NEW Course Structure: B. Tech. (Chemical Engineering)

SEMESTER-I						
S. No.	**Course Code**	**Subject**	**L**	**T**	**P**	**Cr**
1	PH-11101	Physics-I	3	1	0	4
2	HS-11101/ CS-11101	English Language and Composition/ Computer Programming	2	1	0	3
3	CY-11101/AM-11101	Chemistry/Engineering Mechanics	3	1	0	4
4	MA-11101	Mathematics-I	3	1	0	4
5	ME-11101/11102	Engineering Graphics/Workshop	1	0	3	3
6	HS-11102/PH-11201	Communication Skill Workshop Physics (Lab)	0	0	3	2
7	CY-11201/AM-11201	Chemistry (Lab)/Engineering Mechanics (Lab)	0	0	3	2
8	HS-11201/CS-11201	Language Lab/Computer Programming (Lab)	0	0	3	2
		Total Credit				**24**
SEMESTER-II						
S. No.	**Course Code**	**Subject**	**L**	**T**	**P**	**Cr**
1	PH-12102	Physics-II	3	1	0	4
2	HS-12101/CS-12101	English Language and Composition/ Computer Programming	2	1	0	3
3	CY-12101/AM-12101	Chemistry/Engineering Mechanics	3	1	0	4
4	MA-12101	Mathematics-II	3	1	0	4
5	ME-12101/12102	Engineering Graphics/Workshop	1	0	3	3
6	CE-12101	Environment & Ecology	2	0	0	2
7	HS-12102/PH-12201	Communication Skill Workshop/Physics (Lab)	0	0	3	2
8	CY-12201/AM-12201	Chemistry (Lab)/Engineering Mechanics (Lab)	0	0	3	2
9	HS-12201/CS-12201	Language Lab/Computer Programming (Lab)	0	0	3	2
		Total Credit	**-**	**-**	**-**	**26**
SEMESTER-III						
S. No.	**Course Code**	**Subject**	**L**	**T**	**P**	**Cr**
1	CH-13101	Chemical Process Principles	3	1		4
2	CH-13102	Process Instrumentation	3			3
3	AM-13103	Material Science and Engineering	3			3
4	EE-13111	Basic Electrical and Electronics	3			3
5	MA-13104	Numerical Methods and Statistical Techniques	2	1		3
6	AM-13107	Fluid Flow Operations and Hydraulic Machines	3	1		4
7	ME- 13201	Computational Lab			3	2
8	AM-13203	Material Science Lab			3	2
9	AM-13207	Fluid Flow Operations Lab			3	2
		Total Credit				**26**
SEMESTER-IV						
S. No.	**Course Code**	**Subject**	**L**	**T**	**P**	**Cr**
1	CH-14101	Fluid Particle Mechanics and Mechanical Operations	3	1		4
2	CH-14102	Heat Transfer Operations	3	1		4
3	CH-14103	Mass Transfer-I	3	1		4
4	CH-14104	Chemical Engineering Thermodynamics-I	3	1		4
5	CY-14101	Organic and Physical Chemistry	2	1		3

6	CH-14251	Heat Transfer Lab			3	2
7	CH-14252	Fluid Particle Mechanics and Mechanical Operations Lab			3	2
8	CY-14251	Organic and Physical Chemistry Lab			3	2
		Total Credit				**25**
SEMESTER-V						
S. No.	**Course Code**	**Subject**	**L**	**T**	**P**	**Cr**
1	CH-15101	Chemical Reaction Engineering-I	3	1		4
2	CH-15102	Mass Transfer-II	3	1		4
3	CH-15103	Process Dynamics and Control	3	1		4
4	CH-15104	Chemical Engineering Thermodynamics-II	3	1		4
5	HS-15101	Principles of Management	3			3
6	CH-15251	Mass Transfer Lab			3	2
7	CH-15252	Process Dynamics and Control Lab			3	2
8	CH-15253	Process Simulation Lab			3	2
		Total Credit				**25**
SEMESTER-VI						
S. No.	**Course Code**	**Subject**	**L**	**T**	**P**	**Cr**
1	CH-16101	Chemical Reaction Engineering-II	3	1		4
2	CH-16102	Transport Phenomena	3	1		4
3	CH-16103	Environmental Pollution, Monitoring and Control	3	1		4
4	CH-16104	Process Equipment Design	3	1		4
5	CH-16105	Chemical Technology	3	1		4
6	HS-16101	Communication Skills Workshop			2	0
7	CH-16251	Chemical Technology Lab			3	2
8	CH-16252	Chemical Reaction Engineering Lab			3	2
9	CH-16253	Environmental Engineering Lab			3	2
		Total Credit				**26**
SEMESTER-VII						
S. No.	**Course Code**	**Subject**	**L**	**T**	**P**	**Cr**
1	CH-17101	Petroleum Refining and Petrochemicals	3	1		4
2	CH-17102	Optimization of Chemical Processes	3	1		4
3	OE-17501	Open Elective-I	3			3
4	CH-17331-CH-17340	Professional Elective – I	3	1		4
5	CH-17341-CH-17350	Professional Elective – II	3	1		4
6	CH-17691	Major Project – I			12	6
		Total Credit				**25**
SEMESTER-VIII						
S. No.	**Course Code**	**Subject**	**L**	**T**	**P**	**Cr**
1	CH-18101	Hazards and Safety in Chemical Industries	3	1		4
2	CH-18102	Plant Design and Economics	3	1		4
3	OE-18501	Open Elective-II	3			3
4	CH-18331-CH-18340	Professional Elective – III	3	1		4
5	CH-18341-CH-18350	Professional Elective – IV	3	1		4
6	CH-18691	Major Project – II			12	6
		Total Credit				**25**

Total Credits = 24 (I) + 26 (II) + 26 (III) + 25 (IV) + 25 (V) + 26 (VI) + 25 (VII) + 25 (VIII) = 202

LIST OF PROFESSIONAL ELECTIVES FOR UG COURSE STRUCTURE

A) Professional Electives- I & II

S. No.	Subject Code	Proposed Course Code	Subject Name
1.	CH-1731	CH-17331	INTRODUCTION TO BIOCHEMICAL ENGINEERING
2.	CH-1732	CH-17332	ALTERNATE ENERGY SOURCES
3.	CH -1733	CH -17333	POLYMER SCIENCE AND TECHNOLOGY
4.	CH -1734	CH -17334	FOOD TECHNOLOGY AND ENGINEERING
5.	CH -1735	CH -17335	FERTILIZER TECHNOLOGY
6.	CH -1736	CH -17336	TWO PHASE FLOW AND HEAT TRANSFER
7.	CH -1737	CH -1737	ADVANCED PROCESS CONTROL
8.	CH -1738	CH -17338	MATHEMATICAL METHODS IN CHEMICAL ENGINEERING
9.	CH -1739	CH -17339	INTERFACIAL SCIENCE AND ENGINEERING
10.	CH -1740	CH -17340	BIOENERGY ENGINEERING
11.	CH -1741	CH -17341	ELECTROCHEMICAL ENGINEERING
12.	CH -1742	CH -17342	INDUSTRIAL CATALYSIS

B) Professional Electives- III & IV

S. No.	Subject Code	Proposed Course Code	Subject Name
1.	CH -1831	CH -18331	INTRODUCTION TO NANOTECHNOLOGY
2.	CH -1832	CH -18332	INTRODUCTION TO PROCESS INTENSIFICATION
3.	CH -1833	CH -18333	ADVANCED SEPARATION PROCESSES
4.	CH -1834	CH -18334	PROCESS MODELING AND SIMULATION
5.	CH -1835	CH -18335	INTRODUCTION TO MULTIPHASE FLOW
6.	CH -1836	CH -18336	ENERGY ENGINEERING
7.	CH -1837	CH -18337	SCALE-UP IN PROCESS INDUSTRIES
8.	CH -1838	CH -18338	SOLID WASTE MANAGEMENT
9.	CH -1839	CH -18339	INDUSTRIAL CORROSION AND SURFACE COATING
10.	CH -1840	CH -18340	INDUSTRIAL ENZYME ENGINEERING AND FERMENTATION TECHNIQUES
11.	CH -1841	CH -18341	ADVANCES IN FLUIDIZATION ENGINEERING
12.	CH -1842	CH -18342	UPSTREAM HYDROCARBON ENGINEERING

Note:

VII Semester **VIII Semester**

Section - 1

DETAILED SYLLABUS OF COURSES

3rd Semester Syllabus

CH-13101: CHEMICAL PROCESS PRINCIPLES

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

Objectives: *To impart fundamental knowledge about various unit systems for chemical process calculations and to give insight of material and energy balances in various unit operations and processes.*

LESSON PLAN

UNIT 1 **[7L]**

Introduction to various system of units and dimensions, basic quantities and units, derived quantities and units, stoichiometric principles, composition relations, density and specific gravity.

UNIT 2 **[7L]**

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 **[8L]**

Humidity, saturation, vaporization, condensation, wet and dry bulb thermometry, solubility, crystallization and dissolution, solubility of gases.

UNIT 4 **[9L]**

Material Balance in unit operations, material balance without chemical reaction, material balance involving chemical reaction, combustion of solids, liquids, and gaseous fuels, recycling operations, bypassing operations, purging operations.

UNIT 5 **[9L]**

Thermophysics, components of energy balance equations, heat capacity of gases, liquids, and solids, estimation of heat of fusion, heat of vaporization, thermo chemistry, Hess's law of constant heat summation, heat of reaction, effect of temperature on standard heat of reaction, calculation of theoretical flame temperature and actual flame temperature.

Text Books and References:

1. *O.A.Hougen, K.M. Watson, R.A. Ragatz, "Chemical Process Principles", Vol. I, CBS Publishers and Distributors, 1995.*
2. *K.V. Narayanan, B. Lakshmikutty, "Stoichiometry and Process Calculations", PHI Learning Pvt. Ltd., 2006.*
3. *D.M. Himmelblau, J.B. Riggs, '"Basic Principles and Calculations in Chemical Engineering", PHI Learning Pvt. Ltd., 2014.*
4. *B.I. Bhatt, S.M.Vora, "Stoichiometry", Tata McGraw Hill Publishers Ltd., 1996.*
5. *V.Venkataramani, N.Anantharaman, "Process Calculations", PHI Learning Pvt. Ltd., 2011.*

CH-13102: PROCESS INSTRUMENTATION

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

Objectives: *To impart knowledge of basic process instrumentations used in the chemical industries along with performance characteristics of measuring instruments andanalysis of experimental data.*

LESSON PLAN

UNIT 1 Introduction to Instruments and Their Representation: [4 L]

Application of instrument systems, functional elements of a measurement system, classification of instruments, standards and calibration.

UNIT 2 Temperature Measurements: [4 L]

Temperature Scales, temperature measuring instruments: liquid in glass thermometer, bimetallic thermometer, resistance temperature detectors (RTD), thermocouples, pyrometry.

UNIT 3 Pressure Measurements: [4 L]

Measurement of moderate pressure, high pressure and low pressure (vacuum), calibration and standardization.

UNIT 4 Flow Measurements: [5 L]

Positive displacement meters, variable head meters, variable area meters (rotameters), weirs and notches, pitot tube, electromagnetic flow meter, hot wire anemometer, ultrasonic flow meters, laser Doppler anemometer.

UNIT 5 Miscellaneous Measurements: [8 L]

Liquid level, pH, viscosity, conductivity, humidity, gas composition, and nuclear radiation. Static and Dynamic characteristics of measuring instruments, Analysis of experimental data

Text Books and References:

1. D. P. Eckman, "Industrial Instrumentation" CBS New Delhi, 2004.

2. J.P. Holman, "Experimental methods for Engineers" 7th ed. Tata McGraw Hill, New Delhi, 2007.

3. B.C. Nakra, K.K.Chaudhry, "Instrumentation, Measurement and Analysis" 2nded., Tata McGraw Hill, New Delhi, 2004.

4. Patranabis, D., "Principles of Industrial Instrumentation" Tata McGraw Hill, New Delhi, 1999.

5. Doebelin, E., "Measurement Systems: Applications and Design" 4thed., McGrawHill, 1990.

AM-13103: MATERIAL SCIENCE AND ENGINEERING

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

Objectives: *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.)*

LESSON PLAN

UNIT 1: Introduction **3 L**

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

UNIT 2: Structure of Solids and Characterization of Materials **6 L**

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.

UNIT 3: Imperfections in Solids **4 L**

Point defects, Dislocations, Interfacial Defects, Bulk defects.

UNIT 4: Diffusion **4 L**

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

UNIT 5: Mechanical Behaviour of Materials **6 L**

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

UNIT 6: Phase Diagrams and Phase Transformations **6 L**

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.

UNIT 7: Ceramic Materials **2 L**

Ceramic types, Properties, ProcessingApplication, Advanced ceramics.

UNIT 8: Composites **2 L**

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

UNIT 9: Thermal, Electrical, Magnetic, Optical Properties **5 L**

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.

UNIT 10: Economic, Environmental and Social Issues of Material Usage **2 L**

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

Text Books and References:

1. *Callister W. D. Jr., Materials Science and Engineering An Introduction.*
2. *Van Vlack, Material Science.*
3. *Raghavan V, Material Science.*
4. *K. M. Gupta, Material Science and Engineering*

EE-1305: BASIC ELECTRICAL AND ELECTRONICS

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

LESSON PLAN

UNIT 1: 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

UNIT 2: 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**.**

UNIT 3: MEASUREMENT AND MECHATRONICS INSTRUMENTATION

Measuring Instruments: Types of instruments, working principles of Ammeter, Voltmeter, Wattmeter & Energy meter, Digital instruments, 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

Objectives: *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.*

Prerequisites: *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.*

LESSON PLAN

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.

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-13107: FLUID FLOW OPERATIONS AND HYDRAULIC MACHINES

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

LESSON PLAN

UNIT-1: Introduction to Fluid Mechanics- Statics and Kinematics **8 L**

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 L**

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 L**

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 L**

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 L**

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 L**

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

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

List of Experiment

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-13203: MATERIAL SCIENCE LABORATORY

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

List of Experiment

1. Study of various dislocation models, drawing burgers circuit and finding Burgers vector.
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.
3. To study the effect of a surface treatment (Etching) on the strength of glass.
4. Heat treatment processes (Annealing, Normalizing, Quenching) and comparison of hardness before & after heat treatment.
5. To predict creep characteristic of materials by plotting strain vs. time curves for different loadings.
6. Comparative study of microstructures of different given specimens (mild steel, grey C.I., brass, and copper).
7. Specimen preparation for micro structural examination by cutting, grinding, polishing and etching of aluminium specimen.
8. Fabrication of composite by hand-lay up technique.
9. Mechanical testing of composite made by hand-lay up technique in experiment no. 8.
10. To study the fatigue behavior of a given sample.

AM-13207: FLUID FLOW OPERATIONS LABORATORY

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

Pre-requisite: *Fluid Mechanics/ Fluid Flow Operations*

List of Experiment

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.

Text Books and 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.*

4th Semester Syllabus

CH-14101: FLUID PARTICLE MECHANICS AND MECHANICAL OPERATIONS

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

Objectives: *To impart necessary basic knowledge in order to understand, analyse and solve problems related to electrochemical processes.*

Prerequisites: *Students will learn and have the knowledge on electrical double layer, Electrocatalysis and different types of electrochemical techniques. The students will have a practical ability to analyse electrochemical design models, thermal behaviour of reactors and electrochemical reactors.*

LESSON PLAN

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 solid particles: shape &size, Differential and cumulative screen analysis, specific surface area, particle population, different mean diameters for a mixture of particles.

UNIT-2: HANDLING OF PARTICULATE SOLID 7 L

Conveying: Types of conveyors, Mechanical - belt, chain, screw conveyors, elevators & pneumatic conveyors. Storage of solids in bulk protected and unprotected piles, bines, silos, hoppers, feeders, mass flow and funnel flow bins. Weighing of bulk solids and 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, Scrubbers.

UNIT -4: SIZE REDUCTIONAND ENLARGEMENT 8 L

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, Principles of cake filtration, Batch and continuous filters, Flow through filter cake and filter media, Filter aids, compressible and incompressible filter cakes, Filtration equipments - selection, classification and working operations.

UNIT-6: MIXING OF SOLIDS & PASTES **4 L**

Mixing and agitation - Mixing of liquids (with or without solids), Mixing of powders, Selection of suitable mixers, Mixing equipments.

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.

CH-14102: HEAT TRANSFER OPERATIONS

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

Objectives: *To understand the principles and applications heat transfer.*

Prerequisites: *To learn heat transfer by conduction, convection and radiation and design heat transfer equipments 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: 10 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: 6 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; 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 Heat Transfer: A Practical Approach, McGraw Hill, 2nd Edition.

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, Fifth Edition.

CH-14103: MASS TRANSFER – I

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

Objectives: *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.*

LESSON PLAN

UNIT 1: Diffusion: **6 L**

Fick's Law of diffusion, Molecular and Eddy diffusion, Pseudo steady state diffusion, Measurement and calculation of diffusivities, Diffusion in gaseous mixture, liquid mixtures and solids, Unsteady state diffusion.

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, momentum and heat transfer analogies, Mass transfer equipments: batch and continuous stage wise contactors, differential contactors.

UNIT 3: Absorption: **8 L**

Principle of gas absorption, solubility theory, choice of solvent and packing, 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 isotherms, stage wise and continuous contact operations, unsteady state: Fixed-bed adsorption, adsorption equipments, ion exchange.

UNIT 5: Humidification: **7 L**

Definitions related with humidity, wet bulb theory, enthalpy of pure substances, adiabatic gas-liquid contact operation, methods of humidification and dehumidification, design of cooling towers.

UNIT 6: Drying: **5 L**

Theory and mechanism of drying, drying characteristics, drying rate curve, classification of dryers, different modes of drying operations, design of batch and continuous dryers.

Text Books and References:

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

CH-14104: CHEMICAL ENGINEERING THERMODYNAMICS - I

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

LESSON PLAN

UNIT-1: **9 L**

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.

UNIT-2: **8 L**

Diathermic boundary, Zeroth law. Isothermal states. Empirical temperature. Principles of thermometry. Scales of temperature. Gas thermometer. The ideal gas. Ideal gas temperature scale. The first law. Basic form. Energy of a system. The heat interaction. Sign convention. First law for open systems. Steady-flow energy equation and its applications.

UNIT-3: **10 L**

Equations of state. Properties of gases. Properties of steam. Introduction to steam tables. Other equations of state. Vander Waals gas. Critical state. Reduced equation of state. The second law. Kelvin-Planck and Clausius statements. Equivalence of statements. Carnot theorem. Thermodynamic temperature. Kelvin scale. Carnot engine, refrigerator and heat pump.

UNIT-4: **7 L**

Clausius in equality. Definition of entropy. Combined first and second law, Evaluation of entropy. Principle of increase of entropy. Irreversibility and energy. Lost work.

UNIT-5: **5 L**

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

Text Books and References:

1. *Engineering thermodynamics by P K Nag, Tata McGraw Hill.*
2. *Thermodynamics: An engineering approach by Cengel& Boles, McGraw Hill.*
3. *Engineering and Chemical Thermodynamics by Milo D Koretsky, Wiley Publications.*

CY-1401: ORGANIC AND PHYSICAL CHEMISTRY

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

LESSON PLAN

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.

Text Books and 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.*

CH-14251: HEAT TRANSFER LAB

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

List of Experiment

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 Emissivity 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.

CH-14252: FLUID PARTICLE MECHANICS AND MECHANICAL OPERATIONS LAB

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

Objectives: *To enable the students to develop a sound working knowledge on different types of crushing equipments and separation characteristics of different mechanical operation separators.*

Prerequisites: *Students would gain the practical knowledge and hands on various separation techniques like filtration, sedimentation, screening, elutriation and crushing*

List of Experiment

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

Text Books and References:

1. Mechanical operation lab manual of Chemical Engineering Dept., MNNIT Allahabad.

CY-14251: ORGANIC AND PHYSICAL CHEMISTRY LAB

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

List of Experiment

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's I^{st} 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.

5th Semester Syllabus

CH-15101: CHEMICAL REACTION ENGINEERING-I

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

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

Prerequisites: *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. 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: kinetics of reactions **4 L**

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

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

Constant-volume batch reactor, Varying-volume batch reactor, Dependency of rate equation on temperature, Searching for a rate equation.

UNIT-3: Design of Ideal Reactor: For Single Reactions **10 L**

Introduction to ideal reactors for a single reaction, Ideal batch reactor, Ideal mixed flow reactor, and Ideal plug flow reactor, Size comparison of single reactors, Multiple reactor systems, Recycle reactor, and 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.*
5. *Lanny D. Schmidt, "The engineering of chemical reactions" Oxford University Press, New York.*

CH-15102: 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.*

LESSON PLAN

UNIT 1: Distillation: [4L]

Vapor- liquid equilibria: pressure-temperature-concentration phase diagrams, 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: [8L]

Fractionating column: combination of rectification and stripping, Rectification on an ideal plate, design calculations using McCabe Thiele and PonchonSavarit methods: total reflux ratio, minimum and optimum reflux ratio, bottom plate and reboiler, open steam distillation, tray efficiency, calculation 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: [8L]

Principles of extraction, ternary liquid equilibria, effect of pressure and temperature, triangular graphical representation concept of theoretical or ideal stage, single stage operation, multistage continuous operation: co-current and cross current operations, stage calculation, Analytical and graphical solutions of single and multistage operations for miscible and immiscible systems, equipments: mixer settlers, plate column, spray and packed column, etc.

UNIT 5: Solid - liquid extraction: [8L]

Theory, mechanism, types of leaching, solid - liquid equilibria, constant and variable underflow, batch and continuous operations: single and multistage cross current and counter current operations, equipments: percolation tank, agitated vessel, thinkers, classifiers etc.

UNIT 6: Crystallization: [8L]

Principle and solubility curve of crystallization, theory of super saturation, nucleation and crystal growth rate, controlled growth of crystals, equilibrium yield, 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, P.Harriot, "Unit Operations of Chemical Engineering", McGraw Hill Book Co., New York.*

CH-15103: PROCESS DYNAMICS AND CONTROL

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

Objectives: *The objective is to learn the scientific and engineering principles underlying process dynamics and control systems. It develops an insight into chemical process control problems and makes familiar with industrial control systems*

LESSON PLAN

UNIT-1: INTRODUCTION AND DYNAMICS OF PRPCESSES **12 L**

Introduction to process control - Need of process control, process control strategies, process control activities; Theoretical models of chemical processes - Modelling principles, dynamic models and their solutions; Laplace transforms.

UNIT-2: FIRSTAND HIGHER ORDER SYSTEMS **8 L**

Development and properties of transfer functions, linearization of non-linear models Response of first and second order processes, Dynamic response of more complicated processes.

UNIT-3: FEEDBACK CONTROLLERS **7 L**

Concept & type of feedback control, block diagram representation, response of it, Proportional controller, Proportional Integral (PI) controller and Proportional derivative (PD) controller and PID controller.

UNIT-4: DESIGN AND STABILITY **8 L**

Influence of process design on process control, degrees of freedom for process control, Selection of variables, Dynamic behavior and stability of closed loop system- closed loop representation, transfer functions, stability analysis-Routh analysis

UNIT-5: **5 L**

Frequency response – Control system design, Root locus, Bode plot, Nyquist plot.

Text Books and References:

1. *D. E.Seborg, T.F. Edgar and D.A. Mellichamp, "Process Dynamics Control", Wiley,3rd Ed. 2013.*
2. *G Stephanopopulas, "Chemical Process Control", Prentice-Hall India, 1984.*
3. *D. R. Coughanowr, "Process System Analysis and Control", 2nd Ed. McGraw Hill, 1991.*
4. *S. Sundaram "Process Dynamics and Control", Cengage Publishers.*

CH-15104: CHEMICAL ENGINEERING THERMODYNAMICS-II

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

Objectives: *To present thermodynamic principles from a chemical engineering viewpoint.*

Prerequisites: *Students will learn laws of thermodynamics, thermodynamic property relations and the behavior of fluids under PVT conditions, theory and application of solution thermodynamics and chemical reaction equilibrium, compression and refrigeration processes.*

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: [10L]

Fundamental Property relation, Maxwell equation and consistency tests, The Chemical potential and phase equilibria, Partial molar quantities, Gibbs-Duhem Equation, Criteria for thermodynamic equilibrium, Phase equilibrium criteria, Ideal Solutions and Ideal Gas Mixtures, Concept of Fugacity and Fugacity coefficient, Fugacity and Activity Coefficient Models, Non-ideal solutions, Residual and excess properties, Solid-liquid equilibrium, solubility of gases in liquids, Liquid-liquid equilibrium.

UNIT-4: Chemical Reaction Equilibrium: [10 L]

The reaction Coordinate, Application of equilibrium criteria to chemical reactions, the standard Gibbs free energy change and the equilibrium constant, Effect of temperature on equilibrium constant, Evaluation of equilibrium constants, Relation of equilibrium constants to composition, Heat effects, industrial reactions (NH_3 synthesis etc), free energy calculations, Homogeneous and heterogeneous reaction systems, multiple reactions, partially miscible and immiscible systems, Azeotropes, retrograde condensation, thermodynamic diagrams, Multi reaction Equilibria.

UNIT-5: Compression and Refrigeration Cycle: [6 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 & 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. K.V.Narayanan, "A text book of Chemical Engineering Thermodynamics", PHI Learning Private Limited, New Delhi.

4. B.F. Dodge, "Chemical Engineering Thermodynamics", McGraw Hill, New York.
5. S.I. Sandler, "Chemical and Engineering Thermodynamics, Wiley.

HS-1501: PRINCIPLES OF MANAGEMENT

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

Objectives: *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.*

Prerequisites: *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.*

LESSON PLAN

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

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: **6 L**

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

Unit III: **8 L**

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

Unit IV: **11 L**

Organizing Nature 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: **5 L**

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: **5 L**

Organizational Behavior: Organizational change, Conflict Management and Stress Management.
Functional management: Human Resource Management, Financial management, marketing Management.

Text Books & 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

CH-15251: MASS TRANSFER LAB

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

List of Experiment

1. Diffusion of an organic vapour in air.

2. Mass transfer with/without chemical reaction

3. Adsorption studies of dyes on activated carbon

4. Studies on forced draft Cooling Tower.

5. Drying of Solid in tray dryer under forced draft condition.

6. VLE curve for CCl_4- toluene mixture

7. Study of bubble cap multistage batch type distillation column.

8. To study the characteristics of steam distillation using turpentine oil as a feed stock.

9. To study the performance of Swenson Walker crystallizer.

10. Extraction of acetic acid from its mixture with toluene using water

CH-15252: PROCESS DYNAMICS & CONTROL LAB

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

List of Experiment

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.

CH-1553: PROCESS SIMULATION LAB

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

List of Experiment

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 Multi component 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 Multi component 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.

6th Semester Syllabus

CH-16101: CHEMICAL REACTION ENGINEERING-II

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

Objectives: *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.*

Prerequisites: *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 heterogeneous chemical reactions and the design of the reactors such reactions via synthesischemical kinetics, transport phenomena, and mass & energy balances. Derivations of rate expressions from reaction mechanisms for heterogeneous reactions arealso taken into account.*

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 fluid-particle reaction systems, 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, evaluation and elimination of internal and external diffusion resistances, effectiveness factor, heat effects, controlling resistances, rates of chemisorptions, adsorption isotherms, and 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.*
5. *Lanny D. Schmidt, "The engineering of chemical reactions" Oxford University Press, New York.*

CH-16102: TRANSPORT PHENOMENA

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

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

Prerequisites: *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: 8 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: 10 L

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: 8 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.*

CH-16103: ENVIRONMENTAL POLLUTION MONITORING AND CONTROL

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

Objectives: *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.*

Prerequisites: *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 **6 L**

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 **6 L**

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 **4 L**

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.*

CH-16104: PROCESS EQUIPMENT DESIGN

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

Objectives: *To impart the information about design of process equipments and develop understanding about pressure vessel design and storage tank design.*

LESSON PLAN

UNIT 1 **7 L**

Nature of process equipments, general design procedure, basic considerations in design, standards codes and their significance, equipment classification and their selection, design pressure, design temperature, design stress, review of fabrication techniques and environmental considerations in design procedure.

UNIT 2 **8 L**

Proportioning of pressure vessels, selection of L/D ratio, optimum proportions of vessels. Design of unfired pressure vessels subjected to combined loading, purging of vessels. Selection and design of various heads such as flat, hemispherical, elliptical and conical, opening/nozzles, manholes, nozzle reinforcement design, etc. Flanged joints, classification of flanges, design of non standard flanges, types of gaskets, their selection, and design.

UNIT 3 **8 L**

Various types of storage vessels and applications, atmospheric vessels, vessels for storing volatile and nonvolatile liquids, storage of gases, losses in storage vessels, various types of roofs used for storage vessels, manholes, nozzles and mountings. Design of cylindrical and spherical storage vessels; should include base plates, shell plates, roof plates, wind girders, curb angles for self supporting and column supported roofs.

UNIT 4 **9 L**

Types of agitators, their selection, applications, baffling, power consumption which includes twisting moment, equivalent bending moment, design of blades etc. Reaction vessels-Introduction, classification, heating systems, design of vessels, study and design of various types of jackets like plain, half coil, channel.

UNIT 5 **9 L**

Design of heat transfer equipments such as heat exchangers with and without phase change, evaporators, crystallizers.Design of mass transfer equipments such as distillation columns, absorption columns, extraction columns, dryers and cooling towers.

TEXT BOOKS AND REFERENCES:

1. *S. D. Dawande, "Process Design of Equipments", Central Techno Publications, 2005.*
2. *M.V. Joshi, V. V. Mahajani, "Process Equipment Design", Macmillan India Ltd., 2000.*
3. *B.C. Bhattacharyya, "Introduction to Chemical Equipment Design", CBS Publishers & Distributors, 2003.*
4. *D. Q. Kern*, "*Process Heat Transfer*",*Tata McGraw-Hill*, 2004.
5. *J.M. Coulson, J. F. Richardson, R. K. Sinnott, "Coulson and Richardson's Chemical Engineering: Chemical Engineering Design"Vol.6, Butterworth – Heinemann, 2004.*
6. *E. Ludwig, "Chemical Process Equipment Design", Gulf Pub., 2002.*

7. *Indian standards Institution, 'Code for unfired pressure vessels', IS – 2825.*

CH-16105: CHEMICAL TECHNOLOGY

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.*

Prerequisites: *This course provides a detailed understanding of manufacturing of various chemical compounds and the related industries.*

LESSON PLAN

UNIT -1: **5 L**

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

UNIT -2: **5 L**

Sulphur and Sulphuric acid: Manufacture of sulphuric acid&Oleum.

UNIT -3: **5 L**

Cement: Types and Manufacture of Portland cement

UNIT -4: **5 L**

Industrial Gases: Hydrogen, Producer Gas & Water-Gas.

UNIT -5: **5 L**

Manufacture of paints and Pigments.

UNIT-6: **5 L**

Nitrogen industries :- Ammonia, Nitric Acid, Nitrogenous & mixed fertilizers

UNIT-7: **5 L**

Pulp& paper Industry

UNIT-8 **5 L**

Petrochemicals:- Formaldehyde, Ethylene Glycol , Styrene, Butadiene.

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.*

CH-16251: CHEMICAL TECHNOLOGY LAB

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

List of Experiment

1. To determine the aniline point and mixed aniline point of a given oil sample.
2. To determine viscosity of a given sample by Tar viscometer.
3. To determine Conradson carbon residue (CCR) content in a given oil sample.
4. To determine asphaltenes content in a residual fuel oil sample.
5. To determine the calorific value of a given sample by using bomb calorimeter.
6. To determine the flash point of a given oil sample by using Pensky-Martens apparatus.
7. To determine the flash point and fire point of a given oil sample by using Cleveland open cup apparatus.
8. To determine pour point and cloud point of a given oil sample.
9. To carry out proximate analysis of a given sample.
10. To carry out distillation characteristics of a lighter oil fraction via ASTM D86 method.
11. To prepare soap via saponification process.
12. To prepare tooth powder.
13. To prepare pigment of three different colours.

CH-16252 CHEMICAL REACTION ENGINEERING LAB

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

List of Experiment

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-16253 ENVIRONMENTAL ENGINEERING LAB

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

List of Experiment

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.

7th Semester Syllabus

CH-17101: PETROLEUM REFINING ENGINEERING

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

Objectives: *To impart information about the importance of crude oil in energy mix and to acquaint the students about various processes in petroleum refining industry.*

LESSON PLAN

UNIT 1 **[7L]**

World and Indian petroleum refining scenario, composition of crude oil, classification of crude oil, UOP Characterization factor, types of refineries, various petroleum products, Indian specifications, testing methods and their significance.

UNIT 2 **[7L]**

Dehydration and desalting of crude oil, descriptive account of atmospheric distillation, vacuum distillation, various straight-run products, properties and applications, treatment techniques for the straight-run products.

UNIT 3 **[9L]**

Thermal conversion processes, reactions involved in thermal conversion processes, free radical mechanism, thermal cracking, coil visbreaking, coil-soaker visbreaking, delayed coking, fluid coking, flexi coking.

UNIT 4 **[9L]**

Catalytic conversion processes, reactions involved in catalytic conversion processes, carbonium ion mechanism, catalytic cracking, fixed bed catalytic cracking and fluidized catalytic cracking, deep catalytic cracking, hydrocracking, catalytic reforming, isomerisation, alkylation.

UNIT 5 **[8L]**

Heavy oil and petroleum residue upgrading, petroleum coke gasification, fixed bed gasifier, fluidized bed gasifier, entrained bed gasifier, Fischer-Tropsch synthesis for the production transportation fuels from synthesis gas.

Text Books and References:

1. *J.H. Gary, G.E. Handwerk, M.J. Kaiser, "Petroleum Refining:Technology and Economics", Marcel Dekker Publication, 2007.*
2. *J.G. Speight, "The Chemistry and Technology of Petroleum", Marcel Dekker Publication, 2006.*
3. *W.L. Nelson, "Petroleum Refinery Engineering", McGraw Hill Publication, 1958.*
4. *B. K. BhaskaraRao, "Modern Petroleum Refining Processes", Oxford and IBH Publishing Company, 1990.*

5. *R. Prasad, "Petroleum Refining Technology", Khanna Publishers, 2002.*

CH-17102: OPTIMIZATION OF CHEMICAL PROCESSES

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

Objectives: *The present course aims the study of optimization techniques for designing any chemical process, and the principles for developing an executive system.*

Prerequisites: *Numerical methods and other UG level chemical engineering courses*

LESSON PLAN

UNIT 1 **[8 L]**

Introduction to optimization; formulation of objective function; basic concepts-functions, regions, necessary and sufficient conditions for an extreme of an unconstrained function; one dimensional search: scanning and bracketing; Newton, quasi-Newton and secant methods; region elimination method, polynomial approximation methods.

UNIT 2 **[8 L]**

Unconstrained multivariable optimization: Direct methods-random search, grid search, univariate search, simplex method, conjugate search direction and Powell's method; Indirect method-gradient and conjugate gradient methods Newton's method, movement in search direction, secant method.

UNIT 3 **[10 L]**

Linear programming: Basic concept in linear programming; Graphical solution; simplex method; Standard LP from; Obtaining first feasible solution; Sensitivity analysis. Non linear programming: Lagrange multiplier method; Quadratic programming; penalty function and augmented Lagrangian methods; Successive quadratic programming; Optimization of dynamic process.

UNIT 4 **[9L]**

Optimization of staged and discrete processes: Dynamic programming; integer and mixed integer programming; Nontraditional optimization techniques: Simulated annealing; Genetic algorithms; Differential evolution.

UNIT 5 **[6 L]**

Application of optimization in the design of separation process, chemical reactor and large scale process plant.

Text Books and References:

1. *Onwubolu, G.C.; Babu, B.V., "New Optimization Techniques in Engineering; Springer-Verlag, Germany, (2004).*
2. *Edgar, T.F., Himmelblau, D.M., Lasdon, L.S., "Optimization of Chemical Processes" second edition, McGraw-Hill (2001).*
3. *Babu, B.V. "Process Plant Simulation", Oxford University Press, India (2004).*
4. *Jana A.K., "Chemical Process Modeling and Computer Simulation" PHI, New Delhi (2011)*

8th Semester Syllabus

CH-18101: 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 hazards analysis.*

Introduction: *Students learn about implementation of safety procedures, risk analysis and assessment, fire and explosion models, hazard identification, HAZOP.*

LESSON PLAN

UNIT-1: INTRODUCTION **4 L**

Safety terminology, Safety programs, Safety policy, Safety committee: structure and functions, Psychological factors in industrial safety, Accident and loss statistics.

UNIT-2: INDUSTRIAL HYGIENE AND OCCUPATIONAL HEALTH **7 L**

Definition of Industrial Hygiene, Govt. regulations and evaluation, Concept of threshold: TLV, OSHA, FAR, Fatality rate, Occupational health hazards: toxicological studies, Dose versus response, Personal protective equipment (PPE), Material safety data sheet (MSDS), Ergonomics: definition, aims andscope, application ofergonomics in industry for safety, health andenvironment.

UNIT-3: PAST ACCIDENT ANALYSIS **6 L**

Past accident analysis of Flixborough, Bhopal gas tragedy, Three mile island Chernobyl accident, Fukushima Daiichi,Port Wentworth, Pasadena, Jacksonville,Feyzin disaster, Seveso accident analysis.

UNIT -4: FIRE AND EXPLOSION **6 L**

The fire triangle, Potable fire extinguishers, Effects of explosion, Explosions: deflagration, detonation, TNT& TNO, Confine & unconfined explosion, Over pressure, Flash fire, Jet fire, Pool fire, VCE, BLEVE, Fire ball.

UNIT-5: SAFETY MANAGEMENT **6 L**

Process safety management, Risk management and its tools, Safety health and environment(SHE)management, Safety audit, Safety report: preparation andassessment, Safety surveys and review,Emergency response and preparedness.

UNIT-6: HAZARD AND RISK ANALYSIS **7 L**

Hazard identification, Comprehensive risk analysis, Preliminary hazard analysis, FMEA, HAZOP study, Checklists/ What if analysis, Event tree and fault tree analysis, Hazards and their control in: textile industry, fertilizer industry and petroleum refineries, etc.

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*

CH-18102: PLANT DESIGN AND ECONOMICS

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

Objectives: *To impart information about overall plant design for a particular process for the manufacture of particular product considering various aspects such as site selection, plant layout, material of construction, and economic principles involved in construction of a process plant.*

LESSON PLAN

UNIT 1: Methods of Process Design [6L]

General design considerations, material and fabrication selection, hierarchy of chemical process design, economic design criteria, nature of process synthesis and analysis.

UNIT 2: Cash Flow and Investments [8L]

Cash flow for industrial operations, factors effecting investment and production cost, estimation of capital investments, 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: Depreciation and Profitability [8L]

Depreciation, types of depreciation, services life, 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: Optimization of process flow sheets [9L]

Objectives, Introduction, General formulation of the optimization problem, Objective function and decision variables, equality and inequality contraints, lower and upper bounds Linear Programming, Non linear programming with a single variable.

UNIT 5: Process Integration [8L]

Process heuristics, sequences of ordinary distillation columns for ideal mixtures, Heat exchange networks synthesis and utilities, energy targets.

Text Books and References:

1. *M.S. Peters, K.D.Timmerhaus, "Plant Design and Economics for Chemical Engineering", McGraw-Hill, 1991.*
2. *W.D. Seider, J.D. Seader, D.R. Lewin, "Process Design Principles: Synthesis, Analysis, and Evaluation", John Wiley, 1999.*
3. *Perry's Chemical Engineer's Handbook, McGraw-Hill, 2007.*

Section - 2

SYLLABUS OF

PROFESSIONAL ELECTIVES

Professional Electives – I & II

CH-17331: INTRODUCTION TO BIOCHEMICAL ENGINEERING

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

Objectives: *This course introduces the basic aspects of biochemical engineering and bioprocess technology and their commercial implications to the students from various disciplines.*

LESSON PLAN

6 L

UNIT-1: Introduction to microbiology and biochemistry, classification and characteristics of microorganism, Essential chemicals of life - lipids, sugars and polysaccharides, RNA and DNA, amino acids and proteins.

12 L

UNIT-2: Enzymes and their classification, enzyme kinetics, immobilization of enzymes and whole cells, immobilized enzyme kinetics

10 L

UNIT-3: Cell metabolism, regulation, stoichiometry, end products, cell growth kinetics, product formation kinetics, thermal death kinetics, media and air sterilization

5 L

UNIT -4: Transport phenomena in cellular systems, oxygen transfer rates, mass transfer coefficient and interfacial area, mechanical agitation and power requirement

8 L

UNIT-5: Bioreactors: Type, design, operation and scale-up, instrumentation and control. Down-stream processing, environmental concerns

Text Books and References:

1. *J.E. Bailey, D.F. Ollis, "Biochemical Engineering Fundamentals" 2nd Ed., McGraw Hill International Edition, 1987.*
2. *M.L. Shuler, F.Kargi "Bioprocess Engineering: Basic Concepts" 2nd Ed., Prentice-Hall, 2003*
3. *H.W. Blanch, D.S. Clark, "Biochemical Engineering" Marcel Dekker, Inc., 1997.*
4. *P.F. Stanbury, A.Whitaker, "Principles of Fermentation Technology," 2nd edition, Elsevier, (1995)*

CH-17332: ALTERNATIVE ENERGY SOURCES

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

Objectives: *To impart information about alternative energy resources, their principles, potential, limitations and to motivate them for search of new energy resources.*

LESSON PLAN

UNIT-1: INTRODUCTION **5 L**

Definition, Concepts of non conventional energy resources, Criteria for assessing the potential of NCES, Classification of NCES, Solar, Wind, Geothermal, Biomass, Ocean energy sources, Limitations

UNIT-2: PRINCIPLES OF SOLAR RADIATION **8 L**

Definition, Energy available from Sun, Solar radiation data, solar constant, extraterrestrial and terrestrial solar radiation, solar radiation on titled surface, instruments for measuring solar radiation and sun shine, solar energy conversion into heat

UNIT-3: SOLAR ENERGY CONVERSION **9 L**

Flat plate and concentrating collectors, classification of concentrating collectors, orientation and thermal analysis, advanced collectors, solar storage and thermal conversion, photovoltaic energy conversion

UNIT -4: WIND ENERGY **6 L**

Sources and potentials, horizontal and vertical axis windmills, performance characteristics, Betz criteria

UNIT-5: OCEAN ENERGY AND GEOTHERMAL ENERGY **8 L**

Resources, types of wells, methods of harnessing the energy, potential in India.OTEC, Principles utilization, setting of OTEC plants, thermodynamic cycles. Tidal and wave energy: Potential and conversion techniques, minihydel power plants, and their economics.

UNIT-6: NEW ENERGY SOURCES **4 L**

Cavitations Energy, Fuel Cells, Hydrogen, electrochemical energy conversion

Text Books and References:

1. *G.D. Rai, NonConventional Energy Sources, Khanna Publishers.*
2. *Twidell&Wier, Renewable Energy Resources, CRC Press(Taylor & Francis)*
3. *Ashok Desai V, Non-Conventional Energy, Wiley Eastern Ltd, 1990.*
4. *K.M., Mittal Non-Conventional Energy Systems, Wheeler Publishing Co. Ltd, 1997.*
5. *R, Ramesh, K.U. Kurnar, Renewable Energy Technologies, Narosa Publishing House, New Delhi, 1997.*

CH-17333: POLYMER SCIENCE AND TECHNOLOGY

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

Objectives: *To impart the knowledge of basic fundamental of polymer science and technology, reaction engineering and manufacturing of polymers, processing of polymers into plastics, fibers and elastomers.*

LESSON PLAN

UNIT-1: CHARACTERISTICS AND ANALYSIS OF POLYMERS 8 L

The science of large molecules**,** Theory of polymer solutions**,** Average molecular weight, molecular weight distribution, Methods for determination of molecular weight and size, Polymer degradation, Analyzing and testing of polymers**.**

UNIT-2: POLYMER MATERIAL STRUCTURE AND PROPERTIES 8 L

Morphology in crystalline polymers**,** Polymer structure and physical properties**,** mechanical properties of polymers**.**Reheologicalstudies: Deformation, flow and melt characteristics**,** Temperature dependence of viscosity, Simple linear viscoelastic models

UNIT-3: REACTION ENGINEERING 8 L

Condensation and Addition polymers**,** Kinetics of step growth polymerization, radical and ionic chain polymerizations, Co-polymerization, Coordination polymerization**.**

UNIT -4: INDUSTRIAL POLYMERS 8 L

Polymerization techniques,Manufacturing processes and applications: Hydrocarbon plastics, and elastomers, other carbon chain polymers, Thermosetting resins

UNIT-5: PROCESSING OF POLYMERS 8 L

Plastics, fibers and elastomers: Extrusion, injection molding, blow molding, Rotational molding, compression and transfer molding, thermoforming, 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.

4. J.R. Fried, "Polymer Science and Technology", Prentice Hall, Inc

CH-17334: FOOD TECHNOLOGY AND ENGINEERING

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

Objectives: *To impart information about various food processes and unit operations for the manufacture, packaging, preservation of food products considering various aspects such as nutrition retention, stability and shell life.*

LESSON PLAN

UNIT-1: FOOD PROCESS ENGINEERING -FUNDAMENTALS: **5L**

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

UNIT-2: UNIT OPERATIONS IN FOOD INDUSTRY **10 L**

Refrigeration and freezing, types of freezing, freezers, 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: **7L**

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: EXTRUSION AND RHEOLOGY **8L**

Basics and Principles of Extrusion, Cold extrusion and extrusion cooking, Single and twin screw Extruders, Introduction to rheology, types of fluids, Newtonian and non Newtonian fluids, viscoelastic liquids and solids, burger model, creep test, types of rheometer

UNIT-5 IMPROVEMENT OF NUTRITIVE QUALITY: **8L**

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

Text Books and References:

1. Food Microbiology by WC Frazier; Tata McGraw Hill, Delhi

2. Introduction to Food Engineering by R. Paul Singh, Dennis R.
3. Heid, J.L. and Joslyn, M.A.,5th ed., Academic Press, Elsevier.

3. Fundamentals of Food Processing Operation, The AVI Publishing Co; Westport, 1967.

4. Food Process Engineering by Heldman, D.R., The AVI Publishing Co; Westport, 1975.

5. Food Science by Potter, Norman N., Hotchkiss, Joseph H., Fifth Edition, Springer, 1995.

CH-17335: FERTILIZER TECHNOLOGY

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

LESSON PLAN

UNIT-1 : **7L**

Importance of fertilizers for sustainable agricultural activities, Elements required for plants growth, Classification of fertilizers industries in India, Role of co-operative initiatives in fertilizer industry, General function of each of nitrogen, phosphorus, and potassium fertilizers. Nitrogen fixation from the air.

UNIT-2: **8L**

Processes for manufacturing of raw materials for nitrogen, phosphorus, and potassium based fertilizers, viz. ammonia, nitric acid by ammonia oxidation process, phosphoric acid from phosphate rock by strong sulphuric acid process, potassium chloride from sylvinite. Mining of phosphate rock.

UNIT-3: **8L**

Manufacturing of urea, biuret formation in urea synthesis, ammonium carbamate, ammonium nitrate, ammonium sulphate, reactions involved and process conditions in each of these fertilizers.

UNIT-4: **8L**

Processes for manufacture of potassium nitrate, potassium sulphate, Recovery of Potassium salts. Specification and storage of potassium chloride. Specification and storage of potassium nitrate.

UNIT-5: **9L**

Manufacturing of single super phosphate, triple super phosphate, calcium phosphate, sodium phosphate, mono-ammonium phosphate, di-ammonium phosphate, bio-fertilizers, plant growth promoting rhizobacteria, root colonization.

Text Books and References:

1. *G. T. Austin, "Shreve's Chemical Process Industries", McGraw-Hill, 1984.*
2. *L. J. Carpentire, "New Developments in Phosphate Fertilizer Technology", Elsevier, 1971.*
3. *M. Sitting, M.G. Rao, "Dryden's outlines of Chemical technology", East-West Press, 2010.*

CH-17336: TWO PHASE FLOW AND HEAT TRANSFER

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

LESSON PLAN

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/ Two-Fluid Model, Models for Flow Pattern Transition, Models for Bubbly Flow, Models for Slug Flow, Models for Annular Flow, Models for Stratified Flow in Horizontal Pipe, 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: **4L**

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

Text Books and References:

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.*
   Jean J. Ginoux, Two phase flow and heat transfer.
3. *Bergles, Collier & Hewitt, Two phase flow and heat transfer*

in the power and process industries.

CH-17337: ADVANCED PROCESS CONTROL

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

Objectives: *The objective of this course is to provide a fundamental understanding to develop a technology for chemical processes.*

LESSON PLAN

UNIT-1 Frequency Response: 8 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: 8 L

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

UNIT-3 Complex Dynamics: 6 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: 8 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 Books and References:

1. D. E.Seborg, T.F. Edgar and D.A. Mellichamp, "Process Dynamics Control", Wiley,3rd Ed. 2013.

2. G Stephanopopulas, "Chemical Process Control", Prentice-Hall India, 1984.

3. D. R. Coughanowr, "Process System Analysis and Control", 2nd Ed. McGraw Hill, 1991.

4. Ogunnauike and W.H.Ray, "Process Dynamics, Modeling and Control" Oxford Press.1994.

5. W.L.Luybin,"Process modeling, simulation and control for

chemical Engineers" McGraw Hill,1973.

CH-17338: MATHEMATICAL METHODS IN CHEMICAL ENGINEERING

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

Objectives: *The present course aims to help the student to learn, different mathematical technique to solve and analyze different classes of Chemical Engineering problem.*

Prerequisites: *Knowledge of basic chemical engineering courses and general mathematics for applying in chemical engineering problems.*

LESSON PLAN

UNIT:1 **[8 L]**

Modeling, simulation, types of equation, vectors, metrics, norms, inner products, normed linear space, dimension of vector spaces, applications, gram-schmidtortho-normalisation.

UNIT:2 **[8 L]**

Matrices, Eigenvalues, eigen vectors, Rayleigh's quotient, linear algebric eq. ODE, IVP, non self adjoint systems.

UNIT:3 **[8 L]**

Classification of PDE, boundary conditions, developing PDE in Chemical Engineering systems, Infinite dimensional spaces, Fourier series, Cartesian coordinate, cylindrical & spherical coordinate systems, Fourier series & finite Fourier transforms.

UNIT:4 **[8 L]**

Application on ODE & PDE, maximum principles, energy methods, Fredhalm alternative, monotone iteration method, numerical analysis, method of continuation.

UNIT:5 **[8 L]**

Linear stability of a dynamic system, bifurcation theory, Landau-Hopf scenario, period doubling cascades, Ruelle- Takens scenario, characteristic of trajectories.

Text Books and References:

1. *S. Pushpavanam, "Mathematical Methods in Chemical Engineering" PHI, New Delhi, 1998.*
2. *S K Gupta, "Numerical Methods for Engineers" New Age International, New Delhi, 1995.*
3. *C.F. Gerald and P.O. Wheatley, "Applied Numerical Analysis", 5th edition, Addison-Wesley, 1998.*
4. *K J Beers, "Numerical Methods for Chemical Engineering: Applications in MATLAB"CambridgeUniv Press, 2006.*
5. *B. Wayne Bequette, "Process Dynamics Modeling, Analysis, and Simulation," Prentice-Hall-International, Inc., 1998.*

CH-17339: INTERFACIAL SCIENCE AND ENGINEERING

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

Objectives: *This course is aimed at introducing the basic concepts and tools for the analysis of colloidal and interfacial properties and their applications in adhesion, particle-aggregation, wetting, detergency, oilrecovery, flotation, nucleation, bio-surfaces, chromatography, paints, composite materials.*

Prerequisites: *Basic knowledge of physics and chemical engineering*

LESSON PLAN

UNIT:1 **[10L]**

Effects of confinement and finite size; Concepts of surface and interfacial energies and tensions; Apolar (van der Waals) and polar (acid-base) components of interfacial tensions.Young-Laplace equation of capillarity; examples of equilibrium surfaces; multiplicity, etc.Stability of equilibrium solutions; Contact angle and Young's equation; Determination of a polar (vander Waals) and acid-base components of surface/interfacial tensions.Free energies of adhesion; Kinetics of capillary and confined flows.

UNIT:2 Intermolecular, nanoscale and interfacial forces **[10 L]**

Van der Waals, Electrostatic double layer, Acid-base interactions including hydrophobic attraction and hydration pressure.

UNIT:3 Mesoscale Thermodynamics, Mesoscale Phenomena in Soft Matter **[8L]**

Gibbs treatment of interfaces; concept of excess concentration; variation of interfacial tensions with surfactant concentration.Adhesion, wetting, nucleation, flotation, patterning of soft material by self - organization and other techniques.

UNIT:4 Stability of Nanoparticle Dispersions, Nanofluidics **[8 L]**

DLVO and DLVO like theories and kinetics of coagulation plus general principles of diffusion in a potential field/Brownian movement.Stability of thin (< 100 nm) films; self-organization in confined systems; meso-patterning.

Unit:5 Advanced and Functional Interfaces **[4 L]**

Superhydrophobicity, functional coatings, structural colors, nano-adhesives; nanocomposites.

Text Books and References:

1. *Hiemenz, , Paul C. "Principles of Colloid and Surface Chemistry", Marcel Dekker, any edition starting with the 2nd edition, 1986.*
2. *Adamson, Arthur W. Physical Chemistry of Surfaces" Wiley, 5th edition, 1990.*
3. *Hunter, Robert J. "Foundations of Colloid Science", Clarendon, Oxford, Volume 1, 1989.*
4. *Russel, W. B., Saville, D. A. andSchowalter, W. R. "Colloidal Dispersions", Cambridge University Press, 1989.*
5. *Israelachvili, Jacob N." Intermolecular and Surface Forces", Academic Press, 1992 or later editions.*
6. *Oss, C. J. Van "Interfacial Forces in Aqueous Media",*

Marcel Dekker or Taylor & Francis, 1994.

CH-17340: BIOENERGY ENGINEERING

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

LESSON PLAN

UNIT 1 **[7L]**

Biomass sources, characteristics & preparation, chemical composition and properties of different biomass materials, energy plantations, pretreatment techniques for the utilization of biomass, size reduction, briquetting of loose biomass, drying, storage and handling of biomass.

UNIT 2 **[7L]**

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 3 **[8L]**

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 4 **[9L]**

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 5 **[9L]**

Combustion of biomass and cogeneration systems, theory, calculations and design of equipments, cogeneration in biomass processing industries. Case studies: combustion of rice husk, use of bagasse for cogeneration.

Text Books and References:

1. *A.Chakraverthy, "Biotechnology and Alternative Technologies for Utilization of Biomass or Agricultural Wastes", Oxford & IBH publishing 1989.*
2. *K.M. Mital, "Biogas Systems: Principles and Applications", New Age International Publishers Pvt. Ltd., 1996.*
3. *D.L. Klass, G.M. Emert, "Fuels from Biomass and Wastes", Ann Arbor Science Publication, 1985.*

CH-17341: ELECTROCHEMICAL ENGINEERING

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

Objectives: *To impart necessary basic knowledge in order to understand, analyze and solve problems related to electrochemical processes.*

Introduction: *Students will learn and have the knowledge on electrical double layer, Electrocatalysis and different typesof electrochemical techniques.The students will have a practical ability to analyze electrochemical design models, thermal behavior of reactors and electrochemical reactors.*

LESSON PLAN

UNIT-1: INTRODUCTION TO ELECTROCHEMICAL ENGINEERING 5 L

Introduction, Methods of measurement - Steady state techniques, Non-steady state techniques, Eliminating IR drop.

UNIT-2: ELECTROCHEMICAL TRANSFER PROCESS 6 L

Electrochemical transfer processes, Mass transport, Charge transport and heat transfer.

UNIT-3: ELECTROCHEMICAL REACTION ENGINEERING 6 L

Electrochemical thermodynamics and electrode kinetics, Kinetics in electrochemical Reactors.

UNIT -4: SEPARATION PROCESSES IN ELECTROCHEMICAL CELLS 5 L

Separation Systems in electrochemical cells, Materials and corrosion

UNIT-5: THERMAL BEHAVIOR OF REACTORS 6 L

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.

UNIT-6: ELECTROCHEMICAL TECHNIQUES 6 L

Ion selective electrodes: Principles of potentiometry and amperometry,Potential step method (chronoamperometry) under diffusion control derivation of Cottrellequation for a planar and spherical electrode.

Text Books and References:

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. *Geoffrey A., Electrochemical Engineering Principles, Prentice hall publications*
3. *Allen J. Bard and Larry R. Faulkner, Electrochemical Methods: Fundamentals and Applications*
4. *Carl H. Hamann, Andrew Hamnett and Wolf VielstichElectrochemistry , Wiley publications*

CH-17342: INDUSTRIAL CATALYSIS

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

LESSON PLAN

UNIT-1 INTRODUCTION TO CATALYSIS: **4L**

General properties of homogeneous and heterogeneous catalysis, Classification of catalysts and supports.

UNIT-2 GEOMETRIC 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 Books and References:

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*

Professional Elective – III & IV

CH-1831: INTRODUCTION TO NANOTECHNOLOGY

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

Objectives: *The objective of this course is to make students familiar with the basic fundamental of nanotechnology, important concepts in Nanotechnology and its applications.*

Introduction: *Enabling the students to learnthe properties behaviour, implementation of nanotechnology and synthesis of nonmaterial for the future developments*

LESSON PLAN

UNIT-1: FUNDAMENTALS AND OVERVIEW OF NANOSCIENCEOF NANOTECHNOLOGY **6 L**

Definitions, history and current practice, Properties of nano-particles, Overview of current industry applications, Nano-scale science and engineering principles.Different classes of nano-materials:Metal and semi-conductor nanomaterials, Quantum dots, Wells and wires, Molecule to bulk transitions, Bucky balls and Carbon nanotubes.

UNIT-2: CARBON NANOSTRUCTURES **6 L**

Carbonmolecules, Carbon clusters, Carbon nanotube technologies (CNT): Carbon nano-tube applications, Fabricating carbon nano-tubes and nano-wall structures, Key applications of CNT.

UNIT-3: SYNTHESIS OF NANOMATERIALS **6 L**

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 **5 L**

TEM, SEM and AFM technique, Fluorescence Microscopy and Imaging

UNIT-5: NANOFABRICATION **5 L**

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

UNIT-6: APPLICATIONS **5 L**

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

Text Books and References:

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. ***Charles Poole**,Introduction to Nanotechnology, Frank Owens, Wiley India Pvt Ltd 2007.*
5. ***Lynn E. Foster**, Nanotechnology Pearson Released: 2007*

CH-18332: INTRODUCTION TO PROCESS INTENSIFICATION

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

Objectives: *This course is aimed to provide the knowledge leading compact, safe, energy-efficient and environment-friendly novelequipments and processes.*

LESSON PLAN

UNIT I **[6 L]**

Need of process intensification, process intensifying equipments and methods, examples of their application on the commercial scale.

NIT II **[10 L]**

Use of high gravity fields, higee reactor, spinning disc reactors,micro-channel heat exchangers.

UNIT III **[10 L]**

Monolithic catalyst and reactors,reverse flow reactor, micro-reactors.

UNIT IV **[10 L]**

Concept and principle, reactive- distillation, extraction, precipitation adsorption, absorption, fermentation-pervaporation, adsorptive distillation, membrane reactors and bioreactors.

UNIT V **[4 L]**

Industrial practice (methodology, application) PI by improvement in existing plant and process synthesis, pi by plants safety.

Text Books and References:

1. *Stankiewicz,A.;Moulijn, J.A. "Re-engineering the chemical processing plant: process intensification" Marcel Dekker, Inc., New York, 2004.*
2. *Mizrahi,J. "Developing an industrial chemical process: an integrated approach" CRC Press, 2002.*
3. *Keil,F.J."Modeling of Process Intensification" Wiley-VCH Verlag Germany, 2007*
4. *Reay,D.;Ramshaw,C.; Harvey, A."Process Intensification"Elsvier, 2013*
5. *Boodhoo,K.; Harvey,A. "Process Intensification for Green Chemistry", Wiley, 2013.*

CH-18333: ADVANCE SEPARATION PROCESSES

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

Objectives: *To impart the knowledge of advance separation techniques such as membrane separation, advance adsorption, chromatography, Thermal separation, adductive and advanced crystallization and foam separation.*

LESSON PLAN

UNIT 1: MEMBRANE SEPARATION PROCESSES: [15 L]

Principle,classification, structure& characteristics of membranes, membrane modules and application, reverse osmosis, ultrafiltration, microfiltration, nanofiltration, dialysis, gas separation and pervaporation processes, ion selective membranes and their application in electro-dialysis, liquid membranes, membrane reactors.

UNIT 2: ADSORPTION TECHNIQUE: [8L]

Adsorbents, molecular sieves, Single component adsorption 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: [5L]

Principle, classification and techniques of chromatography, chromatographic column, development of gradient-elution separations, equipment and commercial processes.

UNIT 4: THERMAL SEPARATION: [4L]

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: [4L]

Principle, Classification and separation techniques, surface adsorption, Nature of foams, apparatus, Applications and Controlling factors.

Text Books and References:

1. *H.M. Schoen, "New Chemical Engineering Separation Techniques", Inter Science Publications New York.*
2. *C. Loeb, R. E. Lacey, "Industrial Processing with Membranes", Wiley Inter Science.*
3. *J.M. Coulson, 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. *J. J. Mketta, "Unit operation Handbook" (vol-1, MassTransfer),CRC Press.*
7. *R.W. Rousseau, "Handbook of separation Process Technology", Wiley-India.*

CH-18334: PROCESS MODELING AND SIMULATION

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

LESSON PLAN

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 solutions of model equations with partial differential equations using finite difference method, Model parameters estimation: Introduction, method of least squares, curve fitting, etc.

UNIT-4: **7 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.

UNIT-5: **7 L**

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

UNIT-6: **6 L**

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

Text Books and References:

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.*

CH-18335: INTRODUCTION TO MULTIPHASE FLOW

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

LESSON PLAN

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 Books and References:

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.*

CH-18336: ENERGY ENGINEERING

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

LESSON PLAN

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 **8L**

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 .

CH-18337: SCALE-UP IN PROCESS INDUSTRIES

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

LESSON PLAN

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 **[8 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 **[8 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 **[8 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 **[8 L]**

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

Text Books and References:

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.*

CH-18338: SOLID WASTE MANAGEMENT

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

LESSON PLAN

UNIT 1 **[8L]**

Philosophy and organization, status of solid waste management, composition of an integrated waste management strategy, evolution of solid waste management, legislation and government agencies.

UNIT 2 **[8L]**

Types of solid waste, Sources of solid waste, physico-chemical properties of solid waste, materials flow in society, reduction in raw materials usage, reduction in solid waste quantities, reuse of solid waste materials,

UNIT 3 **[8L]**

Generation of solid waste, onsite handling, storage, and processing, collection of solid wastes, transfer and transport, processing techniques and equipment, hazardous waste and their management, process management issues.

UNIT 4 **[8L]**

Recovery of resources from solid waste, Energy recovery methods: chemical and biological methods.Land filling, ocean disposing, source reduction, recycling, incineration, composting.

UNIT 5 **[8L]**

Case studies on major industrial solid waste generation units,coal fired power plant, textile industry, brewery, distillery, oil refinery. Use of refuse-derived fuels.

Text Books and References:

1. *G. Tchobanoglous, H.Theisen, R.Eliassen, "Solid Wastes: Engineering Principles and Management Issues", McGraw-Hill, 1977.*
2. *H.S. Peavy, D.R. Rowe, G. Tchobanoglous, "Environmental Engineering", McGraw-Hill, 1985.*
3. *S. K. Garg, R. Garg, R. Garg, "Environmental Science and Ecological Studies", Khanna Publishers, 2006.*

CH-18339: INDUSTRIAL CORROSION AND SURFACE COATING

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

LESSON PLAN

UNIT-1 INTRODUCTION: **10L**

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: **10L**

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: **10L**

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

UNIT-4 METALLIC COATING: **10L**

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

Text Books and References:

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.

CH-18340: INDUSTRIAL ENZYME ENGINEERING AND FERMENTATION TECHNIQUES

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

LESSON PLAN

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: 8L

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

UNIT-4 ENZYME IMMOBILIZATION: **8L**

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)*

CH-18341: ADVANCES IN FLUIDIZATION ENGINEERING

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

LESSON PLAN

UNIT 1 **[7L]**

Introduction to fluidization, types of fluidization, industrial applications of fluidized beds, cracking and reforming of hydrocarbons, gasification, carbonization, gas - solid reactions.

UNIT 2 **[8L]**

Gross behavior of fluidized bed, minimum and terminal velocities in fluidized beds, design of distributors, voidage in fluidized beds, variation in size distribution with height, viscosity and fluidity of fluidized beds, power consumption, bed expansion.

UNIT 3 **[8L]**

Davidson's model, frequency measurements, bubble behavior, bubbles in ordinary bubbling bed model for bubble phase,emulsion phase, experimental findings, bubbling bed model for emulsion phase interchange co-efficient.

UNIT 4 **[8L]**

Flow pattern of gas through fluidized beds, 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 **[9L]**

Heat transfer between fluidized beds and surfaces, theories of bed heat transfer, comparison of theories, model for entrainment and application of the entrainment model to elutriation.Principles of semifluidization, production of various bed parameters, industrial applications,design of fluidized bed reactors.

Text Books and References:

1. *D. Kunii, O.Levenspiel, "'Fluidization Engineering", John Wiley& Sons, 1992.*
2. *J.F. Davidson, D. Harrison, "Fludization", Academic Press, 1971.*
3. *C. K. Gupta, D. Sathiyamoorthy, "Fluid Bed Technology in Materials Processing", CRC Press, 1998.*
4. *F.A. Zenz, D.F. Othmer, "Fludization and Fluid Particles Systems", Reinhold Publishing, 1960.*

CH-18342: UPSTREAM HYDROCARBON ENGINEERING

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

LESSON PLAN

UNIT 1 **[8L]**

World exploration and production (E&P) scenario, Indian exploration and production (E&P) scenario, petroleum Exploration basics, concept of source, reservoir, migration, stratigraphic and combinational traps, primary and secondary migration, techniques of petroleum exploration, geochemical, gravity, magnetic, electrical and seismic method of hydrocarbon exploration.

UNIT 2 **[8L]**

Basics of drilling fluid, functions of drilling fluid, classification of drilling fluids, properties of drilling fluids, nature of drilling fluid, generic drilling fluid system. Drilling fluids equipment related to pressure and separation. Formulations of drilling fluid, separation of drilled solids from drilling fluid, various rheology models of drilling fluids.

UNIT 3 **[8L]**

Bulk volume, grain Volume, effective pore volume and net volume, porosity, compressibility, Darcy's Law. Absolute and Effective Permeability, Permeability averaging, Transmissibility, Measurements of Permeability heterogeneity, Darcy's law of directional permeability, rock fluid interactions.

UNIT 4 **[8L]**

Enhanced oil recovery methods,correlation of capillary pressure to rock properties,wettability, capillary pressure, equivalent height and transition zone, mobility, relative mobility and flow capacity.

UNIT 5 **[8L]**

Composition of natural gas, properties, fields & reserves in world and in India, energy scenario, major natural gas producing industries of India and their contribution to Indian economy, techniques of utilization, specifications of natural gas for transportation in pipelines, concept of gas to liquid (GTL).

Text Books and References:

1. *J. J. Milson, A. Eriksen, "Field Geophysics", John Wiley and Sons, 2011*
2. *J. W. Amyx, D.H. Bass, R. L.Whiting, "Petroleum Reservoir Engineering", McGraw Hill, 1960.*
3. *D. L. Katz, R. L. Lee, "Natural Gas Engineering-Production and Storage", McGraw-Hill, 1990.*
4. *W.L. Nelson, "Petroleum Refinery Engineering", McGraw Hill Publication, 1958.*
5. *G.D. Hobson, W. Pohl, "Modern Petroleum Technology", Wiley & Sons Publication, 1973.*