Savitribai Phule Pune University
TE Chemical Engineering
2015 course

Savitribai Phule Pune University
Structure for TE (Chemical Engineering)-2015 Course

Subject Code	Subject	Teaching Scheme			Examination Scheme					Total Marks	Credits Th+PR
		L	P	T	In Semester Assessment	TW	PR	OR	End Semester Examination		
					PI				P II		
TERM I											
309341	Chemical Engineering Mathematics	4	-	-	30	-	-	-	70	100	4
309342	Mass Transfer I	4	2	--	30	-	50	-	70	150	4+1
309343	Industrial Organization & Management	3	2	--	30	--	--	50	70	150	3+1
309344	Chemical Process Technology	4	2	--	30	-	--	50	70	150	4+1
309345	Chemical Engineering Thermodynamics II	3	--	--	30	--	--	--	70	100	3
309346	Computer Aided Chemical Engineering I	--	2	--	--	50	--	--	--	50	1
309347	Industrial Training Evaluation	--	--	--	--	50	--	--	--	50	1
	Total	18	8	--	150	100	50	100	350	750	23
TERM II											
					PIII				P IV		
309348	Chemical Reaction Engineering I	4	2	--	30	--	50	--	70	150	4+1
309349	Transport Phenomena	4	--	--	30	--	--	--	70	100	4
309350	Chemical Engineering Design I	3	2	--	30	--	--	50	70	150	3+1
309351	Mass Transfer II	4	2	--	30	--	50	--	70	150	4+1
309352	Process Instrumentation & Control	3	2	--	30	50	--	--	70	150	3+1
309353	Seminar	--	2	--	--	50	--	--	--	50	1
	Industrial Training	To be evaluated in VII Semester									
	Total	18	10	--	150	100	100	50	350	750	23

Examination Duration: In semester: 60 min.
End semester: 150 min.
L: Lecture, P: Practical, T: Tutorial, TW: Term work, PR: Practical, OR: Oral.
PI: Phase one, PII: Phase two, PIII: Phase three, PIV: Phase four.

TERM: I

309341 : CHEMICAL ENGINEERING MATHEMATICS	
Teaching Scheme: Lectures : 4 Hours / Week	**Examination Scheme:** In Semester: 30 End Semester: 70 **Total: 100**

Unit 1: Error and Roots of Equation **8 Hrs**

Problems based on Process Calculation, Fluid Flow operation and Heat Transfer to be solved using following methods: Error Definition, Round of Error, Error Propagation, Total Numerical Error. Bracketing method: Graphical, Bisection, False-Position. Open Method: Single variable Newton Raphson, Secant method, multiple roots. Roots of Polynomial: Mullers Method. Caley Hamilton method.

Unit 2: Linear Algebraic Equation **8 Hrs**

Problems based on Process Calculation, Fluid Flow operation and Heat Transfer to be solved using following methods :Gauss Elimination, Gauss-Jordon Elimination, LU Decomposition, Tridiagonal Systems (Thomas Algorithm), Gauss Seidel and Relaxation Method. Eigen values and Eigen Vectors of Matrices.

Unit 3: Regression Analysis and Interpolation **8 Hrs**

Problems based on Process Calculation, Fluid Flow operation and Heat Transfer to be solved using following methods. Statistical Data Analysis: Least square method, curve fitting and regression. Linear Regression, Polynomial Regression, Multiple Linear regression, Non-linear regression, Newton's Interpolation, Newton's Divided Difference Interpolation, Polynomial, Lagrangian Interpolation. Numerical Integration: Trapezoidal method, Simpson 1/3rd rule, Simpson 3/8th rule

Unit 4: Ordinary Differential Equation **8 Hrs**

Problems based on Process Calculation, Fluid Flow operation and Heat Transfer to be solved using following methods . Euler's method, Modified Euler's method, 2nd order Runge-Kutta Method, 4th order Runge-Kutta method, Systems Equations. Picards method of successive approximations. Ordinary Differential Equation: Boundary Value Problems, Taylor series method.

Unit 5: Finite Difference Methods **8 Hrs**

Problems based on Process Calculation, Fluid Flow operation and Heat Transfer to be solved using following methods .Introduction to finite difference method. Boundry value problems of exact differential equations up to second order. Hyperbolic equations, Finite difference approximations to derivatives. Elliptical Equation, Control Volume Approach, Heat Conduction Equation,

Unit 6: Optimization **8 Hrs**

Problems based on Process Calculation, Fluid Flow operation and Heat Transfer to be solved using following methods: Basic concept of optimization and formulation, Nature of optimization. Linear programming by simplex method. Applications of optimization based on simplex method. Golden search method and its application.

References

1. Steven C Chapra, Raymond P Canale, 'Numerical Methods for Engineers', 5th Edition, Tata McGraw-Hill Publishing Company Limited, New Dehli, 2007

2. Santosh K Gupta, 'Numerical Methods for Engineers', New Age International Publishers Limited, 1995

3. Thomas F Edgar, David M Himmeblau, Leon S Lason, 'Optimization of Chemical Processes', 2nd Edition, Mc-Graw Hill Publication, 2002

4. S. Balgurusamy, 'Numerical methods', Tata McGraw Hill Publication, New Delhi, 2008

5. Curtise F Gerald, Patrick O Wheatley, 'Applied Numerical Analysis', 6th Edition, Pearson Education Asia, 2002.

309342: MASS TRANSFER –I

Teaching Scheme:	**Examination Scheme:**
Lectures : 4 Hours / Week	In Semester: 30
Practical : 2 Hours / Week	End Semester: 70
	Practical: 50
	Total: 150

Unit 1: Introduction **8 Hrs**

General principles of Mass Transfer, classification of Mass Transfer Operations, choice of separation method, methods of conducting mass transfer operations, design principles. Diffusion Mass Transfer, Molecular Diffusion in gases and liquids, diffusivities of gases and liquids, types of diffusion, Fick's and Maxwell law of diffusion, diffusion in solids, unsteady state mass transfer.

Unit 2: Inter-Phase Mass Transfer **8 Hrs**

Mass transfer coefficients in laminar flow and turbulent flow, theories of mass transfer, mass, heat and momentum transfer analogies. Inter-phase mass transfer, equilibrium in mass transfer, the two resistance theory, continuous co-current, countercurrent and crosscurrent processes, cascades.

Unit 3: Gas Absorption **8 Hrs**

Mechanism of gas absorption, equilibrium in gas absorption, application of mass transfer theories to absorption, absorption in wetted wall columns, values of transfer coefficient, absorption in packed tower and spray tower, calculation of HETP, HTU, NTU, calculations of height of packed and spray tower. Absorption in tray towers, absorption and stripping factors, tray efficiencies, calculation of number of trays for absorption, absorption with chemical reaction.

Unit 4: Humidification and Dehumidification- **8 Hrs**

Principles, vapour-liquid equilibria, enthalpy of pure substances, basic definition of all humidification terms, wet bulb temperature relation, psychrometric chart, Lewis relation, methods of humidification and dehumidification, equipment like cooling towers, tray towers, spray chambers, spray ponds, cooling tower design – HTU, NTU concept, calculation of height of cooling tower.

Unit 5: Equipment for gas liquid operation **8 Hrs**

Types of columns, Types of trays, types of packing, Gas dispersal equipment – bubble columns, mechanically agitated vessels, tray towers. Liquid dispersal equipment – Venturi scrubbers, wetted wall columns, spray towers, packed columns

Unit 6: Drying **8 Hrs**

Principles, equilibrium in drying, type of moisture binding, mechanism of batch drying, continuous drying, time required for drying, mechanism of moisture movement in solid, design principles of tray dryer, rotary dryer, drum dryer, spray dryer, fluidized bed and spouted bed dryer, pneumatic dryer and vacuum dryer.

Practical

Minimum Ten practical to be performed out of the following:

1. Tray Dryer – To calculate rate of Drying
2. Rotary Dryer – To study the Characteristics of Rotary Dryer
3. Spray Dryer – To study the design and Operating Principles of Spray Dryer
4. Fluidized Bed Dryer – To study the characteristics of Fluidized bed Dryer
5. Liquid Diffusion – To calculate the Diffusion Coefficient for a liquid –liquid system
6. Winkelmann's method – To find the diffusion Coefficient of vapour in still air
7. To study Solid in air Diffusion
8. Enhancement Factor – To find the enhancement factor for absorption with and without chemical reaction
9. Mass transfer Coefficient – To determine the Mass Transfer Coefficient for Absorption in a Packed Tower

10. Cooling Tower– To study the characteristics of cooling tower
11. Humidifier and Dehumidifier – To study the Characteristics
12. Interphase Mass Transfer Coefficient – To calculate the individual and overall Mass Transfer Coefficient
13. Wetted Wall Column – To find the mass transfer coefficient in a wetted wall Column

References

1. Mass Transfer Operations – Treybal R.E., McGraw Hill

2. Chemical Engineering, Vol. I & II – Coulson J.M. and |Richardson J.F., McGraw Hill

3. Principles of Unit Operations in Chemical Engineering, Foust A.S.

4. Separation Techniques – King C.J.

5. Design of Equilibrium Stage Processes - Smith B.D.

6. Unit Operations of Chemical Engineering, McCabe W.L. and Smith J.C. , McGraw Hill

309343: INDUSTRIAL ORGANIZATION AND MANAGEMENT

Teaching Scheme:	**Examination Scheme:**
Lectures : 3 Hours / Week	In Semester: 30
Practical : 2 Hours / Week	End Semester: 70
	Oral: 50
	Total: 150

Unit 1: Management Science **7 Hrs**

A. Management, its growth, concepts of administration and management of organization. Definition of management, functions, authority and responsibility, unity of command and direction decision making in management by objectives.

B. Personality: Physical appearance, body language, voice, communication style, content of communication, enriched communication through Sensory Specific Language. Business style and professional image: Dress codes, Guidelines for appropriate business attire.

C. Business organization: Different forms of organization, their formation and working, different organization structure- line organization, functional organization, line and staff organization.

Unit 2: Personnel Management **7 Hrs**

Manpower planning, sources of recruitment, selection and training of staff, job evaluation, merit rating, performance appraisal, wage administration and system of wage payment, incentive, motivations, industrial fatigue, trade unions – industrial relations. Introduction to personal selling & salesmanship: Defining personal selling and salesmanship, Selling as a profession, Objectives and importance of personal selling, Essentials of personal selling, traditional & modern selling approach, ethics in Selling, role of selling in marketing, types of selling, qualities of winning sales professionals-physical, mental, social and character traits.

Unit 3: Purchase and stores management **7 Hrs**

Concepts of quotation, tenders and comparative statement, inspection and quality control, inventory, carrying cost and fixed cost of inventory, examples of cost of Inventory, stores management, functions of storekeeper, methods of inventory : LIFO, FIFO. Credit analysis and appraisal principles of credit management: Principles of lending –evaluation of borrower – sanction limit-principles of good lending.

Unit 4: Marketing management **7 Hrs**

Concepts of selling, marketing, definition of marketing, market research and of pricing, penetration, pricing, skimming pricing, distribution of product, advertising and promotion. Introduction to product management: Product management as a basis of marketing organization structure. Role of product manager, skills required for product management. Product management in consumer product industry vs industrial product industry. Overview of product level marketing plans.

Unit 5: Export and import management **7 Hrs**

Concepts of international trade, duties, antidumping duty, cost involved in exporting a product, pricing of export product. Government aids for export promotion, export houses, export promotion counsel, MODVAT, patent and patent rights. Quality Management: TQM, quality circles, ISO systems. Inflation: Meaning, types of inflation, causes, effects, control of inflation, value of money, index numbers, construction, utility, limitations, business cycles, phases of business cycles.

Unit 6: Management Laws **7 Hrs**

Concepts of contract act, offer, and acceptance, types of contracts, void contract, concept of guarantee and warranty. Introduction of MRTP and FERA. Work study: Work measurement, motion and time study flow process chart, flow diagram, silo chart, string chart, therbligs. Patent law: Patent cooperation treaty, patent act 1970, procedure for filing patent applications, patent granting procedures, revocation.

Practical (Minimum eight)

1. Study of marketing strategy analysis
2. Study of ISO systems
3. Study of total quality management
4. Study of international trade: Export and Import
5. Study of incentive plan management
6. Study of organization structure and its types
7. Study of wage administration system
8. Study of management laws
9. Study of product, marketing, and selling management through industrial visit

References

1. Stonier, A. W. and Hague, D. C., "A Text Book of Economic Theory", Longman.
2. Bach, George Leland, "Economics -Analysis, Decision Making and policy", Prentice Hall Inc. Englewood Cliffs N. J.
3. Bonham F, "Economics", Sir Isaac Pitman and Sons Ltd., London.
4. Seth, M. L., "Principles of Economics", Lakshmi Narayan Agarwal, Agra.
5. Agarwal, A. N., "Indian Economy", Vikas Publishing House Pvt. Ltd., New Delhi.
6. Datta R. and Sundharam, K. P. M., "Indian Economy" S. Chand & Co. Ltd., New Delhi
7. Peter F. Drucker, "The Practice of Management", Allied publishers pvt. ltd., Bombay.
8. Barat, Nikhil, "Production management & Control", Academic Publishers, Calcutta.
9. Garrett, Leonard J. & Silver, Milton, "Production Management Analysis", Harcourt Brace Jovanovich, Inc. New York.
10. Kuchhal, S. C., "Financial Management: An- Analytical & Conceptual Approach", Chaitanya Publishing House, Allahabad.
11. Pandey, L. M., "Financial Management", Vikas Publishing House Pvt. Ltd., New Delhi.
12. Kotlel, Philip, "Marketing Management: Analysis, Planning & Control", Prentice –Hall of India Pvt. Ltd: New Delhi
13. Sinha, J. C., "Marketing and Salesmanship", S. Chand & Co., Delhi. 14. H.L. Ahuja, "Modern economics", S. Chand and co. ltd., New Delhi.
15. Management for Business and Industry-C. S. George Jr.
16. Principles of management- Knoots and O. Donnell.
17. Business Organization and management- M. C. Shulka

309344: CHEMICAL PROCESS TECHNOLOGY

Teaching Scheme:	**Examination Scheme:**
Lectures : 4 Hours / Week	In Semester: 30
Practical : 2 Hours / Week	End Semester: 70
	Oral: 50
	Total: 150

Unit I: Basic Concepts **8 Hrs**

The process study should contain raw materials, flow diagram, detailed process description, major engineering problems, advantages and disadvantages of the process and product applications. Unit operations, unit processes, schematic representation and applications for unit operations and unit processes.

Chlor-alkali and elctrolytic industry, sea chemicals

i) Chlor-alkali industry: Production of soda ash, NaOH and Chlorine

ii) Sea chemicals: Sodium-Magnesium compounds, different methods for different salt recovery.

iii) Electrolytic industry: Production of Aluminium, Magnesium.

Unit II: Nitro- Phosphorous Industry and Sulphur Industry **8 Hrs**

i) Nitrogen Industry: Production of Ammonia, Nitric acid, Urea, Ammonium Nitrate.

ii) Phosphorous Industry: Production of Phosphoric acid, single and triple Super Phosphate, Ammonium Phosphate.

iii) Sulphur Industry: Production of Sulphur, Sulphuric acid, Ammonium sulphate.

Unit III: Sugar- Starch, Paper – Pulp and Fermentation Industry **8 Hrs**

i) Sugar-Starch Industry: Production of Sugar, Starch Derivatives

ii) Paper and Pulp Industry: Kraft pulp process, sulphite pulp process, production of paper.

iii) Fermentation Industry: Production of ethyl alcohol, absolute alcohol.

iv) Bio Pharmaceutical Industry: Production of penicillin, antibiotics.

Unit IV: Natural Chemicals **8 Hrs**

i) Coal Chemicals: Destructive distillation of coal, Types of carbonization, Coke oven – construction, working and applications.

ii) Oils, Fats, Soaps and Detergents : Solvent extraction process, hydrogenation of oil, interesterification, production of soap, natural glycerine, production of detergents

iii) Cement : Production of Portland cement

iv) Iron and Steel: Production of steel, blast furnace detail.

Unit V: Industrial Gases and Petroleum Industry **8 Hrs**

i) Industrial Gases: Producer gas, fuel cell, natural gas, water gas

ii) Petroleum Industry: History of production of crude petroleum, characteristics of refineries-refinery operations, pyrolysis, cracking, reforming, polymerization, alkylation, hydroalkylation, isomerization, hydrogenation.

Unit VI: Petrochemical Industry- **8 Hrs**

i) C_1 Compounds: Production of methanol, formaldehyde, and halogenated hydrocarbons.

ii) C_2 Compounds: Production of ethylene and acetylene- steam cracking of hydrocarbons, ethylene dichloride, vinyl chloride.

iii) C_3 Compounds: Production of propylene by indirect hydration, acetone, cumene.

iv) Aromatic Compounds: Production of phenol, phthalic anhydride, and styrene.

Practical (Minimum Eight)

1. Production of Caustic Soda
2. Production of Urea,
3. Production of single /Triple Super Phosphate/ Ammonium Phosphate.

4.Production of paper.
5.Production of ethyl alcohol
6.Production of soap
7.Production of Detergent
8.Production of Portland cement
9. Mass balance calculations of any two processes using process calculation approach.
10. Heat balance calculations of any two processes using process calculation approach.
11. Calculations based on recycle operations.
12. Process flow sheets drawing of any two processes using CAD.

References

1. Chemical Technology- Venkateshwaralu, Vol. I, II, III, IV Chemical Engg. IIT Madras
2. Outlines of Chemical Technology, Dryden
3. Unit Processes in Organic Synthesis, Groggins P., McGraw Hill.
4. Chemical Process Industries, Shreeve R.N., McGraw Hill.
5. Industrial Chemicals, Feith – Keys and Clerk.

309345: CHEMICAL ENGINEERING THERMODYNAMICS II

Teaching Scheme:	**Examination Scheme:**
Lectures : 3 Hours / Week	In Semester: 30
	End Semester: 70
	Total: 100

Unit 1: Solution Thermodynamics **8 Hrs**

Fundamental property relations, chemical potential, effect of T and P on chemical potential, criteria for phase equilibrium, partial properties, ideal gas mixtures, fugacity and fugacity coefficients for pure species, Poynting factor, for species in solution, generalized correlations, ideal solutions.

Unit 2: Solution Thermodynamic applications **8 Hrs**

Excess properties, VLE data, fugacity, activity coefficients, excess Gibb's energy, Margules equation, van Laar equation, property changes of mixing.

Unit 3: Vapor-liquid equilibrium **8 Hrs**

The nature of equilibrium, criteria of equilibrium, effect of T and P on VLE, azeotropes, the phase rule, Duhem's theorem, Raoult's law, VLE by modified Raoult's law, dew point and bubble point calculations, VLE from K-value correlations, Flash calculations, Henry's law.

Unit 4: Phase Equilibria **8 Hrs**

Equilibrium and stability, liquid-liquid equilibrium, solid-liquid equilibrium, osmotic equilibrium and osmotic pressure, thermodynamic consistency.

Unit 5: Chemical Reaction Equilibria **8 Hrs**

The reaction coordinates, Application of the criteria for equilibrium to chemical reactions, the standard Gibbs free energy change and the equilibrium constant, effect of temperature on equilibrium constant, evaluation of the equilibrium constant.

Unit 6: Equilibrium constant 8 **Hrs**

Relation of equilibrium constant to composition, calculation of equilibrium conversion for single reactions, The phase rule and Duhem's theorem for reacting systems, multireaction equilibria, Introduction to fuel cells.

References

1. Introduction to Chemical Engineering Thermodynamics: J. M. Smith, H. C. Van Ness & M. M. Abbott
2. Principles of Chemical Equilibrium: Kenneth Denbigh
3. Chemical Engineering Thermodynamics: B. F. Dodge
4. Chemical Engineering Thermodynamics: T. E. Daubert
5. Thermodynamics for Chemists: Glasstone S.
6. Thermodynamics for Chemical Engineers: Weber and Meissner
7. Chemical and Process Thermodynamics: B. G. Kyle
8. Molecular Thermodynamic: Praunitz
9. Chemical Engineering Thermodynamics: Narayanan
10. Chemical Engineering thermodynamics: Y.V.C. Rao

309346: COMPUTER AIDED CHEMICAL ENGINEERING – I

Teaching Scheme:	**Examination Scheme:**
Practical : 4 Hours / Week	Term Work: 50
	Total: 50

Minimum 10 practical and a compulsory home paper.

Applications of numerical Techniques in chemical engineering to be evaluated by following methods:

Topics may include but are not restricted to:

1. Eigen values and Eigen vector computations for Level Control Applications.
2. Applications of Vectors to problems in Fluid Mechanics, Continuity equations, Stream lines, Equations of motion, Bernoulli's equations.
3. Numerical interpolation
4. Numerical integration.
5. Integration of ODE – Equation for Batch Reactions.
6. Numerical differentiation.
7. Root-finding method – two non linear equations.
8. Linear programming for solving Liquid Level in Tank model.
9. Data fitting.
10. Process calculation using MS-EXCEL.
11. Application of neural networks.
12. Fuzzy logic applications.
13. Application of support vector machines.
14. Design Algorithms
15. Non-linear optimization methods-Interacting and non interacting systems
16. Regression Analysis.

Home paper for each student or group of students is compulsory.

(A paper written by a student may be five to six pages in double spacing, a few figures may get added.)

309347: INDUSTRIAL TRAINING I

Examination Scheme:
Term Work: 50
Total: 50

Students are required to submit neatly typed and bound training report after joining the college. The report should include information about working of the industry as also specific information of the work done by the student in the industry. The students are also required to attach the Original Certificate issued by the competent authority from the industry where he / she has undergone training mentioning the successful completion of the training.
The industrial report is to be submitted within first 15 days of commencement of the fifth term in bound format and soft copy. The department will conduct industrial report presentation session for every student under the head 'Term work' under Industrial training evaluation by the examiner.
Evaluation of Industrial training by students will be based on -

i) Knowledge acquired by him/her during the industrial training

ii) His/her performance in presentation

iii) Report

iv) Discussions

TERM: II

309348: CHEMICAL REACTION ENGINEERING –I

Teaching Scheme:	**Examination Scheme:**
Lectures : 4 Hours / Week	In Semester: 30
Practical : 2 Hours / Week	End Semester: 70
	Practical: 50
	Total: 150

Unit 1: Kinetics of Homogeneous Reactions **8 Hrs**

Defining a rate equation and its representation, single and multiple reactions, elementary and non elementary reactions, molecularity and order of reactions, kinetic models for non-elementary reactions, searching mechanism, rate controlling step.

Unit 2: Analysis and interpretation of Batch Reactor data **8 Hrs**

Constant volume batch reactor, integral and differential methods of analysis, variable volume batch

Unit 3: Reactor Design **8 Hrs**

Introduction, conversion of mass in reactors, performance equation for ideal stirred tank reactor, tubular flow reactor, batch reactor, space time and space velocity.

Isothermal Reactors for single Reactions: Batch reactor, mixed versus plug flow reactors, second order reactions, graphical comparison, multiple reactor system, plug flow reactors in series and in parallel, equal size mixed reactors in series, reactors of different types in series, recycle reaction (flow, batch), auto-catalytic reactions, non- steady flow semi-batch reactors.

Unit 4: Multiple reactions **8 Hrs**

Parallel and series reactions, performance of various ideal reactors, qualitative and quantitative discussion for multiple reactions, instantaneous and overall fractional yield.

Unit 5: Temperature and pressure effects **8 Hrs**

Temperature dependency from Arrhenius law, thermodynamics, collision theory, transition state theory, comparison of theories, rate of reactions predicted by theories, single reactions: heat of reaction from thermodynamics, equilibrium constants from thermodynamics, graphical design procedure, heat effects, adiabatic operations, non adiabatic operations.

Unit 6: Deviations from Ideal Reactor **8 Hrs**

Self mixing of a single fluid & two miscible units, Residence time distribution, F,C,E, curves and relation between them. Models for non-ideal reactions, dispersion model, tanks in series model, segregated flow model.

Practical: Minimum of **eight** experiments out of the following list should be performed.

1. Study of saponification of ethyl acetate reaction in batch reactor.
2. Determination of Arrhenius parameters.
3. Study of pseudo first order reaction. Acid catalyzed hydrolysis of methyl acetate
4. Study of saponification of ethyl acetate reaction in mixed flow reactor.
5. Study of saponification of ethyl acetate reaction in plug flow reactor
6. CSTRs in series.
7. RTD studies in PFR.
8. RTD studies in MFR.
9. RTD studies in Helical coil reactor.
10. CSTR followed by PFR.

References:

1. Chemical Reaction Engineering: Levenspile O.
2. Chemical Engineering Kinetics: Smith J.,
3. Elements of Chemical Reaction Engineering: H. Scott, Fogler.

309349: Transport Phenomena

Scheme:	**Examination Scheme:**
Lectures : 4 Hours / Week	In Semester: 30
	End Semester: 70
	Total: 100

Unit 1: Momentum Transport **8 Hrs**

Importance of transport phenomena, analogous nature of transfer process, introduction of viscosity and mechanism of momentum transport: Newton's law of viscosity, Newtonian & Non-Newtonian fluids, pressure and temperature dependence of viscosity, theory of viscosity of gases and liquids.

Velocity distribution in laminar flow: Shell momentum balances of - a) Flow of falling film b) Flow through the circular tube c) Flow through an annulus d) Flow in a narrow slit e) Adjacent flow of two immiscible fluids

Unit 2: Energy Transport **8 Hrs**

The introduction of thermal conductivity and mechanism of energy transport: Fourier's law of heat conduction, temperature and pressure dependence of thermal conductivity in gases and liquids.

Temperature distribution in solids and in laminar flow & numerical problems -

a) Shell energy balance, boundary conditions b) Heat conduction with electrical heat source c) Heat conduction with a nuclear heat source d) Heat conduction with a viscous heat source e) Heat conduction with a chemical heat source f) Heat conduction with variable thermal conductivity g) Forced and free convection h) Heat conduction in a cooling fin

Unit 3: Mass Transport **8 Hrs**

Introduction of diffusivity and mechanism of mass transport: Definitions of concentrations, velocities and mass fluxes, Fick's law of diffusion, temperature and pressure dependence of mass diffusivity.

Concentration distribution in solids and in laminar flow & numerical problems -

a) Shell mass balances, boundary conditions b) Diffusion through stagnant gas film c) Diffusion with heterogeneous chemical reaction d) Diffusion with homogeneous chemical reaction e) Diffusion through Pyrex tube, leaching etc.

Unit 4: Unsteady Momentum Transport **8 Hrs**

Equations of change for isothermal system -

a) The equation of continuity b) The equation of motion c) Equation of change in curvilinear coordinate systems d) Use of equation of change to set up steady flow problem e) Equation of mechanical energy f) Dimensional analysis of equation of change

Unit 5: Interphase transport in isothermal system **8 Hrs**

Interphase transport - a) Defining friction factors b) Friction factors for flow in tube, around spheres & packed column. Macroscopic balances for Isothermal systems - a) The macroscopic mass, momentum and mechanical energy balances b) Sudden enlargement and liquid-liquid ejector c) Semi empirical expressions for Reynolds stresses

Unit 6: Simultaneous & Analogy momentum, heat and mass transfer **8 Hrs**

Interphase transport in multi component system -

a) Definition of binary mass transfer coefficient in one phase b) Co-relation of binary mass transfer coefficient in one phase at low mass transfer rates c) Co-relation of binary mass transfer coefficient in two phases at low mass transfer rates d) Definition of transfer coefficient for high mass transfer rates Reynolds analogy, Prandtl's analogy, Chilton and Colburn analogy & Martinnelli's analogy.

References

1. Transport Phenomena, Bird R. B., Stewart and Lightfoot, John Wiley & Sons
2. Analysis heat and mass transfer, Eckert Erg and Brake R. M.
3. Fundamentals of momentum, heat and mass transfer, James Welty, Charles Wicks
4. Energy Mass and Momentum transport phenomena in continua", Slattery J. C.

309350: CHEMICAL ENGINEERING DESIGN I

Teaching Scheme:	**Examination Scheme:**
Lectures : 3 Hours / Week	In Semester: 30
Practical : 2 Hours / Week	End Semester: 70
	Oral: 50
	Total: 150

Unit 1: Storage Vessels **7 Hrs**

Study of various types of storage vessels and applications, Atmospheric vessels, vessels for storing volatile and non-volatile liquids, storage of gases, Losses in storage vessels, Various types of roofs used for storage vessels, Design of cylindrical storage vessels as per IS: 803- design of base plates, shell plates, roof plates, wind girders, curb angles for self supporting and column supported roofs. Design of rectangular tanks as per IS: 804.

Unit 2: Design of Tall Vessels **7 Hrs**

Stresses in the shell of a tall vertical vessel, and period of vibration, vessel supports- introduction and classification of supports, design of skirt supports considering stresses due to dead weight, wind load, seismic load, design of base plate, skirt bearing plate, anchor bolts, bolting chairs and skirt shell plates Design of saddle supports, ring stiffeners.

Unit 3: Heat Exchangers **7 Hrs**

Shell and tube heat exchanger- General design considerations- LMTD correction factor, fluid allocation, fluid velocities, stream temperatures, pressure drop, shell side and tube side heat transfer coefficients, overall heat transfer coefficient, mechanical design of shell and tube heat exchanger- thickness of shell and shell cover, channel cover, tube sheet, size and number of tie rods and spacers . Design of double pipe heat exchanger. Plate heat exchanger: advantages, disadvantages, design procedure, temperature correction factor, heat transfer coefficients, pressure drop.

Unit 4: Design of Heat exchange equipments **7 Hrs**

Evaporators: classification, criteria for selection, design of calendria type evaporator. Condensers: heat transfer fundamentals, condensation outside horizontal tubes, condensation inside and outside vertical tubes, condensation inside horizontal tubes, condensation of mixtures. Reboilers**:** types, selection, boiling heat transfer fundamentals, estimation of boiling heat transfer coefficients, pool boiling, convective boiling.

Unit 5: Agitators and Reaction vessels **7 Hrs**

Study of various types of agitators, their selection, applications, baffling, agitator shaft diameter calculations which includes twisting moment, equivalent bending moment, power requirement calculations for agitation systems. Reaction vessels: introduction, classification, heating systems, design of vessels, study and design of various types of jackets like plain, half coil, channel, limpet oil, study and design of internal coil reaction vessels, heat transfer coefficients in coils.

Unit 6: Auxiliary process vessels **7 Hrs**

Study of auxiliary process vessels such as reflux drum, knockout drum, liquid-liquid and gas-liquid separators, entrainment separators, oil water separator, decanter, gravity separator, safety devices used in process industries

References

1. “Process equipment design” by L.E. Brownell and E. Young, John Wiley, New York, 1963.
2. “Introduction to Chemical Equipment Design” by B.C. Bhattacharya C.B.S. Publications.
3. “Process Equipment Design” by M.V. Joshi, Mcmillan India.
4. “Chemical Engineering Vol. 6” by J.M. Coulson, J.F. Richardson and R.K. Sinott, Pergamon Press.
5. “Applied Process Design for Chemical and Petrochemical Plants” vol 1 and 2, Ludwig E.E., Gulf Publishing Company, Texas.

6. “Indian standards Institution” code for unfired pressure vessels, IS - 2825
7. “Chemical Process Equipment-Selection and design” Walas S.M. Butterworth Heinamen, McGraw Hill book company, New York
8. “Chemical Engineering volume 2” by J.M. Coulson, J.F. Richardson, and R.K. Sinott Pergamon Press.

Practicals:

Design of the following equipments using softwares. (Any 6)

1. Cylindrical storage vessels
2. Tall Vessels
3. Shell and Tube heat exchangers ,
4. Plate type Heat Exchanger& Condensers.
5. Double Pipe Heat Exchangers, Finned Heat Exchangers.
6. Condensers (Shell and Tube) : Vertical condensers, horizontal condensers.
7. Reboilers & Vaporisers: Kettle type, Vertical Thermosyphon type.
8. Reaction Vessel
9. Decanter
10. Gravity Separator

309351: MASS TRANSFER –II

Teaching Scheme:	**Examination Scheme:**
Lectures : 4 Hours / Week	In Semester: 30
Practical : 2 Hours / Week	End Semester: 70
	Practical: 50
	Total: 150

Unit 1: Distillation **8 Hrs**

Distillation principle, vapour-liquid equilibria for ideal and non-ideal systems, ideal solutions, positive and negative deviations from ideality, relative volatility, binary and multicomponent systems, methods of distillation - differential , flash, azeotropic, extractive, low pressure, steam distillation, batch rectification.

Unit 2: Continuous Rectification **8 Hrs**

Continuous rectification for binary system, multistage (tray) towers, packed towers for distillation, reboilers, distillation column internals, Lewis Sorrel, McCabe Thiele, and Ponchon-Savarit methods for multistage operations, tray efficiencies, concept of reflux, minimum reflux ratio, optimum reflux, total reflux, Fenske's equation, use of open steam, Partial and total Condensers, cold reflux, Fenske-Underwood equation, concept of multi component distillation.

Unit 3: Liquid-Liquid Extraction **8 Hrs**

Ternary liquid equilibria, single stage extraction, multistage crosscurrent, countercurrent and cocurrent extraction, calculations based on triangular diagrams, x – y coordinates and solvent free basis, Continuous counter current extraction with reflux, total reflux, stage efficiency, continuous contact extraction in packed towers, HTU and NTU concept, types of extractors – stage type and differential type.

Unit 4: Solid-Liquid Extraction (Leaching) **8 Hrs**

Leaching equipment-continuous counter current leaching, ideal stage equilibrium, operating time, constant and variable underflow, number of ideal stages, stage efficiencies, calculation of single stage and multistage leaching processes.

Unit 5: Adsorption and Ion Exchange **8 Hrs**

Adsorption – Basic principle and equilibria in adsorption, types of adsorption-physical and chemical adsorption, break through curve, adsorption hysteresis, calculations of single stage, multistage adsorption, rate of adsorption in fixed bed, adsorption Isotherms-Langmuir and Freundlich, Introduction to pressure swing adsorption (PSA), and temperature swing adsorption (TSA). Ion Exchange: principles of ion exchange, techniques and applications, equilibria and rate of ion exchange, equipments.

Unit 6: Crystallisation & Novel Techniques **8 Hrs**

Principle of crystallization, rate of crystal growth, size distribution, solubility curves, Mier's supersaturation theory, material balance, enthalpy balances, calculation of yield, equipments.

Introduction to membrane separation techniques: ultra filtration, nanofiltration, reverse osmosis, types of membranes and membrane modules, fluxes and driving forces in membrane separation processes.

Practical

Minimum 10 practicals to be performed out of the following list.

1. Simple Distillation
2. Total Reflux
3. Steam Distillation
4. Vapour liquid equilibrium
5. Liquid-liquid equilibrium for ternary system
6. Liquid – Liquid Extraction (single stage and multistage)
7. Characterization of Spray Extraction Column

8. York Schibel Column
9. Distillation using Sieve Plate, Bubble Cap Column
10. Batch/ Continuous Leaching
11. Process of Crystallization and its Characteristics
12. Batch Crystallization
13. Ion Exchange
14. Adsorption

References

1. Treybal R.E. “Mass Transfer Operation”
2. Richardson J. F. and Coulson J.M. “Chemical Engineering”, Vol. I , II
3. McCabe and Smith, ‘Unit Operations in Chemical Engineering”
4. Henley E. J. and Seader H.K. “Stage wise Process Design” , McGraw Hill
5. Smith B.D., “Design of Equilibrium Stage Process”.
6. Foust A.S., “Principles of Unit Operations”
7. King C. J. “Separation Processes”, McGraw Hill
8. A.L. Lyderson, “Mass Transfer in Engineering Practices”, John Wiley

309352: PROCESS INSTRUMENTATION AND CONTROL

Teaching Scheme:	**Examination Scheme:**
Lectures : 3 Hours / Week	In Semester: 30
Practical : 2 Hours / Week	End Semester: 70
	Term Work: 50
	Total: 150

Unit 1: Fundamentals of Process Instrumentation 7 **Hrs**

Need and scope of process instrumentation, classification of process variables, measurement problem analysis, basic measurement terms, Functional elements of instruments, static and dynamic characteristics of measuring instruments (zeroth, first, and second-order instruments/ systems), measurement system configuration, transducer elements (types and classification). Intermediate elements: instrument amplifiers, compensators, differential and integrator elements, signal conditioners (signal generation and processing), filtering and signal analysis, data acquisition and conversion (ADC, DAC), digital signal transmission and processing (serial communication, telemetry), indicating and recording elements.

Unit 2: Temperature measuring instruments **8 Hrs**

Introduction, classification, temperature scales (units), mechanical temperature sensors (filled-system thermometers, expansion thermometers), electrical temperature sensors (RTD, thermistors, thermocouples), radiation sensors (optical and radiation), solid-state sensors, quartz sensors, calibration methods (comparison and fixed point).

Unit 3: Pressure and strain measuring instruments **8 Hrs**

Introduction, classification, low, medium, and high pressure measuring instruments, pressure scales (units), manometers, elastic element pressure gauges with pressure equations (using bourdon tube, diaphragms, capsule, and bellows), transduction/ electrical sensors with pressure equations (based on variable capacitance, resistance, and inductance/reluctance-LVDT), force- balance transducers along with mathematical equations, solid-state devices, thin-film transducers, digital transducers, piezoelectric transducers, vibrating element sensors, pressure multiplexer, calibration of pressure sensors using dead- weight tester, Mechanical, optical, and electrical strain gauges.

Unit 4: Level and Flow Measuring Instruments **8 Hrs**

Level measuring instruments: Introduction, classification, direct methods (point contact methods, sight or gauge glass methods, buoyancy methods using floats and displacers), indirect methods (hydrostatic pressure methods, capacitance methods, radiation methods, ultrasonic methods, weighing method, sonic methods), solid level measurement. Flow measuring instruments: Introduction, classification (rate of flow and total flow meters), pressure head- type flow meters (orifice plate, venturi tube, flow nozzle, pitot tube), variable- area flow meters (rotameters), electromagnetic, mechanical (positive displacement and turbine- type), anemometer, ultrasonic - type, vortex- flow type, thermal - type, laser anemometers, mass flow meters (cover mathematical treatment for all the sensors).

Unit 5: Instrumental Methods of Chemical Analysis **8 Hrs**

Introduction, classification, basic components of analytical instruments, measurements used Absorption and emission spectrometric methods: ultraviolet (UV), visible, and infrared (IR) spectroscopy, atomic absorption spectroscopy (AAS), mass spectroscopy, Refractometry Chromatographic methods: gas chromatography (GC), liquid chromatography (LC), high performance liquid chromatography (HPLC). Electrochemical methods: measurement of pH, colourimetric, conductometric, potentiometric, Process instruments and automatic on-line analysis

Unit 6: Fundamentals of Process Dynamics **8 Hrs**

Introduction to process dynamics (PD), mathematical tools for process control (laplace transform, complex numbers), ideal forcing functions, control-relevant theoretical process modeling, transfer function and state-space models, poles and zeros of transfer function and their effect on dynamic

response, block diagram representation, studying dynamic behavior of linear time invariant (LTI) systems, dynamic behavior of pure gain, pure capacitive, first- order, second-order systems, dead-time systems (derive differential equation model, transfer function, response to standard test signals and response characteristics along with physical examples), process identification using step response data, Introduction to feedback control system (FBCS), Introduction to ON-OFF, P, PI, PD, PID controllers.

Practical

Minimum of **eight** experiments out of the following list should be performed.

1. Calibration and characteristics of temperature sensors
2. Calibration and characteristics of pressure sensors
3. Calibration and characteristics of level sensors
4. Calibration and characteristics of flow sensors
5. Instrumental methods of chemical analysis using GC/HPLC/AAS/UV spectrophotometer, refractometer, pH meter, conductivity meter, etc.
6. Dynamic behavior of first- order systems
7. Dynamic behavior of second- order systems
8. Characteristics of ON-OFF controllers applied to temperature, pressure, level, flow processes
9. Characteristics of P, PI controllers applied to temperature, pressure, level, flow processes
10. Characteristics of PD, PID controllers applied to temperature, pressure, level, flow processes.

Term Work Assessment:

TW assessment is based on practical performance and assignment evaluation. Assignments on every experiment should be given to the students. Students are required to attend industrial visits to update themselves about chemical industries and modern equipments under the head TW.

References

1. Instrument Engineers' Handbook (Process Measurement)- Bella G. Liptak, Elsevier
2. Instrument Engineers' Handbook (Process Control)- Bella G. Liptak, Elsevier
3. Instrumentation devices and systems- Rangan, Sharma, Mani, Tata McGraw Hill Publishing Co. Ltd.
4. Instrumental methods of analysis – Willard, Merritt, Dean, Settle, CBS Publishers and Distributors
5. Instrumental approach to Chemical Analysis- Shrivastava, Jain, S. Chand and Co.
6. Handbook of Analytical Instruments- Khandpur, Tata McGraw Hill Publishing Co. Ltd.
7. Process Control- Bequette, PHI publications
8. Chemical process control- Stephanopoulos, PHI publications
9. Process Dynamics and Control- Seborg, Edgar, Mellichamp- John Wiley and sons Inc.

309353: SEMINAR

Teaching Scheme:	**Examination Scheme:**
Practical : 2 Hours / Week	Term Work: 50
	Total: 50

The seminar may be a review of literature of specific phenomena/new process. Working model to demonstrate the principle, alternatively a small experimentation to investigate chemical engineering data/unit process/ unit operation. Based on this study focused report should be submitted. It is expected that the student collect information from reference books, journals and Internet. The report submitted should reveal the student's internalization of the collected information. Mere compilation from the net and other resources is discouraged.

Format of the Seminar report and TW assessment:

1. The Seminar report should be based on a detailed study of any relevant topic to Chemical Engineering, be neatly written or typed on white paper. The typing shall be with normal spacing and on one side of the paper [A-4 size].
2. The report should be submitted with front and back cover of card paper neatly cut and bound or spirally together with the text.
3. Front cover: This shall have the following details.
    a. Title of the seminar report.
    b. The name of the candidate with roll number examination seat number at the middle.
    c. Name of the guide below the candidate's details.
    d. The name of the institute and year of submission on separate lines at the bottom.
4. Seminar approval sheet.
5. The format of the text of the seminar reports:

The report shall be presented in the form of a technical paper. The introduction should be followed by literature survey. The report of analytical or experimental work done, if any, should then follow.
The discussion and conclusions shall form the last part of the text. They should be followed by nomenclature and symbols used followed by acknowledgement. The bibliography should be at the end. References should be written in the standard format.
The total number of typed pages, excluding cover shall be about 25 to 30 only. All the pages should be numbered. This includes figures and diagrams.
Two copies of the seminar report shall be submitted to the college. The candidate shall present the seminar before the examiners. The total duration of presentation and after-discussion should be about 30 minutes max. [25 min + 5 min]. Audience can ask questions only if the examiner permits. [Such questions will not have any bearing on marks].
The assessment for the subject shall be based on
1. Report submitted.
2. Presentation.
3. Discussion.

309354 : INDUSTRIAL TRAINING II

Teaching Scheme:	**Examination Scheme:**
3-4 Weeks of training in industry.	To be evaluated in seventh semester

The students are required to undergo exhaustive Industrial Training of minimum three to four weeks immediately after the completion of sixth semester and before the commencement of seventh semester in an industry of repute in the field of chemical engineering. The relevant industry is to be finalized in consultation with the head of concerned department before the end of sixth semester.
During the training period the students are expected to undergo rigorous exposure of the industry, its working style, various departments and their working, hands on experience on the various equipments available with the industry. Student should maintain a log book mentioning day to day activity he / she has carried out during the training period.
Students are required to submit neatly typed and bound training report after joining the college. The report should include information about working of the industry as also specific information of the work done by the student in the industry. The students are also required to attach the Original Certificate issued by the competent authority from the industry where he / she has undergone training mentioning the successful completion of the training.
The industrial report is to be submitted within first 15 days of commencement of the seventh term in bound format and soft copy. The department will conduct industrial report presentation session for every student under the head 'Term work' under Industrial training evaluation by the external examiner. Evaluation of Industrial training by students will carried out after Semester VI based on -

i) Knowledge acquired by him during the industrial training

ii) His/her performance in presentation

iii) Report

iv) Discussions