FACULTY OF ENGINEERING

Syllabus for the

T.E (Chemical Engineering)

(w.e.f 2010-2011)

UNIVERSITY OF PUNE

T. E. Chemical Engineering

TERM – I

Subject Code No.	Subject	Teaching Scheme			Examination Scheme				Total
		Theory	Practical	TW/ Drawing	Paper	Practical	Oral	TW	
309341	Chemical Engineering Mathematics	4			100				**100**
309342	Mass Transfer I	4	2		100	50		25	**175**
307351	Industrial Organization & mgmt	3	2		100			25	**125**
309343	Chemical Process Technology	4	2		100		50		**150**
309344	Chemical Engineering Thermodynamics II	3			100				**100**
309345	Computer Aided Chemical Engineering I		4					50	**50**
309346	Industrial Training I (Evaluation)							50	**50**
	Total	**18**	**10**		**500**	**50**	**50**	**150**	**750**

TERM – II

Subject Code No.	Subject	Teaching Scheme			Examination Scheme				Total
		Theory	Practical	TW/ Drawing	Paper	Practical	Oral	TW	
309347	Chemical Reaction Engineering I	4	4		100	50			**150**
309348	Transport Phenomena	4			100				**100**
309349	Chemical Engineering Design I	3		2	100		50	25	**175**
309350	Mass Transfer II	4	2		100	50			**150**
309351	Process Instrumentation & Control	3	2		100		50		**150**
309352	Seminar			2				25	**25**
	Industrial Training II (to be evaluated in Seventh Semester)								**-**
	Total	**18**	**8**	**4**	**500**	**100**	**100**	**50**	**750**

SEMESTER I

309341: Chemical Engineering Mathematics

Teaching Scheme: **Exam Scheme:**

Theory: 4 hr/week **Paper: 100 Marks**

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

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, Multi-Variable Newton Raphson, Secant, Multiple roots. **Roots of Polynomial:** Muller, Baristow

Unit 2: Linear Algebraic Equation **10 Lecture**

Problems based on Process Calculation, Fluid Flow operation and Heat Transfer to be solved using following methods

Naïve Gauss Elimination, Gauss-Jordon Elimination, LU Decomposition, Tridiagonal Systems (Thomas Algorithm), Cholesky decomposition, Gauss Seidel and Relaxation Methods.

Eigen values and Eigen Vectors of Matrices: Faddeev-Leverrier, Power and Householder and Givens Method

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

Problems based on Process Calculation, Fluid Flow operation and Heat Transfer to be solved using following methods

Linear Regression, Polynomial Regression, Multiple Linear regression, Non-linear regression, Newton's Interpolation, Newton's Divided Difference Interpolation Polynomial, Lagrangian Interpolation.

Statistical Analysis: Orthogonal Collocation, Surface Responce

Numerical Integration: Trapezoidal method, Simpson $1/3^{rd}$ rule, Simpson $3/8^{th}$ rule

Unit 4: Ordinary Differential Equation: Initial Value Problems **10 Lecture**

Problems based on Process Calculation, Fluid Flow operation and Heat Transfer to be solved using following methods

Euler's method, Modified Euler's method, 2^{nd} order Runge Kutta Method, 4^{th} order Runge-Kutta method, Systems Equation

Ordinary Differential Equation: Boundary Value Problems

Polynomial method, Power method, Finite Difference Technique, Orthogonal Collation Finite Element, Galerkin Finite Element method

Unit 5: Partial Differential Equation **8 Lecture**

Problems based on Process Calculation, Fluid Flow operation and Heat Transfer to be solved using following methods

Elliptical Equation, Control Volume Approach, Heat Conduction Equation, Explicit method, Implicit method, Crank Nicolson method, Finite Difference method, Galerkin Finite Element

Unit 6: Optimization **10 Lecture**

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
Unconstraint One Dimension Methods: Newton's Method, Quadratic Interpolation, Cubic Interpolation
Unconstraint Multiple Variable: Random search, Grid search, Simplex search, Quasi-Newton method

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 Dehli, 2008
5. Curtise F Gerald, Patrick O Wheatley, 'Applied Numerical Analysis', 6th Edition, Pearson Education Asia, 2002.

309342: Mass Transfer I

Teaching Scheme:
Theory: 4 hr/week
Practical: 2 hr/week

Exam Scheme:
Paper: 100 Marks
Practical: 50 Marks
Term Work: 25 Marks

Unit 1: Introduction (9 lectures)

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:

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 cocurrent, countercurrent and crosscurrent processes, cascades.

(9 lectures)

Unit 3: Gas Absorption

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, calculation 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. (9 lectures)

Unit 4: Humidification and Dehumidification

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. (9 lectures)

Unit 5: Equipment for gas liquid operation

Gas dispersal equipment – bubble columns, mechanically agitated vessels, tray towers.

Liquid dispersal equipment – Venturi scrubbers, wetted wall columns, spray towers, packed columns (9 lectures)

Unit 6 : Drying

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.

(8 lectures)

Reference books :

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

List of Practicals

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) Enhancement Factor – To find the enhancement factor for absorption with and without chemical reaction
8) Mass transfer Coefficient – To determine the Mass Transfer Coefficient for Absorption in a Packed Tower
9) Cooling Tower– To study the characteristics
10) Humidifier and Dehumidifier – To study the Characteristics
11) Interphase Mass Transfer Coefficient – To calculate the individual and overall Mass Transfer Coefficient
12) Wetted Wall Column – To find the mass transfer coefficient in a wetted wall Column

Note On Term Work :

- Minimum number of experiments – 8
- Minimum number of assignments – 2 (out of remaining experiments)
- Besides experimental work, evaluation of term work should be done through periodic tests
- Record of assessment of practical should be maintained on continuous basis

307351: Industrial Organization And Management

Teaching Scheme: **Exam. Scheme:**
Lectures: 3 hrs/week Theory: 100 Marks
Term Work: 2 hrs/week TW: 25 marks

Unit 1: **9 Hrs**

Management Science:

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.

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: **9 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.

Unit 3: Purchase and stores management: **9 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.

Unit 4: Marketing management: **9 Hrs**

Concepts of selling, marketing, definition of marketing, market research and of pricing, penetration, pricing, skimming pricing, distribution of product, advertising and promotion.

Unit 5: Export and import management: **9 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.

Unit 6: Management Laws: **9 Hrs**

Concepts of contract act, offer, and acceptance, types of contracts, Void contract, concept pf guarantee and warranty. Introduction of MRTP and FERA.

Work study:

Work Measurement, motion and time study flow process chart, flow diagram, sio chart, string chart, therbligs.

Practicles:

Reference Books

1) Management for Business and Industry-C.S. George Jr.
2) Principles of management- Knoots and O.Donnell.
3) Business Organization and management- M.C. Shulka

309343: Chemical Process Technology

Teaching Scheme:	**Exam Scheme**
Lectures: 4 Hr/week	Theory: 100 Marks
Practical : 2 Hr/week	Oral: 50 Marks

Unit I: 9 Hrs

Basic Concepts: 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: 9 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 9 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.

Unit IV: Natural Chemicals: 9 Hrs

i) Coal Chemicals: Destructive Distillation of Coal, Types of Carbonization, Coke Oven – Construction, Working and Applications.
ii) Oils and Fats : Basic Chemistry, Solvent Extraction Process, Hydrogenation of Oil, Interesterification.
iii) Soaps and Detergents: Chemistry- Cleaning Action, Production of Soap, Natural Glycerin, Production of Detergents, Applications
iv) Bio Pharmaceutical Industry: Production of Penicillin, Antibiotics.

Unit V: Industrial Gases And Petroleum Industry: 9 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: 9 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

References:

1. Chemical Technology 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.

Term work/ Practical:

1. Heat and Mass balance calculations of any two processes using simulator like Preparation of Ketone, Ester.
2. Process flow sheets drawing of any two processes using CAD.
3. Industrial Visit to Inorganic compound manufacturing unit
4. Industrial Visit to Organic compound manufacturing unit
5. Preparation of soap,
6. Liquid Detergent
7. copper pigment,
8. Phenol formaldehyde resin,
9. Sodium Phenolate,
10. Barium sulphate,
11. Alcohol using fermentation

309344: Chemical Engineering Thermodynamics II

Teaching Scheme:	**Exam. Scheme:**
Lectures: 3 hrs/week	Theory: 100 Marks

Unit: 1 Solution Thermodynamics: 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, for species in solution, generalized correlations, ideal solutions. (7lectures)

Unit 2: Solution Thermodynamic applications: excess properties, VLE data-fugacity, activity coefficients, excess Gibb's energy, Margules equation, van Laar equation, property changes of mixing. (7lectures)

Unit : 3: Vapor – liquid equilibrium: 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

(8 lectures)

Unit: 4: Phase Equilibria: Equilibrium and stability, liquid -liquid equilibrium, solid- liquid equilibrium, osmotic equilibrium and osmotic pressure, thermodynamic consistency. (8 lectures)

Unit 5: Chemical Reaction Equilibria: The reaction coordinates, Application of the criteria for equilibrium to chemical reactions, the standard Gibbs free energy change and the equilibrium constant, effect temperatureon equilibrium constant, evaluation of the equilibrium constant

(7lectures)

Unit 6: Equilibrium constant: relation of equilibrium constant to composition, calculation of equilibrium conversion for single reaction. The phase rule and Duhem's theorem for reacting systems, multireaction Equilibria

(7lectures)

Reference Books:

1) Introduction to Chemical Engineering Thermodynamics: J. M. Smith & H. C. Vanness
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 Thermodynamics: Praunitz
9) Chemical Engineering Thermodynamics : Narayanans

309345: Computer Aided Chemical Engineering – I.

Teaching Scheme:
Practical: 4 hr/week

Exam Scheme:
Term Work: 50 Marks

Minimum 12 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.)

309346: Industrial Training I

Teaching Scheme: -- **Exam Scheme:**

Term Work: 50 Marks

Evaluation of Industrial training carried out by students after Semester IV is to be evaluated.

SEMESTER II

309347: Chemical Reaction Engineering –I

Teaching Scheme:	**Exam Scheme:**
Lectures: 4 hrs/week	Theory: 100 Marks
Practical: 4 hrs/week	Practical: 50 Marks

Unit: 1 Kinetics of Homogeneous Reactions: 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. (9 lectures)

Unit: 2: Analysis and interpretation of Batch Reactor data: Constant volume batch reactor, integral and differential methods of analysis, variable volume batch reactor, integral and differential methods of analysis. (9 lectures)

Unit: 3: Reactor Design: 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 and second order reactions, graphical comparison, multiple reactor system, plug flow reactors in series & / or in parallel, equal size mixed reactors in series, reactors of different types in series, reactors of different types in series, recycle reaction (flow, batch), auto-catalytic reaction, non- steady flow semi-batch reactors. (9 lectures)

Unit: 4: Multiple reactions: Parallel and series reactions, performance of various ideal reactors, qualitative and quantitative discussion for multiple reactions, instantaneous and overall fractional yield. (9 lectures)

Unit: 5: Temperature and pressure effects: 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. (9 lectures)

Unit: 6: Deviations from Ideal Reactor: Self mixing of a single fluid & two miscible units. Residence time distribution, F,C,E, curve and relation between them. Models for non-ideal reactions, dispersion model, tanks in series model segregated flow model. (9 lectures)

Reference:

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

Experiments:

Minimum of ten experiments should be performed. Suggested list is as below

1) Study of first order reaction.

2) Inversion of sucrose
3) Study of pseudo first order reaction. Acid catalysed hydrolysis of methyl acetate
4) Study of a second order reaction – Saponification of ethyl acetate.
5) Determination of Arrhenius parameters
6) Study of homogeneous catalytic reaction, decomposition of hydrogen peroxide, acid catalysed ester hydrolysis.
7) Batch fermentation of sucrose using invertase
8) Study of PFR
9) Study of CSTR
10) Study of CSTR combination in first order reactions
11) Study of F & C curves in CSTR
12) Study of F & C curves in Helical coil reactor
13) Study of PFR & CSTR combination in second order reaction

309348: Transport Phenomena

Teaching Scheme: **Exam Scheme:**
Theory: 4 hr/week **Paper: 100 Marks**

Unit 1 & 2: Momentum Transport: 18 hrs

1. 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.
2. 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) Creeping flow around a solid sphere
    e) Adjacent flow of two immiscible fluids
3. Equations of change for isothermal system
    a) the equation of continuity
    b) the equation of motion
    c) equation of change in curvilinear coordinate
    d) use of equation of change to set up steady flow problem
    e) equation of mechanical energy
    f) dimensional analysis of equation of change
4. Velocity distribution in turbulent flow:
    a) fluctuations and time smoothing quantities
    b) time smoothing of the equation of change for an incompressible fluid
    c) semi empirical expression for the Reynolds
5. Interphase transport in isothermal system:
    a) defining friction factors
    b) friction factors for flow in tube, around spheres packed column
6. Macroscopic balances for Isothermal systems:
    a) the macroscopic mass, momentum and mechanical energy balances
    b) estimation of the friction loss
    c) use of the macroscopic balances to set up steady flow problems.

Unit 3 & 4: Energy Transport: 18 hrs

1. 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

2. Temperature distribution in solids and in laminar flow:
    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 through composite walls. Addition of resistance

f) forced and free convection
g) heat conduction in a cooling fin

3. Temperature distribution in turbulent flow
   a) temperature fluctuations and time smoothed temperature
   b) time smoothing the energy equation
   c) semi empirical expressions for turbulent energy flux
4. Interphase transport in non- isothermal system
   a) definition of the heat transfer coefficients
   b) heat transfer coefficient for forced convection in tubes
   c) heat transfer coefficient for forced convection around submerged objects
   d) heat transfer coefficients for forced convection through packed beds
   e) heat transfer coefficients for free convection

Unit 5: Mass Transport: 9 Hrs

1. 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.
2. Concentration distribution in solids and in laminar flow:
   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 in falling liquid film: forced convection mass transfer
3. Concentration distribution in turbulent flow:
   a) concentration and the time smoothed concentrations
   b) time smoothing of the equation of continuity

Unit 6: 1. Simultaneous & Analogy momentum, heat and mass transfer. 9 Hrs

2. 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

Reference:

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

309349: Chemical Engineering Design - I

Teaching scheme	**Exam scheme**
Lecture: 3 hrs. /week	Paper: 100 Marks
Drawing: 2 hrs. /week	Term work: 25 marks
	Oral: 50 Marks

Unit 1: Material Specifications- types of materials and their basic characteristics, Plastics as MOC for chemical plants, Materials for specific environments like high temperature, low temperature, corrosive services, Indian standards on materials

Equipment Fabrication and Testing- Post weld heat treatment, inspection and non destructive testing of equipment, pressure tests, radiography tests, dye penetration tests, Freon test, magnetic test, Ultrasonic test

Optimization techniques **8 Hrs**

Unit 2: Pressure Vessels-

Proportioning of pressure vessels, selection of L/D ratio, optimum proportions. Design of unfired pressure vessels: Types of pressure vessels, codes and standards for pressure vessels (IS: 2825; 1969), Pressure vessels subjected to internal pressure:

Complete design as per IS: 2825: 1969 involving

1) Shells: cylindrical, spherical
2) Selection and design of various heads

Pressure vessels subjected to external pressure: Design of shell, heads, stiffening rings as per IS: 2825; 1969

Flanges and Nozzles- Classification of flanges, types of flanges, Gasket - types, selection, and design, Bolt design and selection, flange thickness

Nozzle reinforcement, design of compensation **8 Hrs**

Unit: 3 High Pressure Vessels- Materials of construction, stresses in thick cylinder, pre-stressing of thick walled vessels, monoblock, multilayer, Autofrettage, shrink fitted shell, ribbon and wire wound vessel, Analysis and design of high pressure vessels including shell and head along with the stress distribution.

Storage Vessels: Study of various types of storage vessels and applications, Atmospheric vessels, vessels for storing volatile and nonvolatile liquids, storage of gases, Losses in storage vessels, Various types of roofs used for storage vessels, manholes, nozzles and mountings. Design of cylindrical storage vessels as per IS: 803; should include 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. **8 Hrs**

Unit: 4 Design of Tall Vessels- 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 **8 Hrs**

Unit: 5 Heat Exchangers- Codes and standards for heat exchangers, 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

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, **8 Hrs**

Unit: 6 Design of Heat exchange equipments-

Evaporators- Classification, criteria for selection, design

Condensers-Heat transfer fundamentals, condensation outside horizontal tubes, condensation inside and outside vertical tubes, condensation inside horizontal tubes, condensation of steam, mean temperature difference, condensation of mixtures, pressure drop in condensers

Reboilers and vaporizers - types, selection, boiling heat transfer fundamentals, estimation of boiling heat transfer coefficients, pool boiling, convective boiling, design of forced circulation reboilers, thermosyphon reboilers, and kettle reboilers

Plate heat exchanger- Advantages, disadvantages, design procedure, temperature correction factor, heat transfer coefficients, pressure drop **8 Hrs**

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.

Term Work: a) Minimum four number of assignment related to Design and Drawing on above mentioned equipments.
b) Minimum four assignments using AutoCAD.

309350: Mass Transfer II

Teaching Scheme: **Exam Scheme:**
Theory: 4 hrs/week **Paper: 100 Marks**
Practical: 2 hrs/week **Practical: 50 Marks**

Unit 1: Distillation 9Hrs

Vapour – liquid equilibria for ideal and non-ideal systems, relative volatility, ideal solutions, azeotropes, positive and negative deviations from ideality, multi component system, methods of distillation - differential , flash, azeotropic, extractive, low pressure, steam distillation, batch rectification.

Unit: 2 Continuous rectification for binary system, multistage (tray) towers, Lewis Sorrel, McCabe Thiele, and Ponchon Savarit methods for multistage operations, tray efficiencies, concept of reflux, mnimum reflux ratio, optimumreflux, total reflux, Fenske's equation, reboilers, use of open steam, rectification of azeotropic mixtures.

Partial and total Condensers, cold reflux, Fenske-Underwood equation, packed towers for distillation, NTU, HTU, HETP concept and calculations, concept of multicomponent distillation, distillation column internals.

Unit: 3 Liquid-Liquid Extraction 9Hrs

Ternary liquid equilibria, single stage extraction, multistage crosscurrent, countercurrent and cocurrent extraction, calculations based on triangular diagrams, x – y co – ordinates and solvent free basis.

Continuous countercurrent 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): 9Hrs

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: 9Hrs

Adsorption – Basic Principle and Equilibria in adsorption. Single gases and vapors – Adsorption of liquids. Types of adsorption – Physical and Chemical Adsorption Isotherms- Langmuir and Freundlich. Introduction to pressure Swing Adsorption (PSA), and Temperature Swing Adsorption (TSA).

Equipments: Continuous Contact: steady state –moving bed Adsorbers. Ion Exchange-Principles of Ion Exchange, Techniques and applications, Equilibria and rate of ion exchange, equipments.

Unit 6: Crystallisation & Novel Techniques: 9Hrs

Principle rate of crystal growth, population balance and size distribution, calacultion of yield, enthalpy balances, equipment.

Membrane separation techniques- Ultra filtration. Nanofiltration, reverse osmosis, Rate based processes such as diffusion coefficient based inert gas generation from air by carbon molecular sieves.

List of Practicals

Any eight practicals to be conducted out of the following:

1. Simple Distillation
2. Total Reflux
3. Steam Distillation
4. Equilibrium Diagram for Liquid – Liquid Extraction
5. Characterization of Spray Extraction Column
6. York Schibel Column
7. Distillation using Sieve Plate, Bubble Cap Column
8. Batch/ Continuous Leaching
9. Process of Crystallization and its Characteristics
10. Batch Crystallization
11. Ion Exchange

Term work will be based on the conduct of above practical.

Reference Books:

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

309351:Process Instrumentation And Control

Teaching scheme	**Examination scheme**
Theory : 03 hours/ week	**Paper:** 100 marks
Practical: 02 hours/ week	**Oral :** 50 marks

Unit 1: Fundamentals of Process Instrumentation (PI): **06**

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,

Microprocessors , microcontrollers, personal computer (PC) based instrumentation systems (virtual instrumentation using soft wares like Lab view) , input-output (I/O) devices and displays, calibration of instruments.

Unit 2: Temperature, Pressure, and Strain Measuring Instruments: 06

Temperature measuring instruments: 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).

Pressure and strain measuring instruments: 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 3: Level and Flow Measuring Instruments: 06

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 flowmeters (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 4: Instrumental Methods of Chemical Analysis 06

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 5: Fundamentals of Process Dynamics (P.D.): 08

Introduction to process dynamics (P.D.), 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 .

Unit 6: Feedback Control Systems 08

Introduction to feedback control system (FBCS), classification of process variables, selection of controlled variable (CV), manipulated variables (MV), disturbance or load variables (DV), block diagram with essential variables and instrument elements, derivation of closed- loop transfer function for servo and regulator operations, classical feedback controllers -ON-OFF, P, PI, PD, PID (control equation/ law/ algorithm, tuning parameters, open-loop response characteristics along with effect of tuning parameters), simple control performance measures (rise time, overshoot, decay ratio, offset), closed-loop response characteristics of first- and second- order processes with classical controllers.

Industrial process control Systems:

Control system symbols used in process and instrumentation (P&ID) diagrams and drawings, basic regulatory control loops for controlling temperature of liquid heated in stirred-tank heater using electrical (or steam) heating, pressure of air/ gas in pressure vessel, level of liquid inside surge vessel, flow of liquid in pipe line.

Single-loop controllers for surge vessel level control, reactors (batch and CSTR), heat exchangers, distillation column, pumps, compressors.

Reference books:

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.

Practicals:

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

Characteristics of ON-OFF, P, PI, PD, PID controllers applied to temperature, pressure, level, flow processes

309352: Seminar

Teaching Scheme:
TW: 2 hr/week

Exam Scheme:
Term Work: 25 Marks

The mini project may be a review of literature of specific phenomena/new process. Working model to demonstrate the principal, alternatively a small experimentation to investigate chemical engineering data/unit process/ unit operation.
Based on this study focused report should be submitted.

Industrial Training II

Teaching Scheme: -- **Exam Scheme:--**

Industrial training shall be as per norms of the institute. The list of industries where students can undergo training will be approved and published by the department. Period of training will be during vacation without affecting regular class work/examination. During the training, the student shall study/analyze the operation/process/design or the complete industry in detail. They shall submit a report in detail identifying the problems with their suggestion for solution and conclusions to the department through the faculty coordinator assigned for the same at the end of the training period. The minimum duration of industrial training is 1-2 weeks. A committee consisting of two faculty of the department will carry out assessment of the training. Students shall make a presentation before the committee.