B.TECH THIRD YEAR SYLLABUS CHEMICAL ENGINEERING

5th SEMESTER

Sl. No.	Course Name	L	T	P	Credits	Remarks
1	Industrial Psychology & Professional Ethics	2	0	0	2	
2	Mass Transfer I	3	1	0	4	
3	Chemical Reaction Engineering II	3	1	0	4	
4	Instrumentation and Process Control	3	1	0	4	
5	Particle Technology	2	0	0	2	
6	Bio Chemical Engineering	3	1	0	3	
7	Reaction Engineering Laboratory	0	0	3	2	
8	Heat Transfer & Particle Technology Lab	0	0	3	2	
	Total	**16**	**4**	**6**	**23**	

6th SEMESTER

Sl. No.	Course Name	L	T	P	Credits	Remarks
1	Mass Transfer II	3	1	0	4	
2	Transport Phenomena	3	1	0	4	
3	Computer Aided Process Engineering	1	0	3	3	
4	Process Equipment Design	2	0	4	4	
5	Elective- I	3	0	0	3	
6	Economics	2	0	0	2	
7	Instrumentation and Process Control Laboratory	0	0	3	2	
	Total	**14**	**2**	**10**	**22**	

5th SEMESTER

Course Type	Course Code	Name of Course	L	T	P	Credit
	BS 30001	Industrial psychology & Professional Ethics	2	0	0	2

Unit No.	Topics to be Covered
1.	Understanding human experience and behavior: Definition, schools, methods, branches and application of Psychology for Engineers. Basic Psychological Processes: Intelligence, Thinking, Attention, Learning. Motivation and Emotion: Theories, Motivating people at Workplace.
2.	Personality: Definition, Approaches and Theories. Psychological Disorders, Mental health and Workplace. Psychological Problems of Everyday Life: Stress and coping.
3.	Introduction to Psychometric and types of tests. Attitude and work behavior, Group dynamics, Intergroup relations, conflict resolution. Industrial Psychology and Organizational Behavior: Concepts, Hawthorne Studies, Application, Personnel Selection, Job satisfaction.
4.	Leadership and Management. Professional Ethics. (includes code of conduct)

Text Books:

1. Baron, R.A. (2001). Psychology. Prentice-Hall of India Private Limited.
2. Blum, M.L. and Naylor, J.C. (1984) Industrial Psychology. New Delhi. CBS Publishers and Distributors.

References:

1. C. T. Morgan, R. A. King, J. R. Weiss and J. Schopler. (1986). Introduction to Psychology.7th ed. McGraw Hill.
2. Newstrom, J.W. & Davis, K. (2002). Organizational Behaviour- Human Behaviour at Work. New Delhi. Tata McGraw-Hill Pub. Co. Ltd.
   Schultz, D. P., & Schultz, E. S. (2008). Psychology and Work today. Newyork. Mac Milan publishing company.

Course Type	Course Code	Name of Course	L	T	P	Credit
Core	CH 30001	Mass Transfer I	3	1	0	4

Course Objective

This course enables the students:

1. To acquire basic knowledge of mass transfer operation and its application.
2. To learn fundamental knowledge of mass transfer involved in various unit operations.
3. To design mass transfer processes and equipment.

Learning Outcomes

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

1. Explain the basic mechanism of mass transfer including diffusion and convective mass transfer.
2. Find the mass transfer coefficient and solve problems related to interphase mass transfer.
3. Explain the gas-liquid contacting process and solve related problems including Absorption.
4. Solve problems on VLE and problems related to design calculation of distillation columns.
5. Explain enhanced distillation.
6. Develop a process design for humidification and cooling.

Unit No.	Topics to be Covered	Learning Outcome
1.	**Fundamentals of mass transfer:** Diffusional mass transfer, mass transfer coefficients, steady state and unsteady state theories of mass transfer, interphase mass transfer, Whitman's two film theory and its variations, multiphase contacting equipments, concept of transfer unit, unified approach to staged processes.	Fundamental concept of mass transfer, design and problem solving.

2.	**Distillation**: Vapour-liquid Equilibrium, x-y, T-x-y, P-x-y and H-x-y diagrams; Henry's, Raoult's and Dalton's Laws; Ideal and Non-ideal solutions, Azeotropes; Relative Volatility; Flash Vaporization; Differential Distillation: Steam Distillation; Continuous Rectification â Staged Calculation using Ponchon-Savarit and McCabe-Thiele Methods; Complex/Multi-draw Configuration; Packed Distillation Column; Multicomponent Distillation; Azeotropic and Extractive Distillations; Performance Evaluation of Distillation Columns including Reboilers and Condensers.	Fundamental concept of Distillation, design and problem solving.
3.	**Absorption:** Solubility, choice of solvent, concept of rate approach and stagewise approach, stagewise and continuous contact absorbers; rich and lean gasses; absorption with chemical reaction. Counter-current and co-current multistage operations, dilute and concentrated systems, process design and performance evaluation of absorbers.	Fundamental concept of Absorption, design and problem solving.
4.	**Humidification/Dehumidification:** Definitions, Psychrometric chart, Adiabatic saturation and wet-bulb temperatures, Adiabatic and non-adiabatic operations, Dehumidification, Mass and heat balances in bulk and at interfaces, Spray chamber, Cooling towers - counter-current, co-current and cross-current, Performance evaluation of cooling towers, Principles of air conditioning.	Fundamental concept of humidification, design and problem solving.

Text Book:

1. R. E. Treybal, Mass Transfer Operations, McGraw Hill Education 2017.
1. W. L. McCabe, J. C. Smith and P. Harriott, Unit Operations of Chemical Engineering, McGraw Hill Education 2017.
2. E. I. Cussler, Diffusion: Mass Transfer in Fluid Systems, Cambridge University Press 2009.

Reference:

1. J.F. Richardson, J. H. Harker, and J. R. Backhurst, Coulson &Richradson's Chemical Engineering, Volume 2 Butterworth-Heinemann 2002.
2. B.K. Dutta, Principles of Mass Transfer and Separation Processes, Prentice Hall India Learning Private Limited, 2006.

Course Type	Course Code	Name of Course	L	T	P	Credit
Core	CH30001	Chemical Reaction Engineering-II	3	1	0	4

Course Objective

1. To provide the student with principles and kinetic tools useful in analysing the rates of chemical reactions for both heterogeneous non-catalytic and catalytic reactions.

Learning Outcomes

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

1. Understand the effect of velocity, particle size and fluid properties on rate of reactions controlled by mass transfer.
2. Understand the design aspects of multiphase reactors.
3. Design industrial reactors involving chemical reactions with mass transfer.
4. Determine internal and overall effectiveness factors.

Unit No.	Topics to be Covered	Learning Outcome
1.	Multiphase reactions: Introduction to heterogeneous reactions and effects of mass and heat transfer. Gas-Liquis, Liquid-Liquid, Gas-Solid, Solid-Liquid-Gas reactions.	Basics of heterogeneous reactions and rate equations for Gas-Liquids, Liquid-Liquid, Gas-Solid, Solid-Liquid-Gas reactions.
2.	Catalyst preparation and characterization. Mechanism of catalytic reactions, Rate equations for solid catalyzed fluid phase reactions, External mass and heat transfer in catalyst particles, Effectiveness factor, Deactivation of catalyst.	Reactor design for non-catalytic reactions i.e, fluid-fluid and fluid-solid reactions.
3.	Models of Industrial Reactors (Packed bed, slurry, trickle bed, fluidized bed): Pressure Drop considerations, Heat management, Scale-up parameters/methodology for a typical multiphase flow type reactor.	

Text Books:

1. Levenspiel O, Chemical Reaction Engineering, 3^{rd} Edition, Wiley India (1999).
2. Fogler S H, Elements of Chemical Reaction Engineering, 4^{th} Edition, Prentice Hall India (2015).
3. J. M. Smith,Chemical Engineering Kinetics, McGraw Hill 1981.
4. K. R. Westerterp, W. P. M. Van Swaaij and A. A. C. M. Beenackers, Chemical Reactor Design and Operation by Wiley Blackwell 1987.

Reference Books:

1. Schmidt L D, The Engineering of Chemical Reactions, 2^{nd} Edition, Oxford University Press (2005).
2. Froment G F and Bischoff K B, Chemical Reactor Analysis and Design, 2^{nd} Edition, John Wiley & Sons (1990).
3. Doraiswamy L K and Uner D, Chemical Reaction Engineering: Beyond the Fundamentals, 1^{st} Edition, CRC Press (2013).

Course Type	Course Code	Name of Course	L	T	P	Credit
Core	BS30002	Instrumentation and Process Control	3	1	0	4

Course Objective

This course enables the students:

1. To acquire basic knowledge of measurement devices for temperature, pressure, vacuum, fluid flow rate, level and control valves.
2. To understand the control relevant model development.
3. To design feedback control strategies for different processes..

Learning Outcomes

1. Use suitable instruments for measurement of temperature, pressure, vacuum, fluid flow rate, level.
2. Develop control relevant mathematical models.
3. Analyze stability and frequency response.
4. Design simple and advanced regulatory controllers for different processes.
5. Analyze multi input multi output control loops.

Unit No.	Topics to be Covered	Learning Outcome
1.	**Instrumentation:** Static and dynamic characteristic of instruments. Measurement of temperature, pressure, vacuum, fluid flow rate, level and control valves.	Use suitable instruments for measurement of temperature, pressure, vacuum, fluid flow rate, level.
2.	**Process Control:** Modelling considerations for control purposes. • State Space and Transfer function models. • Dynamic behaviour of first and higher order systems. • Concept and dynamic behaviour of feedback control. Frequency response analysis. Stability analysis of feedback systems. Design of feedback controllers. • Feedforward, Ratio, Adaptive and inferential control, dead-time and inverse response compensator. • Control systems with multiple loops.	Develop control relevant mathematical models. Analyse stability, frequency response, Design of simple controllers for different processes.

Text/Reference Books:

1. G. Stephanopoulos, Chemical process control: An introduction to theory and practice, Prentice Hall India 2008.
2. D. E. Seborg, T. F. Edgar, D. A. Mellichamp, and F.J. Dyle III, Process dynamics and control, Wiley 2010.
3. D. Patranabis, Principles of industrial instrumentation, Tata McGraw Hill 2008.

Course Type	Course Code	Name of Course	L	T	P	Credit
Core	CH 30003	Particle Technology	2	0	0	2

Course Objective

1. To provide students with the concept of unit processes and unit operations, and the importance of mechanical operations in the chemical process industries.
2. To enable students to understand the properties, storage, mixing, and transportation of bulk solids.
3. To provide students with the importance of size reduction, actions involved, and parameters affecting size reduction and industrial size-reduction equipment.
4. To enable students to grasp the importance of separation of solids and the types of separation equipment for solid-solid, solid-liquid, and solid-gas separation.

Learning Outcomes

1. Identify unit operations and their role in chemical industries.
2. Select equipment for operations on solid, liquid, and gaseous materials.
3. Understand and analyze unit operation equipment based on mathematical and physical descriptions.
4. Compare performances of existing equipment based on the efficiency and select the best equipment for various unit operations.

Unit No.	Topics to be Covered	Learning Outcome
1.	Determinations of mean particle size, Size distribution equations. Particle size distribution including normal/Gaussian, Particle size reduction and enlargement. Inter-particle forces.	Understand the properties, storage, mixing and transportation of bulk solids. Estimate mean/average particle size of a mixture.
2.	Principles and laws of crushing and grinding. Characteristics of industrial crushers and mills. Industrial screening, effectiveness of screens, cyclones.	Understand importance, uses and types of size reduction equipment. Understand and use laws of size reduction.

3.	Fluid-particle mechanics, free and hindered settling. Industrial classifiers, clarifiers and thickeners, gravity separation, tabling and jigging. Floatation and its kinetics, magnetic and electrostatic separation and precipitation. Mixing of liquids and solids, power requirement in mixing.	Grasp the importance of separation of solids from other solid and fluids. Will be able to do calculations on solid separation processes. Will master the working principles of separation equipment.
4.	Principles of filtration, filtration equipment. Flow through packed and fluidized bed. Introduction to storage and conveying, elevating equipment, hydraulic and pneumatic transport.	Will understand different types of mixing equipment for different applications involving solid and fluid.

Text Book:

1. McCabe, W., Smith, J., Harriott, P. Unit Operations of Chemical Engineering, McGraw Hill Education, 2017.

Reference:

1. Richardson, J. H., Harker, J.H., Backhurst, J.R., Coulson and Richardson's Chemical Engineering, Volume 2, 5th Edition: Particle Technology and Separation, Elsevier, 2006.

Course Type	Course Code	Name of Course	L	T	P	Credit
Core	CH 30006	Biochemical Engineering	3	1	0	3

Course Objective

1. To introduce the concepts of biology and chemical engineering that are necessary for biochemical process development to the students.

Learning Outcomes

1. Understand the definitions and scope of Biotechnology, Biochemical engineering and Bioprocess engineering.
2. Understand the need for chemical engineers to have fundamental knowledge in biology to be a successful biochemical engineer.
3. Understand enzyme kinetics, Inhibitions, immobilization methods, effect of immobilization on kinetics of enzymes.

Unit No.	Topics to be Covered	Learning Outcome
1.	Overview of Biotechnology; Kinetics of Enzyme Catalysis; Immobilized Enzymes: effects of intra and inter-phase mass transfer on enzyme kinetics; Major Metabolic Pathways.	Understand the definitions and scope of Biotechnology, Biochemical engineering and Bioprocess engineering Understand enzymes and cells as the major catalysts in bioprocesses.
2.	Bioenergetics, Glucose Metabolism, Biosynthesis; Microbial Growth: Continuum and Stochastic Models; Design, Analysis and Stability of Bioreactors.	Understand cell growth and their models, Understand enzyme kinetics, and Inhibitions.
3.	Kinetics of Receptor-Ligand Binding; Molecular Genetics and Regulation of Gene Expression; Purification and Bio-product Recovery; Manufacture of Biological Products.	Understand reactor design from bioprocess perspective. Understand separation processes from bioprocess perspective.

4.	Anaerobic digestion and fermentation for food Industry.	Understand Anaerobic digestion and fermentation aspects.

Text Book:

1. M.L. Shuler, and F Kargi, Bioprocess Engineering: basic concepts, Prentice Hall 2001.

Reference:

1. H.W. Blanch, and D.S. Clark, Biochemical Engineering, CRC Press 1997.
2. N.S. Mosier, and M.R. Ladisch, Modern Biotechnology: Connecting Innovations in Microbiology and Biochemistry to Engineering Fundamentals, Wiley-AIChE 2009.

Course Type	Course Code	Name of Course	L	T	P	Credit
Core	CH 30009	Reaction Engineering Laboratory	0	0	3	2

Course Objective
1. Course aims to equip students with hands on experience in different aspects of chemical reaction engineering.

Learning Outcomes
At the end of the course, the student will be able to: 1. Carry out Experiments in homogenous and heterogeneous phases in Batch, Plug flow, Mixed flow reactors. 2. Observe, analyze and interpret the kinetic data for different reactions. 3. Estimate the mass transfer coefficient in agitated vessels and estimate the RTD in packed/un packed tubular reactor.

Unit No.	Topics to be Covered	Learning Outcome
1.	Study of liquid phase homogenous reaction in Batch /Plug flow/Three Staged Mixed reactors.	Hands on experience on Reaction Engineering equipment and various reaction condition optimization.
2.	Development of rate equations for catalytic gas solid reaction.	
3.	Evaluation of mass transfer coefficient in an agitated contactor, Catalytic reaction studies in Berty Reactor.	
4.	RTD studies for water flowing in a tubular reactor with packing/without packing.	

Course Type	Course Code	Name of Course	L	T	P	Credit
Core	CH 30004	Heat Transfer and Particle Technology Lab	0	0	3	2

Course Objective

1. Course aims to equip students with hands-on skills of important experiments on heat transfer and particle technology.

Learning Outcomes

1. Do measurements of temperature and do heat transfer calculations.
2. Carry out experiments, observe and analyze data for conduction, convection, and radiation problems.
3. Understand and carry out experiments in mechanical unit operations involving solid particles.

Unit No.	Topics to be Covered	Learning Outcome
1.	Heat Transfer experiments: Thermal conductivity of metal rod, overall heat transfer co-efficient in a vertical condenser, natural convection, critical heat flux, overall heat transfer co-efficient in horizontal condenser, heat transfer co-efficient in double pipe heat exchanger, composite wall.	Do measurements of temperature and do heat transfer calculations. Carry out experiments, observe and analyze data for conduction, convection and radiation problems.
2.	Experiments on particles: Ball mill performance, roll crusher performance, performance of different types of classifiers, jaw crusher performance, determination of permeability, sampling, solid feeders performance, grind ability tests.	Understand and carry out experiments in mechanical unit operations involving solid particles.

*Depends on number of student groups.

Text Book:

1. McCabe, W., Smith, J., Harriott, P. Unit Operations of Chemical Engineering, McGraw Hill Education, 2017.

Reference:

1. Richardson, J. H., Harker, J.H., Backhurst, J.R., Coulson and Richardson's Chemical Engineering, Volume 2, 5th Edition: Particle Technology and Separation, Elsevier, 2006.

6^{th} SEMESTER

Course Type	Course Code	Name of Course	L	T	P	Credit
Core	CH 30005	Mass Transfer II	3	1	0	4

Course Objective

This course enables the students:

1. To acquire basic knowledge of mass transfer operation and its application.
2. To learn fundamental knowledge of mass transfer involved in various unit operations.
3. To design mass transfer processes and equipment.

Learning Outcomes

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

1. Explain the gas-solid contacting process and solve related problems including Drying.
2. Understand basics of adsorption, chromatography and ion-exchange.
3. Explain membrane filtration.
4. Develop a process design for liquid-liquid extraction and leaching.

Unit No.	Topics to be Covered	Learning Outcome
1	Drying: Theory and mechanism of drying, Batch and continuous drying; Drying rate curves, Estimation of drying times, Cross-circulation and through-circulation drying, Transfer unit concept in drier, Design calculations with special reference to rotary and spray driers.	Concept, design and problem solving on Drying.
2	Liquid-Liquid Extraction: Ternary liquid equilibria, Partial miscibility, Solvent selection, Crosscurrent and counter-current multistage extraction, Extraction with reflux, Extraction equipment, Performance evaluation of extractors.	Concept, design and problem solving on LLE.

3	Leaching: Solid-liquid equilibria, Single and multistage, Cross-current and countercurrent leaching, Steady state and unsteady state operations, Operation and performance evaluation of leaching equipment’s.	Concept, design and problem solving on Leaching.
4	Adsorption and Ion Exchange: Adsorption equilibria - Various isotherms, Breakthrough curves, Ion exchange equilibria, Contact filtration, Design of adsorbers and ion exchangers, Chromatography.	Concept, design and problem solving on Adsorption.
5	Membrane Separations: Reverse osmosis, Dialysis, Microfiltration, Ultrafiltration; Pervaporation, Separation of gases and liquids.	Concept, design and problem solving on Membrane Separation.
6.	Crystallization: Theory of solubility Crystallization, phase diagram (temp/solubility relationship), crystal geometry; crystal nucleation and growth; equilibria and yields.	Concept, design and problem solving on Crystallisation.

Text Books:

1. R. E. Treybal, Mass Transfer Operations, McGraw Hill Education 2017.
2. W. L. McCabe, J. C. Smith and P. Harriott, Unit Operations of Chemical Engineering, McGraw Hill Education 2017.
3. E. I. Cussler, Diffusion: Mass Transfer in Fluid Systems, Cambridge University Press 2009.

References:

1. J.F. Richardson, J. H. Harker, and J. R. Backhurst, Coulson & Richradson’s Chemical Engineering, Volume 2 Butterworth-Heinemann 2002.

2. B.K. Dutta, Principles of Mass Transfer and Separation Processes, Prentice Hall India Learning Private Limited, 2006.

Course Type	Course Code	Name of Course	L	T	P	Credit
Core	CH 40002	Transport Phenomena	4	0	0	4

Course Objective

1. To provide students the basics of vector and tensor operations and their applications.
2. To enable students to understand concepts in momentum transfer, shell balance, governing equations and relevant boundary conditions.
3. To enable students to solve the flow problems using different physical systems and different boundary conditions.
4. To provide students with the derivation of the Navier-Stokes equation, energy balance equations for different systems will be explained.
5. To provide students with knowledge of derivations and solution of equations governing coupled heat, mass and momentum transfer problems.

Learning Outcomes

1. Explain the various types of transport processes relevant in chemical operations.
2. Demonstrate mastery over Vectors and Tensor calculus and its use in solving complex transport problems.
3. Apply concept of Shell Balances for Momentum, Energy and Mass Transport and use the same to solve various transport problems.
4. Apply fundamentals of transport phenomena to solve actual industrial problems involving all these processes simultaneously and understand the similarities among them.

Unit No.	Topics to be Covered	Learning Outcome
1.	Brief revision on 'Transport by molecular motion: Newton's Law of viscosity, Fourier's law of heat conduction, Fick's law of diffusion. Transport in laminar flow or in solids in one dimension.	Demonstrate mastery over Vectors and Tensor calculus and its use in solving complex transport problems.
2.	Development of continuity (conservation) equations, velocity, temperature and concentration profiles, momentum, energy and mass fluxes. Equations of change for isothermal, non-isothermal and multicomponent systems.	Apply concept of Shell Balances for Momentum and use the same to solve various momentum transport problems.

3.	Navier-Stokes equation, equation of energy, equations of motion for free and forced convection (heat/mass). Unsteady state viscous flow, heat conduction and mass diffusion. Momentum, energy and mass transport in boundary layer with relevant analogies.	Apply the concept of Shell Balances for energy and use the same to solve various simultaneous momentum and energy transport problems.
4.	Transport in turbulent flow: time smoothened equations of change. Interphase momentum, heat and mass transfer.	Understand diffusive and convective mass flux, derive species balance equations, and solve species transport problems in multicomponent problems.

Text Book:

1. Bird,R.B., Stewart, W.E. and Lightfoot, E.W. Transport Phenomena, Wiley, 1994.
2. Welty J, Wicks C.E., Rorrer G.L., Wilson R.E., Fundamentals of Momentum, Heat and Mass Transfer, Wiley, 2008.

Reference:

1. Brodkey R.S., Hershey H.C., Transport Phenomena-A unified approach, McGraw Hill, 1988.
2. Slattery J.C., Advanced Tr
3. ansport Phenomena, Cambridge University Press, 1999.

Course Type	Course Code	Name of Course	L	T	P	Credit
Core	CH30007	Computer Aided Process Engineering	1	0	3	3

Course Objective

To introduce computational techniques to UG students in order to solve chemical engineering problems by applications of process simulation software's such as MATLAB and Aspen.

Learning Outcomes

At the end of the course, the student will be able to

1. Code in MATLAB and Run & Analyze the Aspen results.
2. Solve the chemical engineering models by computational technique.
3. Design a unit process and unit operation equipment.

Unit No.	Topics to be Covered	Learning Outcome
1.	Review of numerical methods using Chemical Engineering applications - solution of linear and nonlinear algebraic equations, solution of coupled ordinary differential equations using Matlab.	Basics of numerical techniques and their application in chemical engineering problems.
2.	Solution of coupled ordinary differential equations using Matlab.	Learn MATLAB basic commands, syntax and loops.
3.	Importance of VLE/ LLE calculations for process simulation. Process modeling and simulation, Information Flow diagram, modeling of different process equipment - heat exchangers, boilers, evaporator, L-L extraction, furnaces, flash drum, distillation, absorption, other staged / differential contacting processes, reactors etc.	Learn how to code in MATLAB for numerical techniques to solve chemical engineering problems.
4.	Process flow sheeting and simulators - Simulator components and structures, Salient features of simulators like ASPEN etc. Industrial Automation-Real time systems.	Introduction to Chemical process simulators-ASPEN. property estimation methods in and solving different chemical process units.

Text Books:

1. N. Kaisare, Computational techniques for process simulation and analysis using Matlab. CRC Press (2017).
2. Introduction to Chemical Engineering Computing, Second Edition by Bruce A. Finlayson.Wiley (2014).
3. Numerical Methods for Engineers 7th Edition, Steven C. Chapra and Raymond P. Canale.McGraw hill publishers (2016).

References:

1. S.K. Gupta, Numerical Methods for Engineers. New Age International Publishers (2015).
2. R.G.E. Franks, Modeling and simulation in chemical engineering, Wiley Blackwell (1972).

Kamal l. M. Al-Malah Aspen Plus: Chemical Engineering Applications, Wiley (2016).

Course Type	Course Code	Name of Course	L	T	P	Credit
Core	CH 30008	Process Equipment Design	2	0	4	4

Course Objective

The objective of this course is to make students familiar with the design of specific equipment dealing with parameters such as internal structure, auxiliaries and the dimension of the equipment in order to meet the desired standards specified by industries.

Learning Outcomes

At the end of the course, the student will be able to

1. Gain knowledge on the design of processes as well as the individual equipment accompanying a particular process.
2. Understand that the industrial standards and codes are necessary in order to mechanically design any specific equipment.
3. Attain practical knowledge with the help of several design examples on the concepts and practices employed in several industrial processes.

Unit No.	Topics to be Covered	Learning Outcome
1.	Process and mechanical design of Heat Transfer Equipments: Heat Exchangers -with and without phase change (shell and tube / double pipe / other types), Reboilers, Evaporators.	Students will get to know the concept of process and mechanical design of Heat Transfer Equipment.
2.	Binary distillation: process and equipment design of bubble-cap tray column.	Design and problem solving on bubble-cap tray column.
3.	Gas Liquid Absorber (absorption without chemical reaction): process and equipment design of packed column. Cooling tower design, Crystalliser design, design of driers.	Students will get to know the concept of process and equipment design of packed column. Students will get to know the design of cooling tower, crystalliser, driers.

4.	Fundamental aspects of process data sheet and interpretation of process data sheet for major equipment used in refinery – heat exchanger, distillation Column, Internals, Pump, Pipes, Control Valve.	Students will get to know the equipment used in refinery.

Text Books:

1. D. Q. Kern, “Process heat transfer”, Tata McGraw-Hill Education, 1950.
2. R.W. Serth, “Process Heat Transfer: Principles and Applications”, Elsevier Ltd 2007.
3. W. L. McCabe, J. C. Smith, P. Harriott, “Unit Operations of Chemical Engineering”, 5th edition.
4. B. K. Dutta, “Principles of mass transfer and separation processes”.
5. J. R. Backhurst, J. H. Harker, “Coulson & Richardson Chemical Engineering”, Volume II, 5th edition, 2002, Butterworth-Heinemann.

Reference Books:

1. D.W. Green, and R.H. Perry, “Perry’s Chemical Engineer’s Handbook”, McGraw Hill Education 2007.
2. L. E. Brownell and E.H. Young, “Process Equipment Design”, Wiley 2009.
3. B.C. Bhattacharya, “Introduction to Chemical Equipment Design: Mechanical aspects”, CBS Publications 2008.
4. V.V. Mahajani, S.B. Umarji, Joshi's “Process Equipment Design”, Laxmi Publications 2016.

Course Type	Course Code	Name of Course	L	T	P	Credit
	BS 30003	Economics	2	0	0	2

Unit No.	Topics to be Covered
1.	Introduction, Demand and Supply Analysis, Production and Cost, Price Output Determination, Capital Market and Investment Decisions, Outline of Welfare Economics, Resource Accounting and Sustainability, Income Determination and Fluctuations, Trade, Aid and Development. Economic Systems & Indian Economic Policies.
2.	Geopolitics and world petroleum market; role of OPEC, national oil companies and bilateral contracts; Fundamentals of petroleum business – strategic issues. Dynamics of petroleum pricing; Financial measures and profitability analysis; Risk, uncertainty, and decision analysis; Implications of fiscal and trade policies and regulations for petroleum industry.

Text Books:

1. Contemporary Engineering Economics, by, Chan S. park, Prentice Hall of India (PHI), 3rd Edition.
2. Petroleum Economics and Engineering, by, Abdel Aal, Bakr, and, Al-Sahlavi, 2nd edition.
3. Economics of worldwide Petroleum Production, by, Richard D. Seba, 3rd Edition.

References:

1. Principles of Economics, by, Samuleson and Nordhaus.
2. Principles of Economics, by, N. G. Mankiw.
3. Engineering Economics, by, R. Paneerselvam, PHI.
4. Petroleum Economics, by, Masseron Jean, 4th edition.

Course Type	Course Code	Name of Course	L	T	P	Credit
Core	BS 30004	Instrumentation and Process Control Lab	0	0	2	2

Course Objective

1. Course aims to help the students to gain in-depth understanding of the concepts that were taught in the theory course of instrumentation and process control through hands-on experiments on responses of the systems, Calibration and characterization of instruments.

Learning Outcomes

1. Understand how to setup experiments to study the dynamic response and evaluate the time constants of different first order and second order systems.
2. Understand how to setup experiments to calibrate and characterize instruments.

Unit No.	Topics to be Covered	Learning Outcome
1.	Calibration experiments on thermocouple, resistance thermometer, thermistor. Study and calibration of flapper nozzle assembly, pneumatic and electronic DP transmitter, I/P and P/I converters.	Understand and experience the response of first order and second order systems.
2.	Studies on control valve characteristics. Experiments on Dynamic behavior for interacting and non-interacting tank level system, and temperature control (integrated system). Control performance studies on pressure process, tank level system, heat exchanger.	Understand the different types of valve characteristics. Learn how to calibrate a thermocouple and understand it response. Learn about wastewater management techniques in various industries.

Text Book:

1. G. Stephanopoulos, Chemical process control: An introduction to theory and practice, Prentice Hall India 2008.

2. D. Patranabis, Principles of industrial instrumentation, Tata McGraw Hill 2008.

Reference:

1. D. E. Seborg, T. F. Edgar, D. A. Mellichamp, & F.J. Dyle III, Process dynamics and control, Wiley 2010.

ELECTIVE- I	
Elective - I	1. Petroleum Exploration 2. Bio Energy 3. Wastewater Management 4. Management Techniques for Industrial Sector 5. Principles of Energy Conversion

Course Type	Course Code	Name of Course	L	T	P	Credit
ELECTIVE-I	PE 30013	Petroleum Explorations	3	0	0	3

Principles and methods of geological and geochemical exploration, pathfinders and trace elements in rocks and soils. Primary and secondary dispersion patterns, geochemical anomalies and their interpretation Geophysical Explorations: Gravity method; Magnetic method; Electrical Methods; Seismic Methods: Field procedure, Data acquisition, Data processing, Data processing sequence, Advanced processing, Data processing using software; Interpretation of images, Detection of hydrocarbons.

Books:

Course Type	Course Code	Name of Course	L	T	P	Credit
Elective-I	PE 30014	Bio Energy	3	0	0	3

Course Objective

1. The course will instruct students the science and technology of biofuels and bioenergy.
2. It will give an overview of biomass feedstock and its availability, various technological practices in the generation of biofuels and bioenergy.

Learning Outcomes

1. Students will learn about the benefits of various feedstocks and the processes involved in the biofuel generation.
2. Importance of the available natural resources as the sustainable, efficient, and cost-effective bioenergy sources will be discussed.

Unit No.	Topics to be Covered	Learning Outcome
1.	Introduction to Bioenergy; Current status, merits & demerits. Feedstock,: starch, oilseed, lignocellulosic and algae based, fuel logistics of Biomass.	Students will get an overview of bioenergy, types of biofuels and their sources.
2	Biological conversion technologies, enzyme hydrolysis, ethanol fermentation, comparisons of fossil fuels and bio fuels.	Students will understand the technical aspects of biomass conversion technologies.
3.	Fundamentals of anaerobic digestion, Microbial fuel cells, Bio-refinery. Economic, Social and Ecological Impacts of Bioenergy at Local, National and Global Levels.	Students will learn the importance of microbes in biofuel processes. Learn economic, social and ecological impacts of bioenergy.
4.	Life cycle assessment, current and emerging challenges to bioenergy development, Govt. policies and standards.	Students will learn about different bioenergy policies and the challenges involved.

Text Book:

1. Y. Li, and S. K. Khanal, Bio Energy: Principles & Applications: Wiley-Blackwell 2016.
2. S. Lee, and Y T Shah, Bio Fuels and Bio Energy: Processes and Technologies, CRC Press, 2012.

Course Type	Course Code	Name of Course	L	T	P	Credit
Elective: I	CH 30010	Wastewater Management	3	0	0	3

Course Objective
1. The course provides a thorough understanding of wastewater management to convert the “burden (i.e., wastewater)” into “resources (i.e., clean water, energy, and fertilizer).

Learning Outcomes
1. Understand the categorization of wastewater, and its sources with various characterization methods. 2. Learn the fundamental aspects of physical, chemical, and biological processes for wastewater treatment. 3. Convert the “burden (i.e., wastewater)” into “resources (i.e., clean water, energy, and fertilizer) using wastewater management techniques. 4. Select suitable treatment strategy to target specific contaminants.

Unit No.	Topics to be Covered	Learning Outcome
1.	Introduction to water and wastewater engineering, Methods for characterizations of wastewater properties.	Understand categorization of wastewater, their sources along with various characterization methods.
2.	Physical, chemical and biological process for wastewater treatment, primary, secondary and tertiary treatment including suspended growth and attached growth methods.	Learn the fundamental aspects of physical, chemical, and biological processes for wastewater treatment.

3.	Advanced oxidations process for removal of recalcitrant components in wastewater, nutrient removal, sludge treatment and its removal.	Learn AOPs and their application in the treatment of recalcitrant pollutants along with sludge management.
4.	Progress in zero discharge techniques. Case studies related to treatment of Industrial and municipal effluents.	Learn various case studies related to wastewater treatment .
5.	Standards and regulations.	Learn various standards and regulations.

Text Book:

1. W. Eckenfelder (Jr.) Industrial Water Pollution Control, McGraw Hill (1999).

2. G. Tchobanoglous., L. Burton, and H.D. Stensel, Wastewater Engineering Treatment and Reuse (Metcalf & Eddy), McGraw Hill (2002).

Reference:

1. H.S. Peavy, D. R. Rowe, G. Tchobanoglous, Environmental Engineering, Mcgraw-Hill (1985).

2. A. P. Sincero and G.A. Sincero, Physical-Chemical Treatment of Water and Wastewater, CRC press (2002).

Course Type	Course Code	Name of Course	L	T	P	Credit
Elective: 1		Principles of Energy Conversion	3	0	0	3

Pre-requisite courses

Basics of Thermodynamics.

Course Objective

1. Compare competing energy conversion technologies on an economic and efficiency basis.
2. Be familiar with basic principles of thermal, mechanical, chemical, nuclear, and solar energy conversion.
3. Be familiar with thermodynamic processes and power cycles (thermal and mechanical energy).
4. Be familiar with basic principles of energy storage.

Learning Outcomes

1. At the end of the course students will learn and understand the basic principle involved in energy conversion.
2. Students will get to know about energy conversion efficiency.
3. Students will learn about thermodynamic processes and power cycles.
4. Students will get to know about Thermal, chemical, nuclear, wind energy conversion principles.
5. Students will get to know about the basic principles of energy storage.

Unit No.	Topics to be Covered	LearningOutcome
1	Energy, Growth Rate & Energy Economics energy, energy classification, units, energy conversion, conversion efficiency, energy information and perspectives.	Students will learn and understand the basic principle involved in energy conversion.
2	Thermal-to-Mechanical Conversion · Early engines & efficiency · Thermodynamics & power cycles & efficiency · Rankine Cycle · Brayton Cycle	Students will learn about thermodynamic processes and power cycles.

3	Chemical-to-Thermal Conversion · principles of combustion, fuels: coal, petroleum, gas.	Students will be familiar with basic principles of thermal, mechanical, chemical, nuclear, and solar energy conversion.
4	Electromagnetic-to-Thermal Conversion principles of solar insolation · solar collectors · thermal energy storage.	
5	Electromagnetic-to-Electrical Conversion principles of photovoltaics.	
6	Nuclear-to-Thermal Conversion · principles of nuclear energy · pressurized water reactors · boiling water reactors · boiling water, graphite-moderated reactors · Gen-IV reactors.	
7	Mechanical-to-Mechanical Conversion · principles of wind energy.	
8	Chemical-to-Electrical Conversion · principles of fuel cells.	
9	Introduction to Energy Storage · hydrogen · flow batteries · compressed gas, flywheel.	Students will be familiar with basic principles of energy storage.

Text Books:

1. Energy Conversions by Kenneth Weston.
2. Principles of Energy Conversion by Culp, McGraw-Hill Companies.
3. Lecture notes.

Reference Books

1. BEI International, Hambling, P., (Ed.), Modern Power Station Practice: Nuclear Turbines, and Associated Plant, Pergamon Press, 1992.
2. Drbal, L. F., Boston, P. G., Westra, K. L., Black and Veatch, Power Plant Engineering, Kluwer Academic, 1995.
3. Elliott, T. C., Chen, K., and Swanekamp, R., Standard Handbook of Power Plant Engineering, McGraw-Hill Professional, 2nd ed., 1997 El-Wakil, M. M.,
4. Power Plant Technology, McGraw-Hill, 1984. Jog, M., Hydro-electric and Pumped Storage Plants, John Wiley, 1989.
5. Fritz, J. J., Small and Mini Hydropower Systems, McGraw-Hill, 1984.
6. Central Board for Irrigation and Power (CPIB), India.
7. Design and Construction Features of Selected Dams in India, 1983.
8. Borbely, Anne-Marie, and Kreider, Jan J., (Eds.), Distributed Generation: The Paradigm for the New Millennium, CRC Press, 2003.
9. Larminie, J., and Dicks, A., Fuel Cell Systems Explained, John Wiley, 2003.
10. Vielstich, W., Lamm, A., and Gasteiger, H., Handbook of Fuel Cells: Fundamentals, Technology, Applications, John Wiley, 2003.

11. Appleby, A. J., and Foulkes, F. R. Fuel Cell Handbook, van Nostrand Reinhold, 1996.
12. Harrison, R., Hau, E., and Snel, H., Large Wind Turbines: Design and Economics, John Wiley, 2001.

Management Techniques for Industrial Sector

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