FIRST SEMESTER M. Tech Chemical Engineering

Subject **: 23PCH 101T** **Modeling & Simulation in Chemical Engineering (Theory)**

Lecture	: 4 Hours	No. of Credits	4
University	: 60 Marks	College Assessment	: 40 Marks

Duration of Examination: 3 Hours

Course Objectives: To study the modeling & simulation techniques of chemical processes and to gain skills in using process simulators.

Course Outcomes (CO):

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

CO1: analyze physical and chemical phenomena involved in various process.

CO2: develop mathematical models for various chemical processes by using various simulation approaches.

CO: designed to have detailed understanding of process simulation, tools of simulation, parameter estimation, models and classification of models, alternate classification of models, mathematical modelling.

CO4: formulate mathematical models for mass transfer, heat transfer, fluid flow operations and reaction engineering aspects.

CO5: Simulate a process using process simulators (ASPEN Plus/ ASPEN Hysys).

Unit 1: Introduction to process modeling, Applications of models, classification of models,Principles of Formulation, fundamental laws, general modeling procedure, industrial usage of process modelling and simulation; Macroscopic and microscopic mass, energy and momentum balances

Unit 2: Parameter estimation techniques in theoretical as well as numerical models, population balance, stochastic, and empirical models

Unit 3: Modeling of various mass and heat transfer equipment: distillation, absorption, extraction columns; evaporators; furnaces; heat exchangers; flash vessels etc.

Unit 4: Modeling of Chemical Reactors: single phase and multiphase reactors

Unit 5: Numerical Methods for chemical engineering applications. Introduction and use of different software for modeling and simulation

Recommended Books:

1. W. L. Luyben, Process Modeling Simulation and Control for Chemical Engineers, McGraw Hill, 1990.
2. S.C. Chapra, R.P. Canale, Numerical Methods for Engineers, 6th Edition, Tata-McGraw Hill Publications, 2012.
3. R.E.G. Franks, Modeling and Simulation in Chemical Engineering, Wiely Intrscience, NY, 1972.
4. J. Ingam, I. J. Dunn, Chemical Engineering Dynamic Modeling with PC simulation, VCH Publishers, 2008.
5. D. Himmelblau,Bischof Process Analysis & Simulation, John Wiley & Sons, 1968.

Subject	**: 23PCH 102T**	**Advanced Transport Phenomena (Theory)**	
Lecture	: 4 Hours	No. of Credits	4
University	: 60 Marks	College Assessment	: 40 Marks

Duration of Examination: 3 Hours

Course Objective: Transport phenomena deals with the exchange of mass, energy, and momentum between systems, which plays an important role in engineered and natural systems. The course provides a systematic analysis and fundamental understanding of transport phenomena and its mathematical description which builds the foundation of modern simulation software packages.

Course Outcomes

After passing the course the student will be able to:

CO1: Apply the shell balance approach to derive differential mass and heat balance equations in Cartesian, cylindrical, and spherical coordinates

CO2: Apply the generalized differential mass and heat balance equations and the Navier-Stokes equations to analyze transport problems

CO3: Analyze transport problems in simple geometries and derive analytically the concentration, temperature or velocity distribution and the equations of change for mass, momentum and heat transport.

CO4: Analyze transport problems in complex geometries and calculate numerically the concentration, temperature, or velocity distribution using a simulation software

CO5: Elaborate conceptual and mathematical models, from conservation principles, to complicated systems involving simultaneous mass, momentum, and/or heat transfer processes as well as reactions or other sources/sinks of transport for multi-component mixtures.

Unit 1: Review of mathematics: Scalar, Vectors, Tensors, divergence, relation between rectangular coordinates and cylindrical coordinates, relation between rectangular coordinates and spherical coordinates, partial derivative, substantial derivative, total derivative, line integral, surface integral, integral theorems.

Unit 2: Equations of continuity, equation of motion, the equation of mechanical energy, application of Navier-Stokes equation to solve problems, the equations of change for incompressible non- Newtonian fluids.

Unit 3: Developing equations for obtaining velocity & shear stress distribution for flow of Newtonian, Bingham plastic & power law fluids in spheres etc. from Ist principle, Introduction to 2 dimensional & turbulent momentum transfers

Unit 4: Equations of energy, the energy equation in curvilinear coordinates, use of equations of change to set up steady state heat transfer for problems.

Unit 5: Unsteady state heat conduction expression for rectangular, spherical and cylindrical co-ordinate system from Ist principles, Numerical methods for 2 dimensional steady state conduction and Schmidt method for unsteady state heat conduction with / without surface resistance for obtaining temperature profiles

Recommended Books:

1. R.B. Bird, W. E. Stewart and E. N. Light foot Transport Phenomena Wiley international

Edition, New York 2002.

2. James R. Welty, Charles E. Wicks and Robert E. Wilson, Fundamentals of momentum, heat and mass transfer, John Wiley & sons, Inc, New York, 2008.

Subject	**: 23PCH 103T**	**Advanced Reactor Design (Theory)**	
Lecture	: 4 Hours	No. of Credits	4
University	: 60 Marks	College Assessment	: 40 Marks
Duration of Examination: 3 Hours			

Course Objective: Review of Basic Principles of Chemical Reaction Engineering. Basic Flow Models. Introduction to Stability of Chemical Reactors, Bifurcation Analysis of Reaction Systems. Non-Elementary Homogeneous Reaction Systems. Introduction to Combustion and Analytical Methods in Combustion.

Course Outcomes

CO1: Understand the fundamentals of advanced reactor designs and their characteristics.

CO2: Obtain in-depth knowledge of three types of advanced reactors: metal-cooled reactors, molten salt reactors, and high-temperature gas-cooled reactors.

CO3: Develop a working knowledge of the characteristics of advanced reactors from the perspective of reactor physics, thermal-hydraulics, and fuel performance.

CO4: Gain experience in performing reactor core design for advanced reactors using advanced modeling and simulation tools.

CO5: knowledge of regulations and policies for advanced reactors. Understand the basics of nuclear fuel design and performance in advanced reactors and cost component associated with the advanced nuclear reactor and associated advanced fuel cycle.

Unit 1: Non ideal flow, RTD function, characteristics of RTD, Zero-parameter models, one- parameter models, two-parameter models

Unit 2: Heterogeneous catalysis: Diffusion with reaction in porous catalyst, Mechanism of catalytic reactions. Langmuir - Hinshelwood model, Rideal - Eiley Mechanism, Ratecontrolling steps**,** Development of rate equations for solid catalysed fluid phase reactions; External/internal mass and heat transfer resistances in catalyst particles, catalyst deactivation.

Unit 3: Heterogeneous Catalytic Reactors: Isothermal and adiabatic fixed bed reactors, Non-isothermal and non-adiabatic fixed bed reactors.

Unit 4: Introduction to multiphase reactor design, fluidized bed reactor, slurry reactor, Trickle bed reactor, Photocatalytic reactor, Sonochemical reactors

Unit 5: Theory of mass transfer with chemical reaction (regimes and examples), model contactors

Recommended Books:

1. H.S. Fogler, Elements of Chemical Reaction Engineering, Prentice – Hall, 1986.
2. O. Levenspeil, Chemical Reaction Engineering, 3rd Edition, Wiley, 1999.
3. J.M. Smith, Chemical Engineering Kinetics, McGraw-Hill, 1981.
4. G.F. Froment, K.B. Bischoff, Chemical Reactor Design and Analysis, Addision -Wesley, 1982.
5. L.K. Doraiswamy, M.M. Sharma, Heterogeneous Reactions vol. I and II, John Wiley & Sons Inc.

6. P.V. Danckwerts, Gas Liquid Reactions, McGraw-Hill Book Co., New York, 1970.

Subject : **23PCH 111T Elective I-** 1. **Process Design, Integration and Intensification (Theory)**

Lecture : 4 Hours No. of Credits 4

University : 60 Marks College Assessment : 40

MarksDuration of Examination: 3 Hours

Course Objective: To learn the concept of Process Intensification. Apply the technique of intensification to a range of chemical processes and process Equipment

CO1: Understand The Fundamental of chemical process design, integration and intensification of a desired product through Onion model

CO2: Make an initial choice of reactor for desire product based on conditions of reaction, performance, configuration and heat integration of reactor

CO3: Sequence the distillation column with &/or without heat integration for multicomponent system

CO4: Analyze the design of heat exchanger network based on energy target, utilities and integration of heat & power

CO5: Plan and design a chemical process of desired product by the application of integration of heat & power

Unit 1: Introduction to chemical process design, integration and intensification. Hierarchy andapproach of chemical process design and integration

Unit 2: Choice of reactors: Performance, conditions, configurations, heat integration of reactorsetc.

Unit 3: Distillation sequencing: multicomponent, extractive, azeotropic distillation systems etc.with and without heat integration.

Unit 4: Heat exchanger networks: Energy Target and network design, trade-off & utilities, Heat& power integration.

Unit 5: Case studies on chemical process design, integration and intensification.

Recommended Books:

1. R. Smith, Chemical Process Design and Integration, John Wiley and Sons. Ltd., New Delhi,2005.
2. J. Douglas, Conceptual Design of Chemical Processes. New York, NY: McGraw-Hill Science/Engineering/Math, 1988.
3. W. D. Seider, J. D. Seader, D. R. Lewin. Product and Process Design Principles: Synthesis,Analysis, and Evaluation. 2nd ed. New York, Wiley, 2004.
4. R. Turton, R. C. Bailie, W. B. Whiting, J. A. Shaeiwitz. Analysis, Synthesis, and Design ofChemical Processes, 2nd Edition, Prentice Hall, 2002.
5. L.T. Biegler, I.E. Grossmann, A.W. Westerberg, Systematic Methods of Chemical ProcessDesign, Prentice Hall, 1997.

Subject : **23PCH 112T** **Elective I –2- Bioprocess Engineering (Theory)**

Lecture : 4 Hours No. of Credits 4

University : 60 Marks College Assessment :40

Marks Duration of Examination: 3 Hours

Objectives: To understand the principles, stichiometry, kinetics, modeling and instrumentation of biological processes employed in industrial fermentation.

CO1: Understand The Fundamental of fermentation process.

CO2: Understand the basic principle of enzyme kinetics.

CO3: Analyze the Stoichiometry And Kinetics Of Substrate Utilization And Biomass And Product Formation

CO4: Analyze the design of Bioreactor And Product Recovery Operations.

CO5: Plan and design a Introduction To Instrumenation, monitoring & Process Control In Bioprocesses Measurement of physical and chemical parameters in bioreactors.

Unit-I-Introduction: Fermentation Processes General requirements of fermentation processes- An overview of aerobic and anaerobic fermentation processes and their application in industry - Medium requirements for fermentation processes -examples of simple and complex media Design and usage of commercial media for industrial fermentation. Sterilization: Thermal death kinetics of micro- organisms - Batch and Continuous Heat-Sterilization of liquid Media- Filter Sterilization of Liquid Media and Air.

Unit-II-Enzyme Technology, Microbial Metabolism :Enzymes: Classification and properties-Applied enzyme catalysis - Kinetics of enzyme catalytic reactions- Metabolic pathways - Protein synthesis in cells.

Unit-III-Stoichiometry And Kinetics Of Substrate Utilization And Biomass And Product Formation: Stoichiometry of microbial growth, Substrate utilization and product formation-Batch and Continuous culture, Fed batch culture

Unit-IV-Bioreactor And Product Recovery Operations:Operating considerations for bioreactors for suspension and immobilised cultures, Selection, scale-up, operation of bioreactors-Mass Transfer in heterogeneous biochemical reaction systems; Oxygen transfer in submerged fermentation processes; oxygen uptake rates and determination of oxygen transfer rates and coefficients; role of aeration and agitation in oxygen transfer. Heat transfer processes in Biological systems. Recovery and purification of products.

Unit-V-Introduction To Instrumenation And Process Control In Bioprocesses: Measurement of physical and chemical parameters in bioreactors- Monitoring and control of dissolved oxygen, pH, impeller speed and temperature in a stirred tank fermenter.

TEXT BOOKS:

1. *M.L. Shuler and F. Kargi, "Bio-process Engineering", 2^{nd} Edition, Prentice Hall of India, New Delhi. 2002.*

2 J.E. Bailey and D.F. Ollis," Biochemical Engineering Fundamentals", 2^{nd} Edn., McGraw Hill, Publishing Co. New York., 1985.

3. *D,G. Rao, Second Edition, Introduction to Biochemical Engineering,* Mc Graw Hill India, 2016

REFERENCE:

1. *P.Stanbury, A. Whitakar and S.J.Hall, "Principles of Fermentation Technology" 2nd Edn., Elsevier-Pergamon Press, 1995.*

Subject : 23PCH 113T **Elective I-** 3. **Fluidization Engineering (Theory)**

Lecture : 4 Hours No. of Credits 4

University : 60 Marks College Assessment : 40 Marks

Duration of Examination: 3 Hours

Course Objectives: To study the fluidization phenomena, fluidized bed regimes and models.

Course outcomes:

On successful completion of the course, the student should be able to

CO1: Explain the basics of fluidization.

CO2: Describe the various industrial applications of fluidization.

CO3: Explain the various fluidization regimes, classification of particles.

CO4: Describe the K-L bubbling model.

CO5: Describe the staging of fluidized beds, and calculation of the exchange coefficient.

Unit 1: Introduction: Phenomenon of fluidization, behavior of fluidized bed, contacting modes, advantages and disadvantages of fluidization, fluidization quality, selection of contacting mode

Unit 2: Mapping of fluidization regimes: Characterization of particles, minimum fluidization velocity, pressure drop versus velocity diagram, The Geldart classification of solids, fluidization with carryover of particles, terminal velocity of particles, distributor types, gas entry region of bed, pressure drop requirements, design of gas distributor, power consumption

Unit 3: Bubbles in dense bed: Davidson model for gas flow, the wake region and movement of solids at bubbles, coalescence and splitting of bubbles, bubble formation above a distributor, slug flow. **Bubbling fluidized beds:** Emulsion movement, estimation of bed properties, bubble rise velocity, scale up aspects, flow models, two phase model, K-L model

Unit 4: Entrainment and elutriation: Freeboard behavior, gas outlet, entrainment from tall vessel, freeboard entrainment model, high velocity fluidization, pressure drop in turbulent and fast fluidization. **Solids movement:** Vertical and horizontal movement of solids, Dispersion model, large solids in beds of smaller particles, staging of fluidized beds. **Gas dispersion:** Gas dispersion in beds, gas interchange between bubble and emulsion, estimation of gas interchange coefficient

Unit 5: Design of fluidized bed reactors: Design of catalytic reactors, pilot plant reactors, information for design, bench scale reactors, design decisions, deactivating catalysts, Design of noncatalytic reactors, kinetic models for conversion of solids, models for shrinking particles, conversion of solids of unchanging size

Recommended Books:

1. O. Levenspiel, D. Kunnii, Fluidization Engineering, John Wiley, 1972.
2. Liang-Shih Fan, Gas-Liquid-Solid Fluidization Engineering, Butterworths, 1989.

Subject **: 23PCH 114T** **Elective I- 4. Industrial Waste Management (Theory)**

Lecture : 4 Hours No. of Credits 4

University : 60 Marks College Assessment : 40

MarksDuration of Examination: 3 Hours

Course Objective - *The purpose of this course is to train the students in different waste managementtechniques. A special emphasis will be on techniques for transformation of waste materials into products that can be beneficially utilized. The ultimate goal should, of course, be that no waste is formed in industry or society.*

Course outcomes:

On successful completion of the course, the student should be able to

CO1: Explain the basics of Water Pollutants, Effects of pollutants on environment and health Monitoring and Quality standards.

CO2: Describe the various Water Pollution Sources, classification and treatment methods.

CO3: Explain the various Waste water Treatment Plant Design: Physical unit operations.

CO4: Describe the Advanced Wastewater and Water Treatment, Membrane processes

CO5: Describe the Solid waste disposalmethods, Emerging technologies

UNIT-1- Water Pollutants, Effects, Monitoring and Quality standards: Pollution of water and soil, effect of pollutants on environment and health, monitoring water pollution, water pollution laws and minimum national standards, monitoring, compliance with standards, Latest norms for effluent treatment.

UNIT-2-Water Pollution Sources, Analysis and Methods of control: Water pollution sources and classification of water pollutants - Wastewater sampling and analysis. Treatment of water-pollution: BOD, COD of wastewater and its reduction – Fundamentals of Anaerobic digestion and Aerobic digestion.

UNIT-3-Wastewater Treatment Plant Design: Physical unit operations: Screening, Flow equalization, sedimentation etc., Chemical Unit Processes: chemical precipitation, dis-infection, colour removal by adsorption Biological unit processes: Aerobic suspended - growth treatment processes, aerobic attached- growth treatment processes, anaerobic suspended - growth treatment processes, anaerobic attached-growth treatment processes.

UNIT-4-Advanced Wastewater and Water Treatment: Carbon adsorption - Ion exchange, Membrane processes - Nutrient (nitrogen and phosphorus) removal - Design of plant for treatment and disposal of sludge

UNIT-5-Solids Waste and Landfill Management: Sources and classification - methods of solid waste disposal - Composting (natural) - Accelerated composting withindustrial sludge - Landfill technology - Methods adopted for municipal solid waste - Toxic-waste management, Incineration of industrial waste, Design aspects, economics.Hazardous Waste Management and Risk Assessment: Types of hazardous Wastes-Health effects -

Nuclear fission and radioactive waste treatment and disposal methods. Risk assessment

TEXT BOOKS:

1. C.S. Rao, "Environmental Pollution Control Engineering", Wiley 2nd Edition,New Age International Publishers, 2006.

2. S.P. Mahajan, "Pollution Control in Process Industries", Tata McGraw Hill,New Delhi, 1985

REFERENCES:

1. P. Sincero and G.A. Sincero, Environmental Engineering: A DesignApproach Prentice Hall of India pvt Ltd, N.Delhi.1996

2. Tchbanoglous and F.L. Burton, Metcalf and Eddy's Wastewater Treatment-Disposal And Reuse (Third Ed.), TMH publishing Co Ltd, N. Delhi. (1996)

Subject	**: 23PCH 122T**	**Elective II-1- Modern Chemical Instrumentation (Theory)**	
Lecture	: 4 Hours	No. of Credits	: 4
University	: 60 Marks	College Assessment	: 40 Marks

Duration of Examination: 3 Hours

Course objective: The purpose of this course is to train the students in different modern chemical Instrumentation techniques. A special emphasis will be on techniques for transformation of related knowledge on research & industrial application.

Course Outcomes:

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

CO1: Understand the spectroscopy and its applications
CO2: Understand the spectrophotometry and its applications
CO3: Understand the concept of mass spectrometry and its applications
CO4: Understand the NMR Phenomena principle & application in chemical analysis
CO5: Understand the Characterization techniques for any sample

Unit 1: UV & IR spectroscopy, basic principles of UV & IR, Microwave spectroscopy, radiation sources, monochromators, detectors, instrumentation & Application of qualitative & Quantitative chemical analysis, Raman spectroscopy, sample handling & illumination & applications

Unit 2: Atomic absorption & Atomic emission spectroscopy, flame & flame temperatures, instrumentation & Application, in chemical analysis, fluorescence & phosphoresce, spectrophotometry

Unit 3: Mass spectrometry, basic principles, commercial mass spectrometers, correlation of mass spectra with molecular structure for a few typical cases, application of mass spectral data

Unit 4 : NMR spectroscopy, NMR phenomena, principle & Instrumentation, chemical shift , its measurement, spin – spin coupling, spin – spin splitting, application of NMR in structural diagnosis & Quantitative analysis, electron spin resonance spectroscopy, principle & application in chemical analysis,

Unit 5: Gas chromatography, HPLC, GCMS, SEM, Basic principal of XRD & XRF techniques, Differential Thermal Analysis & Differential scanning calorimeter, thermogravimetry, thermometric titrimetry, electrogravimetry, colorometry, principles applications of colorometry, colorometric titration stripping analysis

Recommended Books:

1. V.M. Parikh, Absorption Spectroscopy of Organic Molecules, Addison - Wesley Publishing Company, 1974.

2. H.H. Willard, I.I. Merritt, J.A. Dean, F.A. Settle, Instrumental Methods of Analysis, Sixth edition, CBS publishers, 1986.

3. D.A. Skoog, D.M. West, Fundamentals of Analytical Chemistry, Saunders-College Publishing, 1982.

4. G.C. Banwell, Fundamentals of Molecular Spectroscopy, TMH, 1992.

Subject : 23PCH 121T
Lecture : 4 Hours
University : 60 Marks
Duration of Examination: 3 Hours

Elective II-2- ADVANCED FOOD PROCESS ENGINEERING (Theory)
No. of Credits : 4
College Assessment : 40 Marks

Course objective: The purpose of this course is to develop the understanding of students in different Advance food processing techniques for transformation of related knowledge on research & industrial application.

Course Outcomes:

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

CO1: Understand the Food Process Engineering Fundamentals.
CO2: Understand the Unit Operations in Food Processing.
CO3: Understand the fundamentals of Food Canning Technology.
CO4: Understand the Separation And Mixing Process In Food Industries.
CO5: Understand the Characterization of Food Biotechnology.

Unit 1: Food Process Engineering - Fundamentals: Raw material and the process- Geometric, Functional and Growth properties of the raw material,Mechanization and the raw material, cleaning - contaminants in food raw materials, function of cleaning and cleaning methods, sorting and Grading of Foods.

Unit 2: Unit Operations in Food Processing: Fluid flow, thermal process calculations, refrigeration, evaporation and dehydration operations to food processing. Heat processing of foods - modes of heat transfer involved in heat processing of foods.

Unit 3: Food Canning Technology: Fundamentals of food canning technology, Heat sterilization of canned food, containers - metal, glass and flexible packaging, Canning procedures for fruits, vegetables, meats, poultry and marine produces.

Unit 4: Separation And Mixing Process In Food Industries: Conversion operations. Size reduction and screening of solids mixing and emulsification, filtration and membrane separation, centrifugation, crystallization, extraction.

Unit 5: Food Biotechnology: Food Biotechnology. Dairy and cereal products.Beverages and food ingredients. High fructose corn syrup. Single cell protein.

TEXT BOOK:

1. *R.T. Toledo, "Fundamentals of Food Process Engineering", AVI Publishing Co., NewYork, 1980.*

REFERENCES:

1. *J.M. Jackson & B.M. Shinn, "Fundamentals of Food Canning Technology", AVIPublishing Co., New York, 1978.*
2. *J.G. Bernnan, J. R .Butters, N.D. Cowell & A. E. V. Lilley, "Food Engineering Operations", 2nd Edn., Applied Science, New York, 1976.*

Subject : 23PCH 123T **(BCHE)Elective II-3- Social Corporate Responsibility (Theory)**

Lecture : 4 Hours
No. of Credits : 4
University : 60 Marks
College Assessment : 40 Marks
Duration of Examination: 3 Hours

Course objective: To Provide students with a comprehensive understanding of Social Corporate Responsibility, Sustainable Development and sustainability challenges (social, economic and regulatory)

Course Outcome -

After completion of the course students are expected to be able to:

CO1-understand and critically discuss the concepts and topics of social corporate responsibility as well as business' responsibility expose to different approaches in SCR and Sustainability

CO2. understand social approaches of business decisions and get introduced to the SCR and Sustainability

CO3. understand sustainability challenges (social, environmental and economic development) that companies face and how transform these challenges into business opportunities

CO4-. understand various approaches of SCR concept, application of SCR, Sustainability practices across different verticals.

CO5- Understand the innovative sustainability solutions that ensures inclusive growth along with the growth of the company and society, SCR

UNIT-1: Introduction to SCR -Meaning & Definition of SCR, Importance of SCR, History & evolution of SCR, Theories of SCR, Indian SCR Law – In depth Analysis, benefits of SCR programme, SCR - Global time line, SCR in India.

UNIT-2: Stakeholders & SCR -Who are stakeholder's, The stakeholder approach, Stakeholder and CSR, Stakeholders theory perspective, Stakeholder theory in action, Stakeholder identification, Stakeholder salience, Stakeholder management, Stakeholder dialogue , Management of stakeholder dialogue

UNIT-3: SCR Planning and Institutionalising-Planning of CSR activities :Responsibility paradigm, SCR Design and Implementation, stakeholder Integration, SCR activities, Bases of evaluation of SCR activities,Measurement of SCR : sustainability indexes, An example of SCR evaluation, SCR in India, SCR initiatives being taken by selected public and private Indian companies

UNIT- 4: Corporate Governance - What is corporate governance, Theories of Corporate governance, Importance of corporate governance, Models and systems of corporate governance, Implementation of corporate governance, Board of Directors, Principals of corporate governance, Corporate governance & SCR

UNIT-5: Corporate sustainability and SCR-What is sustainable development, Corporate sustainability and SCR, Integration of corporate sustainability and SCR, Sustainability Development Goals, SDG compass.

TEXT BOOK:

1. Bharat's Corporate Social Responsibility by KAMAL GARG Edition 2023

REFERENCES:

1. Nirbhay Lumde, Carporate social responsibility in India, first edition, 2023

2. Andrea Giordani, Corporate Social Responsibility, Introbooks ,Jul 2019

Subject	**: 23PCH 101P**	**Modeling & Simulation of Chemical Processes (Practical)**	
Practical	: 4 Hours	No. of Credits	: 2
University	: 100 Marks	College Assessment	: 100 Marks

Modeling and Simulations should be performed based on but not limited to the following List of examples

1. Dynamics of a Stirred Tank Heater with variable Volume
2. Modeling and Dynamics of a Quadruple Tank System.
3. Decoupled SISO control of the Quadruple Tank System.
4. Multi-variable Control of the Quadruple Tank System.
5. Dynamic Matrix Control of the Stirred Tank System.
6. Experiment on Programmed Adaptive Control System
7. Experiment on Time-delay compensation (Smith-Predictor)
8. Experiment on Inverse Response compensation
9. Experiment on multiple outputs controlled by a single input
10. Experiment on a single output controlled by multiple input
11. Introduction to process simulators and CFD software- ASPEN PLUS, HYSYS.
12. Simulation of steady state and Dynamic processes using ASPEN PLUS
13. Simulation of a batch reactor, CSTR, Tubular Reactor, multiphase reactor systems
14. Simulation of a shell and tube heat exchanger
15. Simulation of a condenser
16. Simulation of a pump/compressor
17. Simulation of a fixed bed absorber
18. Simulation of a staged distillation column
19. Simulation of flow in channels and pipes
20. Simulation of flow in sudden expansion/contraction systems
21. Simulation of flow in a square cavity, cylindrical venturi, slit venturi and orifice plate.
22. Process simulation study (flow sheeting)- Production of hydrogen by stream reforming
23. Process simulation study (flow sheeting)- Production of vinyl chloride monomer flowsheet
24. Process simulation study (flow sheeting)- Production of nitric acid from anhydrous ammonia
25. For the simulation of the above Processes/Process Equipment using Computer Programs or Simulation Packages such as ASPEN PLUS/CHEMCAD/HYSYS (UNISIM)/gPROMS etc. canbe used.

SECOND SEMESTER M. Tech Chemical Engineering

Subject	**: 23PCH 201T**	**Advanced Separation Processes (Theory)**	
Lecture	: 4 Hours	No. of Credits	4
University	: 60 Marks	College Assessment	: 40 Marks
Duration of Examination: 3 Hours			

Course Objective: This subject aims to extend your knowledge of basic fluid separation processes to more complex systems commonly encountered in the chemical processing industry. After completing this advanced subject, you are expected to understand the principles of complex fluid separation processes including advanced mass transfer and diffusion theories, equilibrium-based and rate-based methods/models for multi-component absorption, stripping, distillation and extraction, temperature-/pressure-swing adsorption, advanced ion exchange adsorption and chromatographic separation. You will also develop advanced knowledge for design and operation of industrial separation units, the skill of using simulation tools applicable for multicomponent separation, and skill to analyse the energy efficiency, cost-effectiveness and sustainability of the design solutions.

Course outcomes

CO1: Analyze the thermodynamics, advanced mass transfer and diffusion theories underpinning the multi-component separation processes.

CO2: Combine the simulation tools and analysis methods for process flow-sheeting, column dimension calculation, and determination of energy efficiency, cost-effectiveness and sustainability of design solutions for complex separation processes.

CO3: Apply conceptual procedures for the design of multi-component, extractive and/or azeotropic distillation column, temperature-/pressure-swing adsorption column, advanced chromatographic column, and ion-exchange adsorption column.

CO4: Generate experimental skills in operating and analyzing the performance of separation unit operations.

CO5: Appreciate through group-based assignments, an understanding of the design process involving ethical conduct, teamwork spirits, leadership and the need for attention to detail.

Unit 1: Flux Definition, Differential Equations of Mass transfer, Molecular diffusivities, Molecular diffusion, Mass Transfer coefficients

Unit 2: Multicomponent distillation: Bubble point and dew point calculations, Lewis and Matheson calculation, Method of Thiele and Geddes; Azeotropic distillation; Extractive distillation; Molecular distillation; Reactive distillation

Unit 3: Azeotropic and extractive fractional distillation: Separation of homogeneous azeotropes, separation of heterogeneous azeotropes, quantitative treatment of separation of binary heterogeneous azeotropes, selection of addition agents, selectivity, factors affecting selectivity, methods for prediction, mechanism of relative volatility change, choice of entrainer or solvent, design of an azeotropic distillation process, design of an extractive distillation process, methods of solvent recovery

Unit 4: Membrane separation processes: Fundamentals, mechanism and equilibrium relationships, types and structure of membranes, membrane permeation of liquids and gases, effects of concentration, pressure and temperature, dialysis: mechanism, basic idea on dialyser design,industrial application, reverse osmosis, definitions and theory, design considerations, applications, ultra filtration.

Unit 5: Adsorption and Ion Exchange Processes: Adsorption and ion exchange equilibria. Various isotherms. Contact filtration, design of fixed bed adsorber including breakthrough curve.

Recommended Books:

1. R.E. Lacey, S. Loaeb, Industrial Processing with Membranes, Wiley –Inter Science, New York, 1972.
2. C.J. King, Separation Processes, Tata McGraw - Hill Publishing Co., Ltd., 1982.
3. C.J. Geankoplis, Transport Processes and Unit Operations, Prentice-Hall of India Pvt. Ltd., New Delhi, 2000.
4. R.E. Treybal, Mass-Transfer Operations, McGraw-Hill, New York, 1980.
5. J.D. Seader, E.J. Henley, Separation Process Principles, Wiley, 2011.
6. B.K. Dutta, Principles of Mass Transfer and Separation Processes, PHI, 2006
7. T.K. Sherwood, R.L. Pigford, C.R. Wilke, Mass Transfer, McGraw-Hill, New York, 1975.
8. H.M. Schoew, New Chemical Engineering Separation Techniques, Interscience Publishers, 1972.
9. Osadar, Varid Nakagawa, Membrance Science and Technology, Marcel Dekkar, 1992.

Subject	**: 23PCH 202T**	**Advanced Process Dynamics & Control (Theory)**	
Lecture	: 4 Hours	No. of Credits	4
University	: 60 Marks	College Assessment	: 40 Marks

Duration of Examination: 3 Hours

Course objective: To make the students understand basic ideas, challenges, techniques, and applications of process control for controlling various processes.

Course Outcomes: At the end of the Course, the Student will be able to:

CO1: develop the transfer function for a given system to generate response for a given forcing function.

CO2: develop block diagram for a given process

CO3: analyze the stability of a system for different modes of control

CO4: Discuss controller tuning and study the industrial example of SCADA

CO5: explain different advanced control strategies and control valve characteristics

Unit 1: Process Identification and Non-Linear Systems. Introduction and analysis of Non-linercontrol system. Phase plane analysis of second order control system, Analysis of critical points. Method of isoclines for non linear system.

Unit 2: Control of complex processes Process modeling and dynamic response of gas absorber, steam jacketed kettle, heat exchanger, distributed parameter model, non-interacting continuous stirred tank reactors, non-interacting stirred tank heaters.

Unit 3: Feedforward-feedback control configuration. Industrial examples of feedforward-feedback control of heat exchanger, jacketed continuous stirred tank reactor for exothermic and endothermic reactions, stirred tank heater, distillation column, drum boiler, level control, extraction column.

Unit 4: Industrial control system. Control configuration of Supervisory control and data acquisition SCADA, Working control components and network communication of SCADA. Industrial examples of SCADA. Control configuration of distributed control system DCS. Working of Programmable logic controller PLC. Real time monitoring control.

Unit 5: Programmed adaptive control, Gain programmed adaptive control. Reference model adaptive control, Inferential control. Industrial examples of adaptive and inferential control. Reaction curve method.

Recommended Books:

1. B. A. Ogunaike, W. H. Ray, Process Dynamics, Modeling and Control, Oxford University Press, NY, 1994
2. B. W. Bequette, Process Dynamics: Modeling, Analysis and Simulation, Prentice Hall International Series, 1998
3. D. E. Seborg, D. A. Mellichamp, T. F. Edgar, F. J. Doyle III, Process Dynamics and Control, 3rd Edition, Wiley.
4. G. Stephanopoulos, Chemical Process Control, Prentice-Hall, Englewood Cliffs, NJ, 1984
5. T. Marlin, Process Control, 2nd Edition, McGraw Hill Inc, US, 2000.

6. R.P. Vyas, Process control and Instrumentation, Seventh Edition, Denett& Co. publication, 2015.
7. R.P. Vyas, Measurement and Control, Denett& Co. Publication 2010.

Subject	**: 23PCH 203T**	**Advanced Biochemical Engineering (Theory)**	
Lecture	: 4 Hours	No. of Credits	4
University	: 60 Marks	College Assessment	: 40 Marks

Duration of Examination: 3 Hours

Course Objective: To demonstrate ability to plan and execute experiments, and analyze and interpret outcomes.

Course outcome: On successful completion of the course student will be able to

CO1 Understand present unit operations together with the fundamental principles for basic methods in production technique for biologically based products.

CO2 Calculate the need for oxygen and oxygen transfer in a biological production process.

CO3 Understand to explain how microorganisms and biochemical processes can be applied in engineered systems and processes.

CO4 Understand an account of measurement and control of parameters in a bioreactor.

CO5 Calculate yield and production rates in a biological production process, and also interpret data.

Unit 1: Enzyme Kinetics: Models for complex enzyme kinetics, modeling of effect of pH and temperature, models for insoluble substrate, models for immobilized enzyme systems, diffusion limitations in immobilized enzyme system, electrostatic and steric effects.

Unit 2: Major metabolic pathways, bioenergetics, Glucose metabolism, metabolism of nitrogenous compounds, respiration, metabolism of hydrocarbons, anaerobic metabolism, autotrophic metabolism.

Unit 3: Bioreactors: Sterilization techniques, Modifications of batch and continuous reactors, chemostat with recycle, multistage chemostat, fed-batch operation, perfusion system, active and passive immobilization of cells, diffusional limitations in the immobilized system, fermenters.

Unit 4: Homogeneous and heterogeneous reactions in bioprocesses: Reaction thermodynamics, growth kinetics with Plasmid instability, The Thiele Modulus and effectiveness factor, diffusion and reaction in waste treatment lagoon. Reactors and choice of reactors.

Unit 5: Biological waste water treatment: Microbial participation in natural cycle of matter, activated sludge process, design and modeling of activated sludge process, Nitrification, anaerobic digestion, mathematical modeling of anaerobic digester, anaerobic denitrification,phosphate removal.

Recommended Books:

1) Michael L. Shuler, Fikret Kargi, Bioprocess Engineering: Basic Concepts, 2nd Edition, Prentice Hall, 2001.

2) J. E. Bailey, D. F. Ollis, Biochemical Engineering Fundamentals, McGraw- Hill, 1986.

3) P. M. Doran, Bioprocess Engineering Principles, Academic Press, 2nd Edition, 2012.

4) J. M. Lee, Biochemical Engineering, Prentice Hall, Englewood Cliffs, New Jersey, 1992.

Subject (Theory)	**: 23PCH 231T**	**Elective III-** 1. **Advance Petroleum Refining**	
Lecture	: 4 Hours	No. of Credits	4
University	: 60 Marks	College Assessment	: 40 Marks
Duration of Examination: 3 Hours			

Course Objectives:
To provide the concept of petroleum refining and explain the different methods of petrochemical reactions and their applications. To provide the importance of various refining processes and their applications. To explain the significance petrochemicals productions.

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

CO1:	Understand the basic concepts of Refineries
CO2:	Understand the design of distillation column
CO3:	Understand the design various equipment and rate kinetics of different types of cracking
CO4:	Understand the various mechanism of reaction and related rate kinetics
CO5:	Understand Environmental issues and New Trends in petroleum refinery operations

Unit 1 Introduction to petroleum refinery - General Definitions, Composition of petroleum, laboratory tests, refinery feedstocks and products.

Classification of Crude oil, Characterization of crude oil, Composition of crude, Physical properties, Crude oil; analysis and distillation

Unit 2 Design concept of crude oil distillation column design.

Dehydration and desalting of crude, Crude Assay ASTM TBP distillations evaluation of crude oil properties, API gravity various average boiling points and mid percent corves, Evaluation of properties of crude oil and its fractions, Evaluation of crude oil properties and Design of crude oil distillation column.

Unit 3 Thermal and Catalytic cracking, Catalytic Reforming, Hydrotreating and Hydrocracking - Coking and Thermal process, Delayed coking, Catalytic cracking, Cracking reactions, Zeolite catalysts, Cracking Feedstocks and reactors, Effect of process variables, FCC Cracking, Catalyst coking and regeneration, Design concepts, New Designs for Fluidized-Bed Catalytic Cracking Units. Objective and application of catalytic reforming process reforming catalysts. Reformer feed reforming reactor design continuous and semi regenerative process. Objectives & Hydrocracking Reactions, Hydrocracking feedstocks, Modes of Hydrocracking, Effects of process variables. Hydro treating process and catalysts Reside hydro processing, Effects of process variables, Reactor design concepts.

Unit 4 Isomerization, Alkylation and Polymerization, Lube Oil Manufacturing -Isomerization process, Reactions, Effects of process variables, Alkylation process, Feedstocks, reactions, products, catalysts and effect of process variables, Polymerization: Objectives, process, Reactions, catalysts and effect of process variables. Lube oil processing: propane de- asphalting Solvent extraction, dewaxing, Additives production from refinery feedstocks.

Unit 5: Environmental issues and New Trends in petroleum refinery operations-Ecological consideration in petroleum refinery, Waste water treatment, control of air pollution, new trends in refinery, Alternative energy sources, Biodiesel, Hydrogen energy from biomass.

Books Recommended:

1. W.L..Nelson " Petroleum Refining Engineering " Mc Graw- Hill.
2. R.N.Watkins," Petroleum Refinery distillation " Gulf Publishing Co.
3. RobertA Mayers " Hand book of petroleum refining process ".
4. James G Speight " The chemistry and technology of petroleum ".
5. J.H. Gary and G.E. Handwerk " Petrolem Refinery Technologies and economics ".
6. Dr. B.K. Bhaskara Rao, Modern Petroleum Refining Processes (5th Edition)
7. Dr. B.K. Bhaskara Rao, A Text Book on Petrochemicals.
8. Marshall Sitting, Dryden’s Outlines of Chemical Technology

Subject : 23PCH 232T	**Elective III- 2. Nanotechnology (Theory)**
Lecture : 4 Hours	No. of Credits 4
University : 60 Marks	College Assessment : 40 Marks
Duration of Examination: 3 Hours	

Course Objectives:

To provide knowledge of the concept and properties of nanomaterials. To provide scientific understanding of nanomaterials and nanotechnology applications in agriculture, health, and environmental conservation.

Course Outcomes:

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

CO	**Co Statement**
CO1:	Discover Nanotechnology and Nanoscience history

CO2: Provide the information of Fabrication of Nanomaterial

CO3: Analysis and characterization of nanoparticles

CO4: Develop the nanoparticles growth mechanism

CO5: Elaborate the various nanoparticles for various applications in different field

Unit 1: Introduction to Nanotechnology:
Nano Scale, history and Scope of Nano Technology., Nanomaterials, Morphology, Enhanced properties at nano scale, Comparison with bulk materials.

Unit 2: Fabrication of Nanomaterials:
Top-Down Approach, Grinding, Planetary milling and Comparison of particles, Bottom-Up Approach, Wet Chemical Synthesis Methods, Micro emulsion Approach, Colloidal Nanoparticles Production, Sol Gel Methods, Sono-chemical Approach, Microwave and Atomization, Gas phase Production Methods: Chemical Vapor Depositions.

Unit 3: Introduction to Instrumentation and characterization:
Instrumentation Fractionation principles of Particle size measurements, Particle size and its distribution, XRD, Zeta potential, SEM, TEM, AFM, STM, DLS, Spectroscopy. etc.

Unit 4: Kinetics at Nanoscale:
Nucleation and growth of particles, Issues of Aggregation of Particles, Oswald Ripening, Stearic hindrance, Layers of surface Charges, Zeta Potential and pH

Unit 5: Carbon Nanomaterials Synthesis of carbon buckyballs:
List of stable carbon allotropes extended fullerenes, metallofullerenes solid C60, bucky onions nanotubes, nano-cones Difference between Chemical Engineering

processes and nano-synthesis processes. Applications of Nano Technology. Applications in Chemical Engineering like nano-catalyst, bio analytical tools, nano/micro arrays, nanodevices, lab-on-a-chip.

Books Recommended:

1. Sulabha K. Kulkarni, Nanotechnology: Principles and Practices, Capital Publishing Company, 2007.
2. Gabor L. Hornyak., H.F. Tibbals, Joydeep Dutta, John J. Moore, Introduction to Nanoscience and Nanotechnology, CRC Press, 2008.
3. Robert Kelsall, Ian Hamley, Mark Geoghegan, Nanoscale Science and Technology, John Wiley & Sons, 2005.
4. Stuart M. Lindsay, Introduction to Nanoscience, Oxford University Press, 2009.
5. Poole C., and Owens F., Introduction to Nanotechnology, John Wiley, New Jersey, 2003.
6. Singh Nalwa, 10 Volume Enclypedia of Nanoscience and NanoTechnology, 2004.Catherine

Brechignac, Philippe Houdy, Marcel Lahmani (Editors)Nanomaterials and Nanochemistry, Springer-Verlag Berlin Heidelberg, 2007.

Subject	**: 23PCH 233T**	**Elective III-** 3. **Multiphase Flow (Theory)**	
Lecture	: 4 Hours	No. of Credits	4
University	: 60 Marks	College Assessment	: 40 Marks
Duration of Examination: 3 Hours.			

Course Objective: Multiphase flow and heat transfer is an area of interests in fluid dynamics and heat transfer where several different phases co-exist. Although these transport phenomena can be seen our every day-life, for instance, from water boiling in a kitchen and blood streaming in a body to the operation of huge power plants, surprisingly we have little knowledge of multiphase flow since the physical understanding of the phenomena is extremely challenging.

Course Outcomes:

CO1: Describe the most important phenomena and principles of two-phase flow in engineering applications.

CO2: Explain the main points of boiling and condensation, heat transfer, and their enhancement methods.

CO3: Describe the concept boiling crisis (e.g., DNB - departure from nucleate boiling, and dryout) and its modeling.

CO4: Apply the basic two-phase models and flow pattern maps to calculate the pressure drops of two-phase flow at various conditions.

CO5: Apply the models of critical flow and flooding to analyze limiting flow of engineering processes and the learning outcomes to write a scientific review for a topic (to be Identified) in the field of two-phase flow and heat transfer.

Unit 1: Two phase flow: Gas/Liquid and Liquid/liquid systems: Flow patterns in pipes, analysis of two phase flow situations

Unit 2: Prediction of holdup and pressure drop or volume fraction, Bubble size in pipe flow, Lockchart-Martinelli parameters, Bubble column and its design aspects, Minimum carryover velocity. holdup ratios, pressure drop and transport velocities and their prediction.

Unit 3: Flow patterns - identification and classification - flow pattern maps and transition - momentum and energy balance - homogeneous and separated flow models -correlations for use with homogeneous and separated flow models - void fraction and slip ratio correlations - influence of pressure gradient - empirical treatment of two phase flow - drift flux model - correlations for bubble, slug and annular flows

Unit 4: Introduction to three phase flow, Dynamics of gas-solid liquid contactors (agitated vessels, packed bed, fluidized bed, pneumatic conveying, bubble column, trickle beds), Flow regimes, pressure drop, holdup, distributions, mass and heat transfer, reactions, Applications of these contactors

Unit 5: Measurement techniques in multiphase flow: Conventional and novel measurement techniques for multiphase systems (Laser Doppler anemometry, Particle Image Velocimetry)

Recommended Books:

1. R. Clift, M.E. Weber, J.R. Grace, Bubbles, Drops, and Particles, Academic Press, New York, 1978.
2. Y. T. Shah, Gas-Liquid-Solid reactors design, McGraw Hill Inc, 1979
3. L. S. Fan, C. Zhu, Principles of Gas-solid Flows, Cambridge University Press, 1998
4. G. W. Govier, K. Aziz, The Flow of Complex Mixture in Pipes, Van Nostrand Reinhold, New York, 1972.
5. G.B. Wallis, One Dimensional Two Phase Flow, McGraw Hill Book Co., New York, 1969.
6. C. T. Crowe, M. Sommerfeld, Y. Tsuji, Multiphase Flows with Droplets and Particles, CRC Press, 1998
7. C. Kleinstreuer, Two-phase Flow: Theory and Applications, Taylor & Francis, 2003
8. M. Rhodes, Introduction to Particle Technology, John Wiley & Sons, New York. 1998.

Subject	**: 23PCH 234T**	**Elective III-** 4. **Fuel Cell Technology (Theory)**	
Lecture	: 4 Hours	No. of Credits	4
University	: 60 Marks	College Assessment	: 40 Marks
Duration of Examination: 3 Hours			

Course Objectives: Provide thorough understanding of performance characteristics of fuel cell power plant and its components. Outline the performance and design characteristics and operating issues for various fuel cells. Discuss the design philosophy and challenges to make this power plant economically feasible. The design and analysis emphasis will be on the thermodynamics and electrochemistry. Thus at the successful end of the course, the students will have sufficient knowledge for working in a fuel cell industry or R&D organization.

Course Outcomes:

By the conclusion of this course, each student should

CO1: Apply know-how of thermodynamics, electrochemistry, heat transfer, and fluid mechanics principles to design and analysis of this emerging technology.

CO2: Have thorough understanding of performance behavior, operational issues and challenges for all major types of fuel cells.

CO3: Identify, formulate, and solve problems related to fuel cell technology keeping in mind economic viability.

CO4: Use the techniques, skills, and modern engineering tools necessary for design and analysis of innovative fuel cell systems.

CO5: Understand the impact of this technology in a global and societal context and develop enough skills to design systems or components of fuel cells.

Unit 1: Hydrogen Production Methods Production: from fossil fuels, electrolysis, thermal decomposition, photochemical, photocatalytic, hybrid; Hydrogen Storage MethodsStorage: Metal hydrides, Metallic alloy hydrides, Carbon nano-tubes; Sea as the source of Deuterium.

Introduction and overview of fuel cells technology: low and high temperature fuelcells.

Unit 2: Fuel cell thermodynamics. Fuel cell reaction kinetics: Introduction to electrode kinetics. Exchange current and electrocatalysis, Simplified activation kinetics, Catalyst electrode design. Fuel cell thermodynamics - second law analysis of fuel cells, efficiency of fuel cells fuel cell electrochemistry - Nernst equation, Electrochemical kinetics,Butler-Volmer equation

Unit 3: Fuel cell types Classification by operating temperature/electrolyte type, Fuel Cell Performance, Activation, Ohmic and Concentration over potential Fuel cell charge and mass transport. Fuel cell characterization.

Unit 4: Fuel cell modeling and system integration: Balance of plant.

Unit 5: Safety issues and cost expectation and life cycle analysis of fuel cells. Description of some commercially available fuel cell stacks, overview on research activities on fuel cells in world, Research and development related to fuel cell development in India

Recommended Books:

1. R.P. O'Hayre, S. Cha, W. Colella, F.B. Prinz, Fuel Cell Fundamentals, Wiley, NY, 2006.

2. A. J. Bard, L. R. Faulkner, Electrochemical Methods, Wiley, N.Y. 2004.

3. S.(Ed) Basu, Fuel Cell Science and Technology, Springer, N.Y. 2007.

4. H. Liu, Principles of fuel cells, Taylor & Francis, N.Y. 2006.

Subject	**: 23PCH 205T**	**Research Methodology (Theory)**	
Lecture	: 4 Hours	No. of Credits	4
University	: 60 Marks	College Assessment	: 40 Marks
Duration of Examination: 3 Hours			

Course Objective: The course focuses on social science research methods. Methods discussed include interview, content analysis, focus group discussions and surveys.

Course outcomes

By the end of the subject students should be able to:

CO1: Demonstrate the ability to choose methods appropriate to research aims and objectives

CO2: Understand the limitations of particular research methods

CO3: Develop skills in qualitative and quantitative data analysis and presentation

CO4: Develop advanced critical thinking skills

CO5: Demonstrate enhanced writing skills

Unit 1 Research Foundation

What is Research, Objectives of Research, Types of Research, Scientific Research, Research and Theory, Conceptual and theoretical Models, Importance of research methodology in scientific research

Unit 2 Review of Literature

Need for Reviewing Literature, What to Review and for what purpose, Literature Search Procedure, Sources of Literature, Planning of Review work, Note Taking, Library and documentation

Unit 3 Planning of Research

The planning process, Selection of a Problem for Research, Formulation of the Selected Problems, Hypothesis formation, Measurement, Research Design/Plan

Unit 4 Processing of Data and Statistical Analysis of Data

Introduction to Statistical Software, MINITAB, SPSS, Measures of Relationship, Simple Regression Analysis, Multiple Correlation and Regression, Partial Correlation, MATLAB and Neural Network based optimization, Optimization of fuzzy systems, Error Analysis, Results and their discussions

Unit 5 Report and Thesis writing

Types of Reports, Planning of Report Writing, Research Report Format, Principles of Writing, Data and Data Analysis Reporting in a Thesis, Use of Endnote, Bibliography, API , appendix, table, Observations arrangement, Preparation of type script and lay-out of thesis, Use of LATEX Indexing of Journals, Impact factor and social Media for Researchers.

Recommended Books:

1. Research Methodology: Methods and Techniques by C. R. Kothari, New Age International Publishers, ISBN:81-224-1522-9
2. Statistical Methods for Research Workers by Fisher R. A., Cosmo Publications, New Delhi ISBN:81-307-0128-6
3. Design and Analysis of Experiments by Montogomery D.C. (2001), John Wiley, ISBN: 0471260088

4. MINITAB online manual
5. Methodology of Research in Social Sciences by O. R. Krishnaswamy and M. Rangnatham Himalaya publication House, 2005, ISBN: 8184880936
6. SPSS online manual

THIRD SEMESTER M. Tech Chemical Engineering

Subject : 23PCH 341T OPEN Elective IV-1. Waste to Energy (Theory)

Lecture	: 4 Hours	No. of Credits	4
University	: 60 Marks	College Assessment	: 40 Marks

Duration of Examination: 3 Hours

Course Objectives- The objective of the course is to provide insights into waste management options by reducing the waste destined for disposal and encouraging the use of waste as a resource for alternate energy production. Case studies will be discussed to provide a better understanding of the concepts of "Waste to Energy" in the Indian context

Course Outcomes:

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

CO1: To understand of the concept of Waste to Energy.

CO2: To link legal, technical and management principles for production of energy form waste.

CO3: To learn about the best available technologies for waste to energy.

CO4: To analyze of case studies for understanding success and failures.

CO5: To facilitate the students in developing skills in the decision making process of waste to energy.

UNIT 1-Introduction : The Principles of Waste Management and Waste Utilization. Waste Management Hierarchy and 3R Principle of Reduce, Reuse and Recycle. Waste as a Resource and Alternate Energy source.

UNIT 2 Waste Sources & Characterization : Waste production in different sectors such as domestic, industrial, agriculture, post-consumer, waste etc. Classification of waste – agro based, forest residues, domestic waste, industrial waste (hazardous and non-hazardous). Characterization of waste for energy utilization. Waste Selection criteria.

UNIT 3 Technologies for Waste to Energy : Biochemical Conversion – Energy production from organic waste through anaerobic digestion and fermentation. Thermo-chemical Conversion – Combustion, Incineration and heat recovery, Pyrolysis, Gasification; Plasma Arc Technology and other newer technologies.

UNIT 4 Waste to Energy Options : Landfill gas, collection and recovery. Refuse Derived Fuel (RDF) – fluff, briquettes, pellets. Alternate Fuel Resource (AFR) – production and use in Cement plants, Thermal power plants and Industrial boilers. Conversionof wastes to fuelresourcesforother useful energy applications. Energy from Plastic Wastes – Non-recyclable plastic wastes for energy recovery.Energy Recovery from wastes and optimization of its use, benchmarking and standardization. Energy Analysis.

UNIT 5 : Case Studies – Success/failures of waste to energy Global Best Practices in Waste to energy production distribution and use. Indian Scenario on Waste to Energy production distribution and use in India. Success and Failures of Indian Waste to Energy plants.Role of the Government in promoting 'Waste to Energy'

Recommended Books:

1. Marc J Rogoff Dr and Francois Screve, Waste-to-Energy: Technologies and Project Implementation" 2011.
2. Naomi B Klinghoffer, Marco J Castaldi, Waste to Energy Conversion Technology (Woodhead Publishing Series in Energy) Paperback – Import, 30 October 2018
3. Marc J. Rogoff and Francois Screve, Waste-to-Energy: Technologies and Project Implementation, 31 December 1987

Websites: www.envfor.nic.in, www.cpcb.nic.in, www.mnre.gov.in

Subject : 23PCH 342T OPEN Elective IV-2. Energy Conservation & Planning (Theory)

Lecture : 4 Hours No. of Credits 4

University : 60 Marks College Assessment : 40 Marks

Duration of Examination: 3 Hours

Course Objective: The subject aims to provide the student with the knowledge of existing and upcoming industrial utility and energy management theory that allows the student to have a solid theoretical knowledge and be able in the future to design and development of various energy management technologies. The skill to identify, formulate and solve fields problem in a multi-disciplinary frame individually or as a member of a group

Course Outcomes (COs): After learning this course the students will be able to:

CO1. Understand energy scenario and policy

CO2. Understand the significance and procedure for energy conservation and audit.

CO3. Understand causes and remedies for global energy issues.

CO4. Analyze, calculate and improve the energy efficiency and performance of electrical utilities.

CO5. Analyze, calculate and improve the energy efficiency and performance of mechanical utilities.

Unit 1: Energy Outlook, Energy conservation and its importance, Energy intensive industries

Unit 2: Global industrial energy efficiency benchmarking, Engineering fundamentals related to energy efficiency

Unit 3: Principles on energy management, Energy Audit, Detailed thermodynamic analyses of common unit operations

Unit 4: Opportunities and techniques/methods for energy conservation in equipment and utility systems in process industries, Process synthesis, Thermo-economics, Energy Management Information Systems (EMIS).

Unit 5: Software tools for industrial energy efficiency and savings, Case studies on energy conservation and management in process industries

Recommended Books:

1. W.F. Kenney, Energy Conservation in the Process Industries. Academic Press Inc., 1984.
2. Vladimir S. Stepanov, Analysis of Energy Efficiency of Industrial Processes. 1st Edition, Springer-Verlag, 1993.
3. Jakob de Swaan Arons, Hedzer van der Kooi, Krishnan Sankaranarayanan, Efficiency and Sustainability in the Energy and Chemical Industries, 1st Edition, Marcel Dekker, Inc., 2004.

Subject : 23PCH 343T OPEN Elective IV-3. Green & Cleaner Technology (Theory)

Lecture : 4 Hours	No. of Credits 4
University : 60 Marks	College Assessment : 40 Marks
Duration of Examination: 3 Hours.	

Course Objectives: To provide an idea on Green Technology with an approach towards the design, manufacturing and use of chemical products to reduce or eliminate the chemical hazards intentionally. Green Technology is a new and rapidly emerging branch of chemistry. The goal of Green Technology is to create better and safe chemicals while choosing the safest and the most efficient ways to synthesize them. The main goal of Green Technology is to eliminate hazards right at the design stage. The principles of Green Technology demonstrate how chemical production could be achieved without posing hazard to human health and environment.

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

CO1. Understand the Principles of Green Technology and Green Engineering:

CO2. Understand the conceptual clarity about Green Synthesis and Catalysis

CO3. Analyze the learning and understand techniques for Green Industrial Processes

CO4. Apply the Concepts of Cleaner Technologies

CO5: Understand the Challenges and Practical Implementation

UNIT1 Principles of Green Technology and Green Engineering: To learn to modify the processes and products to make them green safe and economically acceptable to the society, Concepts of green chemistry and Process intensification.

UNIT2 Green Synthesis and Catalysis: Green oxidation and photochemical reactions, Microwave and Ultrasound assisted reactions, Synthesis of Green Reagents, Green solvents,Green nanotechnology and Ionic liquids.

UNIT3 Green Industrial Processes: Pollution statistics from various industries like polymer, textile,pharmaceutical, dyes, pesticides and waste water treatment. A greener approach towards all these industries.

UNIT4 Concepts of Cleaner Technologies: Cleaner Production (CP), Definition, methodology, Role of CP in Achieving Sustainability, Benefits, Role of Industry, Government and Institutions, Environmental Management Hierarchy, Relation of CP and EMS. CP case studies: Ammonical nitrogen recovery from waste water, Fluoride removal from waste water, Reuse of water from sewage treatment plant, Gas quenching process: replacement of oil with nitrogen and Reduction of hydrogen cyanide from process stack. Reuse of liquid industrial waste from several industries.

UNIT5 Challenges and Practical Implementation: Responsibilities and potentials of companies for action. Green Productivity and emerging technologies. Implementation of the practical applications of Green emerging technologies and sustainable development.Case studies in Green Technology. Green laws compliance.

Text Books

1. Introduction toGreen Chemistry,Matlack A.S. Publisher:Marcel Dekker,Newyork, 2001.
2. Green Chemistry: Theory and Practice, Anastas P.T. and WarnerJ.C.OxfordUniversity Press, 1998.
3. Pollution Prevention: Fundamentals and Practice, BishopP. L.McGraw-Hill, Boston,2000.
4. Cleaner Production Audit Environmental System Reviews, Modak P., Visvanathan C. and Parasnis M. Asian Institute of Technology, Bangkok, 1995.
5. Handbook of Green Chemistry and Technology, Clark J.H. and Macquarrie D.J.Wiley-Blackwell Publishers, 2002

Subject	**: 23PCH 301T**	**Project Planning and Management (Theory)**	
Lecture	: 4 Hours	No. of Credits	4
University	: 60 Marks	College Assessment	: 40 Marks
Duration of Examination: 3 Hours			

Course Objectives: To make them understand the concepts of Project Management for planning to execution of projects. To make them understand the feasibility analysis in Project Management and network analysis tools for cost and time estimation. To enable them to comprehend the fundamentals of Contract Administration, Costing and Budgeting. Make them capable to analyze, apply and appreciate contemporary project management tools and methodologies in Indian context.

Course Outcomes On completion of this course, the students will be able to:
CO1. Understand project characteristics and various stages of a project.
CO2. Understand the conceptual clarity about project organization and feasibility analyses – Market, Technical, Financial and Economic.
CO3. Analyze the learning and understand techniques for Project planning, scheduling and Execution Control.
CO4. Apply the risk management plan and analyze the role of stakeholders and understand the contract management, Project Procurement, Service level Agreements and productivity.
CO5: Understand the How Subcontract Administration and Control are practiced in the industry.

Unit 1 : ***Basics of Project Management:*** Introduction, Need for Project Management, Project Management Knowledge Areas and Processes, The Project Life Cycle, The Project Manager (PM), Phases of Project Management Life Cycle, Project Management Processes, Impact of Delays in Project Completions, Essentials of Project Management Philosophy, Project Management Principles

Unit 2 : ***Project Identification and Selection:*** Introduction, Project Identification Process, Project Initiation, Pre-Feasibility Study, Feasibility Studies, Project Break-even point

Project Planning: Introduction, Project Planning, Need of Project Planning, Project Life Cycle, Roles, Responsibility and Team Work, Project Planning Process, Work Breakdown Structure (WBS)

Organisational Structure and Organisational Issues: Introduction, Concept of Organisational Structure, Roles and Responsibilities of Project Leader, Relationship between Project Manager and Line Manager, Leadership Styles for Project Managers, Conflict Resolution, Team

Unit 3: ***Resources Considerations in Projects:*** Introduction, Resource Allocation, Scheduling, Project Cost Estimate and Budgets, Cost Forecasts

Project Risk Management: Introduction, Risk, Risk Management, Role of Risk Management in Overall Project Management, Steps in Risk Management, Risk

Identification, Risk Analysis, Reducing Risks

Unit 4: ***Project Quality Management and Value Engineering:*** Introduction, Quality, Quality Concepts, Value Engineering

Project Management Information System: Introduction, Project Management Information System (PMIS), Planning of PMIS, Design of PMIS

Purchasing and Contracting for Projects: Introduction, Purchase Cycle, Contract Management, Procurement Process

Unit 5: ***Project Performance Measurement and Evaluation:*** Introduction, Performance Measurement, Productivity, Project Performance Evaluation, Benefits and Challenges of Performance Measurement and Evaluation, Controlling the Projects

Project Execution and Control: Introduction, Project Execution, Project Control Process, Purpose of Project Execution and Control

Project Close-out, Termination and Follow-up: Introduction, Project Close-out, Steps for Closing the Project, Project Termination, Project Follow-up

Project Management Software: Introduction, Advantages of Using Project Management Software, Common Features Available In Most of the Project Management Software, Project 2000.

Reference Books:

1. Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, by John W. Creswell, 2nd Edition , Sage Publication, 2003
2. Qualitative Inquiry and Research Design: Choosing among Five Approaches, by John W. Creswell, 3rd Edition, Sage publication, 2013.
3. Evaluation: A Systematic Approach, Peter H. Rossi, Mark W. Lipsey, and Howard E. Freeman, 7th edition , Sage publications, 2007.
4. Handbook of Practical Program Evaluation, Joseph S. Wholey, Harry P. Hatry, Kathryn E. Newcomer. 4th edition, Wiley, 2015
5. Program Evaluation and Performance Measurement: An Introduction to Practice, James C. McDavid and Laura R. L. Hawthorn, Sage Publication, 2013.
6. Evaluation, Carol H. Weiss, 2nd Edition, ABE books, 1997.
7. Case Study Research: Design and Methods, Robert K. Yin, 3rd Edition, Sage Publications, 2011

Subject	**: 23PCH 302P**	**Project Seminar**	
Practical	: 3 Hours	No. of Credits	: 8
University	: 100 Marks	College Assessment	: 100 Marks

Each student will undertake an independent project seminar. The student is required to select the topic in consultation with his/her Guide. Student should undertake project concerning Chemical Engineering applications such as design and development, experimental work, industry based problems, generation of new ideas and concept, modification in the existing process/system, development of computer programs, modelling and simulation etc. A preliminary work is to be carried out in this stage of the project. Two neatly typed copies of the Report on the completed work at this stage include comprehensive report on literature survey, design and fabrication of experimental set up and/or development of model, relevant computer programs and the plan forstage II should be submitted at end on the 3rd semester. University and college assessment would be made on the basis of the submitted report and the presentation cum viva-voce examination conducted by the board of examiners.

FOUTH SEMESTER M. Tech Chemical Engineering

Subject	**: PGCHE 401P** (BCHE)	**Project**	
Practical	: 6 Hours	No. of Credits	: 16
University	: 200 Marks	College Assessment	: 200 Marks

Project work undertaken in the 3rd semester will be continued and completed at the end of fourth semester. This stage will include comprehensive report on the work carried out at this stage and relevant portions from project seminar stage, including experimental studies, analysis and/or verification of theoretical model, conclusions. Two neatly typed and bound copies of the report consisting of project seminar stage of 3rd semester and project stage from 4th semester combined together along with its soft copy should be submitted at the end of fourth semester. The student are expected to publish at least one national/international paper based on the project work. The publication/accepted paper for publication shall be included in the report. University and college assessment would be made on the basis of the submitted report and the presentation cum viva-voce examination conducted by the board of examiners.