Bipin Tripathi Kumaon Institute of Technology
Dwarahat

Scheme of Examination as per AICTE Flexible Curricula

Evaluation Scheme and Syllabus for B. Tech. Second Year

Chemical Engineering

SUBJECT CODE: **BCHT 301** COURSE TITLE: **Material and Energy Balance**
EXAMINATION DURATION: 3 Hrs. SEMESTER: III (ODD)

L:3 T:1 P:0 C:4 PRE-REQUISITE: Engineering Mathematics

OBJECTIVES

To provide basic calculation knowledge of principles of material and energy balances for analyzing and apply for designing chemical processing equipment and systems.

COURSE OUTCOMES

After successful completion of the course the students will be able to:
CO [1] Apply steady-state and unsteady state material and energy balance on a system.

CO [2] Ability to implement material and energy balance for system with or without chemical reactions.

CO [3] Analyze and apply all the stiochiometric and balances being applied on a system undergoing chemical process.

CO [4] Estimation and design equipment with inlet and outlet; including recycle-bypass and purging streams for a chemical process.

COURSE DETAILS

S. No	Unit	Topics in the unit	No. of Lectures
1.	Introduction and Material Balance	Units and dimension in chemical engineering, units conversion of dimensional equations, stoichiometric and composition relations, concept of degrees of freedom and linear independence of a set of equations. Concept of material balance, open and closed systems, steady state and unsteady state, multiple component system, selection of a basis, problem solving strategy.	9
2.	Material Balance with and without Chemical Reaction for Single and Multiple Units	Conservation of mass/atom, material balance for Systems without chemical reactions involving single unit and multiple units. Concept of excess reactant, extent of reaction, Material balance for systems with chemical reactions involving single unit and multiple units.	11

3.	Recycle, Bypass, and Purge their Industrial Applications	Calculations for a cyclic processes involving recycle / purge / bypass, material balances involving gases, vapors, liquids and solids and use of real gas relationships, material balance involving gases, vapours, liquids and solids and uses of real gas relationships, vapor-liquid equilibrium and concepts of humidity and saturation, analysis of systems with bypass, recycle and purge, analysis of processes	10
4.	Energy Balance application	Conservation of energy with reference to general energy balance with and without chemical reactions, chemical engineering problems involving reversible processes and mechanical energy balance. Calculations of heat of change of phase (solid – liquid and liquid – vapour), heat of reaction, heat of combustion, heat of solutions and mixing, determination of temperatures for adiabatic and non-adiabatic reactions, use of psychometric and enthalpy-concentration diagrams.	10
5.	Simultaneous Material and Energy Balances	Degrees of freedom analysis for multicomponent systems, combined steady state material and energy balances for units with multiple sub-systems.	3
		TOTAL	43

Text Books

1. Bhatt B.I. and Vora S.M., Stoichiometry, 5th Ed., Tata McGraw-Hill
2. Narayanan K.V. and Lakshmikutty B., Stoichiometry and Process Calculations, Prentice Hall of India.

Reference Books

1. Himmelblau D.M. and Riggs J. B., Principles and Calculations in Chemical Engineering, 8th Ed., Prentice Hall of India.
2. Felder R.M. and Rousseau R.W., Elementary Principles of Chemical Processes, 3rd Ed., John Wiley.
3. Hougen D.A., Watson K.M. and Ragatz R.A., Chemical Process Principles, Part-I, 2nd Ed., CBS Publishers.

Reference link

1. NPTEL video lectures

SUBJECT CODE: BCHT 302
COURSE TITLE: **Chemical Engineering Fluid Mechanics**
EXAMINATION DURATION: 3 Hrs. SEMESTER: III (ODD)
L:3 T:1 P:0 C:4 PRE-REQUISITE: Engineering Physics

COURSE OBJECTIVES

To present the fundamental insights of fluids and their static and dynamic behaviours and fluid machineries correlations, etc.

COURSE OUTCOME

On completion of this course, the students will be able to...

CO [1]. Identify the various basic fluid properties and different flow regimes of fluids and express in basic terms related to fluid flow phenomena.

CO [2]. Formulate and establish the basic equations of fluid flow, integral equation of flow, momentum equation under steady state and unsteady sate condition, Bernoulli's equation and Navier-Stokes etc.

CO [3]. Understand and apply dimensionless analysis and it's signification in chemical Engineering Problems.

CO [4]. Describe effects of roughness, restriction, head loss, friction of flow, etc. on incompressible fluid.

CO [5]. Select and evaluate the performance of various fluid transport and metering devices like mixers, agitated vessels, pumps, compressors, orificemeter, venturimeter, rotameter, and pitot tube, etc.

S. No	Unit	Topics in the unit	No. of Lectures
1	Introduction and fluid statics	Fundamental concepts of fluids; Fluid statics, kinematics and dynamics; Properties of fluids.The basic equation of fluid statics; Pressure – depth relationship; Pressure forces on plane and curved surfaces; Buoyancy and stability; Forces on immersed and submerged bodies; Pressure measurements; Pressure in accelerated rigid body motions.	9
2	Elementary Fluid Kinematics and analysis of flow	Lagrangian and Eulerian descriptions; Flow visualization – streamline, pathline, streakline and timeline, profile plots; Description and classification of fluid motions; Rotational, irrotational, inviscid and potential flows; Deformation of fluids; System and control volume representation; Reynolds transport theorem.	10

		Conservation of mass, linear and angular momentum, and energy; Eulers equation of motion, Bernoulli theorem; Navier-Stokes equations.	
3	Dimensional Analysis, Similitude and Modeling	Dimensional homogeneity and analysis; Methods of finding dimensionless numbers; Selection of variables, Rayleigh and Buckingham's π method; Common dimensionless numbers and their physical significance; Model and Prototypes; Complete and incomplete similarity.	6
4	Internal Incompressible Viscous Flow	General characteristics of pipe flow – laminar, turbulent, entrance region, fully developed; Fully developed laminar/turbulent flow in pipe – shear stress distribution and velocity profiles; Energy correction factors; Energy and hydraulic grade lines; Major and minor losses in pipes, fittings, pipe network; Friction factor.	6
5	Flow Measurements and Fluid Handling Machinery	Flow rate and velocity measurements – Pitot tube, orifice meter, venturimeter, rotameter, notches and weirs. Positive displacement pumps and compressors, centrifugal pumps and compressors, Axial flow pumps and compressors, compressor efficiency. Characteristics of centrifugal pumps; NPSH; Selection of pumps.	14
		TOTAL	45

Text Books

1. Modi P.N. and Seth S.M., Hydraulics and Fluid Mechanics including Hydraulics Machines, Standard Book House, New Delhi.
2. Balachandran P., Engineering Fluid Mechanics, PHI Learning Pvt Ltd., New Delhi

Reference Books

1. Nevers N.D., Fluid Mechanics for Chemical Engineers, 3rd Ed., McGraw Hill Higher Education.
2. Cengel Y.A. and Cimbala J.M., Fluid Mechanics: Fundamentals and Applications, 2nd Ed., McGraw-Hill
3. White F.M., Fluid Mechanics, 7th Ed., Tata McGraw-Hill

Reference link

1. NPTEL video lectures

SUBJECT CODE: **BCHT 303** COURSE TITLE: **Heat Transfer Operations**
EXAMINATION DURATION: 3 Hrs. SEMESTER: III (ODD) L:3
T:1 P:0 C:4 PRE-REQUISITE: Thermodynamics

COURSE OBJECTIVES

This course will provide extensive knowledge on heat transfer by conduction, convection and radiation and their applications. Course helps to design and categorize heat exchangers, condensers and boilers. It also gives a brief idea of Condensation and Heat exchangers their types; it also includes heat transfer application in fluidized bed and combustion calculation.

COURSE OUTCOMES

After the successful completion of the course student should be able to...

CO [1] Identified heat transfer by conduction in steady and unsteady condition. Apply Fourier's law of heat conduction in various geometries and its applications.

CO [2] Classified free and force convection with the help of dimensionless numbers. Derive analogy for laminar and turbulent flow.

CO [3] Application of radiation heat transfer and its governing laws. Define shape factor and solve problem related with it.

CO [4] Classified and design heat exchangers, condensers, boilers and evaporators.

COURSE DETAILS

S. No	Unit	Topics in the unit	No. of Lectures
1.	Heat transfer by conduction	One-dimensional Heat Conduction equation, Boundary conditions; One dimensional steady state heat conduction for slab, cylinder, sphere, composite medium, Thermal conduct resistance, critical thickness of insulation, Fourier law, Finned surfaces, temperature dependent K (T), Transient conduction and use of temperature charts. Lumped system analysis for slabs and long cylinder and spheres.	12
2.	Heat Transfer by convection	Flow over a body, flow inside a duct. Forced Convection: Hydrodynamic and thermal boundary layer, simultaneously developing laminar flow, Turbulent flow inside ducts, Heat transfer to liquid metals. Free Convection: Dimensionless parameters of Free Convection, Correlations of free convection on a vertical plate, Free Convection on a horizontal plate.	11

3.	Boiling and Condensation	Boiling: Boiling of liquids. Nucleate and film boiling. Nusselt equation for horizontal and vertical condenser, Drop and film type condensation, Effect of non-condensable gases.	6
4.	Heat Transfer by Radiation	Concept of black body, Kirchoff's Law Emissivity, absorptivity, black body and grey body radiation. View factors.	4
5.	Heat Exchangers and Evaporation	Classification, temperature distribution in heat exchangers, Overall heat transfer co-efficient, the LMTD method for heat exchanger analysis, correction for LMTD for use with cross flow and multipass exchanger. Double pipe heat exchangers, 1-2 shell and tube exchangers, Finned tube exchangers, fouling factor. Classification and application, evaporator feeding mechanism, operation of single effect evaporators.	12
		TOTAL	45

Text Books

1. Dutta B.K., Heat transfer - Principles and applications, Prentice Hall India

2. Holman J.P., Bhattacharya S., Heat Transfer, McGraw Hill Education Pvt. Ltd

Reference Books

1. Kern, D.Q., Process Heat Transfer, 1st Edition, Tata McGraw Hill Education Private Ltd.

2. Cengel Y.A. and Ghajar A.J., Heat and Mass Transfer: Fundamentals and Applications, 4th Ed., McGraw Hill

3. McCabe W.L, Smith J.C, and Harriot P, Unit Operations in Chemical Engineering, 7th Edition, McGraw-Hill, Inc.

Reference link

1. NPTEL video lectures

SUBJECT CODE:BCHP 302 COURSE TITLE: **Chemical Engineering Fluid Mechanics Lab**
EXAMINATION DURATION: 3 Hrs. SEMESTER: III (ODD) L:0
T:0 P:2 C:1 PRE-REQUISITE: Fluid mechanics

COURSE OBJECTIVES

To determine the various parameters related to fluid flow in pipes and in open channels.

LAB OUTCOMES

On completion of the experiments, the students will be able to

1. Calculate coefficient of discharge through v-notch, venturimeter, and orificemeter.
2. Determine friction losses through different pipes and fittings.
3. Calculate the efficiency of centrifugal pump.
4. Study different types of flow and analyse Bernoulli's law.

LIST OF EXPERIMENTS

1. To find the flow rate using a V notch
2. To find the friction losses in a Straight pipe and in a Bend pipe.
3. Study of Pipe fittings and Valves
4. To study the working principle of a centrifugal pump and determine its efficiency experimentally.
5. To determine the pressure drop in a packed bed.
6. Determination of discharge coefficient with Reynolds Number in case of an orifice meter and a venturimeter.
7. Study and verification of the flow pattern in a Bernoulli's apparatus
8. To determine the minimum fluidization velocity in a fluidized bed.
9. Determination of the fluidization index, segregation index in a fluidized bed
10. Determine the Reynolds number and study different types of flow.

SUBJECT CODE:BCHP 303 COURSE TITLE: **Heat Transfer Operations Lab**
EXAMINATION DURATION: 3 Hrs. SEMESTER: III (ODD) L:0
T:0 P:2 C:1 PRE-REQUISITE: Heat transfer operation

COURSE OBJECTIVES

To determine the amount of heat exchange in various modes of heat transfer including condensation & boiling for several geometries.

LAB OUTCOMES

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

1. Determine the thermal conductivity of different materials.

2. Calculate the rate of heat transfer through different types of heat exchangers in different flow patterns.

3. Study the natural convection phenomena and temperature distribution in various setups (like composite wall, lagged pipe etc.).

LIST OF EXPERIMENTS (Perform any 10)

1. To find out the thermal conductivity of liquids.

2. To find out the thermal conductivity of a metal rod.

3. Find out the Heat Transfer Coefficient during drop wise and film wise condensation.

4. Find out the Heat Transfer Coefficient in a vertical and a horizontal condenser.

5. To find out the emissivity of a surface.

6. To find out the overall thermal conductance and plot the temperature distribution in case of a composite wall.

7. To find out the average heat transfer co-efficient of vertical cylinder in natural convection.

8. To find out the Stefan Boltzmann's constant and compare with the theoretical value.

9. To find out the relation between insulation thickness and heat loss.

10. To find out the overall heat transfer co-efficient of a double pipe heat exchanger.

11. To find out the overall heat transfer co-efficient of 1-2 shell & tube heat exchanger.

12. Study heat transfer through logged pipe.

SUBJECT CODE:BCHP 304 COURSE TITLE:**Soft computing Lab**
EXAMINATION DURATION: 3 Hrs. SEMESTER: III (ODD) L:0
T:0 P:2 C:1 PRE-REQUISITE: MS-EXCEL

COURSE OBJECTIVES
To use different software for solving basic problems of engineering.

LAB OUTCOME

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

1. Understand the importance of software.

2. Solve basic chemical engineering problems using MS-EXCEL and MATLAB.

LIST OF EXPERIMENTS

Experiment using MS-EXCEL and MATLAB.

1. To apply material balance on any chemical engineering unit operation.
2. To apply energy balance on any chemical engineering unit operation.
3. To work on heat transfer problems.
4. To work on a exchanger or evaporator designing using kern's method.
5. To find out effect on conversion and time of operation in a batch reactor.
6. To solve material and energy balance in a simple distillation column.

CHEMICAL ENGINEERING
SEMESTER-IV

SUBJECT CODE:BCHT 402 COURSE TITLE: **Mechanical Operations**
EXAMINATION DURATION: 2 Hrs. SEMESTER: III (ODD) L:3
T:1 P:0 C:4 PRE-REQUISITE: Fluid mechanics and Math.

OBJECTIVE

To impart Knowledge on particle size analysis, size reduction, their storage and transport, separation of solid particles from fluids and flow through porous media along with behavior of solid particles in fluidized state.

COURSE OUTCOME

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

CO [1] Measure the particlesize.

CO [2] Estimate the crushing efficiency of different type'scrushers.

CO [3] Explain the process involved and results obtained by filtration.

CO [4] Explain the methods for storage and handling of solids.

CO [5] Design the methods involved in transport of solid in any industrial process.

COURSE DETAILS

S. No.	Contents	Lecture Hours
1.	**Particle characterization:** General characteristics of solids; Different techniques of size analysis; Shape factor; Surface area determination; Estimation of particle size; Screening methods and equipment; Screen efficiency.	**7**
2.	**Size Reduction:**Methods of size reduction; Classification of equipments; Crushers; Grinders, Intermediate and fine grinding; Laws of size reduction; Energy relationships in size reduction; power requirement; Work index	**7**
3.	**Particle Separation:** Gravity settling; Sedimentation; Elutriation; Centrifugal separation; Cyclones; Hydro cyclones; Electrostatic - Magnetic separators; Floatation	**8**
4.	**Storage and conveying of solids:** Silos; Bins; Hoppers; Transportation of solids in bulk; Types of conveyers; Belt Conveyor; Bucket conveyor; Screw conveyor; Pneumatic conveyor. **Mixing and agitation:** Agitated vessels; Blending and mixing; Suspension of solid particles; Dispersion operations; Agitator selection and scale up.	**10**

5.	Filtration, Filtration equipments; Filter aids. Flow through filter cake and Filter media and pressure drop. Fluidization characteristics, aggregative and particulate fluidization, minimum fluidization velocity, terminal velocity of particles; pressure drop in fluidization.	**10**
	TOTAL	**42**

Text Books

1. Backhurst, J.R. and Harker J.H. Coulson and Richardson Chemical Engineering", Vol. II", 5 Ed., Butterworth- Heinemann.
2. Narayanan C.M. & Bhattacharya B.C., "Mechanical Operation for Chemical Engineers – Incorporating Computer Aided Analysis", Khanna Publishers.

REFERENCE BOOKS

1. McCabe W. L., Smith J.C, Harriott P., "Unit Operations of Chemical Engineering", 7 Ed., McGraw Hill.

Reference link

1. NPTEL video lectures

SUBJECT CODE: **BCHT 403** COURSE TITLE: **Chemical Reaction Engineering-I**
EXAMINATION DURATION: 3 Hrs. SEMESTER: IV (Even) L:3
T:1 P:0 C:4 PRE-REQUISITE: Process calculation

COURSE OBJECTIVES

To provide the comprehensive knowledge of reaction engineering and chemical reactors.

COURSE OUTCOMES

On completion of this course, the students will be able to
CO 1. Identify the reaction type and their kinetics.
CO 2. Design the reactor for the batch and continuous chemical process.
CO 3. Understand the Ideal and Non – Ideal Reactors.

COURSE DETAILS

S.No	Unit	Topics in the unit	No. of Lectures

1.	Rate Equations	Rate equation - elementary - non-elementary reactions - theories of reaction rate and temperature dependency - Design equation for constant and variable volume batch reactors - analysis of experimental kinetics data - integral and differential analysis.	8
2.	Design of Reactors	Design of continuous reactors – stirred tank and tubular flow reactor, recycle reactors - combination of reactors - size comparison of reactors.	10
3.	Design of Multiple Reactors	Design of reactors for multiple reactions – consecutive - parallel and mixed reactions – factors affecting choice - optimum yield and conversion - selectivity, reactivity and yield.	10
4.	Non – isothermal Reactors	Non-isothermal homogeneous reactor systems - adiabatic reactors - rates of heat exchanges for different reactors - design for constant rate input and constant heat transfer coefficient - operation of batch and continuous reactors - optimum temperature progression.	9
5.	Non Ideal Reactors	The residence time distribution as a factor of performance; residence time functions andrelationship between them in reactor; basic models for non-ideal flow; conversion in non ideal reactors.	8
		TOTAL	45

Text Books

1. Levenspiel O, Chemical Reaction Engineering, 3rd Edition, Wiley India Pvt Ltd. 2010
2. Smith J.M, Chemical Engineering Kinetics, 3rd Edition McGraw. 2014
3. Fogler H.S., Elements of Chemical Reaction Engineering, 4thEdition, PHI Learning Pvt Ltd (RS). 2009

Reference Books

1. Froment. G.F. and K.B. Bischoff, Chemical Reactor Analysis and Design, 3rd Edition, Wiley. 2010.
2. Butt, J.B., Reaction Kinetics and Reactor Design, 2nd Ed., CRC Press. 2000

Reference link

1. NPTEL video lectures
2. SUBJECT CODE:**BCHT 405** COURSE TITLE: **Chemical Engineering Thermodynamics**
   EXAMINATION DURATION: 3 Hrs. SEMESTER: IV (Even)
   L:3 T:1 P:0 C:4 PRE-REQUISITE: Nil

COURSE OBJECTIVES

To enable undergraduate students to learn basic concepts of thermodynamics and their application in solving problems related to flow processes and phase equilibrium of heterogeneous and reacting systems.

COURSE OUTCOMES

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

CO [1] Explain various forms of energy related transformation as unit operation or unit process in chemical process industries.

CO[2] Study about different terminology used in Chemical Engineering Thermodynamics.

CO[3] Identify and relate the thermodynamic property of the pure substance and mixture.

CO[4] Explain the phase equilibrium, equilibrium conversion for homogeneous and chemical reaction systems.

CO[5] Know the basic principles of refrigeration and liquefaction process.

COURSE DETAILS

S.No	Unit	Topics in the unit	No. of Lectures
1	Thermodynamic Laws and Property Relations	Laws of thermodynamics and their applications; PVT behaviour of pure substances; PVT behaviour of mixtures; Generalized equations of state; Joule's experiment; Carnot cycle and Carnot theorems; Thermodynamic property relations; Maxwell relations; Partial derivatives and Jacobian method; Residual properties; Partial molar properties; Excess properties of mixtures; Thermodynamic property tables and diagrams	9
2	Properties of Solutions and Phase Equilibria	Criteria for equilibrium between phases in multi component non-reacting systems in terms of chemical potential and fugacity; Application of phase rule; Vapour-liquid equilibrium; Phase diagrams for homogeneous systems and for systems with a miscibility gap; Effect of temperature and pressure on azeotrope composition; Liquid-liquid equilibrium; Ternary liquid-liquid equilibrium.	9
3	Correlation and Prediction of Phase Equilibria	Activity coefficient; Composition models; thermodynamic consistency of phase equilibria; Application of the correlation and prediction of phase equilibria in systems of engineering interest particularly to distillation and liquid extraction processes.	9
4	Chemical	Definition of standard state; standard free energy change and reaction equilibrium constant;	9

	Reaction Equilibria	evaluation of reaction equilibrium constant; prediction of free energy data; equilibria in chemical reactors, calculation of equilibrium compositions for homogeneous chemical reactors; thermodynamic analysis of simultaneous reactions.	
5	Refrigeration Principles	Refrigeration: Principles of refrigeration; methods of producing refrigeration; liquefaction process; coefficient of performance; evaluation of the performance of vapour compression and gas refrigeration cycles	9
		TOTAL	45

Text Books

1. Narayanan K.V, Text Book of Chemical Engineering Thermodynamics, PHI Learning Pvt. Ltd-New Delhi.
2. Smith, J.M., VanNess, H.C., & Abbot M.C, Introduction to Chemical Engineering Thermodynamics, 7th Edition, Tata Mcgraw Hill Education Private Limited.
3. Rao Y.V.C., Chemical Engineering Thermodynamics,

Reference Books

1. Hougen, O.A., Watson, K.M., and Ragatz, R.A., Chemical Process Principles Part II", Thermodynamics, John Wiley.
2. Dodge, B.F., Chemical Engineering Thermodynamics, 1st Edition, 6th im edition McGraw-Hill,.
3. Sandler, S.I., Chemical,Biochemical and Engineering Thermodynamics, 4th Edition, Wiley.

Reference link

1. NPTEL video lectures

SUBJECT CODE:**BCHT 401** COURSE TITLE:**MASS TRANSFER OPERATIONS – I**
EXAMINATION DURATION: 3 Hrs. SEMESTER: IV (Even) L:3
T:1 P:0 C:4 PRE-REQUISITE: Material and Energy balance

OBJECTIVES

To teach the fundamental concepts of mass transfer operations and principles, and apply those concepts to chemical engineering problems. The goal is to provide students with the theoretical and analytical background to understand existing mass transfer operations in chemical industries.

COURSE OUTCOMES

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

CO[1] Discuss the basic principles of Mass transfer and diffusion, and understand its laws and theories.
CO[2] Able to apply mass transfer and separation principles in several unit operations including absorption.
CO[3] Understand humidification and dehumidification, analyze and solve mass transfer problems
CO[4] Understand drying and crystallization operation and apply equilibrium relationship.

Course Details:

S.No	Unit	Topics in the unit	No. of Lectures
1.	Diffusion	Molecular and turbulent diffusion, diffusion coefficient, Fick's Law of diffusion, Dependence of diffusion coefficient on temperature, pressure and composition; measurement and estimation of diffusivity. Diffusion in multi-component gas mixtures. Diffusion in Solids: Molecular, Knudsen and surface diffusion. Interphase mass transfer: Mass transfer coefficients, Diffusion between phases, Equilibrium solubility of gases in liquids, Mass transfer theories, Mass transfer in fluidized beds, Flow past solids and boundary layers, Simultaneous heat and mass transfer.	9
2.	Absorption and Stripping	Equipments, Gas-liquid equilibria, Henry's law, Selection of solvent, Absorption in tray column, Graphical and analytical methods, Absorption in packed columns, HTU, NTU and HETP concepts, Design equations for packed column, Absorption with chemical reaction and mass transfer.	11
3.	Humidification and Dehumidification	Vapour liquid equilibrium and enthalpy for a pure substance, vapour pressure temperature curve, Vapour gas mixtures, Definition and derivations of relationships related with humidity. Fundamental concept of humidification, Dehumidification and	10

		water cooling, Wet bulb temperature, Adiabatic and non-adiabatic operations, Evaporative cooling, Classification and design of cooling towers.	
4.	Drying	Solid-gas equilibria, Different modes of drying operations, Definitions of moisture contents, Types of batch and continuous dryers, Rate of batch drying, Time of drying, Mechanism of batch drying, Continuous drying, Design of continuous dryers.	10
5.	Crystallisation	Equilibrium yield of crystallization, Heat and mass transfer rates in crystallization, Theories of crystallization, Factors governing nucleation and crystal growth rates, Controlled growth of crystal, Classification and design of crystallizers.	3
		TOTAL	43

Text Book

1. Treybal, R "*Mass Transfer Operations*", 3rd Ed., McGraw-Hill New York, 1980.

Reference

1. Sherwood T. K., Pigford R. L. and _ilke P. "*Mass Transfer*" McGraw Hill, 1975.
2 Foust A. S. et.al., "*Principles of Unit Operations*" John Wiley, 1980.
3 Geankoplis, C.J.."*Transport Processes and Unit Operations*", 3rd Ed. Prentice Hall. 1993.

Reference link

1. NPTEL video lectures

SUBJECT CODE:**BCHP 402** COURSE TITLE:**Mechnical Operations Lab**
EXAMINATION DURATION: 3 Hrs. SEMESTER: IV (Even) L:0 T:0
P:2 C:1 PRE-REQUISITE: Nil

COURSE OBJECTIVES

To be familiar with process equipment and develop engineering decision making capability.

LAB OUTCOME

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

1. Measure the particles ize.
2. Estimate the crushing efficiency of different types of crushers.
3. Calculate medium and filter medium resistance of different types of filters.
4. Estimate the pressure drop in packed and fluidized bed
5. Estimate the efficiency of gas solid separator

LIST OF EXPERIMENTS

1. Determination of average particle size of a mixture of particles by screening.
2. Study the operation of Jaw crusher and thereby verify Rittinger's constant.
3. Determination of reduction ratio, maximum feed size and theoretical capacity of crushing rolls.
4. Study the operation of a cyclone separator and thereby finding its efficiency of separation.
5. To find the cake and filter medium resistance of Plate and Frame Filter press.
6. To find the filter medium resistance of a Vacuum Leaf Filter.
7. To find the cake and filter medium resistance of a Rotary drum Filter.
8. To find minimum fluidization velocity of solid in liquid medium.

SUBJECT CODE:**BCHP 403** COURSE TITLE:**Chemical Reaction Engg. Lab**
EXAMINATION DURATION: 3 Hrs. SEMESTER: IV (Even) L:0 T:0
P:2 C:1 PRE-REQUISITE: Chemical reaction engg.

COURSE OBJECTIVES

To provide the comprehensive knowledge of reaction engineering and chemical reactors.

LAB OUTCOMES

On completion of the experiments, the students will be able to

1. Analyse the reaction type and their kinetics.
2. Design the reactor for the batch and continuous chemical process.

LIST OF EXPERIMENTS

1. Find out kinetic constant and study conversion of a given reaction in a batch reactor
2. Find out kinetic constant and study conversion of a given reaction in a plug flowreactor
3. Find out kinetic constant and study conversion of a given reaction in a CSTR
4. Study and operation of an adiabatic batch reactor
5. Study of a reversible reaction in a batch reactor
6. To determine energy of activation of reaction of ethyl acetate with sodium hydroxide
7. Find out specific rate contant and activation energy of a reaction in a plug flow reactor
8. To determine reaction equilibrium constant of reaction of acetic acid with ethanol.
9. To determine changes in free energy, enthalpy and entropy for the reaction of potassium iodide with iodine.
10. Study and operation of a cascade CSTR

SUBJECT CODE:**BCHP403** COURSE TITLE:**Numerical Methods of Analysis Lab**
EXAMINATION DURATION: 3 Hrs. SEMESTER: IV (Even)
L:0 T:0 P:2 C:1 PRE-REQUISITE: NIL

COURSE OBJECTIVES

To teach the student various numerical methods toanalysis the problems of linear, nonlinear and ODE equations, interpolation and approximation, numerical differentiation and integration etc.

LAB OUTCOME

On completion of this lab, the students will be able to
1. Compare the computational methods for advantages and drawback,

2. Implement the computational methods using any of existing programming languages, test such methods and compare between them,

3. Identify the suitable computational technique for a specific type of problems and develop The computational method that is suitable for the underlying problem.

LIST OF EXPERIMENTS

Use of following Techniques in C/C++ Language or Matlab software

1. Solution of single non-linear algebraic equations by Newton Raphson method.
2. Solution of single non-linear equations by Regulafalsi method.
3. Solution of system of linear simultaneous by Gauss Elimination method.
4. Solution of system of linear simultaneous equation by gauss seidel method and successive over relaxation method.
5. Solution of single first order ordinary differential equations by fourth order Runge-Kutta method.
6. Solution of Heat equations (Parabolic equations) by finite difference method.
7. Solution of Laplace equations (elliptic equation) by finite difference method.
8. Solution of wave equations (Hyperbolic equation) by finite difference method.
9. Finding Newton's interpolatory polynomial for n points.
10. Finding Newton's interpolatory polynomial based on finite difference table for n points.
11. Simpson's 3/8-rule.9.

B T Kumaon Institute of Technology, Dwarahat
B.Tech. III Year
Chemical Engineering

Subject with Code : Mass Transfer Operation - II BCHT 501
Course : B.Tech.
Semester/Branch : 5th Semester
Prerequisites: MTO-I

Course objectives: The objective of this course module is to apply principles of mass transfer with a focus on solid-liquid, liquid-liquid and distillation.

Course Outcomes:
CO[1] Separation by solid – liquid and liquid - liquid extraction. Graphical and analytical calculations
CO[2] Use of McCabeTheile method and PonchonSavarit method for distillation
CO[3] Continuous contact equipments like packed towers, sieve, bubble cap towers etc. Determination of number of transfer units and height of transfer units
CO[4] Use of vapour – liquid equilibrium data
CO[5] Determination of plate efficiency

S.No	Topic Name	No. of lectures
1	Extraction: Solid – Liquid, Rate of solid – liquid extraction, contacting strategy, contacting equipment, Equilibrium, extraction calculation, super critical extraction	5
2	Liquid – Liquid : Ternary liquid equilibria, solvent selection, single and multistage and cross current extraction, design calculation for stage wise extraction	6
3	Distillation: Introduction – Vapour liquid equilibrium, T-x-y diagram, bubble and dew point calculation, concept of volatility, deviation from ideality, minimum and maximum boiling azeotrope mixture, enthalpy – concentration diagram	6
4	Flash vaporization, steam distillation, batch distillation, continuous multistage fractionation of binary mistures, multistage batch distillation with reflux, minimum and total reflux. Tray efficiency, Reboiler types.	10
5	McCabe Thiele method, PonchanSavarit method, Distillation in packed column	10
6	Introduction to multi component distillation, azeotropic distillation, extractive distillation	3

Total lectures: 40

BOOKS:

1. Treybal. R. E, ." Mass Transfer Operation ", McGraw –Hill International Edition, 3rd Edition
2. McCabe, W. L. Smith, J, and Harriot, P., " Unit operation of Chemical Engineering", McGraw – Hill International Edition , 6th Edition
3. Geankoplis, C.J., " Transport Process and Unit operation" Prentice Hall 3rd Edition, India
4. Dutta, B. K., "Principles of Mass Transfer and Separation Processes", Prentice Hall, India
5. Seader, J.D Henley, J.E, "Separation Process Principles", 2nd Edition, Wiley India Edition.

SUBJECT CODE: BCHT 502	**COURSE TITLE: CHEMICAL REACTION ENGINEERING -**
EXAM DURATION: 3 HOURS	**SEMESTER : V (ODD)**
L: T: P :: 3 : 1 : 0 CREDITS: 4	

OBJECTIVE:

- To impart the basic concepts of chemical reaction engineering, reactors and contacting pattern
- To develop understanding about reactor analysis and design for heterogeneous reactions
- To impart knowledge about the Biochemical reactions and Bioprocessing

COURSE OUTCOME:

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

- Classify catalysts and predict physical properties of catalyst, surface area, void volume, solid density pore volume distribution.
- Understand the nature and mechanism of catalytic reactions and predict the rate controlling step reactions.
- Analyze the various contacting pattern for two phase system.
- Predict the rate equation for heterogeneous reactions and understand the effect of velocity, particle size and fluid properties on rate of reactions controlled by mass transfer
- Analyze the best kinetic regimes for mass transfer and reaction and predict the rate equation.
- Understand the nature and mechanism of Biochemical reactions.
- Understand the working of Biochemical and polymerization reactors.

REFERENCE BOOKS

S.NO	NAME OF AUTHORS/BOOKS /PUBLISHERS	YEAR OF PUBLICATIO REPRINT
1	Smith, J, M, "Chemical Engineering Kinetics", 3rd Edition, McGraw-Hill (1990).	1990
2	Levenspiel, O., "Chemical Reaction Engineering", 3rd Edition, John Wiley, (1998).	1998
3	Fogler H.S., Elements of Chemical Reaction Engineering, 4th edition, Prentice Hall of India, (2008)	2008
4	Daizo Kunii & Octave Levenspiel, "Fluidization Engineering" 2nd Edition, Elsevier (India Print 2005) 2.	2005
5	Coulson and Richardson's Chemical Engineering Volume 3 - Chemical and Biochemical Reactors and Process Control (3rd Edition)	1994

COURSE DETAILS

Sr.No.	CONTENTS	LECTURE HOURS
I	Introduction to Homogeneous and Heterogeneous reactions, catalysts and Nature of catalysis, Physical properties of catalysts, determination of surface area, void volume and solid density, pore volume distribution; Classification, preparation, testing and characterization of solid catalysts, catalyst selection, catalyst promoters and inhibitors, catalyst poisoning and catalyst deactivation (no kinetics). Adsorption, physical adsorption and chemisorption, adsorption isotherms, mechanisms of catalytic reactions, Shifting of equilibrium in chemical reactions	**8**

II	Solid catalysed reactions, the rate equations for surface kinetics, Reaction and diffusion within porous catalysts, Pore diffusion resistance combined with surface kinetics, effectiveness factor and Thiele modulus, various resistances to transfer of reactants to the catalyst site, intrinsic and global rate of reaction, kinetic regimes, heat effects during reaction, Performance equations for reactors containing porous catalyst particles, design of solid catalytic reactors.	**9**
III	Fluid-solid reactions, experimental methods for finding rates, selection of a model, shrinking core model for spherical particles of unchanging size, rate of reaction for shrinking spherical particles, determination of rate controlling step, kinetics and design, Design of packed bed and fluidized bed reactors.	**9**
IV	Fluid-Fluid Reactions, Rate equation, rate equation for straight mass transfer, kinetic regimes of mass transfer and chemical reaction, rate equation for mass transfer and chemical reactions, fluid-fluid reactor design, deciding the contactor type and contacting pattern.	**8**
V	Introduction to Biochemical reactions: Kinetics of Enzyme Fermentation and Microbial Fermentation, understanding of Biochemical Reactors and study of polymerization reactors, Bioprocessing of edible oils	**8**
		42

Subject with Code : Process Dynamics & Control BCHT 503
Course : B.Tech.
Semester/Branch : 5th Semester

Objectives:

Objective is to introduce the fundamentals of process control with applications using P, PI, and PID controllers. The course will teach the students about mathematical models based on transfer function approach for single loop systems, how to obtain dynamic response of open loop and closed loop systems, stability analysis in transient and frequency domains, and controller tuning methods. The course would end with more advanced concepts like feed-forward control, ratio control, model-predictive control, ratio control, dead-time compensation, etc.

Sl No	Topic Name	Lectures
1	Introductory Concepts: Need for control and automation, control logic, servo and regulatory Control, block diagrams, control structures (feedback vs. feedforward), process and instrumentation diagrams. Laplace transforms, solution of	**08**

	ODEs using Laplace transform,	
2	Transfer function approach, response of first order systems: step, impulse and sinusoidal response, first order systems in series Second order systems, higher order systems, transportation lag and dead time, Linear closed loop systems, development of block diagrams, classical feedback controllers.	**12**
3	Final control element (control valves), block diagram reduction techniques Closed loop response, servo and regulatory problems Stability analysis, Routh stability criterion, Root locus diagrams (rule based),	**07**
4	Introduction to frequency response, notion of stability, Bode diagrams, Nyquist plots, Bode and Nyquist stability criterion, Controller tuning: Ziegler-Nichols method, Cohen-Coon method	**07**
5	Introduction to advanced controllers: cascade control, feed forward control, ratio control, Smith-predictor, IMC, MPC, dead-time compensation, Introduction to digital control	**08**

Total lectures: 42

Course Outcomes

Students will be able to

- Understand the importance of process dynamics (unsteady state operation)
- Tune a controller to reject disturbances or manage operating point transition
- Demonstrate fundamental understanding of process control.
- Develop transfer function (input-output) and models for linear dynamical processes.
- Characterize the dynamics and stability of processes based on mathematical analysis.
- Develop the mathematical model of various chemical processes.
- Explain different control modes and their application in controlling various processes.
- Explain the working of different controllers and valves.

Reference Books:

1. Coughnaowr, D. R., "Process Systems Analysis and Control", McGraw-Hill, Inc.
2. Stephanopolous, G., "Chemical Process Control", Prentice-Hall.

Subject with Code : Process Instrumentation BCHT 511
Course : B.Tech.
Semester/Branch : 5th Semester

Process Instrumentation

Objectives:

Objective is to introduce the fundamentals of Industrial Instrumentation. The course will teach the students about basic functions of industrially used various process parameter measuring devices, different elements of instruments and their working principle. The course would end with more detailed concepts about various types of flow, temperature and pressure measuring devices.

Total lectures: 40

Sl No	Topic Name	Lectures
1	Introduction: Principles of measurement. Error Analysis, Static and dynamic characteristics of instruments. Importance of measuring of Instruments in Process Control, Classification of Instruments, Elements of an Instruments, Selection of instrument for a particular Measurement, transducers.	**09**
2	Pressure: Manometers: U tube manometer, inclined limb manometer, Ring balance manometer, Elastic deformation: bourdon, bellows, diaphragm and electrical type gauges: strain gauge, piezoelectric, pressure transducers.	**07**
3	Measurement of Temperature: Thermocouples, Resistance, Thermometer, Expansion Thermometers, Pyrometers. Measurement of Pressure & Vacuum, Hydrostatic type, Elastic Element type, Electrical Type and other type of instruments like MacLeod Gauge, Thermocouple gauge, Knudson Gauge, Ionization Gauge.	**10**
4	Instruments for Measurement of Flow rate, level & Viscosity, Variable Area & variable head flow meters, Volumetric and Mass flow rate meters, linear velocity measurement systems, Anemometers, Pressure type, Resistance & Capacitance type, Sonic & Ultrasonic, Thermal type Level meters.	**08**
5	Viscometers: Redwood, Saybolt, Engler, Cup & Cone type, Rheo & other types of viscometers, Recent advances in sophisticated analytical instruments in the context of chemical engineering	**06**

Course Outcomes

Students will be

able to

- Understand the importance of accuracy and precision of measurements.
- Understand the working principle of industrial measuring devices

Reference book: Process Instrumentation by Donald P Eckman

Subject with Code : Interfacial Science & Technology BCHT 512
Course : B.Tech.
Semester/Branch : 5th Semester

Course description:

The course aims to introduce the basic concepts and tools for the analysis of colloidal and interfacial properties of the materials which depend on their size, inter-particle distances and forces acting on them. The outcomes of this course will be very useful to understand the basic concepts of adhesion, particle-aggregation, wetting, detergency, oil recovery, flotation, nucleation, bio-surfaces, chromatography, paints, and composite materials. This course will be of very useful for undergraduate students, post-graduate students and researchers in the field of chemical, mechanical, civil, materials and electrical engineering; chemistry and physics; and materials science.

Pre-requisite: None

Objective: Students will be able to understand the basic concepts of nanoparticles, surface and interfacial energies and tensions, intermolecular and surface forces, stability of thin films, preparation of thin films, wetting and dewetting and microfabrication. The knowledge acquired from this course will enable the students to solve the advanced research problems effectively in the field of chemical engineering, analytical and physical chemistry, biochemistry and environmental science, materials science, petroleum engineering and nanotechnology.

Syllabus:

Unit	Topic Name	Lectures
I	Surface and Interfacial Tension: Surface tension of liquids, Calculation, and measurements of surface tension. Measurement of interfacial tension. Concepts of surface and interfacial energies and tensions; van der Waals and acid-base components of interfacial tensions, Young-Laplace equation of capillarity, Stability of equilibrium solutions and thin films; Contact angle and Young's equation, Free energies of adhesion, kinetics of capillary flows.	**12**
II	Intermolecular and Surface Forces: van der Waals force, Mie and Lennard-Jones potentials, Electrostatic Interaction- Electric Interaction in Colloidal Particles, electrostatic interaction (Double Layer), Gouy Chapman Theory, Debye Huckel approximation, charge Density, forces between two particles, potential Energy, Zeta potential.	**10**

III	Smart Materials (polymers): Technological Aspects of thin films, Methods for thin film coating; Spin Coating, Dip Coating, Electrodeposited coatings, Thermal sprayed coatings, Introduction to structural colour and Hydrophobicity.	**08**
IV	Advanced instruments for measuring surface properties – Contact Angle Goniometer, Atomic Force Microscopy, Optical Profiler	**07**
V	Modern Applications of nanomaterials and Interfacial science in detergents, personal products, Pharmaceuticals, food, textile, paint and petroleum industries.	**08**

Total lectures: 45

Course Outcomes

Students will be able to:

- Have basic concepts about surface and interfacial energies, Stability of equilibrium solutions and thin films and forces governing them.
- Understand the Mie and Lennard-Jones potential curve
- Prepare microscale patterned of surfaces using microfabrication techniques with various soft polymers. Will be able to design a microscale roughness having long-term stability with selective applications.
- Understand the recent advances in nanotechnology and its large scale application.

Reference Books:

- Nanospectrum: A Current Scenario by Prof. (Dr.) Sampa Chakrabarti,
- Introduction to Nanotechnology, Charles P. Poole, Jr., Frank J. Owens

Subject with Code : Optimization Techniques BCHT 513
Course : B.Tech.
Semester/Branch : 5th Semester

OBJECTIVE:

1. To provide fundamental knowledge to optimized a process plant.
2. To teach the essential features of optimization problems.
3. To introduce basics of linear programming and the principle of optimality.

COURSE OUTCOME:

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

1. Understand the role of optimization in a chemical process plants.
2. Formulate mathematical models for optimization problems.
3. Analysis of degree of freedom and complexity of solutions to an optimization problem.
4. Understand and analyze the various methods used for unconstrained one dimensional search.

Unit	**Topic Name**	**Lectures**

I	Optimization, Degree of freedom, Optimization formulation of the Problem, Analytical Method, Necessary and sufficient conditions for optimum in single and multi-variable unconstrained and constrained problems.	8
II	Unconstrained one dimensional search, Newton, Quasi-Newton and Secant method for uni-dimensional search, Region climnation methods (Golden Section Fibonacci, Dichotomous etc), Unconstrained multivariable optimization with special focus to Powell's conjugate direction method.	8
III	Linear Programming, graphical simplex method, revised simplex method, duality and transportation problems, unconstrained multi variable search, Direct methods, Indirect method.	8
IV	Forward, Backward and Divided Differences Table, Central Differences, Newton's Forward, Backward and Divided Differences Interpolation Formula, Interpolation Polynomials, Lagrange Interpolation Formula, Sensitivity analysis.	8
V	Principle of optimality, discrete and continuous dynamic programming. Algorithms & Computer Programming: Newton-Raphson Method, Gauss Elimination, Trapezoidal Rule, Simpson's 1/3rd, 3/8th Rule, Runge-Kutta 2nd Order, and R-K 4th Order Methods in reference ot the Applications in Chemical Engineering.	8

Total lectures: 40

Reference books:

1. S.S. Rao "Engineering Optimization", Wiley.
2. Asghar Husain and Kota Gangiah "Optimization Techniques for Chemical Engineers", Macmillan.
3. T.F. Edgar and D.M. Himmelblau "Optimization of Chemical Process", Mc Graw Hill.

Subject with Code : Heat Transfer Operations BCHT 591
Course : B.Tech.
Semester/Branch : 5th Semester

COURSE OBJECTIVES:

This course will present an overview of the heat transfer by conduction, convection and radiation and their various categories of application. It also gives a brief idea of Condensation and Heat exchangers their classification, temperature distribution in heat exchangers and overall heat transfer co-efficient. It also includes Evaporation and its classification, application and feeding mechanism.

COURSE OUTCOMES:

After the successful completion of the course student should be able to:

CO[1] Able to build up the necessary background for the understanding of the physical significance of the heat conduction equations (steady and unsteady state) and its boundary conditions.

CO[2] Prepare the necessary background for the understanding of the physical significance of various concepts and fundamental definitions related to free and forced convection.

CO[3] Able to develop the concept of black body radiation, the absorption, emission and reflection of radiation by real surfaces and solve the real problems of radiation heat transfer.

CO[4] Able to do the thermal analysis and sizing of heat exchanger and evaporator .
CO[5] Able to understand the fundamentals of boiling and condensation and apply the various heat transfer correlations associated with condenser design.

SYLLABUS

Module No	Subtitle of the Module	Topics in the Module	References	No. of Lectures
1.	Heat transfer by conduction	One-dimensional Heat Conduction equation, Boundary conditions; One dimensional steady state heat conduction for slab, cylinder, sphere, composite medium, Thermal conduct resistance, critical thickness of insulation, Fourier law, Finned surfaces, temperature dependent K (T), Transient conduction and use of temperature charts. Lumped system analysis for slabs and long cylinder and spheres.		12
2.	Heat Transfer by convection	Flow over a body, flow inside a duct. Forced Convection: Hydrodynamic and thermal boundary layer, simultaneously developing laminar flow, Turbulent flow inside ducts, Heat transfer to liquid metals. Free Convection: Dimensionless parameters of Free Convection, Correlations of free convection on a vertical plate, Free Convection on a horizontal plate.		10
3.	Condensation	Nusselt equation for horizontal and vertical condenser, Drop and film type condensation, Effect of non-condensable gases. Boiling: Boiling of liquids. Nucleate and film boiling.		4
4.	Heat Transfer by Radiation	Concept of black body, Kirchoff's Law Emissivity, absorptivity, black body and grey body radiation. View factors.		3
5.	Heat Exchangers	Classification, temperature distribution in heat exchangers, Overall heat transfer co-efficient, the LMTD method for heat exchanger analysis, correction for LMTD for use with cross flow and multipass exchanger. Hair pin (double		8

		pipe exchangers) 1-2 shell and tube exchangers, Finned tube exchangers, fouling factor.		
6.	Evaporation	Classification and application, evaporator feeding mechanism, operation of single effect evaporators.		3

Total number of Lectures:40

Text Books:
Heat transfer- Principles and applications; B K Dutta, Prentice Hall India
Heat Transfer – A basic approach by M. NecatiOzisik
Reference Books:
Heat Transfer by W. H. McAdams, Mcgraw-Hill.
Fundamentals of Heat Transfer by M. Mikheyev – Mir publications.
Unit operations of Chemical Engg. W. L. cabe& J. C. Smith – Mcgraw – Hill Publication.
Transport Processes and Unit Operations- C. J. Geankoplis.

Subject with Code : Electrochemical system for Energy application BCHT 592
Course : B.Tech.
Semester/Branch : 5th Semester
COURSE OBJECTIVES

This course introduces principles of electrochemical energy conversion and storage techniques including applications to batteries, fuel cells, super capacitors for present day application.

SYLLABUS

Module No	Subtitle of the Module	Topics in the Module	References	No. of Lectures
1.	Electrochemical energy conversion	Introduction of subject, Basics of galvanic cell, Electrochemical energy conversion, energy storage	1,2	8
2.	Circuit dynamics	Equivalent circuit diagram, Impedance study	2	7
3.	Thermodynamic study	Voltage calculation, Nernst equation, Pourbaix Diagram,	1,2	8
4.	Kinetics study	Faradaic Reactions, Butler-Volmer Equation, Electrocatalysis	2,3	9
5.	Electrochemical devices	Batteries, Fuel cell, Super capacitor	3,4,5	8

Total number of Lectures 40

Text Book:

Newman, John, and Karen E. Thomas-Alyea. *Electrochemical Systems*. 3rd ed. Wiley-Interscience, 2004. ISBN: 9780471477563.
Bard, Allen J., and Larry R. Faulkner. *Electrochemical Methods: Fundamentals and Applications*. 2nd ed. Wiley, 2000. ISBN: 9780471043720.
O' Hayre, Ryan, Suk-Won Cha, et al. *Fuel Cell Fundamentals*. 2nd ed. Wiley, 2009. ISBN: 9780470258439.
Huggins, Robert A. *Advanced Batteries: Materials Science Aspects*. Springer, 2008. ISBN: 9780387764238.
Electrochemical Supercapacitors: Scientific Fundamentals and Technological Applications, B. E. Conway. Springer Science & Business Media, 2013. ISBN: 1475730586, 9781475730586

Subject with Code : Non conventional energy resources BCHT 593
Course : B.Tech.
Semester/Branch : 5th Semester

OBJECTIVE: To impart Knowledge on various energy resources that is available to fulfill the needs and requirements of any country and also the challenges faced by us in near future to accomplish our demand of energy. Also various methods of extraction is studied during the course.
COURSE OUTCOME:
On completion of this course, the students will be able to
1. Understand the various energy resources and their importance
2. Know about solar energy and extraction techniques
3. Know about wind and biomass energy extraction techniques

Units	S. No.	Contents	Lecture Hours
I	1.	Introduction to Energy Sources: Renewable and non-renewable energy sources, energy consumption as a measure of Nation's development; strategy for meeting the future energy requirements Global and National scenarios	5
II	2.	Solar Energy : Solar radiation - beam and diffuse, flat plate collectors, concentrating collectors, Solar air heaters-types, solar ,driers, storage of solar energy-thermal storage, solar pond , solar water heaters, solar distillation, solar cooker, photo voltaic - solar cells & its applications	7
III	3.	Wind energy, its potential and generation, wind mills, its types, Biomass energy, its conversion routes to gaseous and liquid fuels, Biogas plants and their operation,Geothermal energy and its potential , methods of extraction , Ocean energy, its potential and extraction methods, Energy from Biomass: Biomass conversion technologies, Biogas generation plants, classification, constructional details, site selection, digester design consideration	12

4. Know about

IV	4.	Geothermal Energy: Estimation and nature of geothermal energy, geothermal sources and resources, application of geothermal energy, Energy from the ocean: Ocean Thermal Electric Conversion (OTEC) systems, Energy from tides, basic principle of tidal power and energy extraction techniques, wave energy and extraction techniques	8
V	5.	Nuclear Energy: Introduction, nuclear fission and nuclear fusion, Design and types of nuclear reactor, Fuel Cells: Introduction, Design principle and operation of fuel cell, Types of fuel cells, conversion efficiency of fuel cell, application of fuel cells, Hydrogen Energy: Introduction, Hydrogen Production methods, Hydrogen storage, hydrogen transportation, utilization of hydrogen gas, hydrogen as alternative fuel for vehicles.	8
		TOTAL	40

geothermal and ocean energy extraction techniques

5. Know about nuclear and hydrogen energy and fuel cell

Reference books:
1. Non-conventional energy sources by G.D. Rai, Khanna Publishers
2. Alternative Energy Sources by B.L. Singhal Tech Max Publication
3. Non-conventional energy sources by B.H.Khan, TMH Publication

Subject with Code : : PROCESS FLOW SHEET SIMULATION BCHT 522
Course : B.Tech.
Semester/Branch : 5th Semester
Prerequisites: Chemical technology, Process dynamic and control

OBJECTIVE:
- To introduce about flowsheet simulation.
- To teach solution strategy of steady state and unsteady state systems

COURSE OUTCOME:
On completion of this course, the students will be able to:
CO1 Synthesize a flowsheet for the process on paper and implement this in a simulation program.
CO2 Deal with ASPEN PLUS/HYSIS/PRO II/Design II/UniSim/OLI Pro/Aspen Custom Modeler/TK-Solver.
CO3 Use process flowsheet simulations to solve problems in the chemical industry.
CO4 Estimate the thermo-physical properties for the chemical species and identify the correct models to use.
CO5 Design a distillation column, feed height and number of trays in a column.

S.No.	Topic name	No. of lectures
1	**Introduction to Process Simulation:** Background and history of process simulation; Steady State and Dynamic Simulation; Different approaches to process simulation; modules and components in a process simulation package, integration of simulation tools, structure and functionality of commercial simulation tools, selection of flowsheet and simulation software. **Process Flow sheeting:** Approaches to flowsheeting, collection and estimation of thermo-physical properties for the chemical species of the system, thermo-physical properties banks, computer aided flow-sheeting, manual calculations with recycle streams, partitioning and tearing a flowsheet.	8
2	**Fundamentals of systems engineering:** System definition, system properties, aggregation/decomposition, hierarchies of systems; Introduction of canonical modeling concepts: devices, connections, equations, variables. **Formalizing the modeling process :** Methods of structuring complex chemical processes, procedures for process modeling; degrees of freedom in a flow sheet. Numerical properties of the model equations. **Numerical methods for steady-state and dynamic systems:** Differential Algebraic Equations; Synthesis of reaction systems and synthesis of azeotropic separation systems.	9
3	**Processing Simulation with software:** ASPEN PLUS/HYSIS/PRO II/Design II/UniSim/OLI Pro/Aspen Custom Modeler/TK-Solver: Introduction to the Simulation Package; Features of simulation packages; Introduction to the simulation package Graphical User Interface; Example 1:	8

	Flashing of Light Hydrocarbons; Survey of unit operation models; Example-2: Vinyl chloride monomer (VCM) flow sheet.	
4	Flow sheet Calculations and Model Analysis Tools: Sensitivity and casestudy runs; Design specifications and calculator blocks; Example-3: VCM flow sheet sensitivity run / design-spec run. Inorganic chemicals and electrolyte modeling; Example-4: sour water systems (CO2 and H2S removal for example)	6
5	**Physical Properties:** Overview of physical property system; Property model specifications; Property data requirements and input; Physical property analysis; Example-1: Introducing a non-databank component. Multistage Separation: RADFRAC: Rigorous rating and design fractionation model; Example-2: Using RADFRAC in the VCM flow sheet. Introduction to ICARUS (an economic evaluation package inside ASPEN PLUS), Flow sheet Convergence: Example-3: VCM flow sheet convergence	6

Total lectures 37.

REFERENCE BOOKS:

1. Dimian A. C., "Integrated Design and Simulation of Chemical Processes", Elsevier
2. 2. Westerberg, A. W., Hutchison, H. P., Motard, R. L. & Winter, P., "Process Flowsheeting", Cambridge University Press.
3. 3. K.M. Hangos and I. T. Cameron, "Process Modelling and Model Analysis", Aca
4. 4. Kumar, A., "Chemical Process Synthesis and Engineering Design", Tata McGraw Hill. demic Press.
5. 5. W. F. Ramirez, "Computational Methods for Process Simulation", 2nd ed., Butterworths.

Subject with Code : QUALITY ASSURANCE & CONTROL BCHT 512
Course : B.Tech.
Semester/Branch : 5th Semester
Prerequisites: Chemical Technology

OBJECTIVE:

- To impart knowledge about the quality control and quality assurance in chemical industries.
- To teach control charts and total quality management.
- To provide conceptual knowledge of the aspects like QC tests, documentation, quality certifications, ISO and SQC.

COURSE OUTCOME:

On completion of this course, the students will be able to:
CO1 Appreciate the importance of quality assurance and control in chemical industry.
CO2 Understand the role of ISO for process plants.
CO3 Learn the manufacturing operations and controls of process plants.
CO4 Understand the importance of documentation and the scope of quality certifications applicable to industries.
CO4 Understand the responsibilities of QA & QC departments.

S. No.	Topic name	No. of lectures
1	**Quality:**Definition, History, Importance, Cost of Quality, Approaches of	9

	Quality Management, Hierarchy of Quality management: Inspection & Test, Quality Control. **Total Quality Management:** Definition, Models of TQM, Elements of TQM, Principles of TQM. Deming's approach, PDCA cycle, Training for Quality management. **Quality Circle:** Quality Circle structure, Its operation, Characteristics of Quality Circle, Basic problem solving techniques. Introduction to Six Sigma and Taguchi concepts.	
2	**Quality Assurance (QA):** Introduction, Definition, Management principles in QA, Forms of QA, QA in different stages. Quality in material management, Vendor selection & development. ISO: Introduction, ISO 9000 series of standard, ISO:9001 clauses, ISO:17025, Registration process, Benefits of ISO.	6
3	**Statistical Quality Control :** SQC tools, Benefits of SQC, Concept of variation, Assignable & Chance causes, Attributes & variables, Frequency distribution curve & its types. Normal Distribution curve, Problems on FD curve & ND curve. Control chart for variable: Definition, Formulae & its problems. Control chart patterns, Process capability. Problems on x & R chart and Process capability.	7
4	**Quality Improvement Programme:** Histogram, Charts, Brain-storming, Cause & Effect diagram, Pareto analysis. Quality survey: Scope, Types of audit, inspection methods, Quality budget, Vendor Quality Rating. Control chart for attribute : Definition, Formulae & its problems. Problems on p, c charts. Sampling: Definition, types of sampling, importance, benefits and limitations of sampling.	7
5	**Manufacturing operations and controls:** Sanitation of manufacturing premises, processing of intermediates and bulk products, packaging operations, release of finished product, time limitations on production, expiry date calculation, calculation of yields, production record review, packaging, salvaging, handling of waste and scrap disposal.	6

Total lectures 35.

REFERENCE BOOKS:

1. Weinberg S., Good Laboratory Practice Regulations, Vol. 69, Marcel Dekker Series. 2003
2. ICH guidelines. 1990
3. ISO 9000 and Total Quality Management. 2015
4. Piotr Konieczka and Jacek Namiesnik "Quality Assurance and Quality Control in the Analytical Chemical Laboratory", CRC Press. 2009
5. P.L. Jain " Quality Control and Total quality Management", McGraw Hill. 2006
6. Ram Babu Sao " Perfect: Quality Assurance and Quality Control", Create Space Independent Publishing Platform. 2016
7. Amitava Mitra " Fundamentals of Quality Control and Improvement", Wiley. 2016
8. Quality Assurance for the Chemical and Process Industries: A Manual of Good Practices. ASQ Quality Press.

Subject with Code : Design and simulation lab
Course : B.Tech.
Semester/Branch : 5th Semester
Prerequisites:
Numerical Methods, Material and Energy Balance
Objectives

To introduce students to use of software packages such as CHEMCAD/ASPEN/DWSIM, MATLAB, FLUENT/Open FOAM for simulation, and also analysing flowsheets

Contents :

1Introduction to Software Packages

2Setting up models for simulation

3Steady State simulation using ASPEN, Flowsheeting concepts (sequential modular, equation oriented) (3 lectures)

4Dynamic simulation using MATLAB

5CFD simulations using FLUENT/ Open FOAM, geometry & meshing

Outcomes

Students will be able to

1. Solve chemical engineering problems using advanced programming software
2. Use simulation softwares like ASPEN/DWSIM/CHEMCAD and FLUENT/Open FOAM
3. Analyse the techno-economic feasibility of chemical manufacturing facility

VI SEMESTER

Subject with Code : Transport Phenomenon BCHT 601
Course : B.Tech.
Semester/Branch : 6th Semester

COURSE OBJECTIVES

Introduce students with knowledgeto look into the underlying concepts of processes, which often take place simultaneously, and will help to apply concepts to a variety of real-life problems. Students will be able to model the processes and make quantitative statements.

COURSE OUTCOMES

After end of course student will be able to:

CO.1. Understand basic concepts of transport phenomena and thus analyze the role of intermolecular forces in transport process.
CO.2. Demonstrate the role of molecular transport mechanism and thus draw the analogy between heat, mass and momentum transport.
CO.3. Apply the conservation concept and construct the property balance equation, applying both molecular and convective transport.
CO.4. Apply the property balance equation to solve real plant problems like flow through pipes and between parallel plates and show important relationships.
CO.5. Apply concepts of continuity and Navier–Stokes equation and used in solving the real in plant problems.

SYLLABUS

Module No	Subtitle of the Module	Topics in the Module	References	No. of Lectures
1.	Introduction	Transport phenomena and Unit	Brodkey,	4

		Operation, Equilibrium and rate processes, Role of intermolecular forces	Bird, Bodh Raj	
2.	Molecular Transport Mechanisms	Heat, mass and momentum transport by molecular mechanism. The Analogy – Case of Heat Transfer, Case of Mass Transfer, Case of Momentum Transfer, the analogous forms. Heat Transfer. Mass Transfer – Equimolar Counter Diffusion, Partial Pressure. Momentum transfer.	Brodkey, Bird, Bodh Raj	10
3.	General Property Balance	The balance or conservation concept-input-output balance, generation, accumulation, the balance equation in differential form. The one directional balance equation including molecular and convective transport. The three dimensional balance equation. The continuity equation. The general property balance equation for an incompressible fluid.	Brodkey, Bird, Bodh Raj	10
4.	Molecular Transport and the General Property Balance	Steady transport in one dimension involving input-output with no generation (constant area and variable area transport). Steady transport with generation (Heat and mass transport with constant generation, momentum transfer with generation at steady state – laminar flow in a tube, Hagen-Poisseuille Equation, laminar flow between parallel plates).	Brodkey, Bird, Bodh Raj	10
5.	Transport with net convective flux	Convective flux caused by forced convection. Relation between shear stress and shear rate. Navier-Stoke's Equation. Fick's Law.	Brodkey, Bird, Bodh Raj	6

Total number of Lectures 40

Text Book:
1. Brodkey, R.S. & Hershey, H.C., Transport Phenomena – An Unified Approach, McGraw-Hill.
2. Bird, Stewert& Lightfoot, Transport Phenomena, John Wiley.
Reference Books:
1. Introduction to Transport Phenomena: Momentum, Heat and Mass, Bodh Raj, PHI

Subject with Code : Chemical Technology BCHT 602
Course : B.Tech.
Semester/Branch : 6th Semester

COURSE OBJECTIVES

Introduce fundamental concepts of production and existing processes for different chemicals and their importance in chemical process industries.

COURSE OUTCOMES

After successful completion of the course, student will be able to:

CO [1]. Compare production of different acids and will be able to classify different fermentation products.

CO [2]. Classify different manufacturing processes of chloro-alkali industries
and Categorizedifferent cements and manufacturing processes

CO[3]. Compare and classify different fertilizers based on their manufacturing processes and uses.

CO[4].Classify processing of fats and oils. Comparedifferent manufacturing processes for paper production.

CO[5]. Explain basics of polymers and polymerization reactions and their utilization.

SYLLABUS

Module No	Subtitle of the Module	Topics in the Module	References	No. of Lectures
1.	Acid Industries, Fermentation processes	Introduction to the subject, Unit process and operations, manufacturing of acid: sulphuric acid, Manufacturing of hydrochloric acid with process flow diagram, Manufacture of nitric acid with process flow diagram Introduction to fermentation, process and production, Some special products of fermentation	Chemical Technology by Sukla&Pandey	9
2.	Chlor alkali industries, Cement	Introduction to chlor alkali industries: manufacture of soda ash, Manufacture of caustic soda with process flow diagram and major engineering problem related to its production, Manufacture of chlorine and common salt Introduction to cement and its types, Portland cement and its production, major engineering problems related to it, Special types of cement, Setting and hardening of cement, difference between dry process and wet process to manufacture cement	Chemical Technology by Sukla&Pandey, Outlines of Chemical Technology by Dryden	10

3.	Fertilizer	Introduction to fertilizer, Nitrogen fertilizer: manufacture of urea, ammonia, ammonium carbonate with process flow diagram, Phosphetic fertilizer: Manufacture of superphosphate and triple superphosphate with flow diagram, Potassium fertilizer	Outlines of Chemical Technology by Dryden	6
4.	Paper, Fats and Oils	Production and processing of pulp by using different methods, kraft process, Production of different types of paper Introduction to fats and oils of vegetable and animal origin, Processing of oil, hydrogenation, essential oil, Soaps and detergents, Some common terms related to processing of oil and fat	Outlines of Chemical Technology by Dryden	10
5.	Polymers	Introduction to polymers, basics and functionality concept, Classification of polymers, Methods of production of polymers, Manufacture of polyethylene, Naming of nylons and their manufacture, Manufacture of PF and MF resin, epoxy resin, Some common uses of polymers	Polymer science by V. Gowarikar	10

Total number of Lectures 45

Text Book:

Outlines of Chemical Technology by Dryden.
Chemical Technology by Sukla&Pandey.
Chemical Process Industries by Shreve.
Polymer Science and Technology, Fried, 2nd Ed, Prentice Hall
Polymer science by V. Gowarikar

Subject with Code : Energy Resources & Utilization BCHT 603
Course : B.Tech.
Semester/Branch : 6th Semester

OBJECTIVE: To impart Knowledge on various energy resources that is available to fulfill the needs and requirements of any country and also the challenges faced by us in near future to accomplish our demand of energy. Also various methods of extraction is studied during the course.

COURSE OUTCOME:

On completion of this course, the students will be able to
1. Understand the various energy resources and their importance
2. Know about solar energy and extraction techniques
3. Know about wind, biomass, geothermal and ocean energy and extraction techniques
4. Know about coal and its uses and various industrial application
5. Know about crude oil and products, uses of crude oil

Units	Contents	Lecture Hours
I	Indian and global energy scenario, Classification of various energy sources, Renewable and non-renewable energy sources, energy crisis and its remedial measures, Energy Conservation, energy management, energy planning, sustainable development	5
II	Solar Energy, solar collectors, thermal and photovoltaic conversion and utilization methods, various applications of solar energy such as solar water heating, cooking, drying , solar cells, their material and mode of operation. direct and indirect methods of solar energy storage, solar ponds etc	7
III	Wind energy, its potential and generation, wind mills, its types, Biomass energy, its conversion routes to gaseous and liquid fuels, Biogas plants and their operation, Biodiesel, Geothermal energy and its potential , methods of extraction , Ocean energy, its potential and extraction methods	12
IV	Coal, its origin, coal analysis, coal classification, coal preparation, washing and blending and its uses, coal carbonization, pulverization, treatment of coal gas, liquid fuel synthesis from coal, coal gasification, CBM	8
V	Petroleum, composition and classification of Indian crude, Gaseous Fuels: Natural gas, Water gas, producer gas, L.P.G., coke oven gas, blast furnace gas, LNG ,CNG, GTL Technology (gas to liquid)	8
	TOTAL	40

Reference books:

1. Khan B.H. “Non conventional energy resources” TMH publication
2. Sukhatme S.P, "Solar Energy - Principles of Thermal Collection and Storage",2nd Ed., Tata McGraw- Hill, 1996
3. Brame J.S.S. and King J.G., Edward Arnold “Fuel Solid, Liquid and Gases” Edward

Arnold, 1967.

Subject with Code : Computational Fluid Dynamics BCHT 611
Course : B.Tech.
Semester/Branch : 6th Semester

OBJECTIVES:

1. To introduce the widely used techniques in the numerical solution of fluid equations.
2. To disseminate the understanding of issues that arise in the solution of such equations, and modern trends in CFD.
3. To emphasize on 'learning by doing'.

COURSE OUTCOME:

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

1. Classify of the basic equations of fluid dynamics.
2. Understand Basic space and time discretization methods. - Numerical solution of advection, diffusion and stationary problems. Numerical solution of Grid Generation, FDM.
3. Analyze the accuracy and stability of finite difference methods for model equations.
4. Work on programming projects.

Units	Contents	Lecture Hours
I	Basic Concepts of Fluid Flow,philosophy of computational fluid dynamics (CFD),review of equations governing fluid flow and heat transfer, simplified flow models such as incompressible, in viscid, potential and creeping flow, flow classification.	5
II	Grid generation, structured and unstructured grids, choice of suitable grid, grid transformation of equations, some modern developments in grid generation in solving the engineering problems.	7
III	Finite Difference Method (FDM): Discretization of ODE and PDE, approximation for first, second and mixed derivatives, implementation of boundary conditions, discretization errors, applications to the engineering problems.	12
IV	Finite Volume Method: Discretization methods, approximations of surface integrals and volume integrals, interpolation and differential practices, implementation of boundary conditions, application to the engineering problems.	8

V	Case studies using FDM and FVM: Flow and heat transfer in pipes and channels, square cavity flows, reacting flow, reactive flow, multiphase flow, Heat Transfer in Rotary Kiln Reactors, Fluid mixing, etc. Essence of Finite element method (FEM) .	8

Total lectures : 40

Reference books:

1. Fletcher C.A.J. “Computational Techniques for Fluid Dynamics, Vol. 1: Fundamental and General Techniques”, Springer-Verlag.
2. Fletcher C.A.J. “Computational Techniques for Fluid Dynamics,Vol . 2: Specific Techniques for Different Flow Categories”, Springer-Verlag .
3. Anderson. J.D., “Computational Fluid Dynamics”, McGraw Hill.
4. Patankar S.V., “Numerical Heat Transfer and Fluid Flow”, Taylor and Francis

Subject with Code : Nanotechnology BCHT 612
Course : B.Tech.
Semester/Branch : 6th Semester

Course outcome- 1.To foundational knowledge of the Nanoscience and related fields.
2.Understand the synthesis of nanomaterials and their application and the impact of nanomaterials on environment
3.To make the students acquire an understanding the Nanoscience and Applications
4. To help them understand in broad outline of Nanoscience and Nanotechnology.
5.Apply their learned knowledge to develop Nanomaterial's in various application.

Units	Contents	Lecture Hours
I	Introduction Nano Scale, history and Scope of Nano Technology., Nanomaterials, Morphology. Enhanced properties at nano scale. Comparison with bulk materials.	5
II	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, Sonochemical Approach, Microwave and Atomization, Gas phase Production Methods : Chemical Vapour Depositions.	7
III	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	12
IV	Carbon Nanomaterials Synthesis of carbon buckyballs, List of stable carbon allotropes extended fullerenes, metallofullerenes solid C60, bucky onions nanotubes, nanocones Difference between Chemical Engineering processes and nanosynthesis processes.	8
V	Applications of Nano Technology. Applications in Chemical Engineering like nanocatalyst, bio analytical tools, nano/micro arrays, nanodevices, lab-on-a-chip.	8

Total lectures: 40

Books Recommended:
1. Sulabha K. Kulkarni, Nanotechnology: Principles and Practices, Capital Publishing Company, 2007.
2. Gabor L. Hornyak., H.F. Tibbals, JoydeepDutta, 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.

Subject with Code : Sustainable Engineering BCHT 613
Course : B.Tech.
Semester/Branch : 6th Semester

COURSE OBJECTIVES

- Introduce fundamental concepts of sustainable development for society.

COURSE OUTCOMES

After successful completion of the course, student will be able to:

CO 1. To understand the part of engineering and technology for sustainable development process.
CO2. To identify the methods, tools for sustainable product and system development.
CO3. To study the role and effect of various aspects of engineering approaches on environmental, society, and economy towards sustainable development.
CO4. Able to understand the different types of environmental pollution problems and their sustainable solutions that can be suitable for India.

Units	Contents	Lecture Hours
I	Introduction, Need and concept of sustainability, Environment acts and protocols, National and International, Global, Regional and Local environmental issues, Sustainable development, Challenges for Sustainable Development. Multilateral environmental agreements and Protocols - Clean Development Mechanism (CDM), Environmental legislations in India - Water Act, Air Act.	9
II	Air Pollution, Effects of Air Pollution; Water pollution- sources, Sustainable wastewater treatment, Solid waste - sources, impacts of solid waste, Zero waste	9

	concept, 3 R concept. Global environmental issues- Resource degradation, Climate change, Global warming, Ozone layer depletion, Regional and Local Environmental Issues. Carbon credits and carbon trading, carbon foot print.	
III	Basic concepts of sustainable habitat, Green buildings, green materials for building construction, material selection for sustainable design, green building certification, Methods for increasing energy efficiency of buildings. Sustainable cities, Sustainable transport.	6
IV	Basic concepts-Conventional and non-conventional, solar energy, Fuel cells, Wind energy, Small hydro plants, bio-fuels, Energy derived from oceans, Geothermal energy.	8
V	Green Engineering, Industrial Processes: Material selection, Pollution Prevention, Industrial Ecology, Industrial symbiosis.	8

Total lectures: 40

Text Book:

1. Allen, D. T. and Shonnard, D. R., Sustainability Engineering: Concepts, Design and Case Studies, Prentice Hall.
2. Bradley. A.S; Adebayo,A.O., Maria, P. Engineering applications in sustainable design and development, Cengage learning.
3. Environment Impact Assessment Guidelines, Notification of Government of India, 2006.
4. Mackenthun, K.M., Basic Concepts in Environmental Management, Lewis Publication, London, 1998.
5. ECBC Code 2007, Bureau of Energy Efficiency, New Delhi Bureau of Energy Efficiency Publications-Rating System, TERI Publications - GRIHA Rating System.
6. Ni bin Chang, Systems Analysis for Sustainable Engineering: Theory and Applications, McGraw-Hill Professional.
7. Twidell, J. W. and Weir, A. D., Renewable Energy Resources, English Language Book Society (ELBS).
8. Purohit, S. S., Green Technology - An approach for sustainable environment, Agrobios publication

Subject with Code : Safety and Hazard Analysis BCHT 691
Course : B.Tech.
Semester/Branch : 6th Semester

Course outcome-
CO1: Learn the types of chemical based hazards and their prevention

CO2: Discuss the management and prevention of fire and explosion
CO3: Learn the hazard risk management in workplace
CO4: Learn the rules and guidelines on risk assessment and management

Units	Contents	Lecture Hours
I	Origin of process hazards, Laws Codes, Standards, Case Histories, Properties of Chemicals, Health hazards of industrial substances. Toxicology: Toxic materials and their properties, effect of dose and exposure time, relationship and predictive models for response, Threshold value and its definitions, material safety data sheets, industrial hygiene evaluation.	8
II	Fire & explosion: Fire and explosion hazards, causes of fire and preventive methods. Flammability characteristics of chemical, fire and explosion hazard, rating of process plant. Propagation of fire and effect of environmental factors, ventilation, dispersion, purifying and sprinkling, safety and relief valves.	8
III	Other Energy Hazards: Electrical hazards, noise hazard, radiation hazard in process operations, hazards communication to employees, plant management and maintenance to reduce energy.	10
IV	Hazards. Risk Analysis, Component and plant reliability, event probability and failure, plant reliability, risk analysis, HAZOP AND HAZAN, event and consequence analysis (vapor cloud modeling)	7
V	Designing for safety, measurement and calculation of risk analysis. Hazard Assessment: Failure distribution, failure data analysis, modeling for safety, safety training, emergency planning ad disaster management, case studies.	7

Total lectures: 40

Books

1. Crawl D.A. and Louvar J.A., “Chemical Process Safety Fundamentals with Applications,” Prentice Hall, 1990
2. Wentz, C.A., “Safety Health and Environmental Protection,” McGraw Hill, 2001.
3. Lees, F. P., "Loss Prevention in Process Industries", Vol.1 and 2, 2nd ed., Butterworth, 1996

Subject with Code : Research Methodology BCHT 692
Course : B.Tech.
Semester/Branch : 6th Semester

Course Outcome

Upon completing this course, each student will be able to:

- Demonstrate knowledge of research processes (reading, evaluating, and developing);
- Perform literature reviews using print and online databases;
- Employ American Psychological Association (APA) formats for citations of print and electronic materials;
- Identify, explain, compare, and prepare the key elements of a research proposal/report;
- Define and develop a possible HIED research interest area using specific research designs;
- Compare and contrast quantitative and qualitative research paradigms, and explain the use of each in HIED research;
- Describe, compare, and contrast descriptive and inferential statistics, and provide examples of their use in HIED research;
- Describe sampling methods, measurement scales and instruments, and appropriate uses of each;
- Explain the rationale for research ethics, and the importance of and local processes for Institutional Review Board (IRB) review; and
- Demonstrate how educational research contributes to the objectives of your doctoral program and to your specific career aspirations in HIED

Units	• Contents	Lecture Hours
1	• **Objectives and types of research:** Motivation and objectives, research methods vs methodology. Types of research – descriptive vs analytical, applied vs fundamental, quantitative vs qualitative, conceptual vs empirical.	9

	Introduction to drug discovery & development research, objectives, flowchart from discovery to post-marketing research, overview of research methodology in various areas of drug discovery and development research.	
2	• **Research formulation** – Defining and formulating the research problem, selecting the problem, necessity of defining the problem, importance of literature review in defining a problem, Literature review - primary and secondary sources, reviews, monographs, patents, research databases, web as a source, searching the web, critical literature review, identifying gap areas from literature review and research databases, development of working hypothesis.	9
3	• **Research design and methods:** Research design – basic principles, need of research design, features of good design, important concepts relating to research design, observation and facts, laws and theories, Prediction and explanation, research databases, development of models, developing a research plan – exploration, description, diagnosis, and experimentation.	8
4	• **Execution of the research, data collection and analysis**: Aspects of method validation, observation and collection of data, methods of data collection, sampling methods, data processing and analysis strategies and tools, data analysis with statistical packages (Sigma STAT, SPSS for Student t-test, ANOVA, etc), hypothesis testing, generalization and interpretation.	8
5	• **Reporting and thesis writing:** Structure and components of scientific reports, types of report, Technical reports and thesis. Thesis writing – different steps and software tools (Word processing, etc) in the design and preparation of thesis, layout, structure (chapter plan) and language of typical reports, Illustrations and tables, bibliography, referencing and footnotes. Oral presentation – planning, software tools, creating and making effective presentation, use of visual aids, importance of effective communication. • **Research ethics, IPR and scholarly publishing:** Ethics – ethical issues, ethical committees (human & animal); IPR - intellectual property rights and patent law, commercialization, copy right, royalty, trade related aspects of intellectual property rights (TRIPS); Scholarly publishing – IMRAD concept and design of research paper, citation and acknowledgement, plagiarism, reproducibility and	11

	accountability.	

Total lecture : 45

Books:

1. Tuckman, B. W. & Harper, B. E. (2012). *Conducting educational research* (6th ed.). Lanham, MD: Rowan & Littlefield Publishers. (ISBN: 978-1-4422-0964-0)
2. Kothari, C.R., Research Methodology: Methods and Techniques
3. Walker, I. Research Methods and Statistics

Subject with Code : Process Modeling and Simulation BCHT 693
Course : B.Tech.
Semester/Branch : 6th Semester

Course Outcomes (CO): Upon completion of this course, the students will be able to:
1. Analyse physical and chemical phenomena involved in various process.
2. Develop mathematical models for various chemical processes.
3. Use various simulation approaches.
4. Generate random numbers and random variates using different techniques
5. Use of artificial intelligence based modeling methods in chemical engineering.

Units	Contents	Lecture Hours
I	Introduction and fundamentals of process modeling and simulation; industrial usage of process modeling and simulation; Macroscopic mass, energy and momentum balances; incorporation of fluid thermodynamics, chemical equilibrium, reaction kinetics and feed/ product property estimation in mathematical models.	7
II	Simulation of steady state lumped, modeling of chemical process equipments like reactors, distillation, absorption, extraction columns, evaporators, and heat exchangers, microscopic balances for steady state and dynamic simulation;	7
III	Process modeling with dispersion; axial mixing; diffusion, etc. Modeling and simulation of complex industrial systems in petroleum, petrochemicals, polymer, basic chemical industries; Commercial steady state and dynamic simulators; Simulation of process flow sheets.	10
IV	Unsteady state lumped systems and dynamic simulation; Computer algorithms for numerical solution of steady state and unsteady state models.	

		8
V	Introduction to application of artificial intelligence based modeling methods using Artificial Neural Networks, Fuzzy logic, etc.	8

Text/Reference Books

1. Luyben, W. L., “Process Modeling, Simulation and Control for Chemical Engineers,”McGraw Hill.
2. Babu, B.V., “Process Plant Simulation,” Oxford Unicversity Press, 2004.
3. Holland, C. D., “Fundamentals and Modeling of Separation Processes”, Prentice Hall, 1975.
4. Himmelblau, D. M., & Bischoff, K. B., “Process analysis and simulation: Deterministic systems,” John Wiley, New York, 1968.

SUBJECT CODE: BCHP504	COURSE TITLE: PROCESS MODELING & SIMULATION LAB
EXAM DURATION: 2 HOURS	SEMESTER : V (ODD)
L: T: P :: 0 : 0 : 2 CREDITS: 2	PREREQUISITE: NIL

OBJECTIVE:

- To impart conceptual knowledge about the modelling & simulation techniques of chemical processes.
- To teach various simulation approaches and basic knowledge of simulators.
- To provide knowledge about skills in using process simulators for solving chemical engineering processes problem.

COURSE OUTCOME:

COURSE OUTCOME:

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

- Analyze steady-state and unsteady state material and energy balance on a system
- Analyze physical and chemical phenomena involved in various chemical processes.
- Develop mathematical models for various chemical engineering plant based processes.
- Use various simulation approaches such as sequential, simultaneous, and equation oriented.
- Simulate a chemical process using process simulators (ASPEN Plus/ ASPEN Hysys/ MATLAB/ PRO-II/ CHEMCAD/ FlowTran/ Fluent/ MATLAB etc.).

REFERENCE BOOKS

S.NO	NAME OF AUTHORS/BOOKS /PUBLISHERS	YEAR OF PUBLICATION/ REPRINT
1.	Luyben W.L., Process Modeling, Simulation and Control for Chemical Engineering, McGraw-Hill.	1998
2.	Babu, B.V., Process Plant Simulation, Oxford University Press.	2004
3.	Denn, M. M., Process Modeling, Longman Sc & Tech.	1987
4.	Holland, C. D., Fundamentals and Modeling of Separation Processes: Absorption, Distillation, Evaporation and Extraction, Englewood Cliffs, Prentice-Hall.	1974

5.	Finlayson, Bruce A. Introduction to chemical engineering computing. John Wiley & Sons	2012
6.	Jana, Amiya K. Process modelling and control using ASPEN. PHI Learning Pvt. Ltd.	2009
7.	Kamal,I. M. AL-Malah, Aspen plus: chemical engineering applications, Wiley	2017
8.	Juma Haydary, Chemical Process Design and Simulation: Aspen Plus and Aspen HYSYS Applications, Wiley	2019
9.	Alkis Gonstantinides and Navid Mostoufi, Numerical Methods for Chemical Engineers with MATIAB Applications, Prentice Hall PTR	1999
10.	Michael B. Cutlip, Problem Solving in Chemical and Biochemical Engineering with POLYMATH, Excel, and MATLAB, Prentice Hall PTR	2008
11.	Yeong Koo Yeo, Chemical Engineering Computation with MATLAB, CRC Press	2018

COURSE DETAILS:

S.NO.	LIST OF EXPERIMENTS
1.	Introduction to Process Modeling & Simulation.
2.	Practice examples of process Modeling & simulation and solution of problems using MATLAB
3.	Introduction to Aspen Plus and Simulation of individual equipment using ASPEN Plus.
4.	To calculate the VLE data for ideal mixture and various activity coefficient models by using ASPEN Plus.
5.	To determine the Composition of vapor and liquid streams in a flash distillation still using VLE data.
6.	To apply material balance/enthalpy balance in the plate columns.
7.	To study the absorption, reaction and diffusion processes in a contact reactor/bubble absorber/packed tower/plate column through a two film model.
8.	To simulate liquid –liquid extraction column.
9.	To design and optimize a single effect and multiple effect evaporator.
10.	To design of a shell and tube heat exchanger.
11.	To simulate the CSTR/PFR model and compute the component mole fractions in the product stream.
12.	To simulate the laminar flow of water through a constant diameter circular pipe.

13.	To apply complete material and energy balance for a given reactor-separator system.

SUBJECT CODE:	**COURSE TITLE: MINI PROJECT OR INTERNSHIP ASSESSMENT***
EXAM DURATION: 20 MINUTES PRESENTATION	**SEMESTER: V (ODD)**
L: T: P :: 0 : 0 : 2 CREDIT:1	**PRE-REQUISITE: NIL**

OBJECTIVE:

- To inculcate research attitude amongst students.
- To develop presentation skills.
- To teach how to study and solve practical problems

COURSE OUTCOME:

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

- Understand and workout the project problem.
- Gain experience to make a project report.
- Acquire the necessary confidence to carry out main project in the final year.

SUBJECT CODE: BCHP605	**COURSE TITLE: Seminar**
EXAM DURATION: 2 HOURS	**SEMESTER: VI (EVEN)**
L: T: P :: 0 : 0 : 2 CREDIT: 1	**PREREQUISITE: NIL**

OBJECTIVE: The purpose of this course is to prepare our students for:

- To provide them better learning and understanding through presentations.
- To develop better communication skill and confidence.
- To provide a platform for sound discussions of technical & challenging areas.

COURSE OUTCOME:

On successful completion of the lab, the student will be able to:

- Improve their communication skill.
- How to write refined report of any technical topics.
- To learn new challenging area of their domain.
- Knowledge of the application of Artificial Intelligence in Chemical Engineering.
- Knowledge of automation through on ERP module training.

COURSE DETAILS:

- Presentation on Chemical Engineering topics.
- Presentation on ERP module training.
- Presentation on the application of Artificial Intelligence in Chemical Engineering.
- Presentation on some project taken up.
- Presentation on simulation and simulators.
- Presentation on certification process.
- Presentation on Chemical analysis and measuring techniques.
- Presentation on any other innovative idea.

COURSE DETAILS:

- The student jointly or individually is required to prepare a project report based on experimental or theoretical research work The key features such as literature survey, Problem formulation, solving methodologies and future aspects of industries are the major necessities of the report under the supervision of a guide.
- The project report is to be submitted by the end of the semester and the work will be assessed based on the report and the presentation of the work.
- The assessment of all the mini projects should be done by a committee consisting of three or four faculty members - the students will present their project work before the committee - the relative grading and group average marks for the various projects will be fixed by the committee - the guides will award the marks for the individual students in the project maintaining the group average.
- Each group will submit the project report to the department through the guide - the head of the department will certify the copies and keep one copy in the departmental library.

TCH812: Petroleum Refining Technology

Unit I: Petroleum Exploration: Production and Refining of Crude oils; Crude oils: Chemistry and composition (Characteristics and constituents of crude oils, Classification of crude oils).

Unit II: Quality Control of Petroleum Products: Classification of laboratory tests, distillation, vapour pressure, flash and fire points, octane number, performance number, cetane number, aniline point, viscosity index, calorific value, smoke point, char value, viscosity, viscosity index, penetration tests, cloud and pour points, drop point of grease, melting and settling points of wax, softening point of Bitumen, induction period of gasoline, thermal stability of jet fuels, gum content, Total Sulphur, Acidity and Alkalinity, Copper Strip Corrosion Test, Silver – Strip Corrosion Test for ATF, Ash, Carbon Residue (Conradson method, Ramsbottom method) Colour, Density and Specific gravity, Refractive index of hydrocarbon liquids, water separation index (modified) (WSIM), ductility.

Unit III: Petroleum Products: Composition, Properties & Specification of LPG, Naphthas, motor spirit, Kerosine, Aviation Turbine Fuels, Diesel Fuels, Fuel Oils, Petroleum Hydrocarbon Solvents, Lubricating oils (automotive engine oils, industrial lubricating oils electrical insulating oils, Jute Batching oils, white oils, steam turbine oils, metal working oils, etc.) Petroleum Waxes Bitumens, Petroleum coke. Crude Oil Distillation, Desalting of crude oils, Atmospheric distillation of crude oil, Vacuum distillation of atmospheric residue.

Thermal Conversion Process: Thermal Cracking Reactions, Thermal Cracking, Visbreaking, (Conventional Visbreaking and Soaker Visbreaking) Coking (Delayed Coking, Fluid Coking, Flexicoking), Calcination of Green Coke.

Unit IV: Catalytic Converson Process: Fluid catalytic cracking; Catalytic reforming; Hydrocracking Catalytic Alkylation, Catalytic Isomerization; Catalytic Polymerization. Finishing Process, Hydrogen sulphide removal processes; Sulphur conversion processes; Sweetening processes (Caustic treatment, Solutizer process; Doctor treating process; Copper chloride sweetening,; Hypochlorite sweetening ;Air and inhibitor treating process; Merox processes; Sulphuric acid treatment; Clay treatment); Solvent extraction processes (Edeleanu process, Udex process, Sulfolane process), Hydrotreating processes.

Unit V: Lube Oil Manufacturing Process: Evaluation of crude oils for lube oil base stocks, Vacuum distillation, Solvent deasphalting Solvent extraction of lube oil fractions (Furfural, NMP and Phenol), Solvent dewaxing, Hydrofinshing, Manufacture of petroleum waxes (Wax sweating, Solvent deoiling)

Manufacture of Bitumens: Selection of crude oil, Methods of manufacture of bitumens, (Distillation, Solvent precipitation, Air blowing).

Text Book:

1. Nelson, W.L., "*Petroleum Refining Engineering*", McGraw Hill, 4th Ed., 1958,

References

1. Mall, I D , "*Petrochemical Process Technology*", McMillan India, 4th Ed., 1998.

2. Sarkar, G.N., "*Advance Petroleum Refining*", Oscar Publication, 4th Ed., 1998.

TCH822: Plant Design & Economics

Unit I: Process Development: Process selection, study of alternative processes, pilot plant, Scale up methods, Flow sheet preparation, sketching techniques, Equipment numbering, Stream designation, Material and energy balances.

Plant Design: Design basis, Process selection-Selection of equipment, specification and design of equipment's, material of construction, Plant location, Plant layout and installation, Safety, Start up, Shutdown and Operating guidelines.

Unit II: Cost Engineering: Time value of money and equivalence, Interest, cost comparisons by present worth, Annual equivalent cost and capitalized cost methods, Uniform gradient and series. Depreciation, Taxes and Insurances Nature of depreciation, Methods of determining depreciation, depreciation rates in current Indian situation, Types of taxes and insurance's, Procedure for cost comparison after taxes.

Unit III: Cost Estimation: Types of cost estimation, capital investment cost, fixed capital cost, working capital cost, start-up costs, process equipment cost estimation, cost index, Equipment costs due to inflation, Battery limit investments, estimation of plant cost, Estimation of total product cost, Manufacturing cost, General expenses.Profitability: Criteria of profitability, Payout period, Return on investment, Present value, Cash flow analysis, Alternative investment analysis, Sensitive analysis in project profitability.

Unit IV: Economic Optimization and Optimum Design: Nature of optimisation, Uni-variable and multivariable systems, Analytical, graphical and incremental methods of solution, LaGrange multiplier method, Linear programming and dynamic programming establishing optimum conditions, Break even chart for production schedule, Optimum production rates

in plant operation, Optimum conditions in batch, cyclic and semicyclic operation, Sensitivity and response analysis.

Unit V: Optimization of Different Process Equipment: Viz., transportation systems, heat exchangers, evaporators, mass transfer equipments and reactors. Determination of height and diameter of different process equipments at conditions of optimum cost. Pinch Technology analysis. Preparation of techno-economic feasibility report.

Text Book

1. Peters M., Timmerhaus K. & Ronald W., "*Plant Design & Economics for Chemical Engineers*", McGraw Hill, 5th Ed., 2003.

References

1. Couper, J. R., "*Process Engg. Economics (Chemical Industries)*" CRC Press, 4th Ed. 1998.

1. Aries & Newton, "*Chemical Engg. Cost Estimation"*, McGraw Hill, 4th Ed., 1998.

TCH833: Process Utility & Piping Design

Unit I: Various process utilities, their role and importance in chemical plants. Sources of water and their characteristics; Treatment storage and distribution of water; water for use in boilers, cooling purposes, drinking and process; Reuse and conservation of water; Water resource management.

Unit II: Steam Generation and Utilization: Steam generation and its application in chemical process plants, distribution and utilization; Design of efficient steam heating systems; steam economy, Steam condensers and condensate utilization Expansion joints ,flash tank design, steam traps their characteristics, selection and application, waste heat utilization; Lagging, selection and thickness .Selection and sizing of boilers; waste heat boilers.

Unit III: Compressors, blowers and Vacuum Pumps: Compressors, blowers and vacuum pumps and their performance characteristics; Methods of developing vacuum and their limitations, material handling under vacuum, Piping systems; Lubrication and oil removal in compressors and pumps.Air filters,Air and gas leakage. Inert gas systems, compressed air for process, Instrument air.

Insulation**:** Importance of insulation for meeting the process requirement, insulation materials and their effect on various material of equipment piping, fitting and valves etc. insulation for high intermediate, low and sub zero temperatures, including cryogenic insulation.

Unit 1V: Energy losses in pipe lines, concept of equivalent length and equivalent pipes, problems in pipe flow, hydraulic power transmission through a pipe line. Negative pressure in pipe lines, Siphon, Multiple pipe systems, working pressure, design pressure, choice of pipe materials, hydraulic analysis of complex pipe networks.

Unit V: Aids in selecting pipe valves and fittings, standards for piping design, Dimensional and mechanical standards for pipe valves and fittings. Pipe fabrication, vibration, its prevention and control in piping systems.

Text Books

1. Nordell, Eskel, "*Water Treatment for Industrial and Other Uses*", Reinhold Publishing

Corporation, New York., 1961.

2. Crowl, D.A. & Louvar, J.F. "*Chemical Process Safety: Fundamentals with Applications*". New Jersey: Prentice-Hall. (1989).

3. Goodall, P. M., "*The Efficient Use Of Steam*" IPC Science and Technology, 1980.

4. King, R. C. and Croker, S., "*Piping Handbook*", McGraw Hill.

Reference Books

1. Lees, F. P., "*Loss Prevention in Process Industries 3 volume set*" Butterwort - Heinemann, Oxford, 1996.

2. Kellogg, M. W Company., "*Design of Piping Systems*", Pullman Power Products, New York, 1976.