, Reynolds and Colburn analogies between momentum and heat transfer, heat transfer to liquid metals and heat transfer to tubes in cross flow. **Natural Convection:** Natural convection from vertical and horizontal surfaces, Grashof and Rayleigh numbers. **[8L]**

Module III

Heat transfer by radiation: Basic Concepts of radiation from surface: black body radiation, Planks law, Wien's displacement law , Stefan Boltzmann's law, Kirchhoff's law, grey body, Radiation intensity of black body, View factor , emissivity, radiation between black surfaces and grey surfaces. Solar radiations, combined heat transfer coefficients by convection and radiation. **[8L]**

Module IV

Boiling and Condensation: Pool boiling, pool boiling curve for water, maximum and minimum heat fluxes, correlations for nucleate and film pool boiling, drop wise and film wise condensation, Nusselt analysis for laminar film wise condensation on a vertical plate, film wise condensation on a horizontal tube, effect of non-condensable gases on rate of condensation. **Evaporation:** Types of evaporators, boiling point elevation and Duhring's rule, material and energy balances for single effect evaporator, multiple effect evaporators: forward, mixed and backward feeds, capacity and economy of evaporators. **[8L]**

Module V

Heat Exchangers: Introduction, Industrial use, Types of heat exchangers, Co-current, Counter-current & Cross-current, Principal Components of a Concentric tube & Shell-and Tube Heat Exchanger, Baffles, Tubes and Tube Distribution, Tubes to Tube sheets Joint, Heat Exchangers with Multiple Shell & tube Passes, Fixed-Tube sheet and Removable-Bundle Heat Exchangers, log-mean temperature difference, overall heat transfer coefficient, fouling factors, Design of double pipe and shell and tube heat exchangers. **[8L]**

Text books:

1. Holman, J. P., 'Heat Transfer ', 9th Edn., McGraw Hill, 2004.

2. Kern, D.Q., "Process Heat Transfer ", McGraw-Hill, 1999.

3. Cengel, Y.A., Heat Transfer - A Practical Approach, McGraw-Hill, 1998.

Reference books:

1. Incropera, F.P. and Dewitt, D.P., Fundamentals of Heat and Mass Transfer, 5th ed., John Wiley, 2002.

2. McCabe, W.L., Smith, J.C., and Harriot, P., "Unit Operations in Chemical Engineering", 6th Edn., McGraw-Hill, 2001.

3. Coulson, J.M. and Richardson, J.F., "Chemical Engineering " Vol. I, 4th Edn., Asian Books Pvt. Ltd., India, 1998.

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
End Sem Examination Marks	50
Quiz	10+10
Teachers Assessment	5

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination Marks	Y	Y	Y		
End Sem Examination Marks	Y	Y	Y	Y	Y
Quiz	Y	Y	Y	Y	Y

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												PSOs			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO208.1	3	3	3	2	2	2	2	1	2	2	1	2	3	2	2	2
CO208.2	3	3	3	2	2	2	2	1	2	2	1	2	3	2	2	2
CO208.3	3	3	3	2	2	2	2	1	2	2	1	2	3	2	2	2
CO208.4	3	3	3	3	2	2	2	1	2	3	1	2	3	2	2	2
CO208.5	3	3	3	3	2	2	2	1	2	3	1	2	3	2	2	2

3= High, 2 = Medium, 1 = Low

Mapping Between COs and Course Delivery (CD) methods		
CD	**Course Delivery methods**	**Course Outcome**
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, CO2, CO3, CO4, CO5
CD2	Tutorials/Assignments	CO1, CO2, CO3, CO4, CO5
CD3	Seminars	
CD4	Mini projects/Projects	CO4
CD5	Laboratory experiments/teaching aids	
CD6	Industrial/guest lectures	
CD7	Industrial visits/in-plant training	
CD8	Self- learning such as use of NPTEL materials and internets	CO1, CO2, CO3, CO4, CO5
CD9	Simulation	

Lecture wise Lesson planning Details.

Week No.	Lect. No.	Tentative Date	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Actual Content covered	Methodology used	Remarks by faculty if any
1	L1		1	Introduction to heat transfer, Modes of heat transfer	T1, T2, R1, R2	1, 5		PPT	
	L2		1	1-D steady state heat conduction	T1, R2	1, 5		PPT, Chalk -Board	
	L3		1	1-D steady state heat conduction (continued), conduction through composite slab	T1, R1, R2	1, 5		PPT, Chalk -Board	
2	L4		1	Critical radius of insulation	T1, R2	1, 5		Chalk -Board	
	L5		1	Heat transfer from a fin	T1, R2	1, 5		Projector, Chalk -Board	
	L6		1	Fin effectiveness and efficiency	T1, R2	1, 5		Chalk -Board	
3	L7		1	Introduction to unsteady state heat conduction	T1, R2	1, 5		PPT, Chalk -Board	
	L8		1	Tutorial				Assignment	
	L9		2	**Convection:** Natural and forced convection	T1, R2	1, 5		PPT	
4	L10		2	convective heat transfer coefficient	T1, R2	1, 5		Chalk -Board	
	L11		2	Correlation equations for heat transfer in laminar and turbulent flows	T1, R2	1, 5		Projector, Chalk -Board	
	L12		2	Reynolds and Colburn analogies between momentum and heat transfer	T1, R1	1, 5		Chalk -Board	
5	L13		2	heat transfer to liquid metals and heat transfer to tubes in cross	T1, R2	1, 5		PPT, Chalk	

				flow				-Board	
	L14		2	Natural convection from vertical surfaces	T1, R2	1, 5		PPT, Chalk -Board	
	L15		2	Natural convection from horizontal surfaces, Grashof and Rayleigh numbers	T1, R2	1, 5		PPT	
6	L16		2	Tutorial				Assign ment	
	L17		3	Basic Concepts of radiation from surface	T1, R2	1, 5		PPT	
	L18		3	Black body radiation, Planks law, Wien's displacement law	T1, R2	1, 5		Projecto r	
7	L19		3	Stefan Boltzmann's law, Kirchhoff's law, grey body	T1, R2	1, 2, 5		Chalk -Board	
	L20		3	Radiation intensity of black body	T1, R2	2, 5		Chalk -Board	
	L21		3	View factor	T1, R2	1, 2, 5		PPT	
8	L22		3	emissivity, radiation between black surfaces and grey surfaces	T1, R2	2, 5		Chalk -Board	
	L23		3	Solar radiations, combined heat transfer coefficients by convection and radiation	T1, R2	1, 5		Chalk -Board	
	L24		3	Tutorial				Assign ment	
9	L25		4	**Boiling and Condensation:** Pool boiling, pool boiling curve for water	T3, R2	3, 5		PPT	
	L26		4	maximum and minimum heat fluxes, correlations for nucleate and film pool boiling	T3, R2	3, 5		PPT	
	L27		4	drop wise and film wise condensation, Nusselt analysis for laminar film wise condensation on a vertical plate	T3, R2	3, 5		PPT	
101	L28		4	film wise condensation on a horizontal tube, effect of non-condensable gases on rate of condensation	T3, R2	3, 5		PPT	
	L29		4	**Evaporation:** Types of evaporators	T3, R2	3, 5		PPT	
	L30		4	Boiling point elevation and Duhring's rule, material and	T3, R2	3, 5		Chalk	

				energy balances for single effect evaporator				-Board	
11	L31		4	Multiple effect evaporators: forward, mixed and backward feeds, capacity and economy of evaporators	T3, R2	3, 5		Projecto r	
	L32		4	Tutorial				Assign ment	
	L33		5	**Heat Exchangers:** Introduction, Industrial use, Types of heat exchangers, Co-current, Counter-current & Cross-current	T2, R3	4, 5		PPT	
12	L34		5	Principal Components of a Concentric tube & Shell-and Tube Heat Exchanger, Baffles, Tubes and Tube Distribution	T2, R3	4, 5		PPT, Chalk -Board	
	L35		5	Tubes to Tube sheets Joint, Heat Exchangers with Multiple Shell & tube Passes	T2, R3	4, 5		PPT, Chalk -Board	
	L36		5	Fixed-Tube sheet and Removable-Bundle Heat Exchangers	T2, R3	4, 5		PPT, Chalk -Board	
13	L37		5	log-mean temperature difference, overall heat transfer coefficient	T1, R2	4, 5		PPT, Chalk -Board	
	L38		5	fouling factors, Design of double pipe and shell and tube heat exchangers	T2, R3	4, 5		PPT, Chalk -Board	
	L39		5	Design of double pipe and shell and tube heat exchangers (Continued)	T2, R3	4, 5		Projecto r, Chalk -Board	
14	L40		5	Tutorial				Assign ment	

COURSE INFORMATION SHEET: CL 209 Mass Transfer Operations -I

Course code: **CL209**
Course title: Mass transfer operations-I
Pre-requisite(s): Thermodynamics **(**CL 201), Chemical Process Calculations (CL 204)
Co- requisite(s): Transport Phenomena
Credits: L: 3 T: 0 P: 0
Class schedule per week: 03
Class: B. E.
Semester / Level: **I**V / Second
Branch: Chemical Engineering
Name of Teacher:

Course Objectives

This course enables the students:

1.	To learn basic knowledge of mass transfer operation and its application.
2.	To learn basic knowledge of mass transfer equipments.
3.	To design mass transfer equipments.

Course Outcomes

After the completion of this course, students will be to:

CO209.1	Explain the basic mechanism of mass transfer including diffusion and convective mass transfer.
CO209.2	Find the mass transfer coefficient and solve problems related to interphase mass transfer.
CO209.3	Explain the gas-liquid contacting process and solve related problems.
CO209.4	Solve problems on VLE and problems related to design calculation of distillation column.
CO209.5	Explain enhanced distillation.

Syllabus

Module 1
Introduction to mass transfer and applications, Principles of molecular diffusion, Fick's Law, Diffusivity, Equation of continuity and unsteady state diffusion, Diffusion in solids. Convective mass transfer and Mass transfer coefficient, Correlation of mass transfer coefficients. **(8L)**

Module 2
Interphase mass transfer, Theories of Mass Transfer, individual gas and liquid phase mass transfer coefficient, overall mass transfer coefficient, Analogy between momentum, heat and mass transfer, Concept of stage wise contact processes. **(8L)**

Module-3
The mechanism of absorption, Equipment for Gas Liquid contact, Kremser equation, plate and packed tower

internals, Packed tower design, H. E. T. P., H. T. U., and N. T. U. concepts, height of column based on conditions in the gas film, height of column based on conditions in the liquid film, height of column based on overall coefficients, plate type towers, number of plates, plate efficiency, absorption factor. **(8L)**

Module-4

Relative Volatility, calculation of number of plates by McCabe-Thiele method, Total and minimum reflux ratio, distillation with side streams, Enthalpy concentration diagram, calculation of number of plates by and Ponchon and Savarit method, Steam distillation, Azeotropic & Extractive Distillations, batch distillation with reflux, Introduction to multicomponent distillation. (**8L)**

Module-5

Shortcut method on multi component distillation, MESH equations (HK, LK component), Fenske-Underwood- Gilliland method. **(8L)**

Text books:

1. Mass Transfer Operations: R.E. Treybal Mc Graw Hill, 1981
2. Unit Operations of Chemical Engineering: W.L. McCabe, and J.C. Smith McGraw Hill.5th Ed. 1993.
3. Principles of Mass Transfer and Separation Processes, Binay K. Dutta, 2nd edition, Prentice Hall of India,2007.
4. Transport processes and Separation Process Principles, C.J. Geankoplis, Prentice Hall of India, 4th Ed. 2004

Reference books:

Separation Process Principles-Chemical and Biochemical Operations, J. D. Seader, Ernest J. Henley, D. Keith Roper, 3rd Ed., John Wiley & Sons, Inc.

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
End Sem Examination Marks	50

Quiz	10+10
Teachers Assessment	5

Assessment Components	CO1	CO2	CO3	CO4
Mid Sem Examination Marks	Y	Y		
End Sem Examination Marks	Y	Y	Y	Y
Quiz	Y	Y	Y	Y

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												PSOs			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO209.1	3	3	0	2	2	0	0	0	1	0	0	3	3	0	1	2
CO209.2	3	3	0	0	2	0	0	0	1	0	0	3	3	0	1	2
CO209.3	3	3	3	3	2	2	2	2	2	3	1	3	3	2	0	2
CO209.4	3	3	3	3	2	2	2	2	2	2	2	3	3	3	2	2
CO209.5	3	3	3	3	2	2	2	2	2	2	2	3	3	3	2	2

3= High, 2 = Medium, 1 = Low

Mapping Between COs and Course Delivery (CD) methods		
CD	Course Delivery methods	Course Outcome
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, CO2, CO3, CO4
CD2	Tutorials/Assignments	CO1, CO2, CO3, CO4
CD3	Seminars	
CD4	Mini projects/Projects	
CD5	Laboratory experiments/teaching aids	
CD6	Industrial/guest lectures	
CD7	Industrial visits/in-plant training	
CD8	Self- learning such as use of NPTEL materials and internets	CO1, CO2, CO3, CO4
CD9	Simulation	

Lecture wise Lesson Planning Details.

Week No.	Lect. No.	Tentative Date	Ch. No.	Topics to be covered	Text Book / References	COs mapped	Actual Content covered	Methodology used	Remarks by faculty if any
1	L1		1	Introduction to mass transfer and applications	T1, R1	1		PPT Digi Class/Chalk-Board	
1	L2		1	Principles of molecular diffusion	T1, R1	1		PPT Digi Class/Chalk-Board	
1	L3		1	Fick's Law, Diffusivity	T1, R1	1		PPT Digi Class/Chalk-Board	
1	L4		1	Equation of continuity and unsteady state diffusion	T1, R1	1		PPT Digi Class/Chalk-Board	
2	L5		1	Diffusion in solids	T1, R1	1		PPT Digi Class/Chalk-Board	
2	L6		1	Diffusion in solids	T1, R1	1		PPT Digi Class/Chalk-Board	
2	L7		1	Convective mass transfer and Mass transfer coefficient	T1, T3, R1	1, 2		PPT Digi Class/Chalk-Board	
2	L8		1	Correlation of mass transfer coefficients.	T1, T2, T4, R1	1, 2		PPT Digi Class/Chalk-Board	
3	L9		2	Interphase mass transfer	T1, R1	1, 2		PPT Digi Class/Chalk-Board	
3	L10		2	Theories of Mass Transfer	T1, , T2,R1	1, 2		PPT Digi Class/Chalk-Board	
3	L11		2	Theories of Mass Transfer	T1, T2, R1	1, 2		PPT Digi Class/Chalk-Board	
3	L12		2	individual gas and liquid phase mass transfer coefficient	T1, T2, T3,R1	1, 2		PPT Digi Class/Chalk-Board	
4	L13		2	individual gas and liquid phase mass transfer coefficient	T1, T2, T3,R1	1, 2		PPT Digi Class/Chalk-Board	
4	L14		2	overall mass transfer coefficient	T1, T2, T3,R1	1, 2		PPT Digi Class/Chalk-Board	
4	L15		2	Analogy between momentum, heat and mass transfer,	T1, T2, T3, T4, R1	1, 2		PPT Digi Class/Chalk-Board	

4	L16		2	Concept of stage wise contact processes	T1, R1	1, 2		PPT Digi Class/Chalk-Board	
5	L17		3	Introduction to absorption, mechanism of absorption	T1, R1	1, 2, 3		PPT Digi Class/Chalk-Board	
5	L18		3	Equipment for Gas Liquid contact	T1, R1	3		PPT Digi Class/Chalk-Board	
5	L19		3	plate and packed tower internals	T1, T2, T3, R1	3		PPT Digi Class/Chalk-Board	
5	L20		3	Packed tower design, H. E. T. P., H. T. U., and N. T. U. concepts,	T1, T2, T3, T4, R1	3		PPT Digi Class/Chalk-Board	
6	L21		3	height of column based on conditions in the gas film,	T1, T2, T3, T4, R1	3		PPT Digi Class/Chalk-Board	
6	L22		3	height of column based on conditions in the liquid film, height of column based on overall coefficients	T1, T2, T3, T4, R1	3		PPT Digi Class/Chalk-Board	
6	L23		3	plate type towers, number of plates	T1, R1	3, 5		PPT Digi Class/Chalk-Board	
6	L24		3	plate efficiency, absorption factor	T1, R1	3, 5		PPT Digi Class/Chalk-Board	
7	L25		4	Introduction, Vapor -liquid equilibria, Relative volatility	T1, R1	4		PPT Digi Class/Chalk-Board	
7	L26		4	Ideal and non -ideal solutions, azeotrope	T1, R1	4		PPT Digi Class/Chalk-Board	
7	L27		4	Batch distillation and equilibrium flash vaporization,	T1, R1	4, 5		PPT Digi Class/Chalk-Board	
7	L28		4	Feed conditions	T1, R1	4, 5		PPT Digi Class/Chalk-Board	
8	L29		4	calculation of number of plates by McCabe-Thiele method	T1, T2, R1	5		PPT Digi Class/Chalk-Board	
8	L30		4	calculation of number of plates by McCabe-Thiele method	T1, T2, R1	5		PPT Digi Class/Chalk-Board	
8	L31		4	Total reflux ratio	T1, T2, R1	5		PPT Digi Class/Chalk-Board	
8	L32		4	Minimum reflux ratio	T1, T2, R1	5		PPT Digi Class/Chalk-Board	
9	L33		5	Enthalpy concentration diagram	T1, R1	4, 5		PPT Digi	

								Class/Chalk-Board	
9	L34		5	calculation of number of plates by and Ponchon and Savarit method,	T1, R1	5		PPT Digi Class/Chalk-Board	
9	L35		5	calculation of number of plates by and Ponchon and Savarit method,	T1, R1	5		PPT Digi Class/Chalk-Board	
9	L36		5	Steam distillation	T1, R1	5		PPT Digi Class/Chalk-Board	
10	L37		5	Azeotropic & Extractive Distillations	T1, T2, T4, R1	5		PPT Digi Class/Chalk-Board	
10	L38		5	batch distillation with reflux	T1, R1	5		PPT Digi Class/Chalk-Board	
10	L39		5	Introduction to multicomponent distillation.	T1, T2, T3, T4, R1	5		PPT Digi Class/Chalk-Board	
10	L40		5	Introduction to multicomponent distillation.	T1, T2, T3, T4, R1	5		PPT Digi Class/Chalk-Board	

COURSE INFORMATION SHEET: CL 210 Transport Phenomena

Course code:	**CL210**
Course title:	**Transport Phenomena**
Pre-requisite(s):	
Co- requisite(s):	
Credits:	**L:3 T:0 P:0**
Class schedule per week:	**3**
Class:	**B. Tech.**
Semester / Level:	**IV / Second**
Branch:	**Chemical Engineering**
Name of Teacher:	

Course Objectives

This course enables the students:

1.	To understand the mathematical foundation required for analysis of fluid flow.
2.	To understand the mathematical foundation required for analysis of heat and mass transfer.
3.	To learn systematic analysis of fluid flow and heat transfer with emphasis on analogies and specific technique using treating such boundary value problems.

Course Outcomes

After the completion of this course, students will be able to:

CO210.1	Identify and describe mechanisms of transport phenomena, present in given isothermal and non-isothermal, laminar and turbulent flow systems.
CO210.2	Distinguish interrelations between the molecular, microscopic and macroscopic descriptions of transport phenomena
CO210.3	Explain similarities and differences between the descriptions of the combined fluxes and the equations of change for mass, momentum and heat transport.
CO210.4	Apply the method of dimensional analysis to reformulate and then find the form of solutions of the equations of change, to determine the dependence of the interfacial fluxes on system parameters.
CO210.5	Elaborate conceptual and mathematical models, from conservation principles, to complicated systems involving simultaneous mass, momentum, and/or heat transfer processes as well as reactions or other sources/sinks of transport for multi-component mixtures.

Syllabus

Module 1:
Law of conservation, Vectors/Tensors, Newton's law of viscosity, Temperature, pressure and composition dependence of viscosity, Kinetic theory of viscosity, Fourier's law of heat conduction, Temperature, pressure and composition dependence of thermal conductivity, Kinetic theory of thermal conductivity, Fick's law of diffusion, Temperature, pressure and composition dependence of diffusivity, Kinetic theory of diffusivity. [8L]

Module 2:
Shell Momentum balances, velocity profiles, average velocity, momentum flux at the surfaces, Reynold's transport theorem, Equations of Change (Isothermal), equation of continuity, equation of motion, equation of energy (isothermal). [8L]

Module 3:
Shell energy balances, temperature profiles, average temperature, energy fluxes at surfaces, Equations of change (non-isothermal), equation of continuity, equation of motion for forced and free convection, equation of energy (non-isothermal). [8L]

Module 4:
Shell mass balances, concentration profiles, average concentration, mass flux at surfaces, Equations of change (multi-component), equations of continuity for each species, equation of energy (multi-component). [8L]

Module 5:
Introduction to the concept of heat and mass transfer coefficients. Interphase mass transfer, various coefficient of mass transfer and their determination, resistance concept, controlling phase concept, Mass transfer in turbulent flow, Analogies of mass transfer, Empirical equations. Theories of mass transfer, two film theory, Higbies penetration theory, Derivation of flux equation, surface renewal theory. [8L]

Text books:

1. Bird R.B., Stewart W.E. and Lightfoot E.N., "Transport Phenomena",2nd Ed., John Wiley and Sons.
2. Geankoplis C.J., "Transport Processes and Separation Process Principles", 4th Ed., Prentice-Hall of India.

Reference books:

1. Brodkey, R.S., Hershey H.C., "Basic concepts in transport phenomena, a unified approach". Vol 1, Brodkey Publishing.
2. Fox and McDonald's, 'Introduction to fluid Mechanics'
3. Robert E. Treybal, Mass-Transfer Operation

Gaps in the syllabus (to meet Industry/Profession requirements):

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

1. Turbulent flow behaviour
2. Conservation law applicable in thin film.

POs met through Topics beyond syllabus/Advanced topics/Design

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
End Sem Examination Marks	50
Quiz	10+10
Teachers Assessment	5

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination Marks	Y	Y	Y		
End Sem Examination Marks	Y	Y	Y	Y	Y
Quiz	Y	Y	Y	Y	Y

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												PSOs			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO210.1	3	3	3	3	1	1	1	1	1	2	2	2	3	3	3	3
CO210.2	3	3	3	3	1	1	1	1	1	2	2	2	3	3	3	3
CO210.3	3	3	3	3	1	1	1	1	1	2	2	2	3	3	3	3
CO210.4	3	3	3	3	1	1	1	1	1	2	2	2	3	3	3	3
CO210.5	3	3	3	3	1	1	1	1	1	2	2	2	3	3	3	3

3= High, 2 = Medium, 1 = Low

Mapping Between COs and Course Delivery (CD) methods		
CD	**Course Delivery methods**	**Course Outcome**
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, CO2, CO3, CO4, CO5
CD2	Tutorials/Assignments	CO1, CO2, CO3, CO4, CO5
CD3	Seminars	
CD4	Mini projects/Projects	
CD5	Laboratory experiments/teaching aids	
CD6	Industrial/guest lectures	
CD7	Industrial visits/in-plant training	
CD8	Self- learning such as use of NPTEL materials and internets	CO1, CO2, CO3, CO4, CO5
CD9	Simulation	

Lecture wise Lesson Planning Details.

Week No.	Lect. No.	Tentative Date	Ch. No.	Topics to be covered	Text Book / References	Cos mapped	Actual Content covered	Methodology used	Remarks by faculty if any
1	L1		1	Law of conservation	T1,	1, 2		Chock -Board	
	L2		1	Vectors/Tensors	T1, T2	1, 2		Chock -Board	
	L3		1	Newton's law of viscosity, Temperature, pressure and composition dependence of viscosity	T1	1, 2		Chock -Board	
	L4		1	Kinetic theory of viscosity	T1	1, 2		Chock -Board	
2	L5		1	Fourier's law of heat conduction, Temperature, pressure and composition dependence of thermal conductivity	T1	1, 2		Chock -Board	
	L6		1	Kinetic theory of thermal conductivity	T1	1, 2		Chock -Board	
	L7		1	Fick's law of diffusion, Temperature, pressure and composition dependence of diffusivity	T1	1, 2		Chock -Board	
	L8		1	Kinetic theory of diffusivity.	T1	1, 2		Chock -Board	
3	L9		2	Shell Momentum balances, velocity profiles, average velocity, momentum flux at the surfaces	T1, T3	2, 3		Chock -Board	
	L10		2	Shell Momentum balances, velocity profiles, average velocity, momentum flux at the surfaces	T1, T3	2, 3		Chock -Board	
	L11		2	Shell Momentum balances, velocity profiles, average velocity, momentum flux at the surfaces	T1, T3	2, 3		Chock -Board	
	L12		2	Shell Momentum balances, velocity profiles, average velocity, momentum flux at the surfaces	T1, T3	2, 3		Chock -Board	
4	L13		2	Reynold's transport theorem	T4	2, 3, 4		Chock -Board	
	L14		2	equation of continuity, equation of motion, equation of energy	T1, T2	2, 3, 4		Chock -Board	
	L15		2	equation of continuity, equation of motion, equation of energy	T1, T2	2, 3, 4		Chock	

								-Board	
	L16		2	equation of continuity, equation of motion, equation of energy	T1, T2	2, 3, 4		Chock -Board	
5	L17		2	Uses of equation of continuity, equation of motion, equation of energy	T1, T2	5		Chock -Board	
	L18		2	Uses of equation of continuity, equation of motion, equation of energy	T1, T2	5		Chock -Board	
	L19		2	Uses of equation of continuity, equation of motion, equation of energy	T1, T2	5		Chock -Board	
	L20		3	Shell energy balances, temperature profiles, average temperature, energy fluxes at surfaces,	T1	2, 4		Chock -Board	
6	L21		3	Shell energy balances, temperature profiles, average temperature, energy fluxes at surfaces,	T1	2, 4		Chock -Board	
	L22		3	Shell energy balances, temperature profiles, average temperature, energy fluxes at surfaces,	T1	2, 4		Chock -Board	
	L23		3	Shell energy balances, temperature profiles, average temperature, energy fluxes at surfaces,	T1	2, 4		Chock -Board	
7	L24		3	Shell energy balances, temperature profiles, average temperature, energy fluxes at surfaces,	T1	2, 4		Chock -Board	
	L25		3	Shell energy balances, temperature profiles, average temperature, energy fluxes at surfaces,	T1	2, 4		Chock -Board	
	L26		3	equation of energy (non-isothermal)	T1	2, 3, 4		Chock -Board	
	L27		3	equation of energy (non-isothermal)	T1	2, 3, 4		Chock -Board	
8	L28		3	Uses of equation of energy	T1	5		Chock -Board	
	L29		4	Shell mass balances, concentration profiles, average concentration, mass flux at surfaces,	T1	2, 3		Chock -Board	
	L30		4	Shell mass balances, concentration profiles, average concentration, mass flux at surfaces,	T1	2, 3		Chock -Board	
	L31		4	Shell mass balances, concentration profiles, average concentration, mass flux at surfaces,	T1	2, 3		Chock -Board	
9	L32		4	Shell mass balances, concentration profiles, average concentration, mass flux at surfaces,	T1	2, 3		Chock -Board	

	L33		4	equations of continuity for each species, equation of energy (multi-component).	T1	2, 3, 4		Chock -Board	
	L34		4	Uses of equations of continuity for each species, equation of energy (multi-component).	T1	5		Chock -Board	
	L35		5	Introduction to the concept of heat and mass transfer coefficients.	T5	1, 2, 3		Chock -Board	
10	L36		5	Interphase mass transfer, various coefficient of mass transfer and their determination	T5	1, 2, 3		Chock -Board	
	L37		5	resistance concept, controlling phase concept	T5	1, 2, 3		Chock -Board	
	L38		5	Mass transfer in turbulent flow	T5	1, 2, 3		Chock -Board	
11	L39		5	Analogies of mass transfer, Empirical equations	T5	1, 2, 3		Chock -Board	
	L40		5	Theories of mass transfer, two film theory, Higbies penetration theory, Derivation of flux equation, surface renewal theory.	T5	1, 2, 3		Chock -Board	