DEPARTMENT OF CHEMICAL ENGINEERING

THIRD YEAR

REVISED SYLLABUS

Semester I&II

SHRI GURU GOBIND SINGHJI INSTITUTE OF ENGINEERING & TECHNOLOGY,

VISHNUPUNRI, NANDED

2013-14

Semester –V

Sub. Code	CourseTitle	Natureof Subject Compulsory/ Elective	Dept. offering the subject	Weekly Load (Hours)			Credit
				Lect.	Tut.	Lab.	
CH301	ChemicalEngineering Thermodynamics	Compulsory	Chemical	3	1	--	04
CH302	Heat Transfer	Compulsory	Chemical	3	1	2	05
CH303	Mass Transfer-I	Compulsory	Chemical	3	1	2	05
CH304	Process Equipment Design	Compulsory	Chemical	3	1		04
CH305	Chemical Process Industries	Compulsory	Chemical	3	-	-	04
Total Credits				**15**	**04**	**04**	**21**

Semester-VI

Sub. Code	CourseTitle	Natureof Subject Compulsory/ Elective	Dept. offering the sub	Weekly Load (Hours)			Credit
				Lect.	Tut.	Lab.	
CH306	Mass Transfer-II	Compulsory	Chemical	3	1	2	05
CH307	Chemical Reaction Engg-I	Compulsory	Chemical	3	1	2	05
CH308	Process Control & Instrumentation	Compulsory	Chemical	3	1	2	05
CH309	Process Modelling & Simulation	Compulsory	Chemical	3	1	2	05
CH310	Elective–I	Elective	Chemical	3	-	-	03
TotalCredits				**15**	**04**	**08**	**23**

List of elective-I: Safety &Risk Analysis, Renewable Energy Sources, Energy Managemen

SEMESTER- V

CH301	Chemical Engineering Thermodynamics (Credit-04) (Lect-04,Pract.-00)

Objective:

At the end of this course, students will:

1. Be able to select an appropriate equation of state for representing the P-V-T behavior of gases at high pressure and/or liquids.
2. Be able to calculate changes in U, H, and S for ideal gases, and also for nonideal gases through the use of residual properties.
3. Understand the criteria of phase equilibrium for a pure substance and use it to relate the enthalpy of phase change to the saturation pressure curve via the Clapeyron equation.
4. Understand the utility of fugacity as a transformation of the chemical potential that is mathematically well behaved and not as a replacement for pressure.
5. Be familiar with the various ways (P-T, P-x-y, T-x-y and x-y) for representing phase equilibrium behavior of mixtures.
6. Understand the criteria of phase equilibrium for mixtures.
7. Understand the assumptions behind Raoult's law and the ideal solution as well as what things will make them fail.
8. Know how to incorporate non ideal behavior into phase equilibrium calculations through two different approaches: the gamma-phi approach and the equation of state approach. They will understand the advantages and disadvantages of each approach.
9. Be able to select appropriate solution models for use in either of these two approaches.
10. Be able to make the typical phase equilibrium calculations (BUBL P, BUBL T, DEW T and DEW P) using both of these approaches.
11. Be exposed to different techniques for measuring phase equilibria and have experience making actual measurements using the total pressure method.
12. Understand the criteria for chemical reaction equilibria.
13. Be able to calculate compositions at equilibrium for single reactions in a single phase as a function of temperature and pressure.

COURSE CONTENT

1. Introduction To Chemical Engineering Thermodynamic and First Law: The scope of thermodynamics, fundamental and derived quantities, first law of thermodynamics: Formation of 1st law of thermodynamics, state and path functions, thermodynamic systems, steady state flow system, phase rule, reversible process heat capacity.
2. The Second Law of Thermodynamics: Introduction, Mathematical Treatment of Entropy Concept, Combined form of First and Second Law of Thermodynamics, Thermodynamic Relations based on Second Law of Thermodynamics, Calculations of Entropy Changes, and Third Law of Thermodynamics.
3. Heat Effects: Sensible heat effects, Temperature dependence of heat capacity, Evaluation of sensible heat integral, standard heat of reaction, Standard heat of formation, Standard heat of combustion, Heat effects of industrial reactions, Problems
4. Solution Thermodynamics & Phase Equilibria: Chemical potential, partial molar properties, Gibbs/Duhem equation, Ideal gas mixtures, Kay’s rule, real gas mixtures, Fugacity coefficient for pure substances & for species in solution, generalized correlation for fugacity, Ideal gas solution
5. Vapor-Liquid Equilibria (VLE) : Basic equations for VLE, Reduction of VLE data, VLE at low to moderate pressure, Excess Gibbs free energy Model, Margules Equation & Van Laar Equation, Wilson equation . Thermodynamic consistency test of VLE data, Phase Equilibria for Single Component System: Gibbs-Helmholtz Equation, The Chaperon Equation, Clausious-Clapeyron Equation, Application of Clapeyron Equation
6. Chemical Reaction Equilibria: The criteria for chemical equilibrium, Equilibrium constant, Law of chemical equilibrium, Thermodynamic treatment of the law of mass action, Van’tHoff reaction isotherm, Relations between equilibrium constant, Homogeneous gaseous equilibria, Temperature dependence of the equilibrium constant (The Van’t Hoff Equation), Integrated form of the Van’t Hoff equation, Pressure dependence of the equilibrium constant.

Applications of Phase Equilibrium in Ideal Solutions: To construct pressure-composition and boiling point diagrams.

Reference/Text books:

1. J.M. Smith and H.C. Van Ness, "Introduction to Chemical Engg. Thermodynamics 6th Edition,
2. International student edition, McGraw Hill publication.
3. B.F. Dodge, "Chemical Engg. Thermodynamics", International student edition McGraw Hill
4. Publication.
5. D.A. Hougen, K.M. Watson and R.A. Ragatz, "Chemical Process Principles", (Vol. II) 2ndEdn. Asia Publishing House.
6. K.V. Narayanan, "Chemical Engg. Thermodynamics", Prentice Hall India
7. Y.V.C. Rao, Chemical Engineering Thermodynamics, University Press (INDIA) Ltd., Orient Longman Ltd., Hyderabad. Hall India Pvt. Ltd., New Delhi.
8. R.R. Rastogi and R.R.Mishra, an Introduction to Chemical Thermodynamics, Vikas Publishing House Pvt. Ltd, New Delhi.
9. D. Shrinivasan, Chemical Engineering Thermodynamics, New Age International Publisher New Delhi.
10. G.N. Pandey and J.C. Chaudhari, Chemical Engineering Thermodynamics, Khanna Publishers, Delhi.

CH302	Heat Transfer (Credit-5) (Lect-3,Tut.-1,Pract.-2)

Objective:

1. To study the basic principles of heat transmission by conduction, convection, and radiation.
2. Teach students how to identify, formulate, and solve engineering problems involving conduction, convection, and radiation.
3. Teach students basic heat exchanger design and analysis techniques.
4. To understand the fundamentals about heat transfer coefficients and to solve the examples related to heat transferring devices.
5. To understand the importance of various heat exchanging devices such as heat exchanger, evaporator etc. in process industries.

Outcomes:

1. Students will comprehend Fourier's law of heat conduction, Newton's law of cooling, and the Stefan-Boltzmann law of radiation heating.
2. Students will recognize the relationship between thermo-physical properties and heat transfer.
3. Students will comprehend the role and importance of boundary layers and dimensional analysis to convective heat transfer.
4. Students can solve multi-dimensional steady-state or transient heat conduction problems
5. Students can use empirical correlations to solve forced and free convection heat transfer for internal and external flows
6. Students can predict heat transfer by radiation from ideal and actual surfaces and enclosures.
7. Students will have knowledge of different types of heat exchangers and evaporators and their suitability for particular applications.
8. Students can estimate heat exchanger performance given size and inlet conditions and design the geometry required to deliver a desire heat transfer rate.
9. Students will have knowledge of enhanced heat transfer by phase changes.

COURSE CONTENT

1. **Basic modes of heat transfer**: Conduction, convection and radiation, Fourier's law Heat conduction Equation at steady state, heat conduction in slabs, cylinders, spheres, heat generation inside solids. Fourier's heat conduction equation in three dimensions , equation for one dimensional conduction Heat conduction through a semi infinite slab unsteady state heat conduction, heat transfer by forced: convection in laminar and turbulent flow, dimensional analysis method, use of imperials equations heat transfer by forced convection outside tubes, natural convection. Combined heat transfer by conduction, convection, radiation

Radiation heat transfer: Fundamental of radiation, black body radiation, Kirchoff's law, radiant heat exchange between non black surfaces.

2. **Principles of heat flow in fluids**: Heat transfer to fluids without phase change. Regimes of heat transfer in fluids, Heat transfer to fluids with phase change. Drop wise and film type condensation, coefficient for film type of condensation, practical use of Nusselt's equations, application to petroleum industries
   Heat transfer to boiling liquids: Boiling of saturated liquids maximum flux and critical temperature drop, maximum Flux and film boiling.
3. **Evaporation**: Liquid characteristics, types of evaporators, single evaporator capacity economy,boiling point elevation and Duhring's rule. Heat transfer co-efficient, Enthalpy balance for single effect evaporator, multiple effect evaporators, types, methods of feeding, enthalpy balance of multiple effect evaporators, problems.
4. **Introduction to heat transfer to packed and fluidized beds**: General heat transfer characteristics, Calculation for Heat transfer co-efficient. Transfer in jacketed vessels, boilers, furnaces and reactors, reboilers, heat transfer in agitated vessels with and without coils, Heat transfer in packed and fluidized beds.
5. **Heat Exchangers:** Typical heat exchange equipment, overall heat transfer coefficient, overall heat transfer coefficient , log mean temperature difference, individual heat transfer coefficient, calculation of overall coefficient from individual coefficients , transfer units in heat exchangers.
   Fouling factor LMTD in single pass parallel, counter and cross-flow arrangements. N.T.U – effectiveness method for parallel and counter flow heat exchangers general Design aspect of heat exchangers. Problem based on LMTD AND NTU effectiveness method

Reference/Text books:

1. Kern D.Q., Process Heat Transfer, Tata McGraw Hill Book Co., New Delhi, 1990.
2. Arora S.C., Heat Transfer and Mass Transfer, Khanna Published, New Delhi.
3. Coulson J.M., Richardson J.R. Chemical Engineering, Vol. I 5th Edition, Butterworth Heinemann, New Delhi.
4. Dawande S.D., Principles of Heat and Mass Transfer, Central Techno Publications, Nagpur.
5. Eckert E.R.G. and Drake R.M.; 2nd Edition, Heat Transfer and Mass Transfer, McGraw Hill Education,Hollman J.P.; Heat Transfer, McGraw Hill, 1993.
6. Kothandaram C.P., Subramanyan S.; Heat Transfer and Mass Transfer, Databook, 4th Edition, Wiley eastern Ltd., (1989).
7. Kumar D.S., Process Heat Transfer, S.K.Kataria& Sons Publishers, New Delhi.
8. McAdams W.H.; Heat Transmission, McGraw Hill Book Co. New York, 1954.
9. Sukhatme S.P., Text Book on Heat Transfer, Orient Longman Pvt. Ltd.

Labwork:

Perform any eight practical's

1. Determination of Cp of ebonite in Infinite Cylinder.
2. Determination of Thermal Conductivity of a metal rod at different temperatures using Fourier equation.
3. Determination of Heat Transfer Coefficient in Enamelled Vessel.
4. Determination of Heat Transfer Coefficient in Jacketed Kettle and natural convention with or without stirring.
5. Determination of Overall Heat Transfer in Shell and Tube Heat Exchanger.
6. Determination of Overall heat transfer coefficient in film condensation and Drop wise condensation.
7. Determination of Overall heat transfer coefficient in a CSTR.
8. Determination of heat transfer coefficient in steam – air heat exchanger / hot oil.
9. Evaluation of Wilson Plot.
10. Verification of Nusselt Equation.
11. Determination of Stefan Boltzmann constant using ($dT_e/d\theta$) from temperature Vs Time plot.

CH303	Mass Transfer-I(Credit:05) (Lect:03, Tut:01, Pract:02)

Objective:

Students will learn about

1. Fundamentals of Mass transfer i.e., mass transfer coefficient, Ficks Law, classification of mass transfer operation etc.
2. Brief about Diffusion, Distillation and its various types, Extraction and adsorption etc.
3. Estimate the number of stages required for multistage operation.
4. Generation of equilibrium data.

Outcome:

1. Importance of distillation, extraction, adsorption in various chemical processes.
2. Generation of VLE data for the binary and ternary systems.
3. Able to calculate optimum reflux condition & number of stages, solvents requirement and adsorbent selection in case of Distillation, extraction and adsorption respectively.

COURSE CONTENT

1 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.

2 Mass transfer Coefficientsin 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 concurrent, counter current and crosscurrent processes, cascades

3 Distillation: Vapour – liquid equilibria, Raoult's law, X-Y and H-X-Y diagrams, differential distillation and equilibrium distillation, steam distillation, azeotropic distillation, extractive distillation. Fractionation, binary distillation, plate and packed columns for distillation analytical and graphical methods for estimation of number of stages required in distillation column, minimum reflux ratio, optimum reflux ratio, number of stages at optimum reflux, murphree plate efficiency and overall plate efficiency, effect of feed conditions on number of plates for separation Concept of HETP, HTU, NTU in distillation, plate and packed columns, packings for packed columns, pressure drop in plate and packed columns, bubble cap, sieve tray, valve tray plate columns

4 Liquid – Liquid Extractionfundamentals, selection of solvent for extraction, estimation of mass transfer coefficients, triangular diagram representation, equipments for liquid – liquid extraction, plate and packed columns, spray columns, rotary disc contactors, design procedures and equipment selection criteria. Single stage, multistage operations etc. Solid – Liquid Extraction fundamentals, Solvent selection, equilibrium relationship triangular diagram representation, single stage, multistage concurrent and counter current operation, equipments for solid – liquid extraction, their design procedure and selection criteria.

5 Solid – Liquid Extraction fundamentals, Solvent selection, equilibrium relationship, triangular diagram representation, single stage, multistage concurrent and counter current operation, equipments for solid – liquid extraction, their design procedure and selection criteria.

6 Adsorption: Adsorption isotherms, adsorption agents, equipments for adsorption, pressure swing adsorption technology, adsorption phenomena.

Reference/Text books:

1 Treybal R.E.; Mass Transfer Operations, Edition 3rd, McGraw Hill Book Co., New York .References book

2 Arora S.C.; Heat Transfer and Mass Transfer, 3rdEd., Khanna Publishers, (1986).

3 Badger W.L. and Banchero J.T.; Introduction to Chemical Engineering, Tata McGraw Hill Book Co.

4 Brown G.G.; Unit Operations, John Wiley & Sons, New York.

5 Chattopadyay P.; Unit Operations of Chemical Engineering, Vol. 1 & 2, Khanna Publishers, New Delhi.

6 Coulson J.M. and Richardson J.F.; Chemical Engineering Vol. I, II & III, Pergamon Press,

New York 1977.
7 Lyderson A.L.; Mass Transfer in Engineering Practice, John Wiley Co. (1983).
8 McCabe W.L. and Smith J.C. &Harriot; Unit Operations of Chemical Engineering, 5th Edition, McGraw Hill Book Co., New York 1980.
9 Suryanarayana A.; Mass Transfer, New Age International, New Delhi

CH304	Process Equipment Design (Credit: 04) (Lect:03,Tut:01, Pract:00)

Objective:

1. The various aspects of mechanical design in the chemical process plant.
2. Stresses upon the design and analysis of the basic process equipment viz. vessels, heat exchanger, distillation column, agitators, driers and evaporators etc.
3. The course emphasizes on the development of design skills among the students to take design related decisions.
4. Whatever be the earlier conception, today a chemical engineer is expected to be able to make complete design of a piece of chemical equipment.
5. A number of problems will be solved to illustrate the concepts clearly.

Outcomes:

1. They can do mechanical design of different Process Equipment.
2. Student understands the design consideration and material properties required for fabrication of equipment.

COURSE CONTENT

1. **Design Considerations:** Design codes, Maximum working pressure, Design pressure, Design Temperature, Design stress, Factors of safety, Selection of factor of safety design wall thickness, Corrosion ratio, Poisson ratio, Criteria of failure, Elastic stability. Materials of construction: Mechanical properties, Materials, Corrosion, Protective coating, Corrosion prevention, Choice of materials
2. **Design of Pressure Vessels:** Importance of chemical process equipment design, design procedure for pressure vessels subjected to internal pressure, external pressure and combined loading, closures for pressure vessels, optimum proportions of pressure vessels, optimum sizing of vessels Design of pressure vessels subjected to high pressure, monoblock construction, shrink fit construction. Crystallizer Design: Introduction, Types of Crystallizers, Design of crystallizers
3. **Process Design of Heat Exchanger**: Introduction, Types Of Heat Exchanger, Process Design of Shell and Tube Heat Exchanger. Process Design of
   Evaporator: Introduction, Types of Evaporators, Methods of Feeding of Evaporators, Design of Evaporator.
4. **Design of Distillation column:** Design of Sieve Tray for Distillation Column Design of Bubble Cap Tray for Distillation Operation
   Agitators: Introduction, Types Of Agitators, Baffling, Power Requirements, Design Of Turbine Agitator.
5. **Introduction,** Type of Dryers, Design of Rotary Dryer

References books

1. M.V.Joshi, V.V. Mahajan, Design of Process Equipment Design, 3rd Edition, McMillan India.
2. B. C. Bhattacharya, Introduction to Chemical Equipment Design (Mechanical Aspects) CBS Publisher & Distributors, New Delhi.
3. Coulson & Richardson, Chemical Engineering (Vol VI), Pergamon Press.
4. R.E.Treybal, Mass Transfer Operations, McGraw Hill, New Delhi.
5. S.D. Dawande, Process Design of Equipments (Vol. 1& 2) Central Techno Publications, Nagpur.
6. G.K.Roy, Solved Problems In Chemical Engg.,Khanna Publications, NewDelhi.
7. J.H.Perry, Chemical Engineer’s Hand Book, McGrawhill, New Delhi.

CH305	Chemical Process Industries (Credit:03) (Lect:03)

Objective:

1. To familiar with the different industries and products in which chemical engineer can works.
2. To understand the manufacturing processes for various products and also gain the knowledge about the respective industry.
3. To gain the knowledge of various chemical, physical and biological operations involved in process industry.
4. To understand the various unit operations in process industry.
5. To understand the basic concept of flow sheeting.

Outcomes:

1. Students will be able to handle/ operate the various chemical processes.

COURSE CONTENT

1. **Food Industries**: Types of food processing, preservation method, Food Products. Sugar and Starch Industries: sugar and starch. Fermentation Industries: Absolute alcohol, Beer, Wines and liquors, vinegar, citric acid lactic acid.
2. **Oil, Fat and Waxes:** Vegetable oils, animal Fats and oils, Waxes. Soaps and detergents. Pulp and paper industries: Manufacturing of pulp, manufacturing of paper, and structural boards
3. **Agrochemical Industries:** Insecticides, pesticides, Herbicides, plant growth, Nutrients and regulators, compound fertilizers, Biofertilizers, complex fertilizers, various grades of N.P.K. Fertilizer.
4. **Explosives**: Types of Explosives, Explosive characteristics, Industrial explosives, propellants, rockets, missiles, pyrotechnics, matches, toxic chemical weapons. Plastic industries: Raw Materials, general polymerization processes, manufacturing processes, compounding and Molding operation
5. **Dyes:** Classification and manufacturing of dyes.
6. **Petroleum and Petrochemical:** Petroleum production and Refining, Manufacturing of Methanol Formaldehyde, Ethylene and Acetylene, Ethylene dioxide, Isopropanol, Acetone, Isopropyl, Benzene, Butadiene, Phenol styrene
7. **Pharmaceuticals Industries:** Classification ofPharmaceuticals products. Manufacture of Antibiotics, Isolates from plant and animal, vitamins.

Reference/Text books:

1. C.E. Dryden, Outline of Chemical Technology, Affiliated East WestPress.1973.
2. S.D.Shukla, G.N.Pandey, A text book of Chemical technology, 3rdEdition.

---END of SEMESTER---

SEMESTER- VI

CH306	Mass Transfer-II (Credit:05) (Lect:03, Tut:01, Pract:02)

Objective:

1. To study the fundamentals of various separation techniques related to mass transfer operations.
2. Teach students how to identify, formulate, and solve engineering problems involving gas absorption, drying, Crystallization, Humidification and dehumidification etc.
3. Teach students basic of advance separation techniques such as membrane separation, desalination technology, dialysis technique.
4. To understand the fundamentals about mass transfer coefficients and to solve the examples related to mass transferring devices.
5. To understand the importance of various mass transfer operations equipments such as dryer, absorption tower, crystallizer, cooling towers etc. in process industries.

COURSE CONTENT

1. **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.
2. **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. Numericals
3. **Introduction to Membranes Separation technology**:Reverse osmosis, ultra filtration, evaporation, micro filtration, design principles, permeability, desalination technology, dialysis technique, membranes selection and parameters to be considered in design of membranes separation technology
4. **Crystallization**: Theory of Crystallization, saturation, super saturation, nucleation and crystal growth, various equipments for crystallization, their operational and design characteristics, calculation of yield, enthalpy balances, equipment
5. **Humidification and dehumidification** equipments operational characteristics, design procedures and selection criteria along with mass transfer calculations, Types of cooling towers, cooling tower operational characteristics

Reference/Text books:

1. Treybal R.E.; Mass Transfer Operations, Edition 3rd, McGraw Hill Book Co., New York .
2. Arora,Heat Transfer and Mass Transfer, Khanna Publishers, New Delhi. .
3. Badger W.L., Banchero J.T.; Introduction to Chemical Engineering,McGraw Hill Book Co., New York. .
4. Brown G.G.; Unit Operations, John Wiley & Sons, New York.
5. Chattopadhyay P., Unit Operations in Chemical Engineering Vol-I &II,Khanna publishers, New Delhi
6. Coulson J.M., Richardson J.F.; Chemical Engineering Vol.II, edition 3rd, Perganon Press, New York (1987).
7. Lyderson A.L.: Mass Transfer In Engineering Practice, John Wiley & Sons. .
8. McCabe W.L., Smith J.M.&Harriot P.; Unit Operations in Chemical Engineering, 5th Edition, McGraw Hill Book Co., New York, 1993.

Labwork:

1. Rotary Dryer – To study the Characteristics of Rotary Dryer.
2. Tray Dryer – To calculate rate of Drying.
3. Spray Dryer – To study the design and Operating Principles of Spray Dryer.
4. Mass transfer Coefficient – To determine the Mass Transfer Coefficient for Absorption in a

Packed Tower.

5. Enhancement Factor – To find the enhancement factor for absorption with and without chemical reaction.
6. To study the characteristics Cooling Tower experiment.
7. Performance evaluation of fluid bed dryer.
8. To study the characteristics Cooling Tower experiment.
9. Experiments on Fractional Crystallization.
10. Process of Crystallization and its Characteristics Ion Exchange.

CH307	**Chemical Reaction Engineering –I (Credit:05) (Lect:03 ,Tut:01, Pract:02)**

Objective:

1. To understand the fundamental concepts of reaction Engineering
2. Able to solve various numerical related to the reaction kinetics and engineering.
3. Able to Design the Various reactors involved for process manufacturing.

COURSE CONTENT

1. **Introduction to Chemical Reaction Engineering:** Classification of reaction based on various terms, Reaction rate, Chemical kinetics, Variables affecting rate of reaction, Speed of reactions,
   Problems.
2. **Kinetics of Homogeneous Reactions:** Concentration dependent term and temperature dependent terms of rate equation, Single and multiple reactions, Elementary and non-elementary reactions, Molecularity and order of reaction, Rate constant, Representation of reaction rate, Kinetic models, , searching mechanism, rate controlling step. Temperature dependency from Arrhenius' law, thermodynamics, various theories, Activation energy, Problems
3. **Interpretation of Batch Reactor Data:** Constant volume batch reactor, Variable volume batch reactor, Integral method and differential method of analysis of kinetic data, other methods of analysis of kinetic data, Temperature and reaction rate, Problems.
4. **Introduction to Reactor Design:** Types of reactors, PFR, CSTR etc., Material & energy balances single ideal reactor, Space-time and space-velocity, holding time, Introduction of non-ideal flow, Problems. Ideal Reactors for a Single Reaction, Ideal Batch Reactor, Steady State Mixed Flow Reactor, Steady State Plug Flow Reactor, Isothermal Reactors for single Reactions Problems, Design for Single Reactions, Size comparison of single reactors, General graphical comparison, Multiple reactor system, Recycle reactor, Autocatalytic reactions, Problems.
5. **Design for Parallel Reactions & Series:** Introduction to design of parallel reactions, Qualitative and Quantitative discussion on product distribution, Contacting patterns, Reactor Size and arrangement, Selectivity, Yield, reactors in series, reactors of different types in series, reactors of different types in series, Problems, qualitative and quantitative discussion for multiple reactions, instantaneous and overall fractional yield
6. **Temperature and Pressure Effects:** Single and multiple reactions, Heats of reaction from thermodynamics, Equilibrium constant, Temperature, Graphical design procedure, Optimum Temperature Progression, Heat Effects, Adiabatic and non-adiabatic operations, Problems

Reference/Text books:

1. Levenspiel, "Chemical Reaction Engineering", 3rd Edn., Wiley Easter Ltd., New York,1999.
2. J.M. Smith, "Chemical Engineering Kinetics", 3rd Edn., McGraw Hill, New York, 1981.

CH308	**Process Control & Instrumentation (Credit:05) (Lect:03,Tut:01, Pract:02)**

Objective:

Students will learn about

1. System Dynamics and concepts of dynamic response
2. How to represent dynamic systems by equations and by transfer functions in block diagrams
3. How to solve linear, constant-coefficient ODEs by Laplace transform and numerical methods

4. How dynamic systems respond to disturbances, particularly impulse, step, and oscillatory
5. How to calculate and use the frequency response of a system
6. How to estimate the stability limits for system, with or without control
7. How to tune a single-loop controller for better response
8. How to enhance feedback control with cascade, feedforward, and model-based structures
9. An overview of sensors, valves, transducers, controllers.

Outcomes:

1. Determine the time constant for first order and second order systems.
2. Students will be able to use the knowledge gain from the subject, in experimentation.
3. Will be able to control the some process parameter using P, PI, PD and PID controller.
4. Tune the controller for some given process parameters.

COURSE CONTENT

1. Importance, aims and objectives of process control,introduction to system dynamics, concept of dynamic response, first order, second order interacting process gain, overshoot, decay ratio, dead time
2. Introduction to set point, disturbance, closed loop and open loop control feedback and feed forward configurations, dynamics of feedback control system.
3. Types of controllers, P, PI and PID controllers, controller gain, stability analysis, Routh stability criteria.
4. Design of controllers using open loop response, Zieler – Nichols controller settings, Bode and Nyquist stability criteria.
5. Control valve and choice of controller settings. Basic design of pneumatic controllers, electric /electronic controllers, discontinuous control modes two position, classical and modern control actions.
6. Process instruments used for measurement of pressure, temperature, liquid level, flow rate and compositions, pressure gauge, strain gauge, Mcleod gauge, vacuum measurement, transducers, transmitters, digital signal processing.
7. Introduction to set point, error, accuracy, sensitivity Application of control systems to chemical process equipments such as chemical reactors, heat exchangers, distillation columns, boilers etc

Reference/Text books:

1. Babatunde A., Ogunnaike& Ray W.H.; Process Dynamics, Modeling and Control, Oxford Press, New York, (1994)
2. Coughnowr D.R.; Process Systems Analysis and Control: 2Nd Edition McGraw Hill Book Co
3. Harriot P.; Process Control, McGraw Hill, New Delhi, 1984.
4. Perry R.H.; Chemical Engineer’s Handbook, 7thEdition
5. Radhakrishnan V.R.; Instrumentation and Control for the Chemical Mineral and Metallurgical Processes, Allied Publishers Ltd., New Delhi
6. Stephanopoulos G., Chemical Process Control, anIntroduction to Theory and Practice, PHI LearingPvt. Ltd. New Delhi.
7. Smith Carlos A. &Corrieio A.B.; Principles and Practice of Automatic Process Control: 2nd Edition, John Wiley & Sons, New York

CH309	**Process Modeling & Simulation (Credit:05) (Lect:03, Tut:01, Pract:02)**

Objective:

1. Process modelling & simulation is one of the core subjects for chemical engineering. This subject has broad aspects to design models like the process equipments, reactors, process piping and optimization of processes. The theoretical process model based on the principles of continuity equations like mass balance, component continuity equations, energy balance equation etc.
2. Now a day’s number of software’s related to design of all chemical processes are available in market as well as in industry. The main objectives of these subjects are toAwareness about the advance chemical engineering software’s.Develop the practical skill of simulation tools. There is need of to get appropriate knowledge of modern software’s to simulate with different

processes and situations arising in chemical industries. Basically, applications of Chem-CAD, Aspen-tech, Fluent, g-Prom, Mat-Lab etc, are increased in software as well as in hard core industries.

3. Chemical engineering students are not well aware about the applications of these developed software's. Our aim is to build up the fundamentals of chemical engineering and simulation of these fundamentals with practical approach.

Outcomes:

1. The process model design or simulated by using conservation equations like mass balance, component continuity equations, energy balance equation etc. And also using different simulation tool. To get practical approach application using in chemical industries.

COURSE CONTENT

1. Differential equation and population balance models: Physical and thermodynamic properties.Numericalmethodsfordigitalsimulation.
2. Modeling of specific systems with reference to important industries like fertilizer, petrochemicals and petroleum refining. Application of simulation languages. Analysis and design of advanced control systems.
3. Design of control systems formulates variable processes. Process control using digital computers
4. Introduction to process modelling and simulation: Models; Need of models and their classification; Development of detailed mathematical models of evaporators; Distillation columns; Absorption columns and chemical reactors and their simulation and computer program development.
5. Introduction of chemical process flow sheeting and industrial simulators.

Text book:

1. B.V. Babu, Process Modeling & Simulation, 3rd Edition, McGraw Hill India.
2. AsgharHusain, Chemical process Simulation, Wiley Eastern Ltd., New Delhi.
3. A.K.Jana, Chemical Process Modelling and Computer Simulation, Prentice-Hall of India pvt. Ltd. ISBN-978-81-203-4477-8(2011).
4. Luyben W.L, Process modelling & Control fo rChemical Engineers, 2nd Edition, McGraw
5. Babatunde A.Ogunnaike A., Harman Ray W.; Process Dynamics Modelling and Control, IstEdition, Oxford Press N. (1994).
6. Grewal B.S., Engineering Mathematics.
7. Jenson V.J & Jeffery G.V, Mathematical methods in chemical engineering academic press, London.NY1977.
8. Kluwer, Mathematical Modelling of Heat andMass TransferProcessesAcademic Publisher,London.
9. Mickley H. S, Sherwood I. S., Reed C.E., Applied Mathematics in Chemical Engineering, Tata Mc Graw Hill, New Delhi.

CH310	Elective-I(Safety & Risk Analysis)Credit:03 (Lect:03)

Objective:

1. In the chemical process industry plant safety is important. Knowledge of plant safety is essential to prevent accidents and damages while working in plant.
2. A safety audit and risk analysis prepares the plant operators and managers to develop a safe protocol and minimize potential damages to process equipments, people and the environment.

Outcomes:

1. Give an overview of the safety regulations and practices, plant hazards and their control, risk management principles and techniques and accident analysis.

Course Content:

1. Introduction to process plant safety, handling of hazardous chemicals Lower flammability limit (LFL), UFL, LEL, UEL, TLV, electrostatic hazards, Hazard code and explosive limit, TWA,

	Ceiling level, Safety in handling of gases, liquids and solids
2.	Flammable liquid hazards, fire and explosion index, fire ball hazards, oil spillage hazards, Bleveuvce, pool fires, jet fires, radiation hazards
3.	Explosion, emergency and disasters in chemical process plants, onsite and offsite emergencyplan, Fire detectors, smoke detectors Safety audit of chemical process plants, HAZOP studies and fault tree and event tree analysis.
4.	Resources for combating fires, dry chemical powders, fire fighting foam fixed and portable fire extinguishers, FMEA Risk analysis of chemical processes, risk management, risk identification, personnel training, risk to environment
5.	Resources for combating fires, dry chemical powders, fire fighting foam fixed and portable fire extinguishers, FMEA Risk analysis of chemical processes, risk management, risk identification, personnel training, risk to environment

Text / References:

1. Dixit; Safety Evaluation of Environmental Chemicals.
2. Dekkar Marcel; Safety Management and Practices for Hazardous Units, New
3. York1995
4. Greene R.; Safe and Efficient Plant Operation and Maintenance McGraw Hill
5. Book Co. New York
6. Saxena, Safety and Good House Keeping, 3rd Edition on National Productivity
7. Council, New Delhi (1976).
8. Wells G.L.; Safety in Process Plant Design, George Godwin Ltd., (1980).

CH310	**Elective-I(Renewable Energy Sources)Credit:03 (Lect:03)**

Objective:

COURSE CONTENT

1. **Introduction:** Energy scene of supply and demand in India and the world, Energy consumption in various sectors, potential of non-conventional energy resources, energy needs and energy supply, sources, contribution of nonconventional energy.
2. **Solar Energy:** Solar radiation and its measurement, characteristics and estimation, limitations in the applications of Solar Energy, Collectors: flat plate and concentrating types, theircomparative study; design and material selection, efficiency, selective paints and surfaces. Solar water heater applications of Solar Energy for heating, drying, water desalination, solar concentrators, and photovoltaic power generation using silicon cells. Thermal storages, Solar ponds, Solar pumps, Solar power, Solar cookers etc. Direct conversion of solar energy to electricity and its various uses, materials limitations and costs
3. **Bio-Fuels:** Photosynthesis and generation of bio-gas, digesters and their design, selection of material; feed to digester, pyrolytic gasification production of hydrogen, algae production and their uses.
4. **Wind Energy:** Principle of energy from wind, availability, sites election different types of wind turbines, design criteria and material selection economics.
5. **Geo-Thermal Energy:** Geo-technical wells and other resources dry rock and hot a quifer analysis, harnessing geothermal energy resources.
6. **Tidal Energy** Its meaning, causes of tides and their energy potential enhancement of tides, limitations, different methods of using tidal power Principles of ocean thermal energy conversion (OTEC) analysis and sizing of heat exchangers for OTEC.
7. **Ocean Thermal Energy:** Principle of utilization and its limitations description offew systems Other Non-conventional Energy Sources, fluidized bed combustion, heat from waste water and other sources.
8. **Energy Conservation:** Principles of energy conservation. Familiarization with the different energy conservation appliances and practices, improved cooking stoves, benefits of improved cooking stoves over the traditional cooking stoves. Scope of energy conservation in the domestic, commercial and agricultural sector.

Reference/Text books:

1. Duffie J.A., Beckman W A., Solar Engineering of Thermal Processes, JohnWiley1980.
2. KreithF.andKreiderJ.F.,PrinciplesofSolarEngineering,McGrawHill,1978.

3. RaiG.D,Non-ConventionalEnergySources,KhannaPublishers,Delhi.
4. SarkarS.,FuelsandCombustion,2nd Edition,OrientLongman1989.
5. Sukhatme,S.P.,SolarEnergy,2nd Edition,TataMcGraw-Hill,1996.
6. TwiddleJ.,WeirT.,RenewableEnergyResources,CambridgeUniversityPress,1986.
7. Veziroglu,N.,AlternativeEnergySources,Volume5&6,McGraw-Hill.

CH310	**Elective-I(EnergyManagement)Credit:03 (Lect:03)**

Objective:

1. To describe the principles and techniques used in energy conservation and management.
2. To describe the principles of efficient energy usage in residential, commercial and industrial sectors.

Outcomes:

1. Understand the principles and techniques used in energy conservation and management.
2. Understand and apply their knowledge for saving energy in different sectors.

COURSE CONTENT

1. **Energy auditing:** Methodology, analysis of past data, measurements of various parameters, portable and online instruments
2. **Energy economics:** Payback period, Rate of Return, life cycle costing
3. **Steam Systems:** Boiler-efficiency testing, excess air control, Steam distribution and use, steam traps, condensate recovery, flash steam utilization.
4. **Electrical systems:** Demand control, power factor correction, load scheduling/shifting. Motor drives–motor efficiency testing, energy efficient motors, and motor speed control.
5. **Lighting:** Conservation in Pumps, Fans (flow control), Compressed Air Systems, Refrigeration and conditioning systems, Waste heat recovery, heat pipes**.**

References books

1. Callaghan O’Paul; Energy Management, McGraw Hill,1994
2. Dryden I.G.C.; The efficient use of Energy; Ed. Butterworth, London1982
3. Murphy W.R., Mc Kay G.A.; Energy Management, Murphy Butterworth-Heinemann Ltd., 2001.
4. Turner W.C.; Energy Management Handbook–2nd Edition, Fairmont Press, Lilburn, Georgia,1993.