DEPARTMENT OF CHEMICAL ENGINEERING

Motilal Nehru National Institute of Technology, Allahabad- 211004

Course Structure: B. Tech. (Chemical Engineering)

SEMESTER-I						
S. No.	**Sub. Code**	**Subject**	**L**	**T**	**P**	**Cr**
1.	PH-1101	Physics-I	3	1	0	4
2.	HS-1101/ CS-1101	English Language and Composition/ Computer Programming	2	1	0	3
3.	CY-1101/AM-1101	Chemistry/Engineering Mechanics	3	1	0	4
4.	MA-1101	Mathematics-I	3	1	0	4
5.	ME-1101/1102	Engineering Graphics/Workshop	1	0	3	3
6.	HS-1102/PH-1151	Communication Skill Workshop Physics (Lab)	0	0	3	2
7.	CY-1152/AM-1153	Chemistry (Lab)/Engineering Mechanics (Lab)	0	0	3	2
8.	HS-1154/CS-1155	Language Lab/Computer Programming (Lab)	0	0	3	2
		Total	-	-	-	24
SEMESTER-II						
S. No.	**Sub. Code**	**Subject**	**L**	**T**	**P**	**Cr**
1.	PH-1202	Physics-II	3	1	0	4
2	HS-1201/ CS-1201	English Language and Composition/ Computer Programming	2	1	0	3
3.	CY-1201/AM-1201	Chemistry/Engineering Mechanics	3	1	0	4
4.	MA-1201	Mathematics-II	3	1	0	4
5.	ME-1201/1202	Engineering Graphics/Workshop	1	0	3	3
6.	CE-1201	Environment & Ecology	2	0	0	2
7.	HS-1202/PH-1251	Communication Skill Workshop Physics (Lab)	0	0	3	2
8.	CY-1252/AM-1253	Chemistry (Lab)/Engineering Mechanics (Lab)	0	0	3	2
9	HS-1254/CS-1255	Language Lab/Computer Programming (Lab)	0	0	3	2
		Total	-	-	-	26
SEMESTER-III						
S. No.	**Sub. Code**	**Subject**	**L**	**T**	**P**	**Cr**
1	ME-1301	Engineering Thermodynamics	3	1		4
2	CL-1301	Fluid Particle Mechanics and Mechanical Operation	3	1		4
3	AM-1303	Material Science and Engineering	3			3
4	EE-1305	Basic Electrical and Electronics	3			3
5	MA-1304	Numerical Methods and Statistical Techniques	2	1		3
6	AM-1307	Fluid Flow Operations and Hydraulic Machine	3	1		4
7	ME-1351	Computational Lab			3	2
8	AM-1352	Material Science Lab			3	2
9	AM-1354	Fluid Flow Operation Lab			3	2
10	CL-1351	Mechanical Operation Lab			3	2
		Total	17	4	12	29
SEMESTER IV						
S. No.	**Sub. Code**	**Subject**	**L**	**T**	**P**	**Cr**
1	CH-1401	Organic and Physical Chemistry	2	1		3
2	CL-1401	Process Equipment Design-I	3	1		4
3	CL-1402	Heat Transfer Operations	3	1		4
4	CL-1403	Mass Transfer-I	3	1		4

5	CL-1404	Chemical Technology-I	3			3
6	CL-1405	Chemical Process Principles	3	1		4
7	CH-1451	Organic and Physical Chemistry Lab			3	2
8	CL-1451	Heat Transfer Lab			3	2
9	CL-1452	Mass Transfer Lab-I			3	2
			17	5	9	28
SEMESTER-V						
S. No.	**Sub. Code**	**Subject**	**L**	**T**	**P**	**Cr**
1	CL-1501	Chemical Reaction Engineering-I	3	1		4
2	CL-1502	Mass Transfer-II	3	1		4
3	CL-1503	Process Dynamics and Control	3	1		4
4	CL-1504	Chemical Technology-II	3			3
5	CL-1505	Chemical Engineering Thermodynamics	3	1		4
6	HS-1501	Principles of Management	3			3
7	CL-1551	Mass Transfer Lab-II			3	2
8	CL-1552	Chemical Reaction Engineering Lab-I			3	2
9	CL-1553	Process Dynamics and Control Lab			3	2
		Total	18	4	9	28
SEMESTER-VI						
S. No.	**Sub. Code**	**Subject**	**L**	**T**	**P**	**Cr**
1	CL-1601	Advanced Separation Process	3	1		4
2	CL-1602	Transport Phenomena	3	1		4
3	CL-1603	Environmental pollution, Monitoring and Control	3	1		4
4	CL-1604	Chemical Reaction Engineering-II	3	1		4
5	CL-1605	Process Equipment Design-II	3	1		4
6	HS-1601	Communication Skill (workshop)			2	0
7	CL-1651	Environmental Monitoring Lab			3	2
8	CL-1652	Chemical Reaction Engineering Lab-II			3	2
9	CL-1653	Process Design and Simulation Lab			3	2
10	CL-1654	Chemical Technology Lab			3	2
		Total	15	5	14	28
SEMESTER-VII						
S. No.	**Sub. Code**	**Subject**	**L**	**T**	**P**	**Cr**
1	HS-1701	Economics	3			3
2	CL -1701	Plant Design and Economics	3	1		4
3	OE-1701	Open Elective-I	3			3
4	CL -1731-CL1740	Professional Elective – I	3	1		4
5	CL-1741-CL1750	Professional Elective – II	3	1		4
6	CL -1791	Major Project – I			12	6
		Total	15	3	12	24
SEMESTER-VIII						
S. No.	**Sub. Code**	**Subject**	**L**	**T**	**P**	**Cr**
1	CL-1801	Hazards and Safety in Chemical Industries	3	1		4
2	OE-1801	Open Elective-II	3			3
3	CL-1831-CL-1840	Professional Elective – III	3	1		4
4	CL-1841-CL-1850	Professional Elective – IV	3	1		4
5	CL-1891	Major Project – II			12	6
		Total	12	3	12	21

LIST OF PROFESSIONAL ELECTIVES

A) Professional Electives- I & II

S. No	Subject Code	Subject Name
1.	CL-1731	BIOPROCESS ENGINEERING
2.	CL-1732	INDUSTRIAL ENZYME ENGINEERING AND FERMENTATION TECHNIQUES
3.	CL-1733	INTRODUCTION TO BIOTECHNOLOGY
4.	CL-1734	BIOENERGY ENGINEERING
5.	CL-1735	FOOD TECHNOLOGY AND ENGINEERING
6.	CL-1736	OIL AND FAT TECHNOLOGY
7.	CL-1737	FUNDAMENTAL OF POLYMER SCIENCE TECHNOLOGY
8.	CL-1738	DOWNSTREAM PROCESSING
9.	CL-1739	INTRODUCTION TO MULTIPHASE FLOW
10.	CL- 1740	FLUID FLOW AND HEAT TRANSFER IN MICROCHANNEL
11.	CL- 1741	TWO PHASE FLOW AND HEAT TRANSFER
12.	CL-1742	PETROCHEMICAL TECHNOLOGY
13.	CL-1743	PETROLEUM REFINING ENGINEERING AND OIL WELL ENGINEERING

B) Professional Electives- III & IV

S.No	Subject Code	Subject Name
14.	CL-1831	SYNTHESIS OF NANOMATERIAL AND THEIR APPLICATION
15.	CL-1832	ELECTROCHEMICAL ENGINEERING
16.	CL-1833	INDUSTRIAL CATALYSIS
17.	CL-1834	COMPUTER -AIDED PROCESS CONTROL
18.	CL-1835	ADVANCES IN FLUIDIZATION ENGINEERING
19.	CL-1836	PROCESS MODELING AND SIMULATION
20.	CL-1837	INDUSTRIAL CORROSION AND SURFACE COATING
21.	CL-1838	ADVANCED PROCESS CONTROL
22.	CL-1839	SCALE-UP IN PROCESS INDUSTRIES
23.	CL- 1840	SOLID WASTE MANAGEMENT
24.	CL- 1841	ENERGY ENGINEERING
25.	CL-1842	ENERGY MANAGEMENT AND AUDIT

ME -1301: ENGINEERING THERMODYNAMICS

Credit: 4 **L-T-P: 3-1-0**

Module 1: **9L**

Introduction to thermodynamics.System, surroundings, boundaries, classification of systems.Unit and dimensions, conversion factors.Properties of systems, equilibrium, processes, heat and work interaction.The work interaction. Thermodynamic definition of work .characteristics of the work interaction. Evaluation of work.Adiabatic systems and processes.

Module 2: **4L**

Diathermic boundary, Zerothlaw.Isothermalstates.Empiricaltemperature.Principles of thermometry.Scales of temperature.Gasthermometer.The ideal gas.Ideal gas temperature scale.

Module 3: **4L**

The first law.Basicform.Energy of a system.The heat interaction. Sign convention.First law for open systems. Steady-flow energy equation and its applications.

Module 4: **4L**

Equations of state.Properties of gases.Properties of steam.Introduction to steam tables.Other equations of state.Van-der-waalsgas.Criticalstate.Reduced equation of state.

Module 5: **6L**

The second law.Kelvin-Planck and Clausiusstatements.Equivalence of statements.Carnottheorem.Thermodynamictemperature.Kelvinscale.Carnot engine, refrigerator and heat pump.

Module 6: **4L**

Clausiusinequality.Definition of entropy.Combined first and second law, Evaluation of entropy.Principle of increase of entropy.

Module 7: **3L**

Irreversibility and exergy.Lost work.

Module 8: **5L**

Introduction to cycles.Classifications of cycles.Gas power cycles- Otto, Diesel, Brayton. Vapour power cycle- Rankine cycle, vapour- compression refrigeration cycle.

References:

1. Engineering thermodynamics by P K Nag, Tata McGraw Hill
2. Thermodynamics : An engineering approach by Cengel& Boles, McGraw Hill

CL-1301: FLUID PARTICLE MECHANICS AND MECHANICAL OPERATIONS

L: T: P: Cr = 3:1:0:4

Objective

To impart knowledge on solid handling and solid liquid separation.

Introduction

The students will learn properties and handling of particulate solids, size reduction, techniques of solid – solid, solid-fluid separation and mixing.

UNIT-1: Properties of Particulate Solid: 6 L

Introduction to unit operations and their role in Chemical Engineering industries. Types of Mechanical Operations, Characteristics of particulate solids: sampling techniques, specification and screen analysis, particle size distribution, particle size measurement, Surface area measurements and statistical mean diameters.

UNIT-2: Handling of Particulate Solid: 7 L

Transportation,conveying of bulk solids, classification and selection of conveyors. Storage of solids in bulk protected and unprotected piles, bines, silos, hoppers, mass flow and funnel flow Bins, Flow assisting devices, feeders. Weighing of bulk solids, batch and continuous weighing techniques.

UNIT-3; Mechanical Separation: 8 L

Classification of separation methods for mixtures of solid-solid, solid-gas and solid-liquid.Screening, Classifiers, magnetic separation, electrostatic separation.Gravity settling, sedimentation,jigging, Floatation and elutriation. Continuous thickeners, decantation, Phase separation: Centrifugal separation, Electrostatic precipitators. Gas-solid separation: Gravity settling, Impingement separators, Cyclone separators, bag filters, scrubbers.

UNIT-4: Size reductionand enlargement: 8L

Principles of size reduction: Specific properties of solids for size reduction. Energy required for size reduction. Crushing and grinding efficiency. Laws of crushing, pulverization and ultrafine grinding.Classification of crushing and grinding equipment.Size enlargement: Scope and applications, size enlargement techniques, principle of granulation,briquetting, pelletisation, and flocculation.

UNIT-5: Filtration 6 L

Theory of filtration, Batch and continuous filters, Flow through filter cake and filter media,compressible and incompressible filter cakes, filtration equipments - selection, operation anddesign of filters and optimum cycle of operation, filter aids.

UNIT-6: Mixing of Solids & Pastes: 3 L

Mixing and agitation - Mixing of liquids (with or without solids), mixing of powders, selectionof suitable mixers, power requirement for mixing.

Text books and References:

1. Coulson and Richardson: Chemical Engineering, Vol. 2.Butterworth Heinemann Pub
2. Perry R.H. & Chilton C.H., "Chemical Engineers Hand Book",McGraw hill.
3. Foust A. S. & Associates, "Principles of Unit Operations" John Wiley and Sons.
4.McCabe Smith, "Unit Operation in Chemical Engineering" 5th ed. McGraw Hill.

AM-1303: MATERIAL SCIENCE AND ENGINEERING

Credit: 3 **L-T-P: 3-0-0**

Total No. of Lectures-40

Aim: At the end of the course the student will have an understanding of science and engineering aspect of materials. The major focus shall be on the structure, properties, processing, and application of common as well as advanced engineering materials.

Prerequisite: The prerequisite for the course includes a sound knowledge in atomic structure, atomic bonding in solids, crystal structures, crystalline and noncrystalline materials, polymers, and some common properties of materials. (A quiz may be conducted by course co-coordinator (class teacher) within 15 days to check prerequisite knowledge acquired by students.)

Module 1: Introduction **(3)**

Historical perspective of Materials Science, Structure and properties relationship of Engineering Materials, Classification of materials, Advanced Materials.

Module 2: Structure of Solids and Characterization of Materials **(6)**

Introduction to crystal structures and systems, Metallic structures, Ceramic crystal structures, Carbon nano-structures, Crystallographic directions and planes, Miller indices, Density computations, Crystallography, Diffraction methods, Electron microscopy, Metallography, Thermal characterization techniques.

Module 3: Imperfections in Solids **(4)**

Point defects, Dislocations, Interfacial Defects, Bulk defects.

Module 4: Diffusion **(4)**

Diffusion mechanisms, steady and non-steady state diffusion, Factors that influence diffusion, Law's of diffusion, Applications of Diffusion.

Module 5: Mechanical Behaviour of Materials **(6)**

Elastic and plastic properties, Creep, Fatigue, Fracture, Heat treatment of steels.

Module 6: Phase Diagrams and Phase Transformations **(6)**

Unary, Binary, Equilibrium phase diagrams, Eutectic, Eutectoid, Peritectic and peritectoidreactions**,**Transformation rate effects and TTT diagrams.Microstructure and property changes in iron-carbon system, Iron-Carbon (Fe-C or Fe-Fe_3C) Diagram.

Module 7: Ceramic Materials **(2)**

Ceramic types, Properties, ProcessingApplication, Advanced ceramics.

Module 8: Composites **(2)**

Introduction, Applications, Particle reinforced composites; Fiber reinforced composites, Structural composites.

Module 9: Thermal, Electrical, Magnetic, Optical Properties **(5)**

Heat capacity, Thermal expansion, Thermal conductivity, Thermal stresses, Electrical conduction, Semi conductivity, Super conductivity, Electrical conduction in ionic ceramics and in polymers, Dielectric behavior, Ferroelectricity, Piezoelectricity, Diamagnetism and paramagnetism, Ferromagnetism, Antiferromagnetism and ferrimagnetism, Influence of temperature on magnetic behavior, Domains and hysteresis, Optical properties of metals, Optical properties of nonmetals, Application of optical phenomena.

Module 10: Economic, Environmental and Social Issues of Material Usage **(2)**

Economic considerations, Environmental and societal considerations, Recycling issues, Life cycle analysis and its use in design.

Text Books and References:

- Callister W. D. Jr., Materials Science and Engineering An Introduction.
- Van Vlack, Material Science.
- Raghavan V, Material Science.
- K. M. Gupta, Material Science and Engineering.

EE-1305: BASIC ELECTRICAL AND ELECTRONICS

L: T: P: Cr = 3:0:0:3

ELECTRICAL ENGINEERING:

Introduction to Electrical Energy: Generation**:** Types of power Plant, Functional Block diagram of generating stations (Hydel& Thermal Stations); Transmission,DistributionandUtilization,Domestic Wiring: Materials, accessories & ratings of the wiring materials, types of wiring, earthing and electricity rules.

Electric Circuits: Basic Circuit Elements, Ohm's law, KCL & KVL, Node & Loop Analysis, Superposition, Thevenin's Theorem & Norton's Theorem, Maximum Power Transfer Theorem.

Steady-state analysis of AC circuits: Sinusoidal and phasor representation of Voltage & current, single phase ac circuit behavior of R, L and C. Combination of R, L and C in series and parallel, Resonance. Three-phase circuits.

Transformer& Rotating Machines: Principle of operation and construction of single-phase transformer, efficiency and voltage regulation. Principle of electromagnetic energy conversion, Starting and speed control of DC and AC motors

ELECTRONICS ENGINEERING:

Semiconductor Devices: Junction Diode**,** Bipolar -junction Transistor, JFET and MOSFET, Linear IC and its applications

Digital circuits: Number systems, conversion of bases, Boolean Algebra, logic gates, Concept of universal gate, Flip-Flops and counter**.**

MEASUREMENT AND MECHATRONICS INSTRUMENTATION:

Measuring Instruments: Types of instruments, working principles of Ammeter, Voltmeter, Wattmeter & Energy meter,Digitalinstruments,Oscilloscopes.

Transducers and Sensors:for measurement of displacement, velocity, acceleration, force, torque, liquid level, flow, temperature etc.

Signal Conditioning: Operational Amplifiers and Circuits, Instrumentation amplifiers, Voltage to Current converters and Current boosters, Logarithmic amplifiers filters.

Timing Circuits: VCO, Waveform Generator, 555 timer circuits

Converters: Analog to Digital and Digital to Analog Conversion, Sample and Hold circuits, Analog, multiplexers, de-multiplexers

Power Control: SCRs, Triacs and other solid state devices various power converters and power control

Actuators and Motors: Actuators, BrushedDC servo motors, Brushless PM motors and controllers, The AC induction motor as a servo drive, stepper motor.

Controllers for automation: Introduction to microprocessors, Automation of systems using microcontrollers.

Text books and References:

1. V. Del Toro: Principle of Electrical Engineering, PHI
2. W. H. Hayt&Kemmerley, Engineering Circuit Analysis, McGraw Hill.
3. Millman&Halkias, Integrated Electronics, TMH
4. Boylstad&Nashishky, Electronic Devices & circuits, PHI
5. Mavino& Leach, Digital Principles and applications.
6. W.D. Cooper Electronic Instrumentation & Measurement Techniques, PHI
7. D.V.S. Murthy, Transducer and Instrumentation,
8. Richard M. Crowder, Electric Drives and their Controls
9. Douglas V. Hall, Microprocessors and interfacing programming and Hardware
10. Scot Mackenzie ,The 8051 Microcontrollers

MA-1304: NUMERICAL METHODS AND STATISTICAL TECHNIQUES

L: T: P: Cr = 2:1:0:3

Introduction

This course is one of the basic courses of mathematics for engineering students. There are many problems in science and engineering which cannot be solved exactly. Even when a method exists to solve a problem, it may be too complicated to use the method or in most cases, we may have to add an infinite number of terms. In such situations, we use numerical methods. Many non-linear and complex physical problems can be solved through numerical methods.

Objective

Objective of this course is to make students proficient in some numerical and statistical methods to solve certain types of problems and also to determine the maximum possible error in the numerical solution. The following is the contents of the syllabus:

UNIT-1 Errors in numerical computation, **Algebraic and Transcendental Equations: 8 L**

Errors in numerical computation and their analysis, Bisection method, Iteration method, Newton-Raphson Method, Method of False Position, rate of convergence, Method for complex root, Muller's Method, Quotient Difference method,.

UNIT-2Interpolation: 9 L

Introduction, Errors in Polynomial interpolation, Finite differences, Decision of errors, Newton's formula for interpolation, Gauss, Sterling, Bessel's, Everett's Formula, Interpolation by unevenly spaced points, Lagrange interpolation formula, Divided Difference, Newton's General interpolation Formula.

UNIT-3 Curve Fitting, Cubic Spline & Approximation: 7L

Introduction, Method of Least Square curve fitting procedures, Fitting a straight line, Curve fitting by sum of exponential, Data fitting with cubic splines, Approximation of functions.

UNIT-4 Numerical Integration and Differentiation: 5 L

Introduction, Numerical differentiation, Picard Iteration Method of Solution, Numerical integration, Trapezoidal rule, Simpson 1/3 rule, Simpson 3/8 rule, Booles&Weddles rule, Euler- Maclariaun formula, Gaussian Formula, Numerical evaluation of singular integrals.

UNIT-5 Numerical Linear Algebra: 6 L

Numerical techniques for finding solution of system of linear equations and eigen values: Gauss Jordan, Gauss Seidel methods, Power method for estimating eigen values: LU and LL^* factorization of matrices.

UNIT –6 Statistical Computations: 7 L

Discrete and continuous distribution, of function, Poisson and Normal Distribution, Mean &Variance, Moment Generation Function, linear statistical model, theory of least squares and analysis of variance, least squares estimates, and their precision. Test of significance and interval estimates based on least squares theory in one way, two way and three way classified data, Regression Analysis, Least Square fit, Polynomial fit, Linear and Nonlinear Regression, orthogonal polynomials, discriminate analysis.

Total Lecture Classes- 40 Hrs

Text books and References:

1. C.F.Gerald and P.O.Wheatley, Applied Numerical Analysis, Pearson Education
2. M.K.Jain, S.R.K.Iyenger and R.K.Jain, Numerical Methods for Scientific andEngineering Computation, Wiley Eastern Ltd.
3. S.S Sastry, Introductory Methods of Numerical Analysis, Prentice Hall
4. S.Rajasekharan, Numerical Methods for Science and Engineering, S.Chand.
5. James I. Buchman and Peter R.Turner, Numerical Methods and Analysis, McGraw-Hills Inc

AM-1307: FLUID FLOW OPERATIONS AND HYDRAULIC MACHINES

Credit: 4 **L-T-P: 3-1-0**

Total No. of Lectures: 40

Pre-requisite: None

UNIT-1: Introduction to Fluid Mechanics- Statics and Kinematics (8)

Fluid and continuum, Physical properties of fluids, Types of fluid flows, Rheology of fluids.

Manometers, pressure transducers, pressure on plane and curved surfaces, centre of pressure, fluid masses subjected to linear acceleration and uniform rotation about an axis.

Kinematics of Fluid flow: steadiness, uniformity, rotational and irrotational flows, streamline, streakline, pathline, continuity equation, stream function and velocity potential, applications of potential flow.

UNIT-2: Dynamics of Fluid Flow and Dimensional Analysis (8)

Euler's Equation of motion along a streamline and its integration, Bernoulli's equation and its applications, momentum equation and its application to pipe bends. Flow measurement by Pitot tube, orifice, Venturi, nozzle, and bend meter, rotameter.

Dimensional Analysis, Buckingham's Pi theorem, important dimensionless numbers and their physical significance, geometric, kinematic and dynamic similarity, model studies, Hydraulic similitude.

UNIT-3: Laminar and Turbulent Flows (8)

Equation of motion for laminar flow through pipes, Stokes law, transition from laminar to turbulent flow, types of turbulent flow, isotropic and homogenous turbulence, scale and intensity of turbulence, eddy viscosity, Prandtl's mixing length theory, velocity distribution in turbulent flow over smooth and rough surfaces, resistance to flow, minor losses, pipe in series and parallel, power transmission through a pipe, three reservoir problems and pipe network.

UNIT-4: Hydrodynamic Boundary Layer (8)

Introduction with a historical background, boundary layer, displacement and momentum thickness, boundary layer over a flat plate, Prandtl boundary layer equation, laminar boundary layer, application of momentum equation, turbulent boundary layer, laminar sub-layer, separation and its control, drag and lift, drag on a sphere, 2D cylinder and airfoil, Magnus effect.

UNIT-5: Introduction to Compressible Flow (3)

Thermodynamic processes, continuity equation, work done in an isothermal process and adiabatic process, sonic velocity, Mach number, Mach line, Mach angle and Mach cone, properties a stagnation point, flow through a convergent-divergent nozzle and De Laval nozzle, Normal and oblique shocks, Rayleigh and Fanno flows.

UNIT-6: Introduction to Pumps & Compressors (5)

Pumps: Classifications & applications, losses and efficiencies, work and power input, cavitations and maximum suction lift, specific ad minimum speed, comparison between centrifugal and reciprocating pumps, multistage pumps, pumps in series and parallel.

Compressors: Introduction to Hydroelectric power station and its components, Classification of turbines and pumps, similarity laws and specific speed, efficiency, cavitations.

Text Books and References:

1. Fox, R.W., McDonald, A.T., Introduction to Fluid Mechanics, 7th edition, Wiley India.
2. Ojha, C.S.P., Berndtsson, R., Chandramouli, P.N., Fluid Mechanics and Machinery, OxfordUniversity Press, New Delhi.
3. Majumdar, B., Fluid Mechanics with Laboratory Manual, PHI Learning, New Delhi.
4. Som, S.K. and Biswas G, Introduction of Fluid Mechanics & Fluid Machines, TMH, New Delhi.
5. Mohanty, A.K., Fluid Mechanics, PHI Learning, New Delhi.
6. Shames, I.H., Mechanics of Fluids, McGraw Hill, International Students Edition.
7. Agarwal, S.K., Fluid Mechanics and Machinery, TMH, New Delhi.
8. Rathakrishnan E., Instrumentation, Measurements and Experiments in Fluids, CRC Press, New York.
9. Garde, R.J., Fluid Mechanics through Problems, New Age International Pvt. Ltd, New Delhi.
10. Lal, J., Hydraulic Machines, Metropolitan Book Co. Pvt. Ltd., Delhi.
11. Yahya, S.M., Fans, Blowers & Compressors, New Age International Pvt. Ltd., New Delhi.

ME-1351 COMPUTATIONAL (LAB)

1. Make a program to evaluate a given polynomial $f(x)$ for a given value of x using Horner's Rule.
2. Make a program to find the derivative of a given polynomial $f(x)$ for a given value of x.
3. Make a program to find the roots of a given polynomial $f(x)$ using following methods:
   (i) Bisection method.
   (ii) Method of False Position.
   (iii) Iteration method.
   (iv) Newton-Raphson method.
   (v) Secant method.
   (vi) Muller's method.
   (vii) Lin-Bairstow's method.
   (viii) Quotient-Difference method.
4. Make a program to solve the given set of equations using Gauss-Seidel Iterative method.
5. Make a program to determine the following difference tables for given data points:
   (i) Forward Difference table.
   (ii) Backward Difference table.
   (iii) Central Difference table.
   (iv) Divided Difference table.
6. Make a program to find the interpolation polynomial / interpolation value of $f(x)$ at a specified value for evenly spaced data points using the following methods:
   (i) Newton's Forward and Backward Difference methods.
   (ii) Gauss, Stirling, Bessel's and Everett's methods.
7. Make a program to find the interpolation polynomial / interpolation value of $f(x)$ at a specified value for unevenly spaced data points using the following methods:
   (i) Lagrange Interpolation method
   (ii) Newton's General Interpolation method.
8. Make a program to fit a given polynomial to the given set of data points and to evaluate it at a specified value of x.
9. Make a program to find the n^{th} (n = 1, 2 and 3) derivative of $f(x)$ at a specified value of x for the given set of data points.
10. make a program to find the numerical integration of $f(x)$ at a specified value of x for the given set of data points using the following rules:
    (i) Trapezoidal rule.
    (ii) Simpson 1/3 & Simpson 3/8 rules.
    (iii) Boole's and Weddle's rules.
    (iv) Gaussian formula.

AM-1352: MATERIAL SCIENCE LABORATORY

Credit: 2 **L-T-P: 0-0-3**

Experiment 1: Study of various dislocation models, drawing burgers circuit and finding Burgers vector.

Experiment 2: Study of various unit cells and crystals for,

a) Their geometry and symmetry,
b) Total number of atoms and their arrangement,
c) Effective number of atoms per unit cell,
d) Co-ordination number,
e) Atomic packing efficiency,
f) Determining density,
g) Concept of Miller indices and Inter-planer spacing.

Experiment 3: To study the effect of a surface treatment (Etching) on the strength of glass.

Experiment 4: Heat treatment processes (Annealing, Normalizing, Quenching) and comparison of hardness before & after heat treatment.

Experiment 5: To predict creep characteristic of materials by plotting strain vs. time curves for different loadings.

Experiment 6: Comparative study of microstructures of different given specimens (mild steel, grey C.I., brass, and copper).

Experiment 7: Specimen preparation for micro structural examination by cutting, grinding, polishing and etching of aluminium specimen.

Experiment 8: Fabrication of composite by hand-lay up technique.

Experiment 9: Mechanical testing ofcomposite made by hand-lay up technique in experiment no. 8.

Experiment 10: To study the fatigue behavior of a given sample.

AM-1354: Fluid Flow Operations Laboratory

Credit: 2 **L-T-P: 0-0-3**

Pre-requisite: Fluid Mechanics/ Fluid Flow Operations

1. To verify the momentum equation using the experimental set-up on diffusion of submerged air jet.
2. To study the boundary layer velocity profile over a flat plate and to determine the boundary layer thickness.
3. To study the transition from laminar to turbulent flow and to determine the lower critical Reynolds number.
4. To study the variation of friction factor 'f' for turbulent flow in commercial pipes.
5. To calibrate an orifice meter, venturimeter, and bend meter and study the variation of the co-efficient of discharge with the Reynolds number.
6. To study the impact of jets in a flat plate.
7. To study performance of two Centrifugal pumps connected in series and parallel.
8. To study performance of a Reciprocating pump.

REFERENCES:

1. Singh, S. Experiments in Fluid Mechanics, PHI Learning, New Delhi.
2. Prakash, M.N.S., Experiments in Hydraulics and Hydraulic Machines: Theory and Procedures, PHI Learning, New Delhi.
3. Majumdar, B., Fluid Mechanics with Laboratory Manual, PHI Learning, New Delhi.

CL-1351 MECHANICAL OPERATION (LAB)

1. To study the operation of filter press in the laboratory and to evaluate specific cake resistance and medium resistance.
2. To determine the effect of initial concentration & initial suspension height on sedimentation rates.
3. Size distribution of sand particles using sieve shaker.
4. To study the characteristics of fluidized bed.
5. To study the characteristics of fixed bed.
6. To determine the efficiency of jaw crusher for crushing the material of known index.
7. To study the operation of a hammer mill.
8. To study effect of RPM on the power consumption of a ball mill (Variable speed).
9. To study effect of RPM on the power consumption of a ball mill (Constant speed).
10. To study the drying characteristics of a solid material under batch drying condition.
11. To study the batch settling process.

IV SEMESTER

CH-1401: ORGANIC AND PHYSICAL CHEMISTRY

L: T: P: Cr = 2:1:0:3

REACTIONS AND REAGENTS:
Basic ideas relating to addition, substitutions, elimination, oxidation and reduction reactions - Electrophilic and Nucleophilic.Organometallic compounds- Grignard reagent - Synthesis of different types of compounds like alcohol, aldehyde, acid, amine and organometallic.Acetoacetic ester - tautomerism- Base hydrolysis - Acid hydrolysis - Malonic ester - cyano acetic esters- synthesis of dicarboxylic acids and Unsaturated acids.

CARBOHYDRATES: Carbohydrates - Classification - Reactions of Glucose and fructose- Inter conversion - Ascending and descending of series. Structure of glucose and fructose.Industrial uses of cellulose and starch.

ALICYCYCLIC COMPOUNDS, AROMATIC COMPOUNDS, FATS AND OILS:
Alicyclic Compounds- Nomenclature - synthesis of alicyclic compounds using carbon - acroyloin condensation - Diels Alder reaction Freunds's synthesis - Bayer's strain theory postulates, drawbacks- theory of strainless rings-conformations of cyclohexane. Coal tar distillation, separation of benzene, toluene, phenol and naphthalene-Aromaticity exhibited by these compounds. Fats and oils - Saponification- hydrogenation of oils.

AMINO ACIDS, PROTEINS AND DYES:
Amino acids and proteins- classification -synthesis of amino acids - reactions of carboxyl group and amino group - peptide linkage-endgroup analysis-colour reaction of proteins- denaturation. Dyes-colors and constitution - chromophores and auxochromes- quinine theory and electron theory of dyes- preparation colour and application of azodyes-acidic. basic, mordant, direct azodyes-Triphenylmethane dyes - malachite green, crystal violet, Rosaniline, prosaniline mordant dyes- application. Vat dyes-indigo-synthesis and application.

HETEROCYCLIC COMPOUNDS AND NATURAL PRODUCTS:
Heterocyclic compounds-synthesis and reaction of pyrrole ,furan ,thiophene, pyridine, quinine, isoquinoline and anisole. Alkaloids-Isolation from natural products-colour reaction-structural elucidation of nicotine.Terpenoids-Isolation - Isoprene rule-structural elucidation of citral.

REACTION KINETICS: Law of Mass action. Rate order and molecularity of chemical reactions.Methods for their evaluation.Calculation of rate constants. Consecutive – Parallel and opposing reactions. Chain reactions.Energy of activation - Theories on reaction rates. Heterogeneous reactions - zero order reactions - Catalysis - Theory and applications - Inhibitors - Promotors - enzyme catalysis.

PHASE EQUILIBRIA: Phase rule: Application - to one components system (water, sulphur and carbon dioxide), Two component systems (Eutetic, Intermediate compound formation and solid solutions) and simple three component systems. Solutions: Ideal and non ideal solutions solubility of gases in liquids. Henry's law. Completely miscible liquids - Rauolt's law - vapour pressure and boiling point diagrams. Partially miscible liquids – Critical solution temperature -completely immiscible liquids - Nerns: distribution law – Dilute solution and their colligative properties. Molecular weight determination using these properties.

ELECTRICAL CONDUCTANCE:
Electrolytes - strong electrolytes and weak electrolytes - Arrhenius theory of electrolytic dissociation. Debye - Huckell Onsager theory; Ostwald's dilution law - solubility of electrolytes and solubility product - common ion action - acids, bases - definitions) based on proton transference, dissociation constant, amphoteric electrolyte - pH -Buffer solutions. Salts - water of crystallisation, double salts, complex ions and salts, introduction to co-ordination theory - hydrolysis.

ELECTRODE POTENTIAL: Electrode potential-Hydrogen electrode, reference electrodes, electrochemical series, Faraday's laws of electrolysis. Decomposition potential, over voltage, definitions of current density, current concentration, current efficiency, energy consumption; electrical conductance, oxidation - reduction redox couple; e.m.f. and energy relations. Conductometry, Potentiometry - Their applications.

REFERENCES:

1. K. J. Laidler, "Chemical Kinetics", 3rd Edn., Harper & Row Publishers,1987.I.L. Finar, "Organic Chemistry", (Vol. I & II) 5th Edn., ELBS, London.
2. Morrison and Boyd, "A Text Book of Organic Chemistry", 5th and 6th Edn., Prentice Hall of India.
3. B. R. Puri and SL. R. Sharma, "Principles of Physical Chemistry", ShobanLalNagin Chand & Co.
4. P.L. Soni, "Text Book of Physical Chemistry", S. Chand & Co., New Delhi.

CL- 1401: PROCESS EQUIPMENT DESIGN- I

L: T: P: Cr = 3:1:0:4

Objective

The objective is to impart the basic concepts of material science & to develop an understanding about design of equipments pressure vessel design, and storage tanks.

Introduction

This course deals with the ability of an object to withstand an applied stress without failure, both theory and applications of the fundamental principles of mechanics of materials. Force, stress and deformation are analyzed for various types of loading conditions. The concept of principal stresses and the static failure theories will be applied to safety analysis of structural members. The subject imparts knowledge of simple stresses, strains and deformation in components due to external loads, to assess stresses and deformations through mathematical models.Further, this course also deals with the basic concepts of equipments design such as pressure vessel design, and storage tanks. It builds up an understanding of the impact of manufacturing constraints on product design and process planning.

LESSON PLAN

UNIT-1: Stress & Strain Analysis: 8 L

Stress, Strain, Hook's Law, Elastic Constants, Strain Energy, Statically Indeterminate problems, Thermal Effects, Impact Loading, Stress at a Point, Variation of Stress, Stress Transformation (2-D), Analysis of Strain, Strain displacement relations, Strain transformation, Strain Measurements, Constitutive equations, Simple Bending & Shear Stress.

UNIT-2: General Design Considerations 6 L

Introduction to equipment design, loads, material characteristic and their basis of selection, General design considerations: - Design codes, design pressure, materials, welded joint efficiencies, corrosion allowances, design loads, equipment selection and specification.

UNIT-3: Design of Pressure Vessels: 8 L

Design of cylindrical vessels and different end closures subjected to internal pressure, Stress analysis of support and pressure vessels, Design of supports and various heads, Design of vertical pressure vessels considering the wind factors, seismic factor, etc. Design of cylindrical vessels operating under external pressure.

UNIT-4: Bolted Flanges: 6 L

Types of Flanges, and selection, Gaskets, Design of non-standard flanges, specifications of standard flanges.Fabrication of equipment major fabrication steps; welding, non destructive tests of welded joints, inspection and testing, vessel lining, materials used in fabrication of some selected chemical industries.

UNIT-5: Tall Vertical & Horizontal Vessels: 5L

Pressure dead weight, wind, earthquake and eccentric loads and induced stresses; combined stresses, Shell design of skirt supported vessels. Vessel supports; Design of skirt, lug, and saddle supports

Text books and references:

1. Strength of Materials by Ryder.
2. Mechanics of Materials by Gere and Timosheinko.
3. J. M. Coulson, J. F.Richardson and R. K. Sinnot, Chemical Engineering Design (Vol. 6),(Indian Print), Butterworth-Heinemann.
4. Joshi, M.V. – Process Equipment Design

CL- 1402: HEAT TRANSFER OPERATIONS

L: T: P: Cr = 3:1:0:4

Objective

To understand the principles and applications heat transfer.

Introduction

To learn heat transfer by conduction, convection and radiation and heat transferequipments like evaporator and heat exchanger

LESSON PLAN

UNIT-1: Introduction to Heat Transfer: 4 L

Concept of the mechanism of heat flow: conduction, convection and radiation; effect of temperature on thermal conductivity of materials; introduction to combined heat transfer mechanism.

UNIT-2: Conduction: 10 L

One-dimensional general differential heat conduction equation in rectangular, cylindrical and spherical coordinate system; initial and boundary conditions.Steady state one dimensional heat conduction**:** Composite system in rectangular, cylindrical and spherical coordinates without energy generation; thermal resistance concept; analogy between heat and electrical flow; thermal contact resistance; critical thickness of insulation. Fins of uniform cross sectional area; error of measurement of temperature in thermometer wells, volumetric internal energy generation, solution of 2D steady state problems using relaxation method. Transient Conduction**:** Transient heat conduction with known temperature distribution within the system; lumped heat analysis of transient heat conduction problem, time constant of thermocouples.

UNIT-3: Convective Heat Transfer: 8 L

Newton's Law of Cooling, Types of convective heat transfer, Laminar and Turbulent flows, Hydrodynamic and thermal boundary layers, Navier-Stokes Equation, Non-dimensional numbers, Buckingham Pi Theorem. Forced Convection: Basic concept; hydrodynamic boundary layer; thermal boundary layer; flow over a flat plate; flow across a single cylinder and a sphere; flow inside tubes; empirical heat transfer relations; relation between fluid friction and heat transfer; liquid metal heat transfer. Natural Convection: Physical mechanism of natural convection; buoyant force; empirical heat transfer relations natural convection over vertical planes and a cylinder, horizontal planes and cylinders, and a sphere.

UNIT-4: Thermal Radiation: 4 L

Basic radiation concept; radiation properties of surfaces; black body radiation laws; Kirchhoff's Law, Plank Law and Wien's Displacement Law, view factor concept; view factor determination; black body radiation exchange; radiation exchange between diffuse non black bodies in an enclosure; radiation shields; solar radiations.

UNIT-5: Heat Exchangers: 4 L

Type of heat exchangers; fouling factor; overall heat transfer coefficient; logarithmic mean temperature difference (LMTD) method; effectiveness-NTU method; compact heat exchangers.

UNIT-6: Condensation and Boiling: 6 L

Introduction to condensation phenomena; heat transfer relations for laminar film condensation over vertical surfaces and a horizontal tube; pool boiling.

Text Books and References:

1. Elements of Heat Transfer by Bayazitouglu and Ozisik, McGraw Hill Book Company.
2. Heat Transfer by J.P.Holman, McGraw Hill Book Company.
3. Principles of Heat Transfer by F. Kreith, and S.B. Marks, A.B.Pvt. Ltd.
4. Fundamentals of Heat Transfer by F.P Incorpera and P.D.Dewitt, John Wiley and Sons, V Ed.

CL- 1403: MASS TRANSFER – I

L: T: P: Cr = 3:1:0:4

Objective

To impart knowledge on fundamentals of mass transfer phenomena on molecular level and apply on the Chemical Engineering unit operations concerned with the problem of changing the composition of solution.

Introduction

Students will learn to determine mass transfer rates under laminar and turbulent conditions and apply these concepts in the design of absorption,adsorption, humidification columns and dryers.

LESSON PLAN

UNIT-1: Diffusion: 6 L

Fick's Law of diffusion, Molecular and Eddy diffusion, Measurement and calculation of diffusivities in gas and liquids, Diffusion in solids, Analogy between mass, momentum and heat transfer.

UNIT-2: Inter-phase Mass Transfer: 6 L

Mass transfer coefficients and their correlations, Theories of mass transfer: Film theory, two film theory, Penetration and surface removal models.

Mass transfer equipments: Batch and continuous stage wise contactors- Differential contactors

UNIT-3: Gas Absorption and Stripping: 8 L

Principle of gas absorption, Choice of packing and solvent, Gas-Liquid Equilibria, Tray column: graphical and analytical method, Design of packed towers: contacts between gas and liquid, pressure drop and limiting flow rates, HTU, NTU, HETP concepts for calculation of height of packed column, diameter of packed column, Absorption with chemical reaction.

UNIT-4: Adsorption: 8 L

Principle and types of adsorption, Nature of adsorbents, Adsorption equilibria: adsorption isotherms, Stagewise and continuous contact operations, UnsteadyState: Fixed-Bed absorbers, Adsorption equipments, Ion Exchange.

UNIT-5: Humidification: 7 L

Vapor – liquid equilibria, Enthalpy for pure substances, Definition and derivations related with humidity, adiabatic gas-liquid contact operation, Classification of design of cooling towers, Dehumidification operation.

UNIT-6: Drying: 5 L

Solid-gas equilibria, Different modes of drying operations, Definition of moisture, Mechanism and rate of batch and continuous drying, Batch and continuous driers.

Text books and references:

1. R.E.Treybal, "Mass Transfer Operations", McGraw Hill Book Co., New York.
2. W.L. McCabe, J.C. Smith and P. Harriot, "Unit Operations of Chemical Engineering", McGraw Hill Book Co., New York.
3. J.M. Coulson and J.F. Richardson, "Chemical Engineering", Vol. I, II, III, Pergamon Press, Newyork.

CL-1404: CHEMICAL TECHNOLOGY-I

L: T: P: Cr = 3:0:0:3

Objectives

To impart the knowledge on unit processes and unit operations involved in the large scale manufacture of different chemical industries.

Introduction

This course provide a detailed understanding of manufacturing of various inorganic compounds and the related industries such as chloro-alkali, acids, cement and glass, gases and industrial water treatment, paints and fertilizers.

LESSON PLAN

UNIT -1: **6 L**

Chlor-alkali Industries: Manufacture of Soda ash, Manufacture of caustic soda and chlorine - common salt.

UNIT -2: **6 L**

Sulphur and Sulphuric acid: Mining of sulphur and manufacture of sulphuric acid. Manufacture of hydrochloric acid.

UNIT -3: **6 L**

Cement: Types and Manufacture of Portland cement, Glass: Manufacture of glasses and special glasses. Ceramics: Refractories.

UNIT -4: **7 L**

Industrial Gases: Carbon dioxide, Nitrogen, Hydrogen, Oxygen and Acetylene - Water Treatment: Industrial waste water treatment.

UNIT -5: **5 L**

Manufacture of paints and Pigments.

UNIT-6: **8 L**

Nitrogen Fertilizers: Synthetic Ammonia, Nitric Acid, Urea, Ammonium Chloride, CAN, Ammonium Sulphate - Phosphorous Fertilizers: Phosphate rock, phosphoric acid, Super phosphate and Triple Super phosphate, MAP, DAP. Potassium Fertilizers: Potassium chloride and Potassium sulphate.

Text books and references:

1. G.T.Austin, "Shreve's Chemical Process Industries", McGraw Hill Book Co., New York.
2. R.GopalRao, "Dryden's Outlines of Chemical Technology", Affiliated East-West Publishers.

CL -1405 CHEMICAL PROCESS PRINCIPLES

L: T: P: Cr = 3:1:0:4

Objective

The objective of this course is to give fundamental knowledge on material and energy balances in various chemical processes.

Introduction

To deliver concepts and techniques of contemporary chemical, petroleum and environmental engineering processes. Throughout, the course introduces efficient and consistent methods for analyzing material and energy balance problems, organizing solutions, and calculating answers. This subject provides knowledge of the behavior of gases, liquids, and solids: ideal/real gases, single component two-phase systems, gas-liquid systems, and more.

LESSON PLAN

UNIT-1: Stoichiometry: 4 L

Introduction- Units and Dimensions – Stochiometric Principles, Composition Relations, density and specific gravity.

UNIT-2: Ideal Gases and Vapor Pressure: 7 L

Behaviors of Ideal gases -kinetic theory of gases - application of ideal gas law- gaseous mixtures - volume changes with change in composition. Vapor pressure- effect of Temperature on vapor pressure, vapor pressure plots vapor pressure of immiscible liquids-solutions.

UNIT-3: Humidity and Solubility: 6 L

Humidity, saturation, vaporization, condensation, wet and dry bulb thermometry, Solubility and Crystallization, Dissolution, solubility of gases.

UNIT-4: Material Balance: 8 L

Material balances for systems with and without chemical reactions, species and elemental balance, Analysis of systems with by-pass, recycle and purge

UNIT-5: Energy Balance: 7 L

Energy Balance, Heat capacity of gases, liquids and solutions, Heat of fusion and vaporization, Steady state energy balance for systems with and without chemical reactions, Calculations and application of heat of reaction, combustion, formation, neutralization and solution. Enthalpy-concentration charts, Combustion of solids, liquids and gaseous fuels, Calculation of theoretical and actual flame temperatures.

UNIT-6: Simultaneous balances: 6 L

Problems related to simultaneous steady state energy and material balance, unsteady and material balance, simultaneous material and energy balance and its application in process industries.

Text books and references:

1. O.A.Hougen, K. M. Watson and R. A. Ragatz, "Chemical Process Principles", Vol-I, CBS Publishers and Distributors, New Delhi.
2. D. Himmelblau, "'Basic Principles and Calculations in Chemical Engineering", 5th Edn., Prentice Hall of India Ltd.,N.Delhi.
3. B.I.Bhatt and S.M.Vora, "Stoichiometry", Tata McGraw Hill Publishers Ltd., New Delhi.
4. V.Venkataramani and N.Anantharaman, "Process Calculations", Prentice Hall of India Ltd., NewDelhi.

CH-1451 ORGANIC AND PHYSICAL CHEMISRTY (LAB)

1. Preparation & Physical Characterization of organic compounds.
2. Identification of functional groups of organic molecules.
3. Preparation of derivative of the functional groups
   (a) Preparation of p- Nitro acetanilide from acetanilide (Nitration)
   (b) Preparation of acetanilide from aniline (Acetylation)
4. Microwave synthesis of Aspirin-A green chemistry experiment.
5. Wet chemical method for the identification of organic dyes Malachite green, Rosaniline and Indigo.
6. Preparation of buffer solution (AcOH&AcONa) of specific pH and its verification By pH- metry.
7. Determination of distribution (partition) coefficient of I_2 between CCL_4 and water.
8. Kinetic study of hydrolysis of ethyl acetate by volumetric titration method.
9. Verification of Kohlrausch'sIst law for strong electrolytes using conductometric measurement.
10. Verification of Ostwald's dilution law for week electrolytes using conductometric measurement.
11. Determination of the strength of a strong acid by strong base using condctometric titration.
12. Determination of sodium & Potassium by flame photometry.
13. To carry out the proximate analysis of a given sample of fuel.

CL-1451 HEAT TRANSFER (LAB)

1. To determine the thermal conductivity of metal bar.
2. To determine Heat transfer through composite wall.
3. To determine the thermal conductivity of insulating powder.
4. To plot the radial temperature distribution and to determine the thermal conductivity of pipe insulation.
5. To determine the variation of temperature along the length of pin fin under forced convection.
6. To determine the convective heat transfer coefficient for heated vertical cylinder loosing heat to the ambient by free or natural convection.
7. To determine the convective heat transfer coefficient for a horizontal pipe through which air flows under forced convection.
8. To determine the Emmisivity of a grey surface at different temperatures.
9. To determine the value of Stefan Boltzmann constant for radiation heat transfer.
10. To study the condensation phenomenon and to determine overall heat transfer coefficient.
11. To conduct test on a heat pipe and compare the temperature distribution and rate of heat transfer with geometrically similar copper and stainless steel tubes.
12. To study the Shell and Tube Heat Exchanger.

CL-1452 MASS TRANSFER (LAB – I)

1. To determine the vapor liquid equilibrium curve for CCL_4 and toluene or any other mixture.
2. Determination of drying rate and to plot moisture lost with time under for different operating conditions.
3. To determine overall mass transfer co-efficient based on continuous & dispersed phase.
4. To determine individual height of transfer unit based on continuous & dispersed phase.
5. To determine the number of transfer units, height of transfer unit and overall mass transfer co-efficient for the given system.
6. To study the fluidized bed drying.
7. To obtain the breakthrough curve and hence length of unused bed for the given adsorption system.
8. Determination of the diffusion co-efficient of an organic vapor (naphthalene) in air.
9. To study working and operation of the cooling tower operation
10. To measure mass transfer coefficient in extraction column and its variation with flow rate of organic phase (continuous medium)
11. To determine flooding characteristics of packed bed absorption column using Roschig Rings as packing material.

V SEMESTER

CL 1501: CHEMICAL REACTION ENGINEERING-I

L: T: P: Cr = 3:1:0:4

Objective

The objective is to enable understanding of engineering activity concerned with the exploitation of Homogeneous chemical reactions on a commercial scale.

Introduction

Chemical reaction engineering is at the heart of virtually every chemical process. It separates the chemical engineer from other engineers. This field studies the rates and mechanisms of chemical reactions and the design of the reactors in which they take place. The fundamental reactions are the origin of the variety of catalytic processes in homogeneous medium. This course applies the concepts of reaction rate, stoichiometry and equilibrium to the analysis of chemical reacting systems. Derivation of rate expressions from reaction mechanisms and equilibrium or steady state assumptions for homogeneous reactions are taken into account.

LESSON PLAN

UNIT-1: Introduction and Basics of Kinetics **4 L**

Introduction, Kinetics of homogeneous reactions: Concentration dependent & Temperature dependent term of rate equation, searching for a mechanism,

UNIT-2: Analysis of Batch Reactor Data **6 L**

Constant-volume batch reactor, Varying-volume batch reactor, temperature and rate equation, the search for a rate equation.

UNIT-3: Design of Ideal Reactor for a Single Reaction **10 L**

Introduction to ideal reactors for a single reaction, Ideal batch reactor, Ideal Steady-state mixed flow reactor, and steady-state plug flow reactor. Size comparison of single reactors, multiple reactor systems, Recycle reactor, Autocatalytic reactor.

UNIT-4: Design of Reactor for Multiple Reactions **9 L**

Design for multiple Reactions: Reactions in parallel, reactions in series, and series - parallel reactions.

UNIT-5: Heat Effects **4 L**

Temperature and pressure effects on single and multiple reactions.

UNIT-6: Flow Behavior of Reactors **9 L**

Non-ideal flow: Residence time distribution studies: C, E, and F curves, conversion calculations directly from tracer studies. Models for non-ideal flow: one parameter models- tank-in series and dispersion models, multi-parameter models.

Text books and references:

1. O. Levenspiel, "Chemical Reaction Engineering", Wiley Easter Ltd., New York.
2. H. Scott Fogler, “Elements of Chemical Reaction Engineering”, PHI.
3. M. Davis and R. Davis, “Fundamental of Chemical Reaction Engineering”,McCraw Hill, New York.
4. J.M.Smith, "Chemical Engineering Kinetics", McCraw Hill, New York.

CL1502: MASS TRANSFER- II

L: T: P: Cr = 3:1:0:4

Objectives

The objective is to learn the mass transfer operations, where the composition of the separated substances changes without involving chemical reactions.

Introduction

The major part of the cost of a process is that for separations. These separation costs depend directly upon the ratio of final to initial concentration of the separated substances. Students will learn Fundamentals of distillation column, extraction and leaching and crystallization operations and equipments.

LESSON PLAN

UNIT-1: Distillation 4 L

Vapor- Liquid Equilibria: Pressure-Temperature- concentration phase diagram, Enthalpy-concentration diagrams for ideal and non-ideal solutions, Raoults law and its applications, concept of Relative volatility, Maximum and minimum boiling mixtures.

UNIT-2: Single Stage Distillation 4 L

Flash vaporization of a binary mixture, Differential or Simple Distillation of a binary mixture, Steam distillation, Principles of azeotropic and extractive distillations.

UNIT-3: Continuous Distillation of Binary Mixtures 8 L

Fractionating column: Combination of rectification and stripping, Rectification on an ideal plate, Characteristics of multistage (Tray) tower; McCabe Thiele method, PonchonSavarit method, Reflux Ratio: Condenser and top plate; total (Infinite) reflux ratio, minimum and optimum reflux ratio, Bottom plate and reboiler, Use of open steam, Tray efficiency, Determination of height and column diameter, Bubble cap tray, sieve tray, valve tray and packed columns.

Introduction to multi-component distillation system, multistage batch distillation,

UNIT-4: Liquid - Liquid Extraction 8 L

Principles of extraction: Ternary liquid equilibria, Triangular graphical representation concept of theoretical or ideal stage, Equipment used: Mixer settlers, plate column, spray and packed column, rotating disk contactor, sieve tray column.

Single stage operation, multistage continuous operation: co-current operation and cross current operation, Stage calculation, Analytical and graphical solution of single and multistage operation, Systems with complete immiscibility.

UNIT-5: Solid - Liquid Extraction 8 L

Leaching, Solid liquid equilibrium diagram, constant and variable underflow, Batch and continuous operations: Single and multistage cross current and counter current operations, number of equilibrium stages, Equipments: percolation tank, agitated vessel, thinkers, classifiers, continuous counter current decantation.

UNIT-6: Crystallization 8 L

Theories of crystallization, Nucleation & crystal growth rate, Controlled growth of crystals, Equilibrium yield of crystallization, Heat and mass transfer rates in crystallization, Classification and design of Industrial crystallizers.

Text books and references:

1. R.E. Treybal, "Mass Transfer Operations", McGraw Hill Book Co., New York.
2. W.L.McCabe, J.C.Smith and P.Harriot, "Unit Operations of Chemical Engineering", McGraw Hill Book Co., New York.
3. C. J. Geankopolis, "Transport Processes in Chemical Operations", Prentice Hall of India, New Delhi.
4. M. Coulson and J: F. Richardson, "Chemical Engineering", Vol - II, Pergamon Press, New York.

CL1503: PROCESS DYNAMICS AND CONTROL

L: T: P: Cr = 3:1:0:4

Objective

The objective is to learn the scientific and engineering principles underlying process control systems.

Introduction

This course aims into applying and integrating knowledge of chemical engineering to identify, formulate and solve process control problems. It develops an insight into chemical process control problems and makes familiar with industrial control systems. This course will cover the theory underlining the practice of process control and its applications in the chemical processing industry. It will take into account the basic characteristics of first order and higher order processes, the characteristics of various controller modes and methods of tuning of controller, various complex control schemes, characteristics and application of control valves.

LESSON PLAN

UNIT-1:INTRODUCTION **4 L**

Introduction to process variables, static & dynamic characteristics of instruments and their general classification, Elements of measuring systems and their function, signal transmission, transmitters-electronic, pneumatic etc.

UNIT-2: FIRST ORDER SYSTEMS **9 L**

General Concepts, Examples of role of process dynamics and control, background, Laws and language of process control, Introduction to Laplace Transform and its application in process control.Linear open loop systems - First order and Linearized first order systems - Response tovariousdisturbances.

UNIT-3: HIGHER ORDER SYSTEMS **7 L**

First order in series - Higher order systems - Response to various disturbances.

UNIT-4: BLOCK DIAGRAM **8 L**

Controls - Block Diagram - closed loop transfer function –Transient response- Simple alarm Modes of control and controller characteristics.

UNIT-5: STABILITY ANALYSIS **5 L**

Stability - Routh analysis - Frequency response – Control system design - Controller tuning. Root locus, Nyquist plot, Bode plot.

UNIT-6: SPECIAL CONTROLS **6 L**

Cascade - feed forward and ratio control - dead time compensation - Internal Model Control - Control valves - Process identification.

Text books and references:

1. S. Sundaram and T. K. Radhakrishnan, "Process Dynamics and Control", Ahuja Publishers.
2. D. P. Coughnowr, "Process Systems Analysis and Control", McGraw Hill, New York.
3. C. A. Smith and A. B. Corripio, "Principles and Practice of Automatic Process Control", Wiley, New York.
4. P. Harriot, "Process Control", Tata McGraw Hill, New Delhi.
5. D.P. Eckman, "Industrial Instrumentation", Wiley Eastern Ltd., New York.
6. D.P. Eckman, "Automatic Process Control", Wiley Eastern Ltd., New Delhi.

CL-1504: CHEMICAL TECHNOLOGY – II

L: T: P: Cr = 3:0:0:3

Objectives
To impart the knowledge of various chemical industries.

Introduction
This course provide a detailed understanding of manufacturing of various inorganic compounds and the related industries such as pulp and paper, sugar, oil, petrochemical, polymer, fiber, Foam and rubber.

LESSON PLAN

UNIT-1: Natural Products Processing: 6 L
Production of pulp, paper and rayon. Manufacture of sugar, starch and starch derivatives, Gasification of coal and chemicals from coal.

UNIT-2: Industrial Microbial Processes and Edible Oils: 5 L
Fermentation processes for the production of ethyl alcohol, citric acid and antibiotics, Refining of edible oils and fats, fatty acids, Soaps and detergents.

UNIT-3: Petroleum Refining and Petrochemical Precursors: 8 L
Petroleum refining to produce naphtha, fuel hydrocarbons and lubricants. Processes for the production of petrochemical precursors: ethylene, propylene, butadiene, acetylene, synthetic gas, benzene, toluene and xylene, (Cracking, Catalytic reforming and separation of products)

UNIT-4: Polymer Based Industries and Their Characteristics: 6 L
Plastics: Production of thermoplastic and thermosetting resins such as polyethylene, polypropylene, phenolic resins and epoxy resins; Polymers and their applications in engineering practice.

UNIT-5: Fiber Forming and Elastomeric Polymers: 5 L
Synthetic fibers: polyamides, polyesters and acrylics from monomers, Processes for the production of natural and synthetic rubbers, electro-spinning of nano-fibres.

UNIT-6: Sugar Technology 6 L
Sugar technology: introduction, manufacture of sugar (from sugar cane), manufacture of white sugar (sulphitation process, carbonation process), evaporation section, beet sugar.

Text books and references:

1. G.T. Austin, “Shreve’s Chemical Process Industries", Mcgraw Hill Book Co., NewYork.
2. R. GopalRao and M. Sittig, “Dryden’s Outline of Chemical Technology", Affiliated East-West Publishers.

CL -1505:CHEMICAL ENGINEERING THERMODYNAMICS

L: T: P: Cr = 3:1:0:4

Objectives

To present thermodynamic principles from a chemical engineering viewpoint.

Introduction

Students will learn laws of thermodynamics, thermodynamicproperty relations and the behavior of fluids under PVT conditions, theory and application of solution thermodynamics and chemical reaction equilibrium, compression and refrigerationprocesses.

LESSON PLAN

UNIT-1: Fundamentals and Law of Thermodynamics: 8 L

Terminologies of thermodynamics, variables and quantities of thermodynamics, Point and path properties, heat and work, reversible and irreversible processes, phase rule, First law and internal energy, statements of first law for the non flow and flow systems, enthalpy and heat capacity limitations of the first law, Statements of the second law of thermodynamics, available and unavailable energies, entropy function, applications of the second law. Zeroth law of thermodynamics

UNIT-2: Thermodynamic Properties of Real Gases: 8 L

The PVT behavior of fluids, laws of corresponding states and equation of states approaches to the PVT relationships of non ideal gas problems, compressibility factors, generalized equations of state, property estimation via generalized equation of state, fugacity and fugacity coefficients of real gases.

UNIT-3Thermodynamics of Solutions: 6 L

Ideal and non-ideal solution, Concept of Fugacity and Fugacity coefficient, Fugacity and Activity Coefficient Modes, Solid-liquid equilibrium, solubility of gases in liquids, Liquid-liquid equilibrium

UNIT-4: Chemical Reaction Equilibrium: 8 L

Heat effects, industrial reactions (NH_3 synthesis etc), free energy calculations, Homogeneous and heterogeneous reaction systems, multiple reactions, Work of separation, Evaluation of Properties. Phase Equilibrium, Pure component and mixtures, Latent Heat correlation Van Laar, Margules' equation, Gibbs'-Duhem equation, Maxwell equation, consistency tests, multi-component phase equilibrium, partially miscible and immiscible systems, Azeotropes, retrograde condensation, thermodynamic diagram.

UNIT-5: Thermodynamics of Chemical and living system: 9 L

Gibbs free energy –properties, applications, Thermodynamics of oxidation-reduction reactions, Degree of reduction concepts, available electron balances; yield coefficients, Oxygen consumption and heat evolution in aerobic cultures, Effect of temperature on U, H and entropy (S), Energetic of Metabolic Pathways; Energy Coupling (ATP & NADH), Structure and properties of ATP and other energy currencies.

UNIT-6: Compression and Refrigeration Cycle: 5 L

Thermodynamic aspects of compression process, classification of compression processes, basic equation for change of state of gases, the work expression for different situations, the effect of clearance volume, multistage compression, convergent divergent flow, Ejectors. Definitions of refrigeration, Reverse Carnot cycle, Vapor compression and vapor absorption cycle, Gas refrigeration.

Text books and references:

1. J. M. Smith and Van Ness, "Introduction to Chemical Engineering Thermodynamics", McGraw Hill, New York.
2. Rao. Y.V.C. "Chemical Engineering Thermodynamics", Universities Press.
3. S. Sundaram, "Chemical Engineering Thermodynamics", Ahuja Publishers, Delhi.
4. B.F. Dodge, "Chemical Engineering Thermodynamics", McGraw Hill, New York.
5. S.I. Sandler, "Chemical and Engineering Thermodynamics, Wiley.
6. Bioprocess Engineering Principles, .Doaran, P.M, Academic Press.
7. Biochemical Engg. Fundamentals, Bailey &Olis, MGH.
8. Kinetics and Energetic in Biotechnology, Roels J.A, Elsevier.
9. Biological Thermodynamics, Donald T Haynie.

HS 1501: PRINCIPLES OF MANAGEMENT

L: T: P: Cr = 3:0:0:3

Introduction: The emphasis on teaching of Humanities and Social Sciences for the overall intellectual and social development of the students of technology is an important feature of the undergraduate curriculum at MNNIT, Allahabad. This education intends to expand the students' horizon of knowledge by exposing them to areas of study which make them sensitive to a wide range of human problems and social phenomena. Such a holistic education, it is hoped, would enable them to appreciate their role in national reconstruction by responding to the challenges of the time.

Objective: Knowledge on the principles of management is essential for all kinds of people in all kinds of organizations. After studying this course, students will be able to have a clear understanding of the managerial functions like planning, organizing, staffing, leading and controlling. Students will also gain some basic knowledge on international aspect of management.

Unit I: Introduction to Management: **5L**

Definition of Management – Science or Art – Management and Administration, Functions of Management – Types of Business Organization. Levels of management and Managerial skills

Unit II: School of Management Thoughts: **6L**

Evolution of Management thoughts, classical approach, neo- classical approach, contribution of Taylor, Weber and Fayol, modern approach.

Unit III: **8L**

Planning Nature & Purpose – Steps involved in Planning ,Objectives, Setting Objectives, Process of Managing by Objectives,Strategies, Policies & Planning Premises Forecasting Decision-making.

Unit IV: **11L**

OrganisingNature and Purpose – Formal and informal organization – Organization Chart – Structure and Process – Departmentation by difference strategies – Line and Staff authority – Benefits and Limitations – De-Centralization and Delegation of Authority – Staffing – Selection Process - Techniques – HRD – Managerial Effectiveness.

Directing: Scope – Human Factors – Creativity and Innovation – Harmonizing Objectives – Leadership – Types of Leadership Motivation – Hierarchy of needs – Motivation theories – Motivational Techniques – Job Enrichment – Communication – Process of Communication – Barriers and Breakdown – Effective Communication – Electronic media in Communication.

Unit V: Controlling: **5L**

System and process of Controlling – Requirements for effective control – The Budget as Control Technique – Information Technology in Controlling – Use of computers in handling the information – Productivity – Problems and Management – Control of Overall Performance ; Coordination.

Unit-VI: **5L**

Organizational Behavior: Organizational change, Conflict Management and Stress Management.

Functional management: Human Resource Management, Financial management, marketing Management.

REFERENCES:

1 Tripathy PC And Reddy PN, "Principles of Management", Tata McGraw-Hill.

2. Decenzo David, Robbin Stephen A, "Personnel and Human Reasons Management", Prentice Hall of India.

3. JAF Stomer, Freeman R. E and Daniel R Gilbert, "Management", Pearson Education, Sixth Edition.

4. Fraidoon Mazda, "Engineering Management", Addison Wesley.

5. Harold Kooritz& Heinz Weihrich "Essentials of Management", Tata McGraw-Hill.

6. Joseph L Massie "Essentials of Management", Prentice Hall of India, (Pearson) Fourth Edition.

CL-1551 MASS TRANSFER (LAB – II)

1. To study the effect of the dispersed phase flow rate on overall volumetric mass transfer co-efficient.
2. To study the effect of various system parameters like, solvent temperature, solvent rate and particle size on the %age recovery of oil from solid.
3. To estimate the batch distillation curves for a binary system and verify the binary batch distillation equation for a known packed height.
4. To determine overall mass transfer co-efficient based on continuous & dispersed phase.
5. To study the characteristics and efficiency of steam distillation.
6. To study the effect of temperature on diffusion co-efficient.
7. To study the effect of the dispersed phase flow rate on overall volumetric mass transfer co-efficient.
8. To study dispersed phase hold-up study.
9. To study the performance of Bubble cap distillation column.
10. To determine exchange capacity of ion exchange resins in softening of water in an ion exchange column.
11. To find out crystal yield in batch crystallizer.

CL-1552 CHEMICAL REACTION ENGINEERING (LAB – I)

1. To study the kinetics and determine the reaction rate constant (k) for the given saponification reaction in a Batch Reactor at fixed temperature.
2. To determine the effect of temperature on rate constant (k) of saponification in a Batch Reactor.
3. To study the kinetics and determine the reaction rate constant (k) for the given esterification reaction in Batch Reactor at fixed temperature.
4. To determine the effect of temperature on rate constant (k) of esterification reaction in a Batch Reactor.
5. To study the kinetics and determine the reaction rate constant (k) for the given saponification reaction in a Single CSTR at fixed temperature.
6. To determine the effect of temperature on rate constant (k) of saponification in a Single CSTR.
7. To study the kinetics and determine the reaction rate constant (k) for the given esterification reaction in Single CSTR at fixed temperature.
8. To determine the effect of temperature on rate constant (k) of esterification reaction in a Single CSTR.
9. To study the kinetics and determine the reaction rate constant (k) for the given saponification reaction in a Plug Flow Reactor at fixed temperature.
10. To determine the effect of temperature on rate constant (k) of saponification in a Plug Flow Reactor.
11. To study the kinetics and determine the reaction rate constant (k) for the given esterification reaction in a Plug Flow Reactor at fixed temperature.
12. To determine the effect of temperature on rate constant (k) of esterification reaction in a Plug Flow Reactor.
13. To study the kinetics and determine the reaction rate constant (k) for the given saponification reaction in a Semi Batch Reactor at fixed temperature.
14. To determine the effect of temperature on rate constant (k) of saponification in a Semi Batch Reactor.
15. To study the kinetics and determine the reaction rate constant (k) for the given saponification reaction in a Coiled Type Plug Flow Reactor at fixed temperature.
16. To determine the effect of temperature on rate constant (k) of saponification in a Coiled Type Plug Flow Reactor.

CL-1553 PROCESS DYNAMICS & CONTROL (LAB)

1. To study the dynamic response of liquid level in two tank interacting liquid level system.
2. To study the dynamic response of liquid level in two tank non-interacting liquid level system.
3. To study of current to pressure (I to P) and pressure to current (P to I) converter.
4. To study the dynamic behavior of a first order system.
5. To study the characteristics and working principle of the RF-capacitance type level transmitter.
6. To study the characteristics and working principle of the differential pressure transmitter.
7. To study the characteristics and working principle of the current to pressure converter and control valve.
8. To study the performance of cascade controller.
9. To study the performance of on-off/P/PI/PID controllers on level process.
10. To study the performance of on-off/ P/PI/PD/PID controllers on flow process.
11. Study of control valve characteristics .
12. Study of U-tube manometer.

CL-1601: ADVANCE SEPARATION PROCESSES

L: T: P: Cr = 3:1:0:4

OBJECTIVE

To impart the knowledge of advance separation techniques.

INTRODUCTION

Students will learn the advances in various separation techniques, membrane separation, advance adsorption, chromatography, Thermal separation, adductive and extractivecrystallization and foam separation.

UNIT-1: MEMBRANE SEPARATION PROCESSES: 15 L

Principle,Classification, structure & characteristics of membranes; Membrane modules and application; Reverse osmosis, ultrafiltration,micro-filtration, nano-filtration, dialysis; Analysis and modeling of membrane separation processes gas separation and pervaporation processes; Ion selective membranes and their application in electro-dialysis, Liquid membranes; Membrane Reactors.

UNIT-2: ADSORPTION TECHNIQUE: 8 L

Adsorbents-Molecular sieves; Single component adsorption equilibrium and multi component adsorption equilibrium calculation, Langmuir, BET and Gibbs isotherms; Pressure and temperature swing adsorption techniques.

Parametric Pumping: Batch, continuous and semi-continuous pumping; thermal, pH and heatless parametric pumping.

UNIT-3: CROMATOGRAPHY SEPARATION: 5 L

Principle, classification and techniques of chromatography, Chromatographic column, Development of gradient-elution separations, Equipment and commercial processes.

UNIT-4: THERMAL SEPARATION: 4 L

Thermal Diffusion: Basic rate law, Theory of thermal Diffusion Phenomena for gas and liquid mixtures. Equipments design and Applications, Zone Melting: Equilibrium diagrams.

UNIT-5: ADDUCTIVE AND EXTRACTIVE CRYSTALLIZATION: 4 L

Molecular addition compounds, Clathrate compounds and Adducts; Equipments; Applications.

UNIT-6: FOAM AND BUBBLE SEPARATION: 4 L

Principle, Classification and separation techniques, Surface Adsorption; Nature of foams; Apparatus, Applications and Controlling factors.

Books:

1. H. M. Schoen, “New Chemical Engineering Separation Techniques", Inter Science Publications New York.
2. C. Loeb and R. E. Lacey, "Industrial Processing with Membranes", Wiley Inter Science.
3. J. M. Coulson and J. F. Richardson, "Chemical Engineering", Vol.-2, Butterworth - Heinemann London.
4. J. D. Seader, E. J. Henley, Separation Process Principles, John wiley& Sons Inc,
5. K. Sattler, H. J. Feindt, “Thermal Separation Process”, VCH
6.John J. Mketta,Unit operation Handbook (vol-1, MassTransfer),CRC Press.
7.Ronald W. Rousseau, “Handbook of separation Process Technology”, Wiley-India.

CL 1602: TRANSPORT PHENOMENA

L: T: P: Cr = 3:1:0:4

Objectives

To provide an overview of mass, momentum and energy transport phenomena.

Introduction

This course provides knowledge about applying balance equations on fundamental quantities mass, momentum and energy transport at molecular, microscopic and macroscopic level, and to determine velocity, temperature and concentration profiles.

LESSON PLAN

UNIT-1: Laminar Flow: 6 L

Viscosity and the Mechanisms of Momentum Transport**,** Velocity distribution in Laminar flow - Shell momentum balances -Flow through tubes, surfaces, Flow of non-Newtonian fluids.

UNIT-2: Equation of Motion: 10L

Vector and tensor, Equation of change for isothermal process – One dimensional equation of motion and continuity - Euler and Navier - Stokes equation, Dimensional analysis of equation of change.

UNIT-3: Turbulent Flow: 6 L

Velocity distribution in turbulent flow - Semi empirical expressions for Reynolds stress, Inter-phase transport in isothermal system - Ergun's equation.

UNIT-4: Heat Transfer Analysis: 6 L

Thermal Conductivity and Mechanisms of energy transport,Temperature distribution in solids and fluids in laminar flow - Equations of change for multi component systems.

UNIT-5: Mass Transfer Analysis: 6 L

Diffusivityand the mechanism of Mass Transport, Concentration distribution in solids and in fluids, laminar flow - Equations of change for multi component systems.

UNIT-6: Computational Fluid Dynamics 4 L

Introduction, applications and software

Text books and references:

1. J.L. Stuart., 'Transport Phenomena", John Wiley, New York.
2. R. B. Bird, W. Stewart and E. N. Lightfoot, "Transport Phenomena", Wiley, New York.
3. C. J. Geankopolis, "Transport Processes in Chemical Operations", Prentice Hall of India, New Delhi.

CL-1603: ENVIRONMENTAL POLLUTION MONITORING AND CONTROL

L: T: P: Cr = 3:1:0:4

Objective

The aim of this course is to create awareness in every engineering graduate about the importance of environment, the effect of technology on the environment and ecological balance and make them sensitive to the environment problems in every professional endeavour that they participates.

Introduction

At the end of this course the student is expected to understand what constitutes the environment, what are precious resources in the environment, how to conserve these resources, what is the role of a human being in maintaining a clean and useful environment for the future generations and how to maintain ecological balance and preserve bio-diversity.The role of government and non-government organization in environment managements.

LESSON PLAN

UNIT-1: INTRODUCTION 6 L

Ecology & Environment, Biodiversity, Interaction of man and environment, Overall picture of environmental pollution, Ambient air and water quality criteria, Standards and Acts-Indian, EPA& EURO, Effects and control of noise, thermal and radioactive pollution.

UNIT-2: AIR POLLUTION 10 L

Types of pollutants – Natural and manmade air pollutants, Dispersion of pollutant in the atmosphere, Gaussian dispersion model, Meteorological factors, Stability and inversion of atmosphere, Plume behaviour, Control of air pollution from stationary and mobile sources, Methods of measuring and sampling of gaseous and particulate pollutants in ambient air and industrial waste gases, measurement of smoke density and visibility. Control of gaseous pollutants - SOx, NOx, H_2S, VOCS, Auto exhaust.

Stack design, Classification, selection and design of equipment's like cyclones, electrostatic precipitators, bag filters, wet scrubbers, settling chambers.

UNIT-3: WATER POLLUTION 10 L

Waste water characteristics – Physical and chemical composition, Biochemical oxygen demand (BOD), Pathogenic bacteria and chemical toxicity. Types of pollutants in waste water of chemical industries, Methods of sampling, preservation of samples and analysis. Methods for the treatment of liquid wastes to control pollution, Classification viz. physical, chemical and biological methods, Selection and design of equipment like hydrocyclone, settling tanks, filters, ion- exchange.

UNIT-4: SOLID WASTE MANAGEMENT 6L

Characterization of solid wastes, Problems of collection and handling, Various processing techniques used in solid waste management such as compaction, incineration, Composting, landfills and biological processing, Solid waste as resource material.

UNIT-5: POLLUTION ABATEMENT IN CHEMICAL INDUSTRIES 6L

Pollution abatement in important chemical industries like fertilizers, petroleum refineries and petrochemicals, Pulp and Paper, Pharmaceuticals, Tannery, Sugar, Distillery, food processing, cement and electroplating.

UNIT-6: MISCELLANEOUS 4L

Soil pollution, Marine pollution, Noise pollution, Thermal pollution and Nuclear hazards, carbon trading.

Text books and References:

1. Howard S. Peavy, D. R. Rowe & C. Tchobonoglous "Environmental Engineering", McGraw Hill.
2. Metcalf & Eddy, "Waste Water Engineering Treatment, Disposal & Reuse", Tata McGraw Hill.
3. Werner Strauss, 'Air Pollution Control: Measuring and monitoring air pollutant' Wiley.
4. Werner Strauss, 'Air Pollution Control part –II' Wiley.
5. Pandey G. N. and Carney G. C., "Environmental Engineering ". Tata McGraw Hill.

CL 1604: CHEMICAL REACTION ENGINEERING-II

L: T: P: Cr = 3:1:0:4

Objective

The objective is to develop an insight into the heterogeneous reaction systems with a view to tackle real industrial challenges and to develop understanding about reactor analysis and design for heterogeneous systems.

Introduction

Reaction engineering ties together virtually all elements of Chemical Engineering, from thermodynamics and chemical kinetics to mass and energy balances to mass and heat transfer. This field studies the rates and mechanisms of chemical reactions and the design of the reactors in which they take place. The subject offers sufficient knowledge to enable students to develop their professional capacity in both the industrial and productive researcher in the field. Derivation of rate expressions from reaction mechanisms and equilibrium or steady state assumptions for heterogeneous reactions are taken into account. Also, design of chemical reactors via synthesis of chemical kinetics, transport phenomena, and mass and energy balances are explained.

LESSON PLAN

UNIT-1: GENERAL CONSIDERATIONS: 6 L

Introduction to design for Heterogeneous Reacting Systems: Rate equation for heterogeneous reactions, contacting pattern for two-phase systems. Mixing of fluids: Self mixing of single fluids, mixing of two miscible fluids

UNIT-2: NON-CATALYTIC FLUID-PARTICLE REACTIONS SYSTEM: 7 L

Models for non-catalytic heterogeneous reactions, limitations, and selection. Fluid-particle reactors design.

UNIT-3: NON-CATALYTIC FLUID- FLUID REACTIONS SYSTEM: 7 L

Rate equations for instantaneous, fast, intermediate, slow, and infinitely slow reactions.Slurry reaction kinetics. Fluid-Fluid reactors design.

UNIT-4: CATALYSIS AND CHARACTERISTICS OF CATALYST: 8 L

Introduction to catalysis, catalyst: definition and properties, Promoters, inhibitors. Poisons, solid catalyzed reaction system, the rate equation for surface kinetics, Pore diffusion resistance, Porous catalyst particles, turn over frequency.

UNIT-5: REACTORS AND KINETICS OF SOLID CATALYZED REACTIONS: 10 L

Kinetics and Mechanism of Heterogeneous Catalytic Reactions, Various models, Evaluation and elimination of internal and external diffusion resistances, effectiveness factor, heat effects, controlling resistances, rates of chemisorptions, adsorption isotherms, rates of adsorption and desorption, Reactor for solid catalyzed Reaction systems.

UNIT-6: CATALYST DEACTIVATION: 4 L

Mechanism of catalyst deactivation, the rate and performance equations

Text books and references:

1. O. Levenspiel, "Chemical Reaction Engineering", Wiley Easter Ltd., New York.
2. H. Scott Fogler, “Elements of Chemical Reaction Engineering”, PHI.
3. M. Davis, “Fundamental of Chemical Reaction Engineering”, McCraw Hill, New York.
4. J.M.Smith, "Chemical Engineering Kinetics", McCraw Hill, New York.

CL 1605: PROCESS EQUIPMENT DESIGN- II

L: T: P: Cr = 3:1:0:4

Objective

The objective is to impart the basic concepts of process design of equipments and develop understanding about P&ID, I&C drawing, pressure vessel design, storage tank design and heat exchangers.

Introduction

In modern competitive chemical industry, new plants are being continuously set up and the existing ones are being modified and expanded. This involves both technical and economic evaluations. A variety of equipments are needed for storage, handling and processing of chemicals. Each piece of equipment is expected to serve a specific function. This subject is developed to provide the complete knowledge of development of PFD, P&ID & then to sizing of different process equipment which are used in different industries. It builds up an understanding of the impact of manufacturing constraints on product design and process planning. Provide exposure to a range of manufacturing system constraints.

LESSON PLAN

UNIT-1: DESIGN OF PIPE FITTINGS AND JOINTS: 5L

Design and schematic of simple bolts and screws.Rivetedjoints.Design& Drawing of shafts and couplings.

UNIT-2: DESIGN OF REACTION VESSEL AND STORAGE TANK: 4L

Design and schematic of storage tank, (vertical and horizontal) supports, agitating vessel.

UNIT-3: FLOWSHEETING: 5L

Introduction, Flowsheet Presentation, Process Simulation Programs, Specification of Components and Physical Property Models, Simulation of Unit Operations, User Models, Flowsheets with Recycle, Flowsheet Optimization, Dynamic Simulation

UNIT-4: DRAWING AND DESIGN OF PHASE SEPARATION EQUIPMENTS: 7L

Drawing of physical separation equipments such as hydro-cyclones, packed towers, plate columns, electro static precipitators.Design of physical separation equipment such as cyclones, centrifuges, thickeners filtration equipment KO drum.

UNIT-5: DESIGN OF HEAT TRANSFER EQUIPMENTS: 6 L

Design and Drawing of Heat Transfer Equipments such as heat exchangers with and without phase change, evaporators, crystallizes.

UNIT-6: DESIGN OF MASS TRANSFER EQUIPMENTS: 6 L

Design and Drawing of mass transfer equipments such as distillation columns, absorption columns, extraction columns, dryers and cooling towers.

Text & Reference Books:

1. B. C. Bhattacharyya, Introduction to Chemical Equipment Design, CBS Publishers& Distributors, New Delhi.
2. Gavin Towler, R. K. Sinnot, Coulson and Richardson's Chemical Engineering Design: Principles, Practice and Economics of Plant and Process Design
3. Joshi M.V. “Process Equipment Design”, Macmillan India Ltd, New Delhi.
4. L. E. Brownell and E.H. Young, "Process Equipment Design - Vessel Design", Wiley Eastern Edn. New York.
5. Indian & American Codes used in Designing of Equipment (TEMA & IS Codes)

CL-1651 ENVIRONMENTAL MONITORING (LAB)

1. To study the increase in loss of head with respect to time in the filter bed.
2. To study the effect of parameters like pH and temperature on adsorbents.
3. To study change in alkalinity of wastewater by bubbling acidic gas.
4. To check the acidity and alkalinity of water resources.
5. To calculate the amount of solids in a suspension.
6. To measure COD level in wastewater.
7. To measure the conductivity of various wastewater.
8. To plot the pressure drop profile through the filter bed.
9. To measure the sediment removal efficiency and relating this to the hydraulic characteristics of a sedimentation tank.
10. To study the characteristics of anaerobic digester.
11. To determine the effect of velocity of water for separation of equal sized particles of different densities.

CL-1652 CHEMICAL REACTION ENGINEERING (LAB – II)

1. To study the kinetics and determine the reaction rate constant (k) for the given saponification reaction in a multiple reactor (Cascade CSTRs) at fixed temperature.
2. To determine the effect of temperature on rate constant (k) of saponification in a multiple reactor (Cascade CSTRs).
3. To study the kinetics and determine the reaction rate constant (k) for the given esterification reaction in a multiple reactor (Cascade CSTRs) at fixed temperature.
4. To determine the effect of temperature on rate constant (k) of esterification reaction in a multiple reactor (Cascade CSTRs).
5. To study the kinetics and determine the reaction rate constant (k) for the given saponification reaction in a multiple reactor (Combined CSTR & PFR) at fixed temperature.
6. To determine the effect of temperature on rate constant (k) of saponification in a multiple reactor (Combined CSTR & PFR).
7. To study the kinetics and determine the reaction rate constant (k) for the given esterification reaction in a multiple reactor (Combined CSTR & PFR) at fixed temperature.
8. To determine the effect of temperature on rate constant (k) of esterification reaction in a multiple reactor (Combined CSTR & PFR).
9. To determine the activation energy for a non catalytic homogeneous reaction in CSTR.
10. To determine the activation energy for a catalytic homogeneous reaction CSTR.
11. To study the effect of different kinds of packing in a packed bed reactor.
12. To study the residence time distribution in a CSTR at constant flow rate. To plot the exit time distribution of the reactor and thereby obtain E-curve, F-curve and mean residence time, t.
13. To study the residence time distribution in a CSTR with varying flow rates. To plot the exit time distribution of the reactor and thereby obtain E-curve, F-curve and mean residence time, t.
14. To study the flooding characteristics and pressure drops in a trickle bed reactor.
15. RTD studies in a packed bed reactor.

CL-1653 PROCESS MODELLING AND SIMULATION (LAB)

1. Modeling and Simulation of CSTR using programming language.
2. Modeling and Simulation of PFR using programming language. .
3. Modeling and Simulation of Shell and Tube/Plate Type Heat Exchanger using programming language.
4. Modeling and Simulation of Multicomponent distillation column using programming language.
5. Modeling and Simulation of Reactive/Extractive/Azeotropic distillation column using programming language.
6. Modeling and Simulation of Absorption unit using programming language.
7. Steady State and Dynamic simulation of Heat Exchanger using ASPEN HYSYS.
8. Steady State and Dynamic simulation of CSTR using ASPEN HYSYS.
9. Steady State and Dynamic simulation of PFR using ASPEN HYSYS.
10. Steady State and Dynamic simulation of Multicomponent distillation Column using ASPEN HYSYS.
11. Steady and Dynamic simulation of Reactive/Extractive/Azeotropic distillation Column using ASPEN HYSYS.
12. Steady State and Dynamic simulation of Absorption unit using ASPEN HYSYS.

CL-1654 CHEMICAL TECHNOLOGY (LAB)

1. To calculate the calorific value of a given sample by using bomb calorimeter.
2. To calculate the flash point of a sample by using Pensky Martin flash point apparatus.
3. To calculate the flash point and fire point of a sample by using Clereland's apparatus.
4. Melting and drop melting point of Wax.
5. Cloud point and Pour point.
6. Drop point and Softening point of grease.
7. To study the stoichiometry and kinetics of aerobic biological processes.
8. To calculate the aniline point of a sample.
9. To calculate the calorific value of a given sample by using Junker's gas calorimeter
10. To analyze a gas sample (typically fossil fuel flue gas) for its oxygen, carbon monoxide and carbon dioxide content.
11. To determine the amount of carbon residue in petroleum products left after evaporation and pyrolysis of oil and to indicate relative coke-forming propensities.

VII SEMESTER

HS-1701:ECONOMICS

L: T: P: Cr = 3:0:0:3

UNIT-I: **6L**

Introduction to Economics; Nature and Scope of Economics, Significance, Branches of Economics, Micro and Macro, fundamental concepts. Objectives of a firm.

UNIT-II: **8L**

Utility Analysis: cardinal and ordinal view, laws.Demand Analysis; Law of Demand, Exceptions to the law of Demand, Determinants of Demand. Elasticity of Demand- Price, Income, Cross and Advertising Elasticity; Uses of Elasticity of Demand for managerial decision making, measurement of Elasticity of Demand. Demand forecasting meaning, significance and methods.

UNIT-III: **8L**

Supply Analysis; Law of Supply, Supply Elasticity; Analysis and its uses for managerial decision making. Production concepts & analysis; Production function, single variable-law of variable proportion, two variable-Law of returns to scale. Cost concept and analysis, short-run and long-run cost curves and its managerial use.

UNIT-IV: **8L**

Market Equilibrium and Average Revenue Concept.Market Structure: Perfect Competition, features, determination of price under perfect competition. Monopoly: Feature, pricing under monopoly, Price Discrimination. Monopolistic: Features, pricing under monopolistic competition, product differentiation. Oligopoly: Features, kinked demand curve, cartels, price leadership.

UNIT-V: **4L**

Pricing Strategies; Price determination, full cost pricing, product line pricing, price skimming, penetration pricing.

UNIT-VI: **6L**

Indian Economy: National Income; Concepts and various methods of its measurement, Inflation, types and causes, Business Cycle,.

Text books and references:

1. Damodaran Suma – Managerial Economics (Oxford 2006).
2. Hirschey Mark – Economics for Managers (Thomson, India Edition, 2007)
3. Dominick Salvatore - Managerial Economics (Oxford, 2007))
4. Mithani D.M. - Principles of Economics (Himalaya Publishing House, 2005).
5. Dwivedi D.N. - Managerial Economics (Vikas Publication, 7th Edition)

CL-1701 PLANT DESIGN AND ECONOMICS

L: T: P: Cr = 3:1:0:4

Objectives

Give practice to students for the design of different chemical process equipments considering economical point of view.

Introduction

Students learn about Process Design development, capital investments, Interest and investment cost, Depreciation, Profitability, PERT and CPM.

LESSON PLAN

UNIT-1 **4 L**

Introduction, Process Design development. General design considerations, Cost and asset accounting, The Hierarchy of Chemical Process Design, the Nature of Process Synthesis and Analysis, introduction to PERT and CPM.

UNIT-2 **8 L**

Cash flow for industrial operations, factors effecting investment and production cost, estimation of capital investments, cost indices, cost factors in capital investment, production costs, fixed charges, plant overhead costs, financing.Interest and investment cost, present worth and discount annuities, cost due interest on investment, Taxes and insurances, type of taxes.

UNIT-3 **6 L**

Depreciation, types of depreciation, services life, salvage value; present value, methods for determining depreciation. Profitability, alternative investments and replacements, profitability standards, discounted cash flow, capitalized cost, pay out period, alternative investments, analysis with small investments, increments and replacements.

UNIT–4 **6 L**

Optimum design and design strategy, incremental cost, general procedure for determining optimum condition, comparison of graphical and analytical methods, optimum production rates, semi continuous cyclic operation, fluid dynamics, mass transfer strategy of linearization

UNIT-5 **8 L**

Choice of reactor based on reactor performance, reactor conditions and reactorconfiguration. Reactor networks in process flow sheets. Heat exchange networks synthesis and utilities: Energy targets, Integration in distillation columns

UNIT-6 **8 L**

Choice of separation of heterogeneous and homogeneous mixtures - Attainable regionSeparation systems in process flow sheets: multicomponent distillation for ideal and nonidealsystems, distillation column sequences. Introduction to optimization approaches to optimal design, role of simulations in process design, Design under uncertainty and failure tolerance.

Text books and references:

1. M.S. Peters and K.D.Timmerhaus, Plant Design and Economics for Chemical Engineering, McGraw Hill.
2. Process Engineering Economics, Schweyer,
3. W.D. Seider, J.D. Seader, D.R. Lewin, Process Design Principles Synthesis, Analysis, and Evaluation. John Wiley.
4. Perry's Chemical Engineer's Handbook, McGraw-Hill Book Company, New York.

1.BIOPROCESS ENGINEERING (CL-1731)

L: T: P: Cr = 3:1:0:4

UNIT-1: MICROBIAL GROWTH KINETICS: 6L

Introduction, Types of Microorganisms: Structure and function of microbial cells. Fundamentals of microbial growth, Isolation and purification cells and enzymes from cells Methods of inoculation, Assay of Enzymes, Batch, continuous and fed batch processes, mass balance in series of vessels, recycle system, an overview of aerobic and anaerobic processes.

UNIT-2: MEDIA STERILIZATION: 6L

Medium preparation, Methods of media sterilization, batch and continuous sterilization, kinetics of sterilization, Methods of air sterilization, mechanism of air sterilization, filter design.

UNIT-3: DESIGN OF FERMENTER: 6L

Construction materials, Temperature control, Mass transfer and microbial respiration, Baffles, different types of fermenter, Material and energy balance in steady and unsteady reaction systems. Stoichiometry and Kinetics of substrate utilization and Biomass and product formation: Stoichiometry of microbial growth, Substrate utilization and product formation, Recovery and purification of products.

UNIT-4: AERATION AND AGITATION: 6L

Bubble aeration and mechanical agitation, correlation between oxygen transfer coefficient and operating variables, factors affecting volumetric oxygen transfer, the effect of degree of agitation on volumetric oxygen transfer, rheology of fermentation fluids

UNIT-5: SCALE UP: 4L

Scale up concepts, criteria for bioreactors scale up.

UNIT-6: MONITORING OF BIOPROCESSES: 6L

On line data analysis for measurement and control of important physicochemical and biochemical parameters, parameter estimation techniques for biochemical processes, parameter estimation techniques for biochemical processes, computer based data acquisition, Control of physical, chemical and biological environment of the bioreactor. Advanced control strategies viz. PID controllers.

Text & Reference Books:

1. Shuler M L, Kargi F, "Bioprocess Engineering- Basic Concepts", 2nd edition, Prentice Hall of India Ltd. (2002)
2. Aiba S, Humphrey .A E and Millis N F, "Biochemical Engineering", Academic Press (1973)
3. Stanbury P F and Whitaker A, "Principles of Fermentation Technology," 2nd edition, Elsevier, (1995)
4. Bailey J E and Ollis D F, "Biochemical Engineering Fundamentals", McGraw Hill (1986)

1. INDUSTRIAL ENZYME ENGINEERING AND FERMENTATION TECHNIQUES(CL-1732)

L: T: P: Cr = 3:1:0:4

UNIT-1 BASIC CONCEPTS OF ENZYME: 6L

Mechanism of Enzyme Action and kinetic of reaction: Concept of active sites, and energetic of enzyme substrate complex formation, Specificity of enzyme action, Estimation of Michaelis-Menten Parameter

UNIT-2 STABILITY OF ENZYMES: 6L

pH, Temperature, Mechanical forces, Heterogeneous system.

UNIT-3 PRODUCTION AND PURIFICATION OF ENZYMES: 6L

Extract from plant, animal and microbial sources, Methods of characterization of enzymes, Development of enzymatic assays.

UNIT-4 ENZYME IMMOBILIZATION: **6L**

Physical and chemical techniques for enzyme immobilization adsorption, Matrix entrapment, Encapsulation, cross linking, covalent binding, Advantages and disadvantages of different immobilization techniques.

UNIT-5 APPLICATIONS OF ENZYMES: 6L

Classification of enzymes, Commercial application of enzymes in food, Pharmaceutical and other industries, Enzymes for analytical and diagnostic application.

UNIT-6 MASS TRANSFER EFFECTS IN IMMOBILIZED ENZYMES: **6L**

Analysis of film and pore diffusion effects on kinetics of immobilized enzyme reaction, Formulation of dimensionless groups, Calculation of effectiveness factors

Text books and references:

1. Price N C and Stevens L, "Fundamentals of Enzymology: The Cell and Molecular Biology of Catalytic Proteins", 3rd Edition, Oxford University Press (2003).
2. Bailey and Ollis, "Biochemical Engineering Fundamentals", McGraw Hill (1996)
3. Lehninger, A L **"**Principles of Biochemistry", Butterworth Publishers, New York (1993)
4. Conn E E and Stump P K,"Outlines of Biochemistry" John Wiley and Sons, New York (1987)
5. Stanbury P F and Whitaker A, "Principles of Fermentation Technolgy", Pergamon Press (1995)

2. INTRODUCTION TO BIOTECHNOLOGY(CL-1733)

L: T: P: Cr = 3:1:0:4

UNIT-1 INTRODUCTION TO BIOTECHNOLOGY: 6L

Fundamentals of Biochemical Engineering, Biotechnology and Society. Principles and Processes; Application in Health, food, medicine and Agriculture, genetically modified (GM) organisms, bio-safety issues.

UNIT-2 BIOMOLECULES: 6L

Building Blocks of Biomolecules-Structure and dynamics, Structure and function of Macromolecules (Carbohydrates, Proteins, Lipids), Major Cycle (Glycolysis, TCA)

UNIT-3 CELLS 6L

Cell as a basic unit of life, Introduction: Definition, Study of Microbes, Types of microbes, Classification of microbes, Origin of microbiology, Application of microbes in fermentation Biotechnology, Cellular Techniques including chromatography.

UNIT-4 BIOINFORMATICS: **7L**

History of Bioinformatics, Introduction and application, Biological databases (nucleotide and protein data bases, Structure databases) and their retrieval, Sequence file formats, Information Sources Analysis using Bioinformatics tools.

UNIT-5 GENOMICS: 5L

Genetic engineering, Recombinant technology, Introduction Genome Sequencing Projects, Gene Prediction and counting, Genome similarity, SNP's and comparative genomics.

UNIT-6 ENZYMES 5L

Classification of Enzymes, Purification and characterization of enzymes from natural sources,Production, Comparison of chemical and enzyme catalysis.

Text & Reference Books:

1. Text book of Biotechnology by H.K.Dass (Wiley India publication)
2. Biotechnology by B.D.Singh (Kalyani Publishers)
3. Text book of Biotechnology by R.C.Dubey (S.Chand and company)
4. Introduction to Biotechnology by William J. Thieman, Michael A. Palladino, Publisher: Benjamin Cummings
5. Basic Biotechnology by Colin Ratledge Publisher: Cambridge University Press

3. BIOENERGY ENGINEERING (CL-1734)

L: T: P: Cr = 3:1:0:4

Unit I **6 L**

Biomass Sources, Characteristics & Preparation: Biomass Sources and Classification, Chemical composition and properties of different biomass materials and bio-fuels , Sugarcane molasses and other sources for fermentation ethanol-Sources and processing of oils and fats for liquid fuels, Energy plantations, Preparation of woody biomass: Size reduction, Briquetting of loose biomass, Drying, Storage and Handling of Biomass.

Unit II **7 L**

Biogas, Technology: Feedstock for biogas production, Aqueous wastes containing biodegradable organic matter, animal residues, Microbial and biochemical aspects- Operating parameters for biogas production. Kinetics and mechanism,

Dry and wet fermentation, Digesters for rural application, High rate digesters for industrial waste water treatment.

Unit III **5 L**

Bio-Ethanol and Bio-Diesel Technology: Production of Fuel Ethanol by Fermentation of Sugars, Gasohol as a Substitute for Leaded Petrol, Trans-Esterification of Oils to Produce Bio-Diesel.

UNIT IV **9 L**

Pyrolysis and Gasification of Biomass: Thermo-chemical conversion of ligno-cellulose biomass - Biomass processing for liquid fuel production, Pyrolysis of biomass – Pyrolysis regime, effect of particle size, temperature, and products obtained. Thermo-chemical gasification principles: Effect of pressure, temperature and of introducing steam and oxygen, Design and operation of Fixed and Fluidized Bed Gasifiers.

UNIT V **5 L**

Combustion of Biomass and Cogeneration Systems: combustion of Woody Biomass: Theory, Calculations and Design of Equipments, Cogeneration in Biomass Processing Industries. Case Studies: Combustion of Rice Husk, Use of Bagasse for Cogeneration.

Text & Reference Books:

1. Chakraverthy A, “Biotechnology and Alternative Technologies for Utilization of Biomass or Agricultural Wastes”, Oxford & IBH publishing Co, 1989.
2. D. Yogi Goswami, Frank Kreith, Jan. F .Kreider, “Principles of Solar Engineering”, 2nd Edition, Taylor & Francis, 2000, Indian reprint, 2003

4. FOOD TECHNOLOGY AND ENGINEERING (CL-1735)

L: T: P: Cr = 3:1:0:4

UNIT-1FOOD PROCESS ENGINEERING -FUNDAMENTALS: **6L**

Fundamentals of food process engineering, application of quantitative methods of material and energy balance in food engineering practice.

UNIT-2UNIT OPERATIONS IN FOOD INDUSTRIES: 8L

Fluid flow, thermal process calculations, refrigeration, evaporation and dehydration operations in food processing.Basic Principles of Food Preservation; Preservation of food by removal or supply of heat, dehydration, irradiation, addition of chemicals and fermentation; CA/MA storage; Water activity and food stability.

UNIT-3 FOOD CANNING TECHNOLOGY: 6L

Fundamentals of food canning technology, Heat sterilization of canned food, containers - metal, glass and flexible packaging, Canning procedures for fruits, vegetables, meats, poultry marine products.

UNIT-4 MECHANICAL OPERATIONS IN FOOD PROCESSING: 6L

Conversion operations, Size reduction and screening of solids, mixing and emulsification and membrane separation, centrifugation, extraction.

UNIT-5 FOOD BIOTECHNOLOGY: 6L

Food Biotechnology, Dairy and cereal products, Beverages and food ingredients, High fructose corn syrup, Single Cell protein

UNIT-6 IMPROVEMENT OF NUTRITIVE QUALITY: 6L

Process such as fortification, enrichment, germination fermentation, inactivation of nutritional factors, stabilization of nutrients and increasing the availability of nutrient

Text & Reference Books:

Food Microbiology; WC Frazier; Tata McGraw Hill, Delhi
Modern Food Microbiology; James M Jay; CBS Publishers, Delhi
Essentials of Food & Nutrition by Swaminathan, Vol. 1 & 2
Chemical changes in food during processing by Richardson
Nutrition and Dietetics by Rose
Technology of Food Preservation by Desrosier
Food Science by Potter

5. OIL AND FAT TECHNOLOGY (CL-1736)

L: T: P: Cr = 3:1:0:4

Unit-1 Industrial Oils And Fats: 6 L

Raw material properties, Sources, composition, properties, classification, General survey of oils, and analysis of oils and fats.

Unit-2 Recovery and Refining of Oils from Raw Materials: 5 L

Extraction of oils, Mechanical and solvent extraction methods. Refining and hydrogenation of oils, Edible oil processing.

Unit-3 Manufacture of Fatty Acids, Glycerin and Soap: 4 L

Fat splitting and hydrolysis. Manufacture of glycerine and fatty acids, Soap manufacture.

Unit-4 Technology of Oil Based Detergents: 6 L

Oil based raw material for detergents, Detergents manufacturing processes, Oleo-Chemicals for other applications

Unit-5 Modern Development in Detergents: 6 L

Indian Oils, Fats and Detergents Industries, Manufacturing of Synthetic detergents and Surfactants

Unit-6 6 L

Alpha Olefin from natural oils and conversion to sulphonate, Fatty alcohols and their sulphates form natural oils.

.**Text & Reference Books:**

1. D.Swern, "Baileys Industrial Oils and Fat Products", 4th Edn. Vol.I&II, Wiley, 1982.
2. Edgar Woollatt, "The Manufacture of Soaps, Other Detergents and Glycerine", 1st Edn, Ellis Horwood, 1985.

6. FUNDAMENTAL OF POLYMER SCIENCE TECHNOLOGY (CL-1737)

L: T: P: Cr = 3:1:0:4

UNIT-1 CHARACTERISTICS AND ANALYSIS OF POLYMERS: 7L

The science of large molecules**,** Theory of polymer solutions**,** Measurement of molecular weight and size, Polymer degradation, Analyzing and testing of polymers**.**

UNIT-2 POLYMER MATERIAL STRUCTURE AND PROPERTIES: 7 L

Morphology in crystalline polymers**,** Polymer structure and physical properties**,** Deformation, flow and melt characteristics**,** Rheology and mechanical properties of polymers**.**

UNIT-3 POLYMER SYNTHESIS AND REACTION ENGINEERING: 7 L

Condensation and Addition polymerization**,** Ionic and Coordination polymerization**,** Co-polymerization,Ring opening polymerization.

UNIT-4 MANUFACTURING OF THERMOPLASTICS POLYMERS: 6L

Polyethylene, polypropylene, polyvinylchloride and copolymers, polystyrene, Teflon, Fibers-polyamides (Nylon 6,6), polyesters (Dacron), Acrylics

UNIT-5 MANUFACTURING OF THERMOPLASTICS POLYMERS: 6L

Phenol-formaldehyde, Melamine-formaldehyde, Polyurethane, Epoxides, Rubbers and elastomers.

UNIT-6 PROCESSING OF POLYMERS- PLASTICS, FIBERS AND ELASTOMERS: 7L

Plastics-extrusion, injection molding, blow molding, compression and transfer molding; Spinning of fibers.

Text books and references:

1. F.W. Billmeyer, "Text Book of Polymer Science", 3rd Edn., Wiley Inter Science.
2. F. Rodriguez, "Principles of polymer systems",4th Edn., Taylor and Francis, Washington.
3. “Encyclopedia of Polymers Science and Technology", John Wiley-Inter Science.

Fried, J.R., “Polymer Science and Technology”, Prentice Hall, Inc

8. DOWNSTREAM PROCESSING (CL-1738)

L: T: P: Cr = 3:1:0:4

Unit I Requirement of Downstream Processing **6L**

Basic concepts of separation Technology, Overview of a bioprocess including upstream anddownstream processing, Importance of downstream processing in biotechnology,characteristics of biological molecules, New Separation process in modern biotechnology;Separationcharacteristics of proteins and enzymes – size, stability & other biologicalproperties; Selection of purification methodologies, Characteristics of fermentation broth &its pretreatment.

Unit II Biomass Removal and Disruption **8L**

Biomass removal and disruption: Cell disruption by Mechanical and non mechanicalmethods, Chemical lysis, Enzymatic lysis, physical methods, Sonication, Types ofHomogenizers, Centrifugation; Sedimentation; Flocculation.

Unit III Product Isolation **8L**

Liquid - liquid extractions, Precipitation (salt, pH, organic solvent, high molecular weightpolymer). Separation of particulate by filtration, Rotary Vacuum Filtration, Centrifugation &Ultracentrifugation (Batch, continuous, basket), settling, sedimentation, decanting;Product Purification: Electrophoresis; Different Electrophoresis technique –Isoelectric, focussing

Unit IV Membrane Based Separation **6L**

Membrane based purification: Microfiltration, Ultrafiltration, Reverse osmosis (UF and RO);Dialysis; Electrodialysis; Diafiltration; Pervaporation; Perstraction, Biotechnologicalapplication, Structure and characteristics of membranes; Liquid membranes; Supported liquidmembrane; Membrane reactors.

Unit V Separation by Adsorption and Chromatography **8L**

Types of adsorption; adsorbents types, their preparation and properties, Types of adsorptionisotherms and their importance; Chromatography: general theory, partition coefficients, zonespreading, resolution and plate height concept and other chromatographic terms andparameters; chromatographic method selection; selection of matrix; separation based on size,charge, hydrophobicity and affinity**:** Gel filtration, Ion exchange chromatography, Affinitychromatography, IMAC chromatography; Covalent chromatography; Reverse phasechromatography (RPC) and hydrophobic interaction chromatography (HIC), HPLC, role ofHPLC in protein characterization; Chromatofocussing; Polishing of BioproductsbyCrystallization of small and large molecules, drying and Formulations

Unit VI Product Polishing **4L**

Crystallization, Drying. A Few case studies: Citric acid, Glutamic acid,PenicillinG,Extracellular Enzymes, Intracellular enzymes, Antibodies.

Text & Reference Books:

1. Bioseparation Techniques, Sivasankar, Prentice-Hall of India, 2004.
2. Bioseparations (Principles & techniques), B. Sivasankar, Prentice-Hall of India, 2005.
3. Comprehensive biotechnology- Murray Moo-Young, Vol. II-latest ed., Pergan Publishers.
4. H. J. Rehm and G. Reed, Biotechnology- Vol. 3, 4, 5, Verlag Publishers
5. Stanbury&Whitteker, Principles Of Fermentation Technology, Pergamon Press

6. A Biologist's Guide to Principles & Techniques of Practical Biochemistry- Wilson and
7. Golding, Cambridge University Press
8. Biochemical Engg. -Bailly&Ollis, Academic Press.
9. Product Recovery in Bioprocess Technology, Heinemann, Butterworth Publication.

9. INTRODUCTION TO MULTIPHASE FLOW (CL-1739)

L: T: P: Cr = 3:1:0:4

UNIT- I: Flow past immersed bodies: **6 L**

Drag and drag coefficients, flow through beds of solids, motion of particles through fluids, fluidization, types of fluidization and applications.

UNIT-2: Two-phase flow: 4 L

Two–phase flow through pipes, Lockhart-Martinelli parameters and their application in analysis of two-phase flows.

UNIT-3: Interaction of fluids: 6 L

Mixing of a single fluid; degree of segregation, early and late mixing of fluids, models for partial segregation, mixing of two miscible fluids, Gas-liquid flow phenomenon, Types of regimes formation – trickle, pulse, bubble, dispersed bubble, spray regime etc.

UNIT-4: Types of Multiphase-Reactors: 8 L

Various types of multiphase reactors e.g. packed bed, packed bubble column, trickle bed reactor, three phase fluidized bed reactor, slurry bubble column, stirred tank reactor. Characteristics of above mentioned reactors such as; fluid flow phenomena and flow regimes, flow charts/ correlations, pressure drop, liquid hold up etc, Reactors involving Newtonian and non-Newtonian fluids.

UNIT-5: RTD in Multiphase Flow systems: 9 L

Non Ideal Flow: Residence time distribution of fluid in vessel, E, F & C Curve, Mean and variance, the Dirac delta function, residence time, linear and non-linear processes, models for non ideal flow, dispersion model, N tanks in series model, model for small deviations from plug flow and long tails, conversion in a reactor using RTD data, diagnosing ills of operating multiphase reactors, models for multiphase reactors, Two parameter model, PD model, three parameter models, PE Model.

Text & Reference Books:

1. Levenspiel O, "Chemical Reaction Engineering", 3rd Ed, John Wiley & Sons, Singapore (1999).
2. Fogler H Scott, "Elements of Chemical Reaction Engineering", 3rd ed, Prentice Hall Inc. (1999).
3. Shah Y.T., "Gas-Liquid-Solid Reactor Design", McGraw Hill Int. New York, 1979.
4. Westerterp K.R., van Swaaij W.P.M., and Beenackers A.A.C.M., "Chemical Reactor Design and Operation", John Wiley & Sons, 1993.
5. Doraiswamy L.K., and Sharma M.M., "Heterogeneous Reactions: Volume 2 Fluid- Fluid-Solid Reaction", John Wiley & Sons, 1984, Singapore.

10. FLUID FLOW & HEAT TRANSFER IN MICROCHANNEL (CL-1740)

L: T: P: Cr = 3:1:0:4

Unit 1 **4L**

Introductionand applications of fluid flow in microchannel; Micro-fabrication techniques; Dimensional analysis and role of dimensionless numbers in microchannel.

Unit 2 **8L**

Fundamental Transport Equations viz. Momentum balance, Mass Balance and Energy balance in microchannel.

Unit 3 **8L**

Statistical mechanics, Continuum assumption and limits of linear transport properties; multiphase flow in microsystem; pressure drop models in single and two phase flow in microchannels.Slip velocity, Continuum flow (with slip), free molecular flow;Electro-osmotic flow, electric double layer; Capillary filling, passive valves, electro-wetting;

Unit 4 **9L**

Introduction to heat transfer in micro-channels.Convective Heat transfer in microchannel with and without phase change. Boiling and Condensation in microchannels. Concepts and examples of micro heat exchange devices.

Unit 5 **8L**

Micro-mixing and its characterization;Heat transfer in multi-channel stack with chemical reactions; Viscous heating and entropy generation in channel flow; Microfluidic network for heat and mass transfer, Dispersion in micro-channel; entrance effect, Field flow fractionation.

Text & Reference Books:

1. Oliver Brand, Gary K. Fedder, ChristoferHierold, Jan G. Korvink, and Osamu Tabata; Advanced Micro &Nanosystems, Volume 5, Micro Process Engineering: Fundamentals, Devices, Fabrication, and Applications; Wiley –VCH
2. Satish G. Kandlikar , SrinivasGarimella, Dongqing Li, Dongqing Li, Heat transfer and fluid flow in minichannels and microchannels; Elsevier
3. By Nam-Trung Nguyen, Nam-Trung Nguyen Steven T. Wereley; Fundamentals and Applications of Microfluidics; Artech house

11. TWO PHASE FLOW AND HEAT TRANSFER (CL-1741)

L: T: P: Cr = 3:1:0:4

UNIT-1: INTRODUCTION: 6L

Introduction to two phase flow: type and applications,Flow Patterns in Adiabatic Flow, Flow Pattern Transitions in Adiabatic Flow, Flow Patterns in Diabatic Flow, Void Fraction and Slip Ratio, Methods of identifications for two-phase flow, Measurement technique in two phase flow. Introduction to two phase flow problems in process industry.

UNIT-2: MODELING OF TWO-PHASE FLOW: 8L

Homogeneous Model/Drift Flux Model, Separate-Phase Model (Two-Fluid Model), Models for Flow Pattern Transition, Models for Bubbly Flow, Models for Slug Flow, Models for Annular Flow, Models for Stratified Flow (Horizontal Pipes), Models for Transient Two-Phase Flow.

UNIT-3: PRESSURE DROP IN TWO-PHASE FLOW: 8L

Local Pressure Drop, Analytical Models for Pressure Drop Prediction: Bubbly Flow, Slug Flow, Annular Flow, Stratified Flow; Empirical Correlations for various flow types, Pressure Drop in Rod Bundles, Pressure Drop in Flow Restriction.

UNIT-4: POOL BOILING HEAT TRANSFER: 8L

Introduction to two phase heat transfer, Modes of pool boiling, boiling curve, Heat transfer mechanism in pool boiling: bubble nucleation, growth and departure from a Heated Surface, Bubble emission Frequency, Waiting Period, Correlation of Nucleate Boiling Data, Pool Boiling Crisis, Film Boiling in a Pool; Forced convection boiling, Burnout.

UNIT-5: HEAT TRANSFER IN CONDENSATION: 6L

Type of condensation, Film condensation, Drop-wise condensation, Condensation on a vertical plate, Condensation on tubes and spheres.

UNIT-6: ENHANCED HEAT TRANSFER: 6L

Introduction to enhanced heat transfer, Techniques for enhanced heat transfer: Active Techniques, Passive techniques and compound techniques.

Text & Reference Books:

1.L. S. Tong and Y. S. Tang, “Boiling Heat Transfer and Two-Phase Flow”, Second Edition, Taylor& Francis.

2. S. G. Kandlikar, "Handbook of Phase Change: Boiling and Condensation" Taylor & Francis.

3. Jean J. Ginoux, Two phase flow and heat transfer.

4.Bergles, Collier & Hewitt, Two phase flow and heat transfer in the power and process industries.

12. PETROCHEMICAL TECHNOLOGY (CL-1742)

L: T: P: Cr = 3:1:0:4

UNIT-1: PRIMARY PROCESSING OF CRUDE OIL: 6 L

Classification of crude oil, Atmospheric distillation.Vacuum distillation of residue-products and distillation practice. Production and consumption pattern of petrochemicals in India, Feedstocks for petrochemicals-Natural gas, LPG, Refinery off-gases, Hydroforming of petroleum stocks, Naphtha and fuel oils, Petroleum coke.

UNIT-2: SECONDARY PROCESSING OF CRUDE OIL: 6 L

FCCU, Hydro cracking, Visbreaking, Thermal cracking, Coking, Reforming, Alkylation, Polymerization and Isomerisation process. Ethylene and acetylene via steam cracking of hydrocarbons

UNIT-3: TREATMENT-TECHNIQUES: 6 L

Treatment techniques for removal of objectionable gases.Odors to improve performance, Storage stability. Extraction of aromatics, Olefins and recovery operations from petroleum products, Steam reforming and partial oxidation processes for syngas.

UNIT-4: PETROCHEMICALS: 6 L

Chemicals from methane and synthetic gas: Ammonia, Methanol and Hydrogen Cyanide, Chemicals from olefins; Ethylene derivatives, Propylene derivatives and Butylene derivatives, Aromatics, intermediates for synthetic fibers, Plastics and rubber.

UNIT-5: ENVIRONMENTAL ASPECTS IN REFINERY AND PETROCHEMICALS: 5 L

Waste water and effluent gases treatment from alkylation units and petrochemical units.

UNIT-6: SAFETY 4 L

Safety and fire hazard aspects in the petroleum industries.

Text books and references:

1. W.L. Nelson, "Petroleum Refinery Engineering", 4th Edn., McGraw Hill , New York 1985.
2. B. K. BhaskaraRao, "Modern Petroleum Refining Processes", 2nd Edn., Oxford and IBH Publishing Company, New Delhi, 1990.Khanna Publishers.
3. G. D. Hobson and W. Pohl., “Modem Petroleum Technology", Gulf Publishers 2nd. Edn., 1990.
4. R. A. Meyers, "Handbook of Petroleum Refining Processes", McGraw Hill , 1st Edn., 1980.
5. F. Hatch md Sumi Malar, "From Hydrocarbons to Petrochemicals", Gulf Publishing Company, 1st Ed. 1981.

13. PETROLEUM REFINING ENGINEERING AND OIL WELL ENGINEERING (CL-1743)

L: T: P: Cr = 3:1:0:4

UNIT-1: INTRODUCTION TO PETROLEUM INDUSTRY: 6 L

World petroleum resources, petroleum industries in India. Scope and Purpose of Refining: Global and Indian refining scenario, Petroleum refining industry in India practice and prospects, An overview of the entire spectrum of the refinery products, refinery configuration development, Physio-chemical characteristics of Petroleum and Petroleum products

UNIT-2: REFINERY PROCESSES: **8 L**

Desalting and Stabilization of crude, Process description of typical simple distillation, Fractional distillation, crude oil distillation, vacuum distillation etc, Degree of separation and degree of difficulty of separation, Packie charts, ASTM, TBP and EFV Distillation. Fuel Refining: Cracking, coking, reforming, alkylation, isomerisation, polymerization, sweetening, visbreaking.

UNIT-3: LUBE REFINING: **8 L**

Solvent extraction, dewaxing, propane deasphalting. Wax Refining: Deoiling of crude wax, crystallization, catalytic, sweating microcrystalline and petroleum wax applications.

UNIT-4: HYDRO PROCESSING: 8 L

Hydro cracking, hydro treating, hydro finishing. Refinery Feedstock: Nature and effect of different types of refinery feedstock and their impurities on refinery configuration and operation. Refinery Gas Processing: Process description of typical light ends unit, acid gas removal using gas treating processes.

UNIT-5: PHASE SEPARATION EQUIPMENTS 8 L

Two Phase oil and gas separation equipment: Types, their description, vessel sizing, theory of separation and separator design.

Three Phase Oil gas and water separators: Types of separators, their description. Various control and vessel internals, theory and sizing of three phase separator.LACT units.

UNIT-6: SAFETY AND POLLUTION CONSIDERATIONS IN REFINERIES: **4 L**

Treatment methods, sweetening, hydrodesulphurization, smoke point improvement, health and environmental concerns.

Text & Reference Books:

1. Nelson W L, “Petroleum Refinery Engineering”, McGraw Hill Book Co. 1985).
2. Watkins R N, “Petroleum Refinery Distillation”, Gulf Publishing Co.
3. Gary J H and Handework G E, “Petroleum Refining Technology and Economics”, Marcel Dekker, Inc. (2001).
4. Jones D S J, “Elements of Petroleum processing”, John Wiley & Sons (1995)
5. Waquier J P, “Petroleum Refining” Vol. I & II Editions, Technip (1995)
6. Guthre, V.B., "Petroleum Products", Hand-Book McGraw Hill.

CL-1801 HAZARDS AND SAFETY IN CHEMICAL INDUSTRIES

L: T: P: Cr = 3:1:0:4

Objectives

To introduce awareness on the importance of plant safety and risk analysis.

Introduction

Students learn about implementation of safety procedures, risk analysis andassessment, fire and explosion models, hazard identification, HAZOP.

LESSON PLAN

UNIT-1: INTRODUCTION **6 L**

Risk Analysis**,** Rapid risk analysis, Comprehensive risk analysis, Failure types and release rate calculations, Emission and dispersion, Dispersion models for dense gas, Plume dispersion, Jet dispersion, and Toxic dispersion model Evaluation of risk contours.

UNIT-2:CONSEQUENCE ANALYSIS: **5 L**

Radiation, Tank on fire**,** Flame length, Radiation intensity calculation and its effect on plant, people & properly, UCVCE,

UNIT-3:FIRE AND EXPLOSION: **6 L**

Explosion due to deflatration, Detonation, TNT, TNO & DSM model, Over pressure, Effects of explosion, Risk contour, Flash fire, Jet fire, Pool fire, BLEVE, Fire ball.

UNIT -4:RISK MANAGEMENT: **7 L**

Overall risk analysis, Generation of Meteorological data, Ignition data, Population data, Overall risk contours for different failure scenarios, Disaster management plan, Emergency Planning, on site & offsite emergency planning, Risk management & IS0 14000, EMS models, Case studies, Marketing terminal, gas processing complex, refinery.

UNIT-5:PAST ACCIDENT ANALYSIS: **6 L**

Hazard identification, Safety Audits, Checklists, What if Analysis, Vulnerability models, Event tree and Fault tree Analysis, Past accident analysis Flixborough, Mexico, Bhopal, Vizak3 miles, island chernoobyl, feyzih disasters, seveso accident analysis.

UNIT-6:HAZOPS: **6 L**

Principles, Risk ranking, Guide word, Parameter, Deviation, Consequences, Recommendations, Coarse HAZOP study, Case studies Pumping system, Reactor System, Mass transfer system.

Text books and references:

1. K. V. Raghavan and A. A Khan, "Methodologies in Hazard Identification and Risk Assessment", Manual by CLRI.
2. V. C. Marshal, "Major Chemical Hazards", Ellis Hawood Ltd., Chichester, United Kingdom.
3. Kletz, "Risk Analysis Hazops" Institute of Engineers, U.K.
4. Frank P. Less, "Loss Prevention in Process Industries", Vol. I, II & III Butterworth, London.

14. SYNTHESIS OF NANOMATERIAL AND THEIR APPLICATION (CL-1831)

L: T: P: Cr = 3:1:0:4

UNIT-1: INTRODUCTION TO THE PRACTICE AND DISCIPLINE OF NANOTECHNOLOGY: **6L**

The nanoscale dimension and paradigm, Definitions, history and current practice, Overview of current industry applications, Nanoscale science and engineering principles.Different classes of nanomaterials:Metal and Semiconductor Nanomaterials, Quantum Dots, Wells and Wires, Overview of chemistry fundamentals for nanotechnology, Molecule to bulk transitions**,** Bucky balls and Carbon Nanotubes.**,** Self-assembly and overview of Complex Adaptive Systems (CAS).

UNIT-2: CARBON NANOTUBE TECHNOLOGIES (CNT): **6L**

From graphite to buckyballs to CNT, Carbon nanotube applications and MWNT, Fabricating carbon nanotubes and nano-wall structures, Key applications of CNT and MWNT.

UNIT-3: SYNTHESIS OF NANOMATERIALS: 6L

Top-down (Nanolithography, CVD), Bottom-up (Sol-gel processing, chemical synthesis), Physical Vapor deposition, Wet deposition techniques,Self-assembly (Supramolecular approach), Molecular design and modeling.

UNIT-4: CHARACTERIZATION: 5L

TEM, SEM and AFM technique, Fluorescence Microscopy and Imaging

UNIT-5: NANOFABRICATION 5L

Nanolithography**,** Thin film processes**,** semiconductors, MEMS:Overview and history of development, Industry applications: Challenges and future development.

UNIT-6: APPLICATIONS: **5L**

Solar energy conversion and catalysis, Molecular electronics and printed electronics, Liquid crystalline systems, Linear and nonlinear optical and electro-optical properties, Applicationsin displays and other devices, Advanced organic materials for data storage, Photonics, Plasmonics, Chemical and biosensors, Nanomedicine and Nanobiotechnology.

Text & Reference Books:

1. Hari Singh Nalwa, "Nanostructured Materials and Nanotechnology", Academic Press, 2002
2. A.Nabok, "Organic and Inorganic Nanostructures", Artech House, 2005
3. C.Dupas, P.Houdy, M.Lahmani, Nanoscience: "Nanotechnologies and Nanophysics", Springer-Verlag Berlin Heidelberg, 2007
4. Introduction to Nanotechnology by Charles Poole, Frank Owens, Wiley India Pvt Ltd 2007.
5. Nanotechnology by Lynn E. Foster, Pearson Released: 2007

15. ELECTROCHEMICAL ENGINEERING (CL-1832)

L: T: P: Cr = 3:1:0:4

UNIT-1INTRODUCTION TO ELECTROCHEMICAL ENGINEERING: **5L**
Introduction, Methods of measurement - Steady state techniques, Non-steady state techniques, Eliminating IR Drop.

UNIT-2ELECTROCHEMICAL TRANSFER PROCESS: **6L**
Electrochemical Transfer Processes, Mass Transport, Charge Transport and Heat Transfer.

UNIT-3ELECTROCHEMICAL REACTION ENGINEERING: **6L**
Electrochemical Thermodynamics and Electrode kinetics, Kinetics in Electrochemical Reactors.

UNIT-4 DESIGN AND MODELING IN ELECTROCHEMICAL PROCESSES: **6L**
Optimization and Factorial Design of Experiments, Experimental Modeling of Industrial Processes.

UNIT-5 SEPARATION PROCESSES IN ELECTROCHEMICAL CELLS: **6L**
Separation Systems in Electrochemical Cells, Materials and corrosion

UNIT-6 THERMAL BEHAVIOR OF REACTORS: **7L**
General aspects of thermal behavior in electrochemical reactor, Thermal behavior under CSTR conditions, the estimation of heat losses; the thermal behavior under PFR conditions; Thermal behavior of batch electrochemical reactors.

Text & Reference Books:

1. J.C. Kuriakose and J. Rajaram, "Chemistry in Engineering and Technology", Vol.1 & 2, Tata Mcgraw Hill Publishing Company (P) Ltd., New Delhi, 1996.
2. Electrochemical Engineering Principles by Geoffrey A. Prentice, Prentice hall publications
3. Electrochemical Methods: Fundamentals and Applications by Allen J. Bard , Larry R. Faulkner
4. Electrochemistry by Carl H. Hamann, Andrew Hamnett, Wolf Vielstich, Wiley publications

16. INDUSTRIAL CATALYSIS (CL-1833)

L: T: P: Cr = 3:1:0:4

UNIT-1 INTRODUCTION TO CATALYSIS: **6L**
General properties of homogeneous and heterogeneous catalysis, Classification of catalysts and supports.

UNIT-2GEOMETRIC AND ELECTRONIC FACTORS IN CATALYSIS: **6L**
Adsorption and reaction kinetics in catalytic (heterogeneous) system.

UNIT-3CATALYST PREPARATION: **6L**
Preparation and evaluation of industrial catalysts.

UNIT-4 KINETICS OF HETEROGONOUS REACTIONS: **8L**
Reaction engineering applied to catalytic homogeneous and heterogeneous chemical reactions. Theories of heterogeneous catalysis

UNIT-5 CATALYST POISONING: **6L**
Catalyst poisoning and deterioration (sintering) origination of catalyst.

UNIT-6 ELECTRO CATALYSIS AND FUEL CELL: **8L**
Photo catalysis for the removal of air and water pollutants and conversion of solar energy, Polyfuctional catalysts.

Text & Reference Books:

1. Fundamentals of Industrial Catalytic Processes by C. H. Bartholomew, Robert J. Farrauto , Wiley-AIChE; 2 edition
2. Concepts of Modern Catalysis and Kinetics by I. Chorkendorff, J. W. Niemantsverdriet , Wiley-VCH; 2nd edition
3. Handbook of Industrial Catalysts by Lloyd, Lawrie, Springer publications
4. Industrial Catalysis: A Practical Approach by Jens Hagen, Wiley-VCH; 2 edition

5.

17. COMPUTER-AIDED PROCESS CONTROL (CL-1834)

L: T: P: Cr = 3:1:0:4

Unit-1: **4L**

Introduction to Computer-Aided Process Control

Unit-2 **8L**

Hardware, Analog and digital interfacing, Sensors and transducers,

Unit-3 **8L**

System software: Real time programming, Application software: data logging, filtering.

Unit-4 **10L**

Z transforms discrete time dynamics systems, adaptive control, and introduction to MIMO control systems.Digital control algorithm: Conversion of analog PI, PD, PID into digital;

Unit-5 **10L**

Direct synthesis method; Dead beat control; Control algorithm for load changes.Introduction to DDC, DCS, supervisory, optimizing and hierarchical computer control.

Text & Reference Books:

1. Computer aided process control by S.K.Singh, Prentice Hall of India Pvt.Ltd.
2. Process Control Engineering by P. Sai Krishna, I. K. International Pvt Ltd, 2010
3. Industrial Instrumentation & Control by S.K.Singh, Tata McGraw-Hill Education

18. ADVANCES IN FLUIDIZATION ENGINEERING (CL-1835)

L: T: P: Cr = 3:1:0:4

Unit-1 Introduction and Applications: 6L

Introduction to Fluidized bed systems, Fundamentals of fluidization. Industrial applications of fluidized beds - Physical operations, synthesis reaction, cracking and reforming of hydrocarbons, Gasification, Carbonization, Gas - solid reactions, calcining and clinkering.

Unit-2 Gross Behavior of Fluidized Bed: 6L

Gross behavior of fluidized bed, Minimum and terminal velocities in fluidized beds, Types of fluidization.Design of distributors.Voidage in fluidized beds.TDH, variation in size distribution with height, viscosity and fluidity of fluidized beds.Powerconsumption.Bed expansion.

Unit-3 Analysis of Bubble and Emulsion Phase: 7L

Davidson's model, Frequency measurements, Bubble behavior, bubbles in ordinary bubbling bed model for bubble phase. Emulsion phase, Experimental findings, Turnover rate of solids. Bubbling bed model for emulsion phase interchange co-efficient.

Unit-4 Flow Pattern of Gas and Heat & Mass Transfer in Fluidized Beds: 7L

Flow pattern of gas through fluidized beds, Experimental findings, The bubbling bed model for Gas inter-change Interpretation of Gas mixing data, Heat and Mass Transfer between fluid and solid: Experiment findings on Heat and Mass Transfer, Heat and Mass Transfer rates from bubbling bed model.

Unit-5 Heat Transfer between Fluidized Beds and Surface: 7L

Heat transfer between fluidized beds and surfaces, Experiment finding, theories of bed heat transfer, comparison of theories, Entrainment of or above TDH, model for Entrainment and application of the entrainment model to elutriation

Unit-6 Semi Fluidization: 6L

Principles, production of various bed parameters, Industrial applications,Design of fluidized bed reactors, Concept of RTD, Basic design principles for fluidized bed reactors.

Text books and references:

1. D.Kunii and O.Levenspiel,'Fluidization Engineering "2nd. Edn.,]ohn Wiley& Sons, 1992.
2. Handbook of Fluidization and Fluid-Particle Systems (Chemical Industries) by Wen-Ching Yang, CRC Press publications.
3. Fluid Bed Technology in Materials Processing by C. K. Gupta, D. Sathiyamoorthy, CRC Press; 1st edition.

19. PROCESS MODELING AND SIMULATION (CL-1836)

L: T: P: Cr = 3:1:0:4

UNIT-1: **8 L**

Introduction to modeling and simulation, classification, Uses of mathematical models, Principles of model formulation, Fundamental laws- continuity equation, energy equation, equations of motion, Transport equations, equations of state, equilibrium and kinetics, Introduction to process simulators and mathematical tools.

UNIT-2: **6 L**

Numerical solution of model equations with Linear and non linear algebraic, Equations in one and more than one variables, ordinary differential equations in one and more than one variables

UNIT-3: **6 L**

Numerical solution of model equations with partial differential equations using finite difference method. Model Parameters Estimation: Introduction, method of least squares, curve fitting, etc.

UNIT-4: **8 L**

Lumped Parameter Models: Formulation and solution techniques for vapor-liquid equilibrium models, batch and continuous distillation column, mixing tank, stirred tank with heating, CSTR with multiple reactions. N-CSTRs in series, Non-isothermal CSTR, Non-ideal CSTR models.

UNIT-5: **8 L**

Steady State Distributed Parameter Models: Formulation and solution of split boundary value problems - shooting technique, quasi-linearization techniques, counter current heat exchanger, tubular reactor with axial dispersion.

UNIT-6: **6 L**

Unsteady State Distributed Parameter Models: convective problems, diffusive problems, combined convective and diffusive problems.

Text & Reference Books:

1. K. M. Hangos and I. T. Cameron, “Process Modeling and Model Analysis”, Academic Press, 2001.
2. W.L. Luyben, “Process Modelling, Simulation and Control for Chemical Engineers”, 2nd Edn., McGraw Hill Book Co., New York, 1990.
3. W. F. Ramirez, “Computational Methods for Process Simulation”, Butterworths, 1995.
4. Process Dynamics: Modeling, Analysis and Simulation, B Wayne Bequette, Prentice Hall. International Inc.
5. Computational Methods for Process Simulation, 2nd ed., W F Remirez, Butterworth-Heinemann.
6. Roger E. Franks, “Modeling and Simulation in Chemical Engineering”, JohnWiley and Sons, 1972.
7. Mark E. Davis, “Numerical Methods and Modeling for Chemical Engineers”, John Wiley & Sons, 1984.
8. Singiresu S. Rao, “Applied Numerical Methods for Engineers and Scientists” Prentice Hall, Upper Saddle River, NJ, 2001
9. Seinfeld and Lapidus, “Mathematical Methods in Chemical Engineering”, Prentice Hall, 1974.

20. INDUSTRIAL CORROSION AND SURFACE COATING (CL-1837)

L: T: P: Cr = 3:1:0:4

UNIT-1 INTRODUCTION: 8L

Survey of paint industry and its scope in India. Pigments and their classification. Methods of manufacture: white, colored, metallic and luminous pigments.

UNIT-2 CLASSIFICATION OF PAINTS: 8L

Oil, emulsion, and water soluble paints and their manufacturing processes; Drying oils; Natural and synthetic resins; Solvents and plasticizers.

UNIT-3 DEFINITION AND CLASSIFICATIONOF VARNISH: **6L**

Oleoresinious and spirit varnishes; Manufacture of different types of varnishes. Ceramic coating: Glazing and enameling.

UNIT-4 METALLIC COATING: 6L

Electroplating, Galvanizing, Tinning, Polymeric coating; Protective and decorative coatings, Powder Coating.

Text & Reference Books:

1. Noel, H., "Out of Paint Technology", Charles Griffin and Co., Ltd.
2. Morgans, W.M., "Outlines of Paint Technology", Vol.I, Charles Griffin and Co.
3. Bidlack, C. and Edgar W. P., "Paints and Varnish Production Manual", Chapman & Hall Ltd.
4. Turner, G.P.A., "Introduction to Paint Chemistry Principles of Paint Technology", Oxford University Press.

21. ADVANCED PROCESS CONTROL (CL-1838)

L: T: P: Cr = 3:1:0:4

UNIT-1 FREQUENCY RESPONSE: 6 L

Review of control system design in Laplace, time, and frequency domains, controller design using Laplace, time and frequency response-Analysis of some common loops Bode diagrams for Ist&IInd order system, Bode stability criteria, Zigler- Nichols and Cohen-coon Tuning rules and Nyquist Plots.

UNIT-2 DESIGN OF CONTROLLERS FOR DIFFICULT & COMPLEX DYNAMICS: 7 L

Inverse response systems - controller design - design of inverse response compensator, Time delay systems - controller design - Smith predictor method,.

UNIT-3 COMPLEX DYNAMICS: 5 L

Dynamics and Control of complex processes. Theoretical analysis of complex processes like jacketed kettle, absorber and heat exchanger

UNIT-4 MULTIVARIABLE SYSTEMS: 6 L

Feed forward control, cascade and ratio control - Introduction to stage space methods-Design of controllers using state-space methods - Introduction to multiloop systems- Relative gain analysis.

UNIT-5 CONTROLLERS DESIGN AND ART OF PROCESS CONTROL: 6 L

Degrees of freedom analysis - Introduction to distillation system - Controller design for mutliloop systems. Interaction and pairing of control loops, the art of process control.

UNIT-6 DESIGN OF DIGITAL CONTROLLERS: 7 L

Supervisory control systems-Digital computer control - sampling & filtering of continuous measurements, Developments of discrete time models - Dynamic response of discrete time systems. Analysis of sampled data control System-Design of digital controllers.

Text & Reference Books:

1. D. R. Coughanowr, "Process System Analysis and Control", 2nd Edn. McGraw Hill, 1991.
2. G Stephanopopulas, "Chemical Process Control", Prentice-Hall India, 1984.
3. D. E.Seborg, T.F. Edgar and D.A. Mellichamp, "Process Dynamics Control", John Wiley, 1989.
4. Ogunnauike and W.H.Ray, "Process Dynamics, Modeling and Control" Oxford Press.1994.
5. Luybin W.L.; Process modeling, simulation and control for chemical Engineers; “McGraw Hill, 1973.”

22. SCALE-UP IN PROCESS INDUSTRIES (CL-1839)

L: T: P: Cr = 3:1:0:4

UNIT-1 INTRODUCTION **4 L**

Introduction to pilot plants and Models, Process Development, Process study, the principle of similarity and similarity criteria

UNIT-2 PILOT PLANTS AND PLANT MODELS **6 L**

Dimensional analysis and its application in scaling-up or scaling-down the chemical process plant, Project engineering, Practical consideration; Safety considerations, successful plant operations and case studies.

UNIT-3 MATHEMATICAL EQUATIONS **6 L**

Mathematical Equations representing the Mechanical, Thermal, Diffusional and chemical processes and derivation of the dimensionless groups from these differential equations. Rate of chemical reaction of Homogeneous and Heterogeneous chemical reactions.

UNIT-4 THE REGIME CONCEPT **5 L**

The Regime Concept, Laupichleir's study of catalytic water gas reaction, chemical dynamic and mixed regime, Effect of temperature on physical and chemical reactions. Similarly criteria for the principle types of regime and scale equations.

UNIT-5 SCALE UP OF HEAT TRANSFER EQUIPMENTS **6 L**

Scale-up methods for Heat-Transfer equipment e.g.-Heat Exchangers, Steam or vapor Heaters, Evaporators, Condensers and Coolers.

UNIT-6 SCALE-UP OF MISCELLANEOUS EQUIPMENT **7 L**

Scale-up methods for mixing equipment and other miscellaneous equipment used in chemical process industries.

Text & Reference Books:

1. R.E. Johnstone and M.W. Thring, "Pilot Plants, Models and Scale-up methods in Chemical Engineering ", McGraw Hill Book Company, New York, 1957.
2. Bisio&Kabel, "Scale-up in Chemical Industry".
3. D.G. Jordan, "Chemical Process Development", Vol. I & II, Interscience Publishers, 1988.

23. SOLID WASTE MANAGEMENT (CL-1840)

L: T: P: Cr = 3:1:0:4

UNIT-1 Introduction: **8L**

Philosophy and organization, Status of solid waste management, Compotation an integrated waste management strategy. Evolution of solid waste management, Legislation and Government agencies.

UNIT-2 Management: **8L**

Planning solid waste management progress, Generation of solid waste, Onsite handling, Storage and processing, Transfer and transport, Processing techniques and equipment, Hazardous waste and their management, Process management issues, Planning, Recovery of resources- Conversion, Chemical and Biological methods.

UNIT-3 Disposal of solid waste: **7L**

Land filling, Ocean disposing, Source reduction, Recycling, Incineration, Composting.

UNIT-4 Case studies on major industrial solid waste generation units: 7**L**

Coal fired power plant, Textile industry, Brewery, Distillery, Oil refinery, radioactive generation units. Case studies on spills, Sludge lagooning and incineration.

Text & Reference Books:

1. Solid Wastes, Martell, 1975, John Wiley, NY.
2. Solid Wastes, George Tchobanuglour, H.Theisen and R.Eliassen.
3. Handbook of Solid Waste by Frank Krieth, 1996, McGraw Hill Inc., NY.

24. ENERGY ENGINEERING (CL-1841)

L: T: P: Cr = 3:1:0:4

UNIT-1: Coal **6L**

Classification, properties, washing and storage, combustion, carbonization, liquefaction and gasification, briquetting of pulverized coal, proximate and ultimate analysis, merits and demerits of solid, liquid and gaseous fuels.

UNIT-2: Liquid fuels **8L**

Properties, handling, storage and transportation, combustion characteristics and associated problems, fuel specification and standards, Origin of petroleum, classification and refining of crude petroleum, knocking, octane rating and cetane rating of fuels ,Gaseous fuels: Manufacture, properties and characteristics of natural gas, CNG, LPG, coal gas, coke oven gas, producer gas and water gas

UNIT-3: Alternate energy sources **7L**

Biomass combustion and pyrolysis, bio-gas production, Solar energy- Flat plate collector, analysis and construction of solar water heater, solar pond, solar desalination and solar space heating and cooling. Geothermal energy sources and their harnessing, energy from wind and tides, energy storage and distribution

UNIT-4: Combustion process **6L**

Nature of combustion, mechanism of combustion reactions, chain reaction – hydrogen-oxygen reaction, velocity of flame propagation, limits of inflammability, structure of flame, kinematics of liquid and solid fuel combustion.

UNIT-5: Energy conservation measures **5L**

Waste heat recovery, use of low grade hot streams, condensate and flue gases, improvement in heat energy, steam trap

UNIT-6: Energy auditing **7L**

Mapping of distribution of energy supply and demand in a chemical plant, identification of energy intensive areas, energy auditing and acts.

Text books and references:

1. Fuel and Combustion – Smith N.L. &Stainson K.W.
2. Principles of Solar and Energy Handbook: Kreider J.F., Frank and Kreith, F
3. Unconventional energy sources: G.D. Rai, Khanna Publishers.
4. Renewable Energy Resources: John Twidell and Tony Wein
5. Industrial Energy Conservation: A hand book for engineers and managers - Reay D.A.
6. Fuels & Combustion: Samir, Sirkar, Orient Longman Pub. 2nd ed. Mumbai.
7. Solar Energy Engineering – S.P. Sukhatma, 2nd ed, TMH Pub, Ltd. New Delhi
8. Fuels Combustion & Refractory- O.P.Gupta, KhannaPublishers .

25. ENERGY MANAGEMENT AND AUDIT (CL-1842)

L: T: P: Cr = 3:1:0:4

UNIT-1: Energy Scenario **6L**

Commercial and Non-Commercial Energy, Primary Energy Resources, Commercial Energy Production, Energy Needs of Growing Economy, Long Term Energy Scenario, Energy Pricing, Energy Sector Reforms, Energy and Environment: Air Pollution, Climate Change, Energy Security, Energy Conservation and its Importance, Energy Strategy for the Future, Energy Conservation Act-2001 and its Features. Kyoto Protocol, Global warming.

UNIT-2: Energy Management & Audit **8L**

Definition, Types of energy audit, Energy management (audit) approach-understanding energy costs, Bench marking, Energy performance, Matching energy use to requirement, Maximizing system efficiencies, Optimizing the input energy requirements, Fuel and energy substitution, Energy audit instruments.

UNIT-3: Energy Action Planning **6L**

Key elements, Force field analysis, Energy policy purpose, perspective, Contents, Formulation, Ratification, Organizing - location of energy management, Top management support, Managerial function, Roles and responsibilities of energy manager, Accountability.

UNIT-4: Motivating-motivation of employees **4L**

Information system designing barriers, Strategies; Marketing and communicating-training and planning.

UNIT-5: Financial Management **6L**

Investment-need, Appraisal and criteria, Financial analysis techniques- Simple payback period, Return on investment, Net present value, Internal rate of return, Cash flows, Risk and sensitivity analysis; Financing options, Energy performance contracts and role of ESCOs.

UNIT-6: Project Management **8L**

Definition and scope of project, Technical design, Financing, Contracting, Implementation and performance monitoring.Implementation plan for top management, Planning Budget, Procurement Procedures, Construction, Measurement &Verification.Energy Monitoring and Targeting: Defining monitoring & targeting, Elements of monitoring & Targeting, Data and information-analysis, Techniques -energy consumption, Production, Cumulative sum of differences (CUSUM).

Text books and references:

1. Capehart, Barney L., Wayne C. Turner and William J. Kennedy, “Guide to Energy Management”, Third Edition, Fairmont Press, Atlanta, GA, 2000;
2. Albert Thumann and D. Paul Mehta “Handbook of Energy Engineering”, 4th ed. Lilburn, GA: Fairmont Press; 1997
3. Loftness, Robert L. “Energy Handbook.” 2d ed. New York: Van Nostrand Reinhold Co., 1984.
4. Turner W. “Energy Management Handbook”, Ed., John Wiley &. Sons, New York, 1982
5. Lapedes, DN “Encyclopedia of Energy”, McGraw-Hill, New York, (1976)