COURSE STRUCTURE
AND
DETAILED SYLLABUS

II, III & IV – B.TECH – I & II - SEMESTERS

CHEMICAL ENGINEERING

FOR
B.TECH FOUR YEAR DEGREE COURSE
(Applicable for the batches admitted from 2015-16)

ANURAG GROUP OF INSTITUTIONS
AUTONOMOUS
VENKATAPUR, GHATKESAR, HYDERABAD – 500 088, TELANGANA STATE.

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II YEAR I SEMESTER **COURSE STRUCTURE**

Subject Code	Category	Subject Name	Lectures	T/P/D	Credits
A53001	BS	Mathematics - III	4	1	4
A53029	ES	Basic Electrical and Electronics Engineering	3	1	3
A53030	PC	Chemical Technology	4	1	4
A53017	BS	Environmental Studies	3	1	3
A53031	BS	Analytical Chemistry	3	1	3
A53032	PC	Chemical Process Calculations	3	1	3
A53033	MC	NSS/NSO	2	0	0
A53211	ES	Electrical Engineering Lab	0	3	2
A53212	BS	Analytical Chemistry Lab	0	3	2
Total			**22**	**12**	**24**

II YEAR II SEMESTER **COURSE STRUCTURE**

Subject Code	Category	Subject Name	Lectures	T/P/D	Credits
A54001	BS	Probability and Statistics	3	1	3
A54030	ES	Industrial Instrumentation	3	1	3
A54031	PC	Chemical Engineering Fluid Mechanics	4	1	4
A54032	BS	Organic Chemistry	3	1	3
A54033	PC	Chemical Engineering Thermodynamics-1	4	1	4
A54034	PC	Mechanical Unit Operations	3	1	3
A54018	MC	Gender Sensitization	2	0	0
A54215	PC	Chemical Engineering Fluid Mechanics Lab	0	3	2
A54216	PC	Mechanical Unit Operations Lab	0	3	2
Total			**22**	**12**	**24**

III YEAR I SEMESTER **COURSE STRUCTURE**

Subject Code	Category	Subject Name	Lectures	T/P/D	Credits
A55050	PC	Chemical Engineering Thermodynamics-II	3	1	3
A55051	PC	Chemical Reaction Engineering-I	3	1	3
A55052	PC	Mass Transfer Operations-I	3	1	3
A55053	PC	Process Heat Transfer	3	1	3
A55054 A55055 A55056	PE	**Core Elective-1** Technology of Pharmaceuticals and Fine Chemicals Computational Fluid Dynamics Environmental Biotechnology	4	1	4
A55057 A55058 A55059	PE	**Core Elective-2** Nuclear Engineering Frontiers of Chemical Engineering Bioprocess Engineering	4	1	4
A55060	MC	Logical Reasoning and Quantitative Aptitude	2	0	0
A55214	HS	Advanced English Communication Skills Lab	0	3	2
A55215	PC	Process Heat Transfer Lab	0	3	2
Total			**22**	**12**	**24**

III YEAR II SEMESTER **COURSE STRUCTURE**

Subject Code	Category	Subject Name	Lectures	T/P/D	Credits
A56055	PC	Process Dynamics and control	3	1	3
A56056	PC	Mass Transfer Operations-II	3	1	3
A56057	PC	Chemical Reaction Engineering-II	3	1	3
A56058 A56059 A56060	PE	**Core Elective-3** Material Science for Chemical Engineers Advanced Separation Techniques Pulp and paper technology	4	1	4
A56061 A56062 A56063	PE	**Core Elective-4** Optimization of Chemical Processes Numerical Methods for Chemical Engineers Electrochemical Engineering	4	1	4
A56064 A56065 A56066	PE	**Core Elective-5** Petroleum and Petrochemical Technology Fluidization Engineering Fertilizer Technology	3	1	3
A56067	MC	English for Life Skills	2	0	0
A56215	PC	Mass Transfer Operation Lab	0	3	2
A56216	PC	Chemical Reaction Engineering Lab	0	3	2
Total			**22**	**12**	**24**

IV YEAR I SEMESTER **COURSE STRUCTURE**

Subject Code	Category	Subject Name	Lectures	T/P/D	Credits
A57059	PC	Transport Phenomena	3	1	3
A57060	PC	Process Modeling and Simulation	3	1	3
A57061	PC	Chemical Process Equipment Design	3	1	3
A57062	PC	Biochemical Engineering	3	1	3
A57063	PC	Plant Design and Economics	3	1	3
A57064 A57065 A57066	OE	**Open Elective-1** Design and Analysis of Experiments Industrial Safety and Hazard Management Introduction to Nanotechnology	3	1	3
A57218	PC	Process Dynamics and Control Lab	0	3	2
A57219	PC	Simulation Lab	0	3	2
A57220	PW	Industry Oriented Mini Project	0	0	2
Total			**18**	**12**	**24**

IV YEAR II SEMESTER **COURSE STRUCTURE**

Subject Code	Category	Subject Name	Lectures	T/P/D	Credits
A58028 A58029 A58030	OE	**Open Elective-2** Polymer Technology Energy Engineering Corrosion Engineering	3	1	3
A58031 A58032 A58007	OE	**Open Elective-3** Industrial Pollution Control Engineering Intellectual Property Rights Management Science	3	1	3
A58216	PW	Technical Seminar	0	6	3
A58217	PW	Comprehensive Viva - Voce	0	0	3
A58218	PW	Project work	0	15	12
Total			**06**	**23**	**24**

Note: All End Examinations (Theory and Practical) are of three hours duration.
T – Tutorial **P – Practical** **D – Drawing**

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II-Year B.Tech-CHEM - I-Semester **L T/P C**
4 1/- 4

(A53001)MATHEMATICS-III

PREREQUISITES: First year mathematics-I & II

COURSE OBJECTIVES:

- To acquaint students with the fundamental concepts of Numerical Analysis
- To develop an understanding of the role of Numerical Analysis in engineering.
- To familiarize students with computer-based computational analysis through a suitable Software Package
- To develop alternative ways to solve a problem and systematic approach of a solution in real Life
- To provide an understanding of the processes by which real life problems are analyzed
- To develop an understanding of the role of numerical methods in engineering.
- Able to know basic properties of standard partial differential equations to solve engineering problems.
- To gain experience of doing independent study and research

UNIT-I: Solution of Non- linear Equations and Linear System of Equations.
Solution of Algebraic and Transcendental Equations – The Bisection Method – The Method of False Position – The Iteration Method – Newton-Raphson Method.
Solving system of non-homogeneous equations by L-U Decomposition method (Crout's Method) Jacobi's and Gauss-Seidel Iteration method,

UNIT-II: Interpolation:
Introduction- Errors in Polynomial Interpolation – Finite differences- Forward Differences-Backward differences – Central differences – Symbolic relations and separation of symbols-Difference Equations - Differences of a polynomial-Newton's formulae for interpolation – Central difference interpolation Formulae – Gauss Central Difference Formulae – Interpolation with unevenly spaced points-Lagrange's Interpolation formula.

UNIT-III: Numerical Differentiation, Numerical Integration & Curve fitting
Numerical Differentiation, Generalized Quadrature (Newton's Cote's formula), Trapezoidal, Simpson's and Weddle's rules and problems. Curve fitting: Fitting a straight line – Second degree curve – exponential curve-power curve by method of least squares.

UNIT – IV: Numerical solution of IVP's in ODE
Numerical solution of Ordinary Differential equations: Solution by Taylor's series-Picard's Method of successive Approximations-Euler's Method-Runge-Kutta Methods –Predictor-Corrector Methods- Adams-Bash forth Method-Milne Thompson Method.

UNIT-V: Partial differential equations

Introduction and formation of partial differential equation by elimination of arbitrary constants and arbitrary functions, solutions of first order linear (Lagrange) equation and nonlinear (Standard type) equations, Charpits Method, Method of separation of variables for second order equations. Classification of general second order partial differential equations. Applications of Partial Differential Equations-One dimensional wave equation, Heat equation.

COURSE OUTCOMES:

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

- Be aware of the use of scientific methods in modern scientific computing.
- Be Familiar with numerical solution of Non Linear equations.
- Be Familiar with numerical interpolation and approximation of functions.
- Be Familiar with calculation and interpretation of errors in Numerical Methods
- Be Familiar with numerical differentiation and integration.
- Be Familiar with curve fitting.
- Apply Partial differential equations to solve complex engineering problems.

TEXT BOOKS:

1. Grewal B.S (2007), Higher Engineering Mathematics, 40th Edition, New Delhi, Khanna Publishers.
2. Iyengar T.K.V., Krishna Gandhi B. & Others (2011), Mathematical Methods, 10th Revised Edition, New Delhi, S. Chand & Company Limited.
3. Advanced Engineering Mathematics: Erwin Kreyszig, Wiley.

REFERENCE BOOKS:

1. Shahanaz Bathul (2007), Mathematical Methods, 3rd Edition, Hyderabad, Right Publishers.
2. Jain R. K., and Iyengar S. R. K (2008), Advanced Engineering Mathematics, 3rd Edition, New Delhi, Narosa Publication House.
3. Introductory Methods of Numerical Analysis. S.S. Sastry, Prentice Hall.
4. Numerical Analysis (Paper IV), First Edition 2010, Telugu Akademi, Hyderabad.
5. Schaum's outline series on Matrices.
6. Mathematical Methods of Science and Engineering (Aided with Matlab) Kanti B.Datta (2012), Seventh Edition, CENGAGE Learning.

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II-Year B.Tech-CHEM - I-Semester	**L**	**T/P**	**C**
	3	**1/-**	**3**

(A53029)BASIC ELECTRICAL AND ELECTRONICS ENGINEERING

PREREQUISITES: First year physics

COURSE OBJECTIVES:

- Able to get the basic knowledge about the electric & magnetic circuits.
- Able to understand the AC fundamentals
- Able to understand the working of various electrical machines (DC/AC).
- Able to get the knowledge about various measuring investments.

UNIT I

Ohm's law, Kirchhoff's laws- Nodal Analysis, Mesh analysis - Series, and Parallel circuit's.- star-delta Transformation (simple problems)- Electromagnetic induction. Faraday's law, Lenz's Law- Self and mutual inductances. Coefficient of Coupling.
Generation of alternating emf- average and rms values of alternating quantity-representation of alternating quantities by phasors - single phase series and parallel circuits (simple problems) - series and parallel resonance.

UNIT II

DC Generators: Principle operation of DC machines-emf equation-types of DC generators-magnetization and load characteristics of DC generators.
DC Motor: Principle of operation of DC Motor. Torque equation, back emf equation, types of dc motors, characteristics of DC Motor. DC motor starter (Three point starter), efficiency calculation, Swinburne's test, speed control.

UNIT- III

Construction and principle of operation of Single phase transformer- emf equation- O.C & S.C tests -efficiency and regulation calculation.

UNIT – IV

Principle and Operation of Three phase Induction Motors-Types of Induction motors, Slip-Torque Characteristics.
Principle and operation of three phase Alternators, O.C & S.C Tests- Regulation by Synchronous impedance method.

UNIT- V

Electrical Instruments: Basic principle of indicating instruments - Moving coil and Moving iron instruments (Ammeter and Voltmeters).

COURSE OUTCOMES:

- Explore in designing basic electric circuits using fundamentals of electrical engineering.
- To study the application &operation of various DC & AC machines.
- Identify requirements of electric machines for domestic & industrial purpose.
- Operation & application of various electrical measuring instruments.

TEXT BOOKS:

1. Introduction to Electrical Engineering by M.S Naidu AND S. Kamakshiah,TMH.
2. Basic electrical engineering by T.K.Nagasarkar and M.S Sukhija, oxford university press, 2005.

REFERENCES:

1. Theory and problems of Basic Electrical Engineering BY D.P. Kotari & I.J Nagarat Pearson Education/PHI
2. Principle of Electrical Engineering BY V.K. MEHETHA, S.Chand Publications.
3. Basic electrical Engineering V.N MITTLE, Second Edition, TMH

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II-Year B.Tech-CHEM - I-Semester **L T/P C**
4 1/- 4

(A53030)CHEMICAL TECHNOLOGY

PREREQUISITES: First year Chemistry

COURSE OBJECTIVES:

- Understand the use of various unit process and unit operations involved in various chemical process industries.

UNIT- I

Inorganic Industries

Chlor-Alkali Industry-Manufacture of Soda ash, caustic soda and chlorine, Sulfur and sulfuric acid, Cement-Portland cement and Special cement.

Unit – II

Fertilizer industries

Nitrogen Industries: manufacturing and uses: Ammonia, Urea and Nitric acid.
Phosphorous Industries: manufacturing and uses of Phosphoric acid and Calcium Phosphate
Potash industries: Production of NPK fertilizers, potassium sulphate, potassium chloride

Unit – III

Organic Chemical Industries

Oils: Definition, constitution, extraction of vegetable oils, refining and hydrogenation of oils.
Soaps and Detergent, Carbohydrate- Sugar and Starch: Manufacture of cane sugar, production of starch from maize and uses of starch and sugar.
Fermentation- Ethyl Alcohol, Pulp and Paper Industry: Methods of pulping production of sulphates and sulphite pulp. Recovery of chemicals from black liquor

Unit – IV

Petrochemicals: Manufacture and uses of Formaldehyde, Acrylonitrile, Vinyl Acetate, ethanolamines and Aromatics

Unit – V:

Polymer Industries : Introduction, Fibre-manufacturing of Nylon66, Plastic-manufacturing of Polyethylene, Polycondensation-production of Phenol formaldehyde, Elastomer-manufacturing of Rubber and Cellulosic – Rayon.

COURSE OUTCOMES:

- The student will understand the process and unit operations involved in various industries related to chemical engineering.

TEXT BOOKS:

1. Shreve's Chemical Process Industries edited by Austin, McGraw-Hill.5th ed.1985.
2. Dryden's Outlines of Chemical Technology, edited by M.Gopal Rao and M.Sittig, 2nd ed. 1973.

REFERENCES:

1. Industrial Chemistry by B.K.Sharma
2. Hand book of industrial chemistry Vol 1&II K.H.Davis & F.S. Berner, edited by S.C. Bhatia, CBS publishers

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II-Year B.Tech-CHEM - I-Semester **L T/P C**
3 1/- 3

(A53017)ENVIRONMENTAL STUDIES

PREREQUISITES: Nil

COURSE OBJECTIVES:

- To introduce the knowledge about Environment.
- To introduce students to the concepts of pollution, Biodiversity
- To develop an awareness about global Environmental problems.
- To learn to protect environment, legal issues, Sustainable development.

UNIT – I

Multidisciplinary nature of Environmental Studies: Definition, Scope and Importance – Need for Public Awareness.

Ecosystems: Concept of an ecosystem – Classification, structure and function of different ecosystems - Producers, consumers and decomposers. - Energy flow in the ecosystem - Ecological succession - Food chains, food webs and ecological pyramids.

Biodiversity and its conservation: Introduction - Definition: genetic, species and ecosystem diversity. - Bio-geographical classification of India - Value of biodiversity: consumptive use, productive use, social, ethical, aesthetic and option values. India as a mega-diversity nation - Hot-spots of biodiversity - Threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts. ICUN categories of biodiversity and RED DATA book - Conservation of biodiversity: In-situ and Ex-situ conservation of biodiversity.

UNIT - II

Natural Resources: Renewable and non-renewable – Natural resources and associated problems: Forest resources – Use and over – exploitation, deforestation,– Timber extraction, mining, dams and other effects on forest and tribal people: Water resources – Use and over utilization of surface and ground water – Floods, drought, conflicts over water, dams – benefits and problems – Mineral resources: Use and exploitation, environmental effects of extracting and using mineral resources. - Food resources: World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture, fertilizer-pesticide problems, water logging, salinity. - Energy resources: Growing energy needs, renewable and non-renewable energy sources use of alternate energy sources. Land resources: Land as a resource, land degradation, man induced landslides, soil erosion and desertification. Role of an individual in conservation of natural resources: Equitable use of resources for sustainable lifestyles.

UNIT – III

Environmental Pollution: Definition, Cause, effects and control measures of different kinds of pollution (Air, Water, Soil, Marine, Noise, Thermal, Nuclear, e –Waste)

Carbon Capture & Sequestration – different storage sources, major disadvantages, environmental effect**s**

Social Issues and the Environment: From Unsustainable to Sustainable development -Urban problems related to energy -Water conservation, rain water harvesting, and watershed management. -Climate change, global warming, ozone layer depletion, nuclear accidents and holocaust.

UNIT – VI

Waste management technology: Solid waste Management: Causes, effects and control measures of urban and industrial wastes. - Role of an individual in prevention of pollution, Disaster management: floods, earthquake, cyclone and landslides.

Waste water and sewage treatment technology: primary, secondary and tertiary treatments. Bioremediation, Phyto-remediation, ZLD (zero liquid discharge), membrane technology. Application of GIS and GPS system in environmental science.

Environmental policy, Rules and regulations. EIA (Environmental Impact Assessment) & EMP (ENVIRONMENTAL Management Plan) – Environment Protection Act. - Air (Prevention and Control of Pollution) Act. -Water (Prevention and control of Pollution) Act -Wildlife Protection Act –Forest Conservation Act.-Public awareness. Global environmental problems and global efforts.

UNIT – V

Towards sustainable future: concept of sustainable development, threats of sustainability, population and its explosion, over exploitation of resources, strategies for achieving sustainable development. Environmental education, Conservation of resources. Urban sprawl, sustainable cities and sustainable communities, human health. Role of IT in environment, environmental ethics, concept of green building, Basic principles of Green engineering, clean development mechanism (CDM), Low carbon life cycle, Polluters-pay principle.

Field work: Visit to a local area to document environmental assets River/forest Grassland/hill/ mountain Visit to a local polluted site-Urban/Rural/industrial/ Agricultural Study of common plants, insects, birds, Visit to effluent treatment Plant/sewage treatment plant Study of simple eco systems pond, river, hill slopes, etc.

Mini projects by students which is mandatory.

COURSE OUTCOMES:

- Conservation of natural resources
- Understand Requirement to conserve environment.
- Understand the National and international efforts to save globe.
- Know importance of sustainable development

TEXT BOOKS:

1. Textbook of Environmental Studies for Undergraduate Courses by Erach Bharucha, University Press Private Limited, Reprinted in 2005.
2. Environmental Studies: From Crisis to Cure by R.Rajagopalan, Oxford University Press, 2nd Edition, 2005

REFERENCES:

1. Environmental Science: Towards a Sustainable Future by Richard T.Wright. PHL Learning Private Ltd .New Delhi, 2008
2. Environmental Engineering and science by Gilbert M.Masters and Wendell P.Ela. PHI Learning Pvt. Ltd. 4th edition, 2008

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II-Year B.Tech-CHEM - I-Semester **L T/P C**
3 1/- 3

(A53031)ANALYTICAL CHEMISTRY

PREREQUISITES: First year Chemistry (theory and practical)

COURSE OBJECTIVES:

- To understand basic Analysis of chemical compounds using volumetric and Gravimetric Analysis.
- To develop the concepts of electronic Spectroscopy , Infrared Spectroscopy & their analysis.
- Be familiar with the correct use and operation of spectrometers, including UV/visible, FTIR, and atomic absorption/emission.
- To study the basic chromatographic techniques, theory of Industrial Analysis techniques such as Gas Chromatography & HPLC.

UNIT – I

Principle of Analytical Methods: **Gravimetric analysis**: Precipitation, types of precipitates, impurities, co-precipitation, post-precipitation, conditions for participation, precipitation from homogeneous solution, Gravimetric determination of Fe and Ni calculations.

Volumetric Analysis: Acid base titrations: Indicators; Oxidation-reduction titrations; Iodometric and Iodimetric titrations, Estimation of Chlorine and chlorides, Complexation using ligands, complexometric titration with EDTA, simple calculations; analysis of Na_2CO_3, Fe_2O_3.

UNIT –II

Electronic Spectroscopy: Absorption spectra, Lamberts Law, Beer's Law - Combined law equation; Deviations from Beer's Law. Terminology associated with electronic spectroscopy- (Molar absorptivity**,** bathochromic effect, hypsochromic effect) types of absorption bands and theoretical interpretation, effect of solvent and structure on λ max-, various electronic transitions. Woodward – Fieser rules for calculating absorption maximum in conjugated dienes, trienes and α, β- unsaturated carbonyl compounds.

Block diagram of a UV- visible spectrophotometer – quantitative analysis; direct method for the determination of metal ions; Chromium and Manganese, Quantitative analysis, structure determination- based on bonding, electron transitions and group frequencies.

UNIT – III

Infrared Spectroscopy: Introduction – Requirement of IR absorption (selection rule), Principle of IR spectroscopy, Types of molecular vibrations – Stretching vibrations and Bending vibrations, Fundamental modes of vibrations – Linear and nonlinear molecules. Factors affecting the group frequencies – coupled interactions, electronic effects and hydrogen bonding. Instrumentation - IR radiation source, monochromator, and detectors. FTIR Instrument and its advantages, sample handling techniques – solution, nujol mull and KBr pellet, Characteristic group infrared absorption for organic molecules, Applications of

IR to structural elucidation of simple organic molecules and to functional group analysis (-OH, -NH_2, -CHO, -CO-R, -CONH).

UNIT – IV

Introduction to Chromatography: Classification - Theory - distribution coefficient, rate of travel, retention time, retention volume, adjusted retention volume, net retention volume, specific retention volume, column capacity, separation number, column efficiency, resolution.

Paper chromatography: Types of Paper chromatography, RF value.

Thin Layer Chromatography: Stationary phase, mobile phase, sample application, development techniques – evaluation and documentation, advantages and disadvantages.

UNIT–V

Gas Chromatography: Principle of Gas Chromatography, block diagram of gas chromatograph, Function of each component, Detectors (FID, ECD), stationary phase for column, mobile phase, chromatogram, qualitative analysis, quantitative analysis, retention time, retention volume, capacity factor.

HPCL: Principles of high performance liquid chromatography, Block diagram of HPCL, Systems, functions of each component, stationary phases, eluting solvents, pumps, detectors, quantitative applications of HPLC.

COURSE OUTCOMES:

- Have firm foundations in the fundamentals and application of current analytical chemistry and scientific theories.
- Are able to design, carry out, record and analyze the results of chemical experiments.
- Knowledge of the proper procedures and regulations for safe handling and use of chemicals and can follow the proper procedures and regulations for safe handling when using chemicals.
- Find gainful employment in industry or government sector or be accepted at professional schools or find employment in various organizations.

TEXT BOOKS:

1. Instrumentaiotn methods of analysis – Chatwal & Anand– Himalaya Publications, 2003.
2. Analytical Chemistry – Y.Anjaneylu, K. Chandrasekhar, V. Manickam- PharmaMed Press, 2007.

REFERENCES:

1. Quantitative analysis – R.A. Day & A.L.Underwood Printice – Hall of India, Pvt. Ltd. 5th edition, 2000.
2. Vogels Text book of Quantitative chemical analysis – J.Mendham, R.C Denny, J.D. Barnes, M J.K.Thomas, Pearson Education, 6th edition, 2002.
3. Instrumental methods of analysis – Willand Merrit and Dean, caps publications & Distribution, 1999.

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II-Year B.Tech-CHEM - I-Semester **L T/P C**
3 1/- 3

(A53032)CHEMICAL PROCESS CALCULATIONS (THEORY)

PREREQUISITES: First year physics, Chemistry & Mathematics

COURSE OBJECTIVES:

- To gain apply the principles of process calculations in the project, design and complex systems by making it a simple by complete understanding.
- To learn modern estimation techniques of process calculations to solve chemical engineering problems.

UNIT-I

Stoichiometric relation: basis of calculations, methods of expressing compositions of mixtures and solutions, density and specific gravity, Baume and API gravity scales Behavior of ideal gases: applications of ideal gas law to gaseous mixtures, gases in chemical reactions, include combustion processes.

UNIT-II

Vapor pressure: Liquefaction and liquid state, vaporization, boiling Point, effect of temperature on vapor pressure, Antoine equation, Vapor pressure plots, estimation of critical properties, vapor pressure of immiscible liquids and ideal solutions, Raoult's law. Non-volatile solutes.

UNIT-III

Humidity and Saturation: Properties of air-water vapor mixtures, Absolute Humidity, molal humidity, Relative and percentage saturation, dew point, humid heat, wet bulb and dry bulb temperatures, use of humidity charts for engineering calculations.

UNIT-IV

Material balances: Tie substances, yield, conversion, limiting reactants, excess reactants, processes involving chemical reactions, Material balances with the help of stoichiometric equations, Material balance calculations for processes involving recycle, bypass and purge Material balances involving drying, dissolution and crystallization.

Unit-V

Thermophysics: Energy, energy balances, heat capacity of gases, liquid and mixture solutions, Kopp's rule, latent heats, heat of fusion and Heat of vaporization, Trouton's rule, Kistiakowsky equation for non-Polar liquids, enthalpy and its evaluation Thermochemistry: Calculation and applications of heat of reaction, combustion, formation and neutralization, Kirchhoff's equation, enthalpy concentration change, calculation of theoretical actual flame temperature.

COURSE OUTCOMES:

- Fundamental laws of Stoichiometry.
- Calculation of Vapor Pressures for Liquids using appropriate laws & critical Properties of ideal solution mixtures.
- Calculation of Properties for Air-Water system using Humidification principles.
- Study of Material balances for Unit Operations with and with chemical reactions & Energy balance calculations.

TEXT BOOKS:

1. Chemical Process Principles, Part-I, Material and Energy Balance by Hougen O A, Watson K.M and Ragatz R. A. John Wiley and sons, New York, 1963, 2nd Ed.

REFERENCES:

1. Basic Principles and Calculation in Chemical Engineering by D. H. Himmelblau, 5th Ed. PHI, 2001
2. Stoichiometry by B.I, Bhatt and S.M. Vora (3rd Ed.) Tata Mc Graw Hill Publishing Company, Ltd. New Delhi (1996)

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II-Year B.Tech-CHEM - I-Semester **L T/P C**
0 -/3 2

(A53211)ELECTRICAL ENGINEERING LAB

COURSE OBJECTIVES:

- Know about fundamental of electric circuits.
- Realize basic theoretical concepts & laws real physical world.
- Acquaint with symbolic representation of different circuit elements.
- Acquaint with different AC & DC measuring devices
- Know physically about rotating machines
- Realize about different sources used
- Know about electrical safety & standards

(At least **ten** experiments out of the following twelve experiments should be performed)

1. Verification of KVL and KCL
2. Series and Parallel resonance (to determine bandwidth, quality factor, selectivity)
3. Magnetization Characteristics of dc shunt generator (to determine critical resistance and critical speed)
4. Load test on DC Shunt Generator (to draw the characteristics of dc shunt generator)
5. Swinburne's Test (to calculate predetermined efficiency of dc shunt machine)
6. Brake test on DC Shunt Motor
7. Speed control of DC Shunt Motor
8. O.C & S.C Test on Single phase Transformer
9. Brake test on three phase Induction Motor
10. Regulation of Three phase Alternator by Synchronous Impedance Method
11. Load Test on single phase Transformer
12. Brake test on DC Compound Motor

COURSE OUTCOMES:

- Realize fundamentals of electrical Technology
- Identify and use various electrical measuring devices
- Explore themselves in designing basic electric circuits.
- Use symbolic representation to represent any electric circuits.

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II-Year B.Tech-CHEM - I-Semester	**L**	**T/P**	**C**
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(A53212)ANALYTICAL CHEMISTRY LAB

COURSE OBJECTIVES:

- Be familiar with good laboratory practice and the development of standard operating procedures.
- To teach proper solution handling and standards preparation and To reinforce the principles of good laboratory practice.
- To provide a basic understanding of common analytical techniques.
- To provide guidance on the appropriate choice of technique for a given size & type of sample.

(At least **Ten** experiments out of the following thirteen experiments should be performed)

1. Estimation of ferrous iron (II) in solution using Potassium Dichromate.
2. Estimation of copper (II) using standard sodium thiosulphate.
3. Estimation of total, permanent and temporary hardness of water by EDTA.
4. Estimation of Total alkalinity of water.
5. Determination of λ_{max} of a given solution and verify Beer's law and apply it to find the concentration of the $KMNO_4$ using colorimeter.
6. Estimation of Zinc using potassium ferrocyanide.
7. Percentage purity of lime stone.
8. Estimation of Chlorides in water.
9. Estimation of Dissolved oxygen in water.
10. Determination of total residual chlorine in water.
11. Determination of stability constant by Job's method.
12. Assay of paracetamol/ Ibuprofen sample using spectrophotometer.

COURSE OUTCOMES:

This will be achieved through a mixture of highly integrated lectures, tutorials, and laboratory experiments. By the end of the course, students will be expected to demonstrate the following core competencies:

- Present results correctly, and test for precision and accuracy.
- Correctly prepare standard solutions and use appropriate calibration methods.
- Use appropriate method to perform scientific calculations and produce graphs.
- Be familiar with the correct use of volumetric glassware to prepare solutions and perform titrations.

TEXT BOOKS:

1. Vogel's Text book of Quantitative Chemical Analysis, Sixth Edition – J. Mendham et al, Pearson Education.
2. Laboratory manual of engineering chemistry, S.K.Bhasin and Sudha Rani , Dhanpat Rai & Co.

REFERENCE BOOKS:

1. A text book on experiments and calculations. S.S. Dara.
2. Text Book of engineering chemistry by R. N. Goyal and Harrmendra Goel.

APPARATUS AND EQUIPMENT REQUIRED

GLASSWARE:

Burettes, Pipettes (10ml, 20 ml, 25 ml), Conical Flasks (250 ml), Standard Flasks (25 ml, 50 ml, 100 ml, 250 ml, 500 ml, 1000 ml) Graduated Pipettes, Beakers (100 ml, 250 ml, 500 ml, 1000 ml) Reagent Bottels (100 ml, 250 ml, 500 ml,), Test Tubes, Test Tube Stands, Burette Stands, Porcelain Tiles, Brushes, Wash Bottles, Droppers, Conical Flaks (250 ml, 100 ml), Weighing Bottles.

EQUIPMENT:

Colorimeter, UV- Visible Spectrophotometer, Hot Water Bath, Hot Plates, Distilled Water, Plant/De - ionizer, Magnetic- Stirrer, Chemical Balances, Weighing Boxes and Electrical Balance.

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II-Year B.Tech-CHEM - II-Semester	**L**	**T/P**	**C**
	3	**1**	**3**

(A54001)PROBABILITY & STATISTICS

PREREQUISITES: First year mathematics-I

COURSE OBJECTIVES:

- Understand Chance causes and random variable that describes randomness or an uncertainty in certain realistic situation. It can be of either discrete or continuous type.
- In the discrete case, study of the binomial and the Poisson random variables and the Normal random variable for the continuous case predominantly describe important probability distributions. Important statistical properties for these random variables provide very good insight and are essential for industrial applications.
- The types of sampling, Sampling distribution of means ,Sampling distribution of variance, Estimations of statistical parameters, Testing of hypothesis of few unknown statistical parameters.
- Understanding the Experiment and the design of experiment.
- The random processes, The classification of random processes, Markov chain, Classification of states
- Stochastic matrix (transition probability matrix),Limiting probabilities, Applications of Markov chains

UNIT-I: Probability: Sample space and events, Classical and Statistical definition of Probability, The axioms of probability, Some Elementary theorems of Probability, Conditional probability, Bayes' theorem. Random variables, Discrete and continuous random variable,

UNIT-II: Definitions of Probability Distribution function, Probability mass function, Probability density function and properties. Definitions of Mathematical expectation, Moments (about origin & Centre), Definition of moment generating function for discrete and continuous random variable.

Discrete Distributions: Binomial and Poisson distributions (definition and problems) their mean, variance and moment generating function.

Continuous Distribution: Normal and exponential distributions (definition and problems) related properties.

Concepts of Joint Distribution function of more than one random variable, Definition of joint, marginal and conditional distribution (for two variables only).

UNIT-III: Sampling distribution: Populations and samples - Sampling distributions of mean (σ known and unknown). Estimation: Concept of Point estimation and its properties (definition only), Concept of interval estimation with examples.

Test of Hypothesis: Null & Alternative Hypothesis, Critical region, Type I and Type II errors, level of significance, one tail, two-tail tests. Large sample test: concerning means – proportions (One and Two samples).

UNIT-IV: Small sample test: Chi-Square test, Student's t-test (Single mean, Difference of mean and paired samples) and F-test.
Design of Experiment: Introduction to ANOVA (one – way, two – way), Principles of Design of Experiment, completely randomized design (CRD), randomized complete block design (RBD), Latin Square Design (LSD).(No Derivations only concept, definitions and problems)

UNIT-V: Stochastic Process: Introduction to stochastic Process, Classification of Random Processes, Stationary and non-stationary random process, Stochastic Matrix.
Markov Chain: Classification of States, Classification of chains, Random Walk and Gambler Ruin.

COURSE OUTCOMES:

- Students would be able to identify distribution in certain realistic situation. It is mainly useful for circuit as well as non-circuit branches of engineering. Also able to differentiate among many random variables involved in the probability models. It is quite useful for all branches of engineering.
- The student would be able to calculate mean and proportions (small and large sample) and to make important decisions from few samples which are taken out of unmanageably huge population. It is mainly useful for non-circuit branches of engineering.
- Students would be able to design their experiment with the basic norms and test their design efficiency. It is useful to all the branches of engineering.
- The student would able to understand about the random process, Markov process and Markov chains which are essentially models of many time dependent processes such as signals in communications, time series analysis, queuing systems. The student would be able to find the limiting probabilities and the probabilities in nth state. It is quite useful for all branches of engineering

TEXT BOOKS:

1. Probability and Statistics for Engineers and Scientists by Sheldon M. Ross, Academic Press.
2. Probability and Statistics for Engineers by Richard A Johnson, Pearson Education.
3. Introduction to Probability by Charles M Grinstead, J Laurie Snell, American Mathematical Society.

REFERENCES:

1. A.V. Skorokhod, Basic Principles and Applications of Probability Theory, Springer.
2. Arnold O. Allen, Probability & Statistics, Academic Press.
3. Hwei P. Hsu, Theory and Problems of Probability, Random Variables, and RandomProcesses, Schaum's Outline Series, McGraw- Hill.
4. Mendan Hall, Probability & Statistics, Beaver Thomson Publishers.
5. Miller and John E. Freund, Probability & Statistics for Engineers, Prentice Hall of India.
6. Montgomery: Design and Analysis of Experiments, Wiley.
7. T.T. Soong, Fundamentals of Probability and Statistics for Engineers, JohnWiley & Sons, Ltd.
8. Zivorad R. Lazic, Design of Experiments in Chemical Engineering, Wiley-VCH.

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II-Year B.Tech-CHEM - II-Semester	**L**	**T/P**	**C**
	3	**1/-**	**3**

(A54030)INDUSTRIAL INSTRUMENTATION

PREREQUISITES: First year Physics

COURSE OBJECTIVES:

- To learn purpose and importance of measuring different variable in process industry using relative equipment.
- To learn fundamentals and working principles of temperature sensing devices.
- To learn relation between pressure, vacuum, and head and those relationships helps in measuring required variables in industry.
- To learn composition analysis of different kinds of compounds in pharmacy, metallurgical industries.

Unit –I
Elements of instruments, static and dynamic characteristics, basic concepts of response of first order type instruments, mercury in glass thermometer, bimetallic thermometer, pressure spring thermometer, static accuracy and response of thermometers.

Unit-II
Thermo electricity: Industrial thermocouples, thermocouple wires, thermo couple wells and response of thermocouples. Thermal coefficient of resistance, industrial resistance thermometer bulbs and circuits, radiation receiving elements, radiation, photoelectric and optical pyrometers.

Unit-III
Pressure vacuum and head: liquid column manometers, measuring elements for gauge pressure and vacuum, indicating elements for pressure gauges, measurement of absolute pressure, measuring pressure in corrosive liquids, static accuracy and response of pressure gauges.

Unit-IV
Density and specific gravity, direct measurement of liquid level, pressure measurement in open vessels, level measurements in pressure vessels, measurement of interface level, density measurement, and level of dry materials.
Head flow meters, area flow meters, open channel meters, viscosity meters, quantity meters, flow of dry materials, viscosity measurements.

Unit –V

Composition analysis, spectroscopic analysis by absorption, emission, mass and color measurement spectrometers, gas analysis by thermal conductivity, analysis of moisture, gas chromatography, refractometer .

Recording instruments, indicating and signaling instruments, transmission of instrument readings, control center, instrumentation diagram, process analysis.

COURSE OUTCOMES

- Ability to comprehend of measuring instruments & its characteristics.
- Understanding Composition analysis instruments like gas chromatography etc.
- Ability to identify indicating elements for Pressure in liquids like corrosive liquids.
- Understanding the functioning of recording elements, role of control centre & where instrumentation diagrams had its utilization.

TEXT BOOKS:

1. Industrial Instrumentation by Donald P.Eckman, Wiley eastern, 1950.

REFERENCES:

1. Principles of industrial instrumentation by Patra Nabis, TMH 2010.
2. Instruments for measurements and control by Holbrock W.C. Van Nostrand East West.
3. Hand book Instrumentation, Considine, McGraw Hill, 1982.
4. Instrumentation for Process measurement and Control, Norman A. Anderson, 3rd Edition, CRC press, 1997.
5. Industrial instrumentation Principles and Design by Tattamangalam R.Padmanabhan, 2000.

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II-Year B.Tech-CHEM - II-Semester	**L**	**T/P/D**	**C**
	4	**1/-**	**4**

(A54031)CHEMICAL ENGINEERING FLUID MECHANICS

PREREQUISITES: Nil

COURSE OBJECTIVES:

- To impart to the student knowledge on fluid properties, fluid statics, dynamic characteristics for through pipes and porous medium, flow measurement and fluid machineries.

UNIT-I

BASIC CONCEPTS, Fluid statics, Applications of fluid statics, Manometers, decanters, centrifuge, dimensional analysis: Buckingham π theorem,

FLUID FLOW PHENOMENA: Newtonian and Non- Newtonian fluid flow, turbulence, Reynolds number-its significance, Boundary layer theory.

UNIT-II

BASIC LAWS FOR SYSTEMS: Mass, momentum and energy balance, Bernoulli's equation, introduction to Navier Stoke's and Euler's equations, macroscopic balance.

UNIT-III

INCOMPRESSIBLE FLOW: in pipes and channels, laminar flow in pipes and channels, Hagen- Poiseuille's equation, turbulent flow in pipes and channels, moody chart, friction losses in expansion and contractions, effects of fittings and valves

COMPRESSIBLE FLUIDS**:** Processes of compressible flow, Isentropic flow through nozzles (chocked flow), adiabatic frictional flow, and isothermal frictional flow.

UNIT-IV

FLOW PAST IMMERSED BODIES: concept of drag, drag coefficient with Reynolds number, flow through packed bed and fluidized bed, flow through bed of solids, motion of particles through the fluid, particle settling.

FLUIDIZATION: types of fluidization, minimum fluidization velocity, pneumatic conveying and other industrial uses.

UNIT-V

TRANSPORTATION AND METERING OF FLUIDS: pipe, fittings and valves, classification of pumps, classification of pumps, centrifugal pumps - cavitation, NPSH, characteristic curves, positive displacement pumps, fans, blowers and compressors.

FLUID METERS: volume flow measurement: full bore meters, Area meters, and local velocity measurement: Pitot tube, hot wire anemometers, mass flow meters

COURSE OUTCOMES:

On completion of this course, the students would have knowledge on

- Fluid properties, their characteristics while static and during flow through ducts, pipes and porous medium.
- Several machineries used to transport the fluid and their performance

TEXT BOOKS:

1. McCabe, W, L., Smith, J, C., Harriott, Peter. Unit Operations of Chemical Engineering, McGraw Hill Higher Education Publication, New Delhi.
2. Transport processes and unit operations by Christie J. Geankoplis, PHI

REFERENCES:

1. Vijay Gupta, Santhosh Kumar Gupta, Fluid Mechanics and its application, New Age International Publication, New Delhi.
2. Ron Darby, Chemical Engineering fluid Mechanics, Marcel Dekker Inc, NY (1996).
3. J. O. Wilkes, Fluid Mechanics for Chemical Engineers, Prentice Hall (1999).

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II-Year B.Tech-CHEM - II-Semester	**L**	**T/P/D**	**C**
	3	**1**	**3**

(A54032) ORGANIC CHEMISTRY

PREREQUISITES: First year chemistry

COURSE OBJECTIVES

- To identify a chemical species by means of written or spoken words and understand some important types of organic reactions in terms of the underlying mechanism principles involved.
- Understand the basics of stereochemistry, physical properties of isomers, synthesis and applications of stereochemistry and Gain of knowledge of stereo isomers, conformational isomers.
- Understand the synthesis, properties and applications of some important polymers.
- Understand the synthesis, properties and applications of some important heterocyclic compounds and some important dyes.

UNIT-I

Organic Compounds (nomenclature), Basic concepts of functional groups, Fundamentals of reaction mechanism; electro negativity, dipole moment, Types of Organic reactions.

Polar effects – Inductive effect, electrometric effect, mesomeric effect, Concept of reactive intermediates- carbanions, carbocations, carbenes and free radicals, Hyper conjugation, steric inhibition of resonance – examples. Nucleophilic addition and substitution reactions. Aldol condensation and Perkin reaction.

UNIT II

Electrophilic addition and substitution reactions. Friedel-Craft alkylation & acylation reaction, Beckmann rearrangement.

Free radical reactions (a) Halogenation of Alkane (b) Addition of HBr to Alkene in the presence of peroxide (2) Allylic halogenations using N-Bromosuccinamide(NBS) (3) Thermal halogenations of Alkanes.

UNIT – III

Stereo isomerism; Optical isomerism; Symmetry and chirality; Optical isomerism in lactic acid and tartaric acid; Sequence rules; Enantiomers, diastereomers; Geometrical Isomerism; E-Z system of nomenclature, conformational analysis of ethane and Cyclohexane.

UNIT – IV

Polymerization Reactions – Basic concepts; Types of Polymerization – Addtion and Condensation Polymerizations, Plastics- Thermosetting and Thermoplastics – Differences, Molecular weights of polymer: Number average molecular weight, Weight average molecular weight. Preparation, Properties and Engineering uses of the Following: Polyethylene, Polypropylene, PMMA, Epoxy resins and Silicone Resins, Rubber - Processing of Natural Rubber, Vulcanization and Compounding. Elastomers- Neoprene, Butyl rubber and Polyurethane Rubber.

UNIT V

Heterocyclic compounds: Aromatic Character, basicity and chemical reactivity, Nomenclature, Preparation, Properties and uses of (1) Pyrrole (2) Furan (3) Pyridine (4) Quinoline (5) Iso-quinoline.

Dyes - colours and constitution, chromophore and auxochrome theory, modern theory of colour, classification of dyes - by structure and by methods of application. Preparation, colour and application of (1) Malachite green (2) Fluoroscien (3) Congored (4) Bismark brown.

COURSE OUTCOMES

- Understand the terminology associated with the IUPAC nomenclature, describe, analyze and interpret the structure and reactivity relationship of organic molecules.
- Describe the general approaches to study organic mechanism.
- Understand the bromination especially at allylic position by using NBS
- Recognize the basis of chirality and symmetry in organic chemistry,streogenic elements and stereoisomerism, polarimetry, optical activity of organic molecules.

TEXT BOOKS:

1. Organic Chemistry- Reactions and Reagents- O.P. Agrawal– Krishna Prakashan Media (P) Ltd. – 2009.
2. Organic Reactions and their Mechanisms, II Edition – P. S. Kalsi– New age International Publishers– 2000.

REFERENCES:

1. Organic Chemistry Vol- I-IL. Finar, V Edition– Pearson Publication.
2. Text book of Organic Chemistry – P.L. Soni– Sultan Chand & Sons, New Delhi– 2003.
3. Polymer Science – Gaurikar and others– New age International Publishers, New Delhi – 2003.

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II-Year B.Tech-CHEM - II-Semester	**L**	**T/P/D**	**C**
	4	**1**	**4**

(A54033)CHEMICAL ENGINEERING THERMODYNAMICS-I

PREREQUISITES: Chemical Process Calculations & First year Physics

COURSE OBJECTIVES

- Understand the concepts of internal energy, heat, work and energy conversion, and can calculate heat and work quantities for industrial processes.
- Use equations of state, correlations and tables for real fluids.
- Reiterate the laws of thermodynamics, and understand the practical implications of these laws in engineering design.
- Understand processes involving power production, refrigeration, and liquefaction, and be able to calculate relevant system efficiencies for these processes.

UNIT I

Introduction: The scope of thermodynamics, temperature and Zeroth Law of Thermodynamics, defined quantities; volume, pressure, work, ,heat, Energy classifications, , energy in transition, heat and work, point and path properties, thermodynamic state and state functions, reversible and irreversible processes, equilibrium, The phase rule.

UNIT-II

The first law and other basic concepts: Joules Experiments, The first law of thermodynamics and Internal Energy, enthalpy, the steady-state steady-flow process, constant-V and constant- P processes heat capacity.

Volumetric properties of pure fluids: The PVT behavior of pure substances, virial equations, the ideal gas, the applications of the virial equations, second virial coefficients from potential functions. Cubic equations of state, generalized correlations for gases, generalized correlations for liquids.

UNIT-III

Thermodynamic properties of fluids: Property relations for homogeneous phases, residual properties, two phase systems, thermodynamic diagrams, tables of thermodynamic properties, generalized property correlation for gases.

Thermodynamics of flow processes ; principles of conservation of mass and energy for flow systems, analysis of expansion processes ; turbines, throttling ; compression processes – compressors and pumps ; calculation of ideal work and lost work.

UNIT-IV

The second law of thermodynamics: Statements of the second law, heat engines, thermodynamic temperatures scales, thermodynamic temperature and the ideal gas scale, Entropy, Entropy changes of an ideal gas, mathematical statement of the second law, the third law of thermodynamics, entropy from the microscopic view point.

UNIT-V

Refrigeration and liquefaction: The Carnot refrigerator, the vapor compression cycle, the comparison of refrigeration cycles, the choice of refrigerant, absorption refrigeration, the heat pump, liquefaction processes

COURSE OUTCOMES

Students will be able to:

- Identify, formulate and solve engineering problems in classical thermodynamics involving closed and open systems for both steady state and transient processes.
- Estimate the heat and work requirements for Industrial Processes.
- Have the ability to estimate thermodynamic properties of substances in gas or liquid state of ideal and real mixture.
- To introduce the principles of chemical engineering thermodynamics and illustrate their applications in the design of chemical process plants.

TEXT BOOKS:

1. Smith , J.M., Van Ness, H.C and Abbott., " Introduction to Chemical Engineering Thermodynamics ", 7th ed, Mc Graw Hill., 2005.

REFERENCES:

1. Kyle, B.G., "Chemical and Process Thermodynamics", 3rd ed. " Pearson, Prentice Hall of India Pvt.Ltd., 1999.
2. K.V.Narayanan, Chemical Engineering Thermodynamics, Prentice Hall of India Pvt Ltd., 2009
3. Hougen, O.A., Watson, K.M., and Ragatz, R.A., "Chemical Process Principles, Part II ", Thermodynamics, John Wiley, 1970.
4. Dodge, B.F., " Chemical Engineering Thermodynamics ", McGraw-Hill, 1960

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II-Year B.Tech-CHEM - II-Semester	**L**	**T/P/D**	**C**
	3	**1**	**3**

(A54034)MECHANICAL UNIT OPERATIONS

PREREQUISITES: First year Mathematics I & II

COURSE OBJECTIVES:
In this course, the students will learn characterization of solids, size reduction, techniques of solid – fluid separation and mixing

UNIT-I
Properties, handling and mixing of particulate solids: Characterization of solid particles, properties of particulate masses, storage and mixing of solids, types of mixers, mixers for cohesive solids, mixers for free flowing solids.
Transportation of solid particulate mass, belt, screw, apron conveyers, bucket elevators, pneumatic conveying

UNIT-II
Size reduction: Principles of comminution, size reduction equipment crushers, grinders, ultra fine grinders, cutting machines, Equipment operation. Screening, Industrial screening equipments

UNIT–III
Filtration, cake filters, centrifugal filters, Principles of cake filtration. Clarifying filters, liquid clarification, gas cleaning, and principles of clarification.
Cross flow filtration, types of membranes, permeate flux for ultra-filtration, Concentration polarization, particle rejection of solutes

UNIT-IV
Separations based on motion of particles through fluids, gravity settling processes and centrifugal settling processes, float and sink method, differential settling, coagulation, Flotation-separation of ores, flotation agents

UNIT -V
Agitation and mixing of liquids: Agitation of liquids, circulation velocities, power consumption in agitated vessels. Blending and mixing of liquids, suspension of solid particles, dispersion operations.
Crystallization: crystal geometry, principles of crystallization equilibrium and yields, nucleation, crystal growth.

COURSE OUTCOMES:

By the end of this course, the student should be able to:

- the students will understand about different types of size reduction processes
- Understand and apply the basic methods of characterization of particles and bulk solids, e.g. average particle size, settling velocity;
- Describe the operation of filter processes and types of filters used to perform solid-liquid separations, and calculate their power requirement
- Design a mixed tank, calculate its power requirements and scale-up the design;

TEXT BOOKS:

1. Unit Operations in Chemical Engineering by W.L. McCabe and J.C. Smith and Peter Harriott, Mc Graw Hill 5th ed. 1993.

REFERENCES:

1. Chemical engineers hand book, J.H. Perry, 7th ed. Mc Graw Hill.
2. Badger and Bencharo, "Introduction to Chemical Engineering". TMH,
3. Narayanan C.M.& Bhattacharya B.C. "Mechanical opeartions for chemical engineers", Khanna.

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II-Year B.Tech-CHEM - II-Semester	**L**	**T/P/D**	**C**
	2	**0**	**0**

(A54018)GENDER SENSITIZATION

COURSE OBJECTIVES:

- To develop students sensibility with regard to issue of gender in contemporary India.
- To provide a critical perceptive on the socialization of men and women
- To introduce students to information about some key biological aspects of genders.
- To expose the students to debates on the politics and economics of the work.
- To help students reflect critically on gender violence.
- To expose students to more egalitarian interactions between men and women.

UNIT 1

Understanding Gender:
Gender: why should we study it? (Towards a world of equals: (Unit-1)
Socialization: Making women, making men towards a world of equals: (Unit-2)
Introduction. Preparing for womanhood. Growing up male. First lessons in caste. Different masculinities.
Just relationships: Being together equals (towards a world of equals: (Unit-3).
Mary kom and onler .love and acid just do not mix. Love letters mothers and fathers. Further reading: Rosa parks-the brave heart.

UNIT-II

Gender and Biology:
Missing women: sex selection and its consequences towards a world of equals: (Unit-4)
Declining sex ratio. Demographic consequences. Gender spectrum: Beyond the (towards a world of equals: (Unit-10)
Too or many? Struggles with discrimination .additional reading: our bodies our health (towards a world of equals: (Unit-13)

UNIT-III

Gender and Labor: House work: the invisible labor (towards a world of equals: (Unit-3)
"My mother doesn't work ", "share the load".
Women's work: its politics and economics (towards a world of equals: (Unit-7)
Fact and Fiction: unrecognized and unaccounted work. Further reading: wages and conditions of work.

UNIT-IV

Issues of the violence: Sexual harassment: say no! (Towards a world of equals: (Unit-6), sexual; harassment, not eveteasing-couping with every day harassment-Further reading: "chupulu"
Domestic violence: speaking out (towards a world of equals: (Unit-8)
Is home a safe place? When women unite [film].rebuilding lives. Further reading: New forums for justice.
Thinking for sexual violence (towards a world of equals: (Unit-11)

Blaming the victim-I fought for my life …..” Further reading: the caste face of violence.

UNIT-V

Gender Studies:

Knowledge: through the lens of gender (towards a world of equals: (Unit-5).point of view. Gender and the structure of knowledge: Further reading: unacknowledged women artists of Telangana.

Whose history? Questions for historians and others (towards a world of equals: (Unit-9)

Reclaiming a past. Writing other histories .Further reading: missing pages from modern Telangana History.

Essential Reading: All the units in the textbook, “Towards a world of equals: A bilingual Textbook on Gender” written by A.Suneetha, Uma Bhrugubanda, Duggirala Vasantha, Ramamelkote, Vasuda Nagaraj, Asman Raseed, Gogu Shyamala, Deepa Srinivas, Susietharu

Note: Since it is interdisciplinary course resource persons can be drawn in the field of English literature or sociology or political science or any other qualified faculty who has expertise in this field

COURSE OUTCOMES:

- Student will make relations without based on gender priority.

Reference Books:

1. Sen, Amartya, “More than One Million Women are Missing.” New York Review of Books 37.20 (20 December 1990). Print. ‘We Were Making Hisoty…’ Life Stories of Women in the Telangana People’s Struggle. New Delhi: Kali for Women, 1989.
2. Tripti Lahiri. “By the Numbers: Where Indian Women Work.” Women’s Studies Journal (14 November 2012) Available online at:http://blogs.wsj.com/ India real time/2012/11/14/by-the-numbers-where-Indian-women-work/>
3. K.Satyanarayana and Susie Tharu (Ed.) Steel Nibs Are Sprouting: New Dalit Writing From South India, Dossier 2, Telugu and Kannada http://harpercollings.co.in/BookDetail.asp?Book Code=3732
4. Vimala. “Vantilliu (The Kitchen)”. Women Writing in India: 600 Bc To the Present, Volume It: The 20th Century, Ed. Susie Tharu and K.Lalitha. Delhi: Oxford University Press, 1995. 599-601.
5. Shatrunghna, Veena et al. Women’s Work and its impact on Child Health and Nutrition, Hyderabad, National Institute of Nutrition, Indian Council of Medical Research, 1993.
6. Stree Shakti Sanghatana. “We Were Making History…’ Life Stories of Women in the Telangana People’s Struggle, New Delhi: Kali for Women, 1989.
7. Menon, Nivedita, Seeing like a Feminist. New Delhi: Zubaan-Penguin Books, 2012
8. Jayaprabha, A. “Chupulu (Stares)”. Women Writing in India: 600BC to the Present. Volume II: The 20th Century Ed. Susie Tharu and K.Lalita, Delhi: Oxfor Univerity Press. 1995, 596-597.
9. Javeed. Shayan and Anupam Manuhaar. “Women and Wage Discrimination in India: A Critical Analysis.” International Journal of Humanities and Social Science Invention 2,.4 (2013).

10. Gautam, Liela and Gita Ramaswamy. “A ‘conversation’ between a Daughter and a Mother.” Broadsheet on Contemporary Politics. Special Issue on Sexuality and Harassment: Gender Politics on Campus Today. Ed. Madhumeeta Sinha and Asma Rasheed. Hyderabad: Anveshi Research Center for Women’s Studies, 2014.
11. Abdulali Sohaila. “I Fought For My Life… and Won.” Available online at: http://www.thealternative.in/lifestyle/i-fought-for-my-lifeand-won-sohaila-abdulal/
12. Jeganathan pradeep, Partha Chatterjee (Ed). “Community, Gender and Violence Subaltern Studies XI”. Permanent Black Ravi Dayal Publishers, New Delhi, 2000.
13. K.Kapadia. The Violence of Development: The Politics of Identity, Gener and Social Inequalities in India. London: Zed Books, 2002.
14. S.Benhabib. Situating the Self: Gender, Community, and Postmodernism in Contemporary Ethics, London: Routledge, 1992.
15. Virginia Woolf. A Room of One’s Own, Oxford: Black Swan, 1992.
16. T.Banuri and M. Mahmood, Just Development Beyond Adjustment with a Human Face, Karachi: Oxford University Press, 1997.

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II-Year B.Tech-CHEM - II-Semester	**L**	**TP/D**	**C**
	-	**3**	**2**

(A54215)CHEMICAL ENGINEERING FLUID MECHANICS LAB

COURSE OBJECTIVES:

- To gain practical knowledge on the measurement of Fluid Flow and their characteristics at different operating conditions. To determine experimentally the flow characteristics of fluids and also to determine the efficiency of the flow measuring devices and fluid transport machineries.

At least **Ten** experiments out of the following Twelve experiments should be performed)

1. Experiments on Reynolds Apparatus for determination of flow regime.
2. Determination of co efficient of Discharge for Orifice meter
3. Determination of co efficient of Discharge for Venturi meter
4. Determination of Discharge co- efficient of given V-notch.
5. Determination of efficiency of a centrifugal pump.
6. Calibration of a Rota-meter
7. Frictional losses in straight pipes and construction of fanning friction factor vs. Reynolds Number plot.
8. Frictional losses in bend pipes and construction of fanning friction factor vs. Reynolds Number plot.
9. Determine absolute viscosity of glycerol – water mixture.
10. To determine the pressure drop across the packed column.
11. Experiment on fluidization techniques and determination of
    (a) Minimum fluidization velocity;
    (b) Pressure drop profile
12. Experiment is to verify the Bernoulli's theorem

LIST OF EQUIPMENTS/MACHINES REQUIRED:

1. Reynolds apparatus
2. Orifice meter
3. Venturi meter
4. V - notch apparatus
5. Centrifugal pump
6. Rota meter
7. Set of straight pipes.
8. Set of fittings in pipe
9. Canon viscometer
10. Packed column apparatus
11. Fluidized column
12. Bernoulli's apparatus

COURSE OUTCOMES

- Understand concepts on nature of fluids, pressure concepts and measurement of pressure by various experimental methods and by mathematical relations and enhancement of problem solving skills.

- Understand clear concepts on flow of incompressible fluids in conduits and thin layers and friction factor variations with velocity and friction losses using Bernoulli's equations and they will be demonstrated experimentally.

- Determine viscosity using cannon Fenske viscometer and terminal velocity experiment.

- Understand principles and working of various types of pumps, transportation and metering of fluids using various experimental techniques and applications to industry.

TEXT BOOKS:

1. W. L. McCabe and J. C. Smith, "Unit Operations In Chemical Engineering", 4th Edn.,McGraw Hill Publishing Co., 1985.

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II-Year B.Tech-CHEM - II-Semester	**L**	**TP/D**	**C**
-	**3**		**2**

(A54216)MECHANICAL UNIT OPERATIONS LAB

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

(At least **Ten** experiments out of the following twelve experiments should be performed)
List of Experiments:

1. To determine the time of grinding in a ball mill for producing a product with 80 % passing a given screen.
Major equipment - Ball mill Apparatus, Sieve shaker, Different sizes of sieves, Weighing balance.

2. To verify the laws of crushing using any size reduction equipment like crushing rolls or vibrating mills and to find out the working index of the material.
Major equipment – Jaw Crusher, Sieve shaker, Different sizes of sieves, Weighing Balance, Energy meter

3. To find the effectiveness of hand screening of a given sample by a given screen.
Major equipment - Vibrating Sieve shaker, Different sizes of sieves, Weighing Balance

4. To separate a mixture of oil into two fractions using froth flotation technique.
Major equipment - Froth flotation cell

5. To obtain batch sedimentation data and to calculate the minimum thickener area under given conditions.
Major equipment- Sedimentation apparatus

6. To determine the specific cake resistance and filter medium resistance of slurry in plate and frame filter press.
Major equipment - Plate and Frame filter press.

7. Verification of Stoke's law.
Major equipment – Stoke's law apparatus.

8. To take a representative sample from a bulk by two methods, Cone& Quartering and to find out the average size {volume-surface mean diameter} of the samples.

9. To find the size analysis of a given fine sample using beaker decantation method.

10. To verify the laws of crushing using any size reduction equipment like roll crusher find out the working index of the material.
– Roll Crusher, Sieve shaker, Different sizes of sieves, Weighing Balance, Energy meter.

11. To separate a mixture of particles by jigging
Major Equipment – Mineral Jig

12. To analyze a given powder for its particle size distribution. / Cumulative and Differential methods of particle size distributions

13. To calculate separation efficiency of particles in a mixture using cyclone separator.
Major Equipment – Cyclone separator

14. To determine the bulk, tapped and true density along with the flow ability and porosity of a given fine sample

COURSE OUTCOMES:

- Students would gain the practical knowledge and hands on various separation techniques like filtration, sedimentation, screening, froth flotation, and beaker decantation and size reduction operations.

TEXT BOOKS:

1. Unit Operations in Chemical Engineering by W.L. McCabe and J.C. Smith and Peter Harriott, Mc Graw Hill 5th ed. 1993.

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III-Year B.Tech-CHEM - I-Semester	**L**	**T/P**	**C**
	3	**1/-**	**3**

(A55050)CHEMICAL ENGINEERING THERMODYNAMICS-II

PREREQUISITE: Chemical Engineering Thermodynamics-1, Mathematics

COURSE OBJECTIVES:

- Understand and calculate the heat effects on Industrial Reactions.
- Familiarity with basic concepts in solution thermodynamics.
- Explain the underlying principles of phase equilibrium in two-component and multi-component systems
- Determine equilibrium compositions of chemical reactions.

Unit -I:

Heat effects: Sensible heat effects, Internal energy of ideal gases: Microscopic view, Latent heats of pure substances, heat effects of industrial reactions, Standard heat of reaction, Standard heat of formation, Standard heat of combustion, temperature dependence of heat of reaction.

Fugacity and fugacity coefficient for species in solutions, generalized correlations for Fugacity coefficient, the ideal solutions, excess properties.

Unit-II:

Solution thermodynamics: Theory: Fundamental property relation, chemical potential as a criterion for phase equilibrium, partial properties, ideal gas mixtures, fugacity and fugacity coefficient for pure species.

Solution thermodynamics: applications: the liquid phase properties from VLE data, models for the excess Gibbs energy, property changes of mixing, heat effects of mixing processes.

Unit -III:

VLE at low to moderate pressures: The nature of equilibrium, the phase rule, Duhems theorem, VLE: Qualitative behaviour, Simple models for vapour liquid equilibrium, Vapor liquid equilibrium by Modified Raoult's law, VLE from K-Value Correlations.

The gamma /Phi formulation of VLE, Dew point and bubble point calculations, flash calculations, solute (1)/sol vent (2) systems.

Unit –IV:

Thermodynamic properties and VLE from equations of state: VLE from cubic equations of state.

Topics in phase Equilibria: Equilibrium and stability, liquid-liquid equilibrium (LLE), vapor- liquid–liquid equilibrium (VLLE), solid-liquid equilibrium (SLE), solid vapor equilibrium (SVE), equilibrium absorption of gases on solids.

Unit –V:

Chemical reaction equilibria: The reaction coordinate, application equilibrium criterion to chemical reactions, the standard Gibb's energy change and the equilibrium constant, effect of temperature on equilibrium constants, relation of equilibrium constants to composition, equilibrium conversion for single reactions, Phase rule and Duhem's theorem for reacting systems.

COURSE OUTCOMES:

Students will be able to:

- Analyze the heat effects involved in Industrial Chemical Processes.
- Determine the thermodynamic properties of mixtures of gases, liquids and solids.
- Have the ability to determine the equilibrium states of a wide range of systems, ranging from mixtures of gases, liquids, and solids that can each include multiple components.
- Solve problems dealing with multi-phase chemical systems and reactive systems.

TEXT BOOKS :

1. Smith , J.M., Van Ness, H.C. and Abbott., " Introduction to Chemical Engineering Thermodynamics ", 7^{th} ed, Mc Graw Hill, 2005.

REFERENCES:

5. Kyle, B.G., " Chemical and Process Thermodynamics 3rd edn. ", Pearson, Prentice Hall of India Pvt.Ltd., 1999.
6. Y.V.C. Rao, Chemical Engineering Thermodynamics, University Press Pvt Ltd, 2004.
7. K.V. Narayanan, "A Text Book Chemical Engineering Thermodynamics", PHI Learning Pvt Ltd., New Delhi, 2001.
8. Hougen O.A, Watson. K. M and Ragatz R.A., "Chemical Process Principles (part II)", 2^{nd} Ed, CBS Publishers, 2004.

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III-Year B.Tech-CHEM - I-Semester **L T/P C**
3 1/- 3

(A55051)CHEMICAL REACTION ENGINEERING-I

PREREQUISITE: Chemical Process Calculations, Chemistry, Mathematics-I, II, III

COURSE OBJECTIVES:

- To Provide Thorough Understanding Of Reaction Engineering And To Design Reactor And Identify Type Of Reactor By Using Chemical Kinetics And Using Information From Thermodynamics, Heat Transfer And Mass Transfer Economics.

UNIT-I

Overview of chemical reaction engineering - classification of reactions, variables affecting the rate of reaction, definition of reaction rate, kinetics of homogeneous reactions-concentration dependent term of rate equation, temperature dependent term of rate equation, searching for mechanism, predictability of reaction rate from theory.

UNIT-II

Interpretation of batch reactor data-constant volume batch reactor-Analysis of total pressure data obtained in a constant-volume system, the conversion, Integral method of analysis of data-general procedure, irreversible uni-molecular type first order reaction, irreversible bimolecular type second order reaction, irreversible tri molecular type third order reactions, empirical reactions of nth order, zero order reaction, overall order of irreversible reaction from half life, fractional life method, irreversible reaction in parallel, homogeneous catalyzed reaction, autocatalytic reactions, irreversible reaction in series.

UNIT-III

Constant volume batch reactor-first order reversible reaction, second order reversible reactions, reversible reaction in general, reactions of shifting order, Differential method of analysis of data, Varying volume batch reactor-differential method of analysis ,integral method of analysis, zero order first order, second order, nth order reactions, temperature and reaction rate, the search for a rate equation. Introduction to reactor design - general discussion. Symbols and relationship between C_A and X_A, Ideal reactors for a single reaction-ideal batch reactor, Steady-state mixed flow reactor, Steady-state plug flow reactor.

UNIT-IV

Design for single reactions-Size comparison of single reactors, multiple reactor systems, recycle reactor, Autocatalytic reactions. Design for parallel reactions-Introduction to multiple reactions, qualitative discussion about product distribution, quantitative discussion about product distribution and of reactor size.

UNIT-V

Series Reactions - Irreversible first order reactions in series, quantitative discussion about product distribution, quantitative treatment, plug flow or batch reactor, quantitative treatment, mixed flow reactor, first order followed by zero-order reaction, zero order followed by first order reaction.

Temperature and pressure effects-single reactions-heats of reaction from thermodynamics, heats of reaction and temperature, equilibrium constant from thermodynamics, equilibrium conversion, general graphical design procedure, optimum temperature progression, heat effects, endothermic reaction in mixed flow reactors-A special problem, multiple reactions, adiabatic operation, non-adiabatic operation comment and extension.

COURSE OUTCOMES:

1. Describe the algorithm that allows the student to solve chemical reaction engineering problems through logic rather than memorization.
2. Determine the reaction order and specific reaction rate from experimental data and describe the steps in a catalytic mechanism and how one goes about deriving a rate law, mechanism, and rate-limiting step that are Consistent with experimental data.
3. Work together to solve both open-ended and closed-ended reaction engineering problems.
4. Use relevant theory to describe the molecular basis for elementary chemical reaction rates.

TEXT BOOKS:

1. Chemical reaction engineering by Octave Levenspiel, 3rd ed. John Wiley and Sons, 1990.

REFERENCES:

1. Elements of Chemical reaction engineering by H.S. Fogler, 2nd ed.PHI,1992.
2. Chemical engineering Kinetics by J.M. Smith, 3rd ed. Mc Graw Hill, 1981.

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III-Year B.Tech-CHEM - I-Semester	**L**	**T/P**	**C**
	3	**1/-**	**3**

(A55052)MASS TRANSFER OPERATIONS-I

PREREQUISITE: Fluid Mechanics, Chemical Process Calculations

COURSE OBJECTIVES:

- To discuss the fundamental concepts of mass transfer principles and their application to separation and purification of processes, to provide students with theoretical/analytical back ground to understand mass transfer operations to tackle the complex problems.

UNIT- I

The Mass Transfer Operations: Classification of the Mass-Transfer Operations, Choice of Separation Method, Methods of Conducting the Mass-Transfer Operations, Design Principles, Molecular Diffusion In Fluids: Molecular Diffusion, Equation of Continuity, binary solutions, Steady State Molecular Diffusion in Fluids at Rest and in Laminar Flow, estimation of diffusivity of gases and liquids, Momentum and Heat Transfer in Laminar flow Diffusion: Diffusion in Solids, Fick's law Diffusion, Types of Solid Diffusion.

UNIT- II

Mass Transfer Coefficients: Mass Transfer Coefficients, Mass Transfer Coefficients in Laminar Flow (Explanation of equations only and no derivation), Mass Transfer Coefficients in Turbulent Flow, eddy diffusion, theories of mass transfer and their applications , Mass, Heat and Momentum Transfer Analogies, Turbulent Flow in Circular Pipes.(Mass transfer data for simple situations)

Inter phase Mass Transfer: Concept of Equilibrium, Diffusion between Phases, Material Balances in steady co-current and counter current stage processes, Stages, Cascades

UNIT-III

Equipment For Gas-Liquid Operations: Gas Dispersed, Sparged vessels (Bubble Columns), Mechanical agitated equipments(Brief description),Tray towers, General characteristics, Different types of Tray Efficiencies, Liquid Dispersed venturi Scrubbers, Wetted-Wall Towers, Packed Towers, Mass transfer for packed towers, End effects and Axial Mixing, Tray tower vs Packed towers.

Absorption and Stripping: Absorption equilibrium, ideal and non ideal solutions selection of a solvent for absorption, one component transferred: material balances. Determination of number of Plates (Graphical),Absorption Factors, estimation of number of plates by Kremser Brown equation, Continuous contact equipment; HETP, Absorption of one component, Determination of number of Transfer Units and Height of the Continuous Absorber, overall coefficients and transfer units, dilute solutions, overall height of transfer units

UNIT-IV

Humidification Operations: Vapor-Pressure Curve, Definitions, Psychometric Charts, Enthalpy of gas-vapor Mixtures, Humidification and Dehumidification, Operating lines and Design of Packed Humidifiers, Dehumidifiers and Cooling towers, Spray Chambers

UNIT-V

Drying: Equilibrium, Definitions, Drying Conditions- Rate of Batch Drying under constant drying conditions, Mechanisms of batch drying, Drying time Through Circulation Drying, Classification of Drying Operations: Batch and Continuous Drying Equipment, Material and Energy Balances of Continuous Driers.

COURSE OUTCOMES:

- Analyze diffusion of fluids and related mass transfer theories
- Knowledge of concepts of Stages, Transfer Units and efficiency stages.
- Understand the principles of mass transfer operations humidification, drying, crystallization and absorption.
- Perform material and energy balance calculations in mass transfer operations humidification, drying, crystallization and absorption.
- Able to select and design the equipments for humidification, drying, crystallization and absorption operations.

TEXT BOOKS:

1. Mass transfer operations by R.E. Treybal, 3rd ed. Mc Graw Hill, 1980.
2. McCabe, W.L., Smith, J.C., and Harriot, P., "Unit Operations in Chemical Engineering", McGraw-Hill VII Edn., 2004.

REFERENCES:

1. Diffusion: mass transfer in fluid system by E. L. Cussler, 2nd Ed, 1997.
2. Transport processes and Separation Process Principles 4th Ed., by Christie J. Geankoplis, PHI Learning Pvt. Ltd., New Delhi, 2009
3. Principles of mass transfer and separation processes, Binay .K. Dutta, PHI Learning Pvt Ltd, India, 2007

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III-Year B.Tech-CHEM - I-Semester	**L**	**T/P**	**C**
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(A55053)PROCESS HEAT TRANSFER

PREREQUISITE: Chemical Process Calculations, First year Physics

COURSE OBJECTIVES:

- To understand the fundamentals of heat transfer mechanisms in fluids and solids and their applications in various heat transfer equipment in process industries.

UNIT I:

Introduction

Nature of heat flow, conduction, convection, natural and forced convection, radiation.

Heat transfer by conduction in Solids

Fourier's law , thermal conductivity, steady state conduction in plane wall & composite walls, compound resistances in series, heat flow through a cylinder, conduction in spheres, thermal contact resistance, plane wall: variable conductivity

Unsteady state heat conduction

Equation for one-dimensional conduction, Semi-infinite solid, finite solid.

Unit- II:

Principles of heat flow in fluids

Typical heat exchange equipment, countercurrent and parallel current flows, energy balances, rate of heat transfer, overall heat transfer coefficient, electrical analogy, critical radius of insulation, logarithmic mean temperature difference, variable overall coefficient, multi-pass exchangers, individual heat transfer coefficients, resistance form of overall coefficient, fouling factors, classification of individual heat transfer
coefficients, magnitudes of heat transfer coefficients, effective coefficients for unsteady-state heat transfer.

Natural convection

Natural convection to air from vertical shapes and horizontal planes, effect of natural convection in laminar-flow heat transfer, free convection in enclosed spaces, mixed free & forced convection.

Unit- III:

Heat Transfer to Fluids without Phase change

Regimes of heat transfer in fluids, thermal boundary layer, heat transfer by forced convection in laminar flow, heat transfer by forced convection in turbulent flow, the transfer of heat by turbulent eddies and analogy between transfer of momentum and heat, heat transfer to liquid metals, heating and cooling of fluids in forced convection outside tubes.

Heat transfer to fluids with phase change

Heat transfer from condensing vapors, heat transfer to boiling liquids.

Unit- IV:

Heat exchange equipment

General design of heat exchange equipment, heat exchangers, condensers, boilers and calendrias, extended surface equipment, heat transfer in agitated vessels, scraped surface heat exchangers, heat transfer in packed beds, heat exchanger effectiveness (NTU method)

Evaporators

Evaporators, performance of tubular evaporators, capacity and economy, multiple effect evaporators, vapor recompression.

Unit- V:

Radiation

Introduction, properties and definitions, black body radiation, real surfaces and the gray body, absorption of radiation by opaque solids, radiation between surfaces, radiation shielding, radiation to semi transparent materials, combined heat transfer by conduction, convection and radiation.

COURSE OUTCOMES:

1. Student able to understand the basic concepts and laws of the three modes of heat transfer
2. Student can apply analytical techniques to the solution of conduction heat-transfer problems
3. Student will analyze the heat transfer processes involved in boiling and condensation
4. Student can perform basic calculations of common heat exchangers to determine relevant design parameters

TEXT BOOKS:

1. Unit Operations of Chemical Engineering by McCabe, Smith and Peter Harriot, McGraw-Hill 5th edition 1993

REFERENCES:

1. Heat transfer, 4th edition, J. P. Holman , McGraw-hill, New York,1976.
2. Chemical Engineering, Vol-1, J.Coulson and R.F.Richardson, Pergamon Press, 2005.
2. Heat transfer: Principles and Applications. B.K. Dutta, PHI Learning, India, 2004
3. Process Heat Transfer by Donald Q. Kern. McGraw-hill New York, 1950

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III-Year B.Tech-CHEM - I-Semester	**L**	**T/P**	**C**
	4	**1/-**	**4**

(A55054)TECHNOLOGY OF PHARMACEUTICALS AND FINE CHEMICALS
Core Elective-1

PREREQUISITE: First year Chemistry

COURSE OBJECTIVES

Students will learn about

- Grading of chemicals which play a very important role in understanding the standards and impurities present in different chemicals by limit test
- Process manufacturing of few pharmaceutical drugs and fine chemicals,
- Formulations of different pharmaceutical dosage forms like tablets and capsules.
- Information on different methodologies in extraction and sterilization.

Unit I:

A brief outline of grades of chemicals, sources of impurities in chemicals, limit test, principles of limit test for arsenic, lead, iron, chloride and sulfate in Pharmaceuticals.

Unit II:

Outlines of Preparation, properties, uses and testing of the following Pharmaceuticals - sulfacetamide, paracetamol, riboflavin, nicotinamide. Outlines of Preparation, properties, uses and testing of the following fine chemicals - Methyl orange, fluorescence, procaine hydrochloride, paramino salicylic acid, isonicatinic acid hydrazide.

Unit III:

Manufacture with flowsheets, properties uses and testing of the following Pharmaceuticals – aspirin, penicillin, calcium gluconate, Ibuprofen

Manufacture with flow sheets, properties uses and testing of the following ferric ammonium citrate, pthallic anhydride and phenol chlorobenzene process.

Unit IV:

Brief on different drug delivery systems (tablets, capsules, injections, topical applications etc), Tablet making and coating, granulation equipments, packaging and preparation of capsules, extraction of crude drugs.

Unit V:

Sterilization: Introduction, methods of sterilization, heat (dry and moist), heating with bactericide, filtration, gaseous sterilization and radiation sterilization, suitable example to be discussed.

COURSE OUTCOMES:

- How to identify impurities in different chemicals and set them according to standards.
- Able to transforming raw materials into useful pharmaceutical and fine chemical products with commercial interest through systematic use of engineering concepts and methods.
- Able to formulate and develop, use of excipients in tablets, capsules and coating techniques.
- Get exposed to extraction and sterilization techniques in pharmaceuticals.

TEXT BOOKS:

1. Remington's Pharmaceutical Science, Mac publishing company, 13th ed. 1965.
2. Blently's TEXT BOOK of Pharmaceutics by H A Rawlins, B Tindell and Box, 8th ed. OU Press, London, 1977.

REFERENCES:

1. Text Book of Pharmaceutical Chemistry by Blently and driver. Oxford University press, London, 8th ed. 1960.

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III-Year B.Tech-CHEM - I-Semester **L T/P C**
4 1/- 4

(A55055)COMPUTATIONAL FLUID DYNAMICS
Core Elective-1

PREREQUISITE: Mathematics-I, II, III, and Fluid Mechanics

COURSE OBJECTIVE:

To make the students to demonstrate competence in setting up computational fluid dynamics models for some industrially important applications. This technical competence in building and conducting CFD simulations is a skill which enhances employability.

UNIT-I

CONSERVATION LAWS AND TURBULENCE MODELS: Governing equations of fluid flow and heat transfer –mass conservation, momentum and energy equation, differential and integral forms, conservation and non-conservation form. Characteristics of turbulent flows, time averaged. Navier Strokes equations, turbulence models-one and two equation, Reynolds stress, LES and DNS

UNIT-II

FINITE DIFFERNCE APPROXIMATION

Mathematical behavior of PDE, finite difference operators, basic aspects of discretization by FDM, explicit and implicit methods, error and stability analysis

UNIT-III

FINITE VOLUME METHOD

Diffusion problems – explicit and implicit time integration; Convection-diffusion problems – properties of discretization schemes, central, upwind, hybrid, QUICK schemes; Solution of discretized equations.

UNIT-IV

FLOW FIELD COMPUTATION

Pressure velocity coupling, staggered grid, SIMPLE algorithm, PISO algorithm for steady and unsteady flows

UNIT-V

GRID GENERATION

Physical aspects, simple and multiple connected regions, grid generation by PDE solution, grid generation by algebraic mapping.

CORSE OUTCOMES:

- Upon completing the course, the student should have a Hands-on experience with a commercial CFD program.

TEXTBOOKS:

1. Anderson, J. D., “Computational Fluid Dynamics: The Basics with Applications”, McGraw-Hill, 1995.
2. Fletcher, C. A. J., “Computational Techniques for Fluid Dynamics”, Springer Verlag, 1997.
3. Versteeg, H.K. and Malalasekera, W., “An Introduction to Computational Fluid Dynamics: The Finite Volume Method”, Pearson Education Ltd., 2007.

REFERENCES:

1. Chung T.J Computational Fluid Dynamics Cambridge University Press, 2003.
2. Muralidhar, K., and Sundararajan, T., “Computational Fluid Flow and Heat Transfer”, Narosa Publishing House, New Delhi, 2001.
3. Ghoshdastidar, P.S., “Computer Simulation of flow and heat transfer” Tata McGraw – Hill Publishing Company Ltd. 1998.
4. Subas, V. Patankar “Numerical heat transfer fluid flow”, Hemisphere Publishing Corporation, 1980.
5. Taylor, C and Hughes, J.B. “Finite Element Programming of the Navier Stock Equation”, Pineridge Press Limited, U.K., 1981.

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III-Year B.Tech-CHEM - I-Semester **L T/P C**
4 1/- 4

(A55056)ENVIRONMENTAL BIOTECHNOLOGY
Core Elective-1

PREREQUISITE: Environmental Science

COURSE OBJECTIVES:

- To understand the role of various environmental pollutants, bio-oxidation, biotransformation
- To know the involvement of microbes in waste water treatment, chemicals

UNIT-I

INTRODUCTION TO ENVIRONMENTAL POLLUTANTS: Water, Soil and Air: their sources and effects. Removal of Specific Pollutants: Sources of Heavy Metal Pollution, Microbial Systems for Heavy Metal Accumulation, Bio sorption & detoxification mechanisms.

ECO-FRIENDLY BIO-PRODUCTS FROM RENEWABLE SOURCES: Fundamentals of composting process: composting technologies, composting systems and compost quality,

UNIT-II

BIOLOGICAL WASTE TREATMENT: Biological waste water treatment: Principles and design aspects of various waste treatment methods with advanced bioreactor configuration: activated sludge process, trickling filter, fluidized expanded bed reactor, up flow anaerobic sludge blanket reactor, contact process, fixed/packed bed reactor, hybrid reactor, sequential batch reactor. Solid waste management: landfills, recycling and processing of organic residues, minimal national standards for waste disposal

UNIT-III

BIODEGRADATION OF XENOBIOTIC COMPOUNDS Xenobiotic compounds: Aliphatic, Aromatics, Poly aromatic Hydrocarbons, Polycyclic aromatic compounds, Pesticides, Surfactants and microbial treatment of oil pollution.

UNIT-IV

BIOTRANSFORMATIONS AND BIOCATALYSTS Basic organic reaction mechanism - Common prejudices against Enzymes.- Advantages & Disadvantages of Biocatalysts - Isolated Enzymes versus whole cell systems.- Mechanistic Aspects and Enzyme Sources.- Bio-catalytic Application - Catalytic Antibodies; Stoichiometry, kinetics, and thermodynamics of microbial processes for the transformation of environmental contaminants.

BIOREMEDIATION AND BIO-RESTORATION: Introduction and types of bioremediation, bioremediation of surface soil and sludge, bioremediation of subsurface material, in-situ and Ex-situ technologies, and phytoremediation- restoration of coal mines a case study. Bio restoration

UNIT-V

BIOOXIDATION & MICROBIAL LEACHING Bio-oxidation – Direct and Indirect Mechanisms – Bio-oxidation Kinetics; Bacterial oxidation of Sphalerite, Chalcopyrite and Pyrite.; Extraction of metals from ores; Recovery of metals from solutions; Microbes in petroleum extraction; Microbial desulfurization of coal.

BIOTECHNOLOGY IN ENVIRONMENT PROTECTION: Current status of biotechnology in environment protection and its future, plasmid borne metabolic activities, bio augmentation.

COURSE OUTCOMES:

- Understand the role of environmental biotechnology in order to make environment in sustainable manner

TEXTBOOKS:

1. Environmental Processes I-III, J. Winter, 2nd ed., Wiley Publications
2. Introduction to Waste Water Treatment- R. S. Ramalho, Academic Press.
3. Bharucha Erach, the Biodiversity of India, Mapin Publishing Pvt. Ltd.
4. Environmental Biotechnology, B.C. Bhattacharya & Ritu Banerjee, Oxford Press, 2007.

REFERENCES:

1. Environmental Biotech, Pradipta Krimar, I.K. International Pvt. Ltd., 2006.
2. Environmental Microbiology & Biotechnology, D.P. Singh, S.K. Dwivedi, New Age International Publishers, 2004.
3. Biodegradation and Bioremediation 1999 (2nd editon). Martin Alexander, Elsevier Science & Technology.
4. Environmental Biotechnology by Bruce Rittmann and Perry McCarty Subas, V. Patankar “Numerical heat transfer fluid flow”, Hemisphere Publishing Corporation, 1980.

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III-Year B.Tech-CHEM - I-Semester	**L**	**T/P**	**C**
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(A55057)NUCLEAR ENGINEERING
Core Elective-2

PREREQUISITE: First year Physics and Chemistry

COURSE OBJECTIVES:

- The objective of this course is to make students familiar with the concepts of nuclear reactions, and reactor physics.

UNIT I

Nuclear Physics
Nuclear model of the atom - Equivalence of mass and energy - Binding - Radio activity - Half life - Neutron interactions - Cross sections.

UNIT II

Nuclear Reactions and Reactor Materials
Mechanism of nuclear fission and fusion - Radio activity - Chain reactions - Critical mass and composition - Nuclear fuel cycles and its characteristics - Uranium production and purification - Zirconium, thorium, beryllium.

UNIT III

Reprocessing
Nuclear fuel cycles - spent fuel characteristics - Role of solvent extraction in reprocessing - Solvent extraction equipment.

UNIT IV

Nuclear Reactions
Reactors - Types of fast breeding reactors - Design and construction of fast breeding reactors - heat transfer techniques in nuclear reactors - reactor shielding.

UNIT V

Safety, Disposal and Proliferation
Nuclear plant safety- Safety systems - Changes and consequences of an accident - Criteria for safety - Nuclear waste - Type of waste and its disposal - Radiation hazards and their prevention - Weapons proliferation.

COURSE OUTCOMES:

- To introduce to the students, the various concepts in the design of nuclear reactors and power plants.

TEXT BOOKS:

1. Thomas J.Cannoly, “Fundamentals of Nuclear Engineering ", John Wiley (1978).
2. Lamarsh U.R. " Introduction to Nuclear Engineering”, 2nd Edition ", (1983), Addison Wesley M.A.

REFERENCES:

1. Collier J.G., and G.F.Hewitt, “Introduction to Nuclear Power ", (1987), Hemisphere Publishing, New York.
2. Lipschutz R.D. “Radioactive Waste - Politics, Technology and Risk ", (1980), Ballingor, Cambridge. M.A.

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III-Year B.Tech-CHEM - I-Semester	**L**	**T/P**	**C**
	4	**1/-**	**4**

(A55058)FRONTIERS OF CHEMICAL ENGINEERING (THEORY)
Core Elective-2

PREREQUISITE: Heat Transfer, Mass Transfer, Fluid Mechanics

COURCE OBJECTIVES:
Student will be able to understand the concepts of chemical engineering and its applications

UNIT I
PROCESS INTENSIFICATION
Novel reactor configurations; combination of reaction and separation; use of different energy fields, lab on a chip.

UNIT II
CHEMICAL PRODUCT DESIGN
Scope and importance; identification of needs and specifications; sources of ideas and Screening ideas; selection of product idea; process development for product manufacture; Specialty chemical manufacture; economic aspects.

UNIT III
RENEWABLE ENERGY
Hydrogen production, Hydrogen economy, Fuel Cell Technology, biofuel cells and biohydrogen,
Solar energy

UNIT IV
MATERIALS ENGINEERING
Polymers and composites, ceramics and glasses, colloidal dispersions and nanoparticles, thin films and electronic materials

UNIT V
BIOENGINEERING
Biomechanics, biotransport and biomaterials, biomolecular and cellular engineering, drug discovery and development.

COURCE OUTCOMES:

Student able to design bioreactors, and get to solve fuel cell technology.
Students can get an idea about renewable energy resources.

TEXT BOOKS:

1. Keil, F. J., Modeling of Process Intensification Wiley-VCH Verlag GmbH & Co. KGaA2007
2. Cussler, E.l. and Moggridge, G.D., "Chemical product design" Cambridge University Press, Cambridge, 2001

REFERENCES:

1. Hoffmann,P, Tomorrow's energy: hydrogen, fuel cells, and the prospects for a cleaner planet, MIT Press, Sabon, 2002
2. Mitchell, B.S., An introduction to materials engineering and science for chemical and materials engineers, John Wiley and Sons Inc., New Jersey, 2004

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III-Year B.Tech-CHEM - I-Semester **L T/P C**
4 1/- 4

(A55059)BIOPROCESS ENGINEERING
Core Elective-2

PREREQUISITE: Chemical Reaction Engineering, Chemical Process Calculations

COURSE OBJECTIVES:

The course will cover engineering principles, processes and techniques for using biological agents such as cells, enzymes or antibodies for the production of chemicals, food, biofuels and pharmaceuticals, and waste treatment. The course will include stoichiometry and kinetics of reactions that employ biological agents; design, analysis and operation of reactors (fermentors); and product recovery and purification (downstream processing).

Unit I:
Introduction: Biotechnology and bio processing, An overview of biological basics, Basics of enzyme and microbial kinetics: Enzyme kinetics, Mechanistic models for simple enzyme kinetics, effects of P^H and temperature, Immobilized enzyme systems.
Operating considerations for bioreactors:
Cultivation method, modifying batch and continuous reactors, immobilized cell systems: Active immobilization of cells, Passive immobilization. Solid state fermentations.

Unit II:
Selection, Scale-up, Operation & Control of bioreactors:
Scale-up and its difficulties, bioreactor instrumentation and control, Sterilization of process fluids: Sterilization of liquids, Sterilization of gases.

Unit III:
Recovery and Purification of products: Strategies to recover and purify products, Separation of insoluble products: Filtration, Centrifugation, Coagulation and flocculation. Cell disruption: Mechanical methods, Non-mechanical methods.
Separation of soluble products: Liquid- Liquid extraction, Adsorption, Dialysis, Reverse osmosis, Ultra filtration and micro filtration, Chromatography.

Unit IV:
Bio process considerations in using animal cell culture: Structure and biochemistry of animal cells, Methods used for the cultivation of animal cells, Bioreactor considerations for animal cell culture, Products of animal cell culture.
Bio process considerations in using plant cell cultures: Plant cells in culture compared to microbes, bio reactors for plant cell cultures.

Unit V:

Mixed cultures: Simple models describing mixed culture interactions, mixed cultures in nature, Industrial utilization of mixed cultures, Biological wastewater treatment, an example of industrial utilization of mixed cultures.

Genetically engineered organisms: Influence of product on process decisions, guidelines for choosing host-vector systems, Metabolic engineering, Protein engineering.

COURSE OUTCOMES:

- Processes involved in production of chemicals, food, bio fuels and pharmaceuticals using biological agents.
- design and operation of reactors using biological agents
- unit operations and processes for product recovery
- economics of bioprocesses

TEXT BOOKS:

1. Bioprocess Engineering, 2nd ed., M.L.Shuler and F.Kargi, PHI Learning Pvt. Ltd, New Delhi, 2009.

REFERENCES:

1. Biochemical Engineering Fundamentals, 2nd ed., j.E.Bailey and D.F.Ollis, McGraw-Hill, New York, 1987.
2. Bioprocess Engineering Principles, P.M.Doran, Elsevier, Gurgaon, 2005.

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III Year B.Tech. CHEM – I Sem. **L T/P C**
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(A55060) LOGICAL REASONING & QUANTITATIVE APTITUDE
(MANDATORY COURSE)

COURSE OBJECTIVES:

- To impart the knowledge of logical reasoning and aptitude
- To understand the number system and data sufficiency
- To sharpen the brains of students about the general aptitude

UNIT I

Series Completion : Number Series, Alphabet Series, Alpha – Numeric Series
Analogy: Completing the Analogous Pair, Simple Analogy, Choosing the Analogous Pair, Double Analogy, Word Analogy and Number Analogy. Classification / Odd One Out: Word Classification, Number Classification, Letter Classification.
Coding – Decoding: Letter Coding, Number Coding, Matrix Coding, Substitution, Deciphering Message Word Codes, Jumbled coding.

UNIT II

Blood Relations: Deciphering Jumbled up Descriptions, Relation Puzzle.
Direction sense test – Number, Ranking & Time Sequence Test – Arithmetical Reasoning– Mathematical Operations.
Number System : Test for Divisibility, Test of prime number, Division and Remainder – HCF and LCM of Numbers – Fractions.
Ratio and Proportion: Properties of Ratio, Comparison of Ratios, Useful Simple Results on Proportion – Partnership and Share – Mixtures.

UNIT III

Data Sufficiency: Problems in which a question on any topic such as Coding – Decoding, Blood Relations, Directions, Arithmetical Reasoning, etc.
Puzzle Test: Classification Type Questions, Seating Arrangements Comparison Type Questions, Sequential Order of Things, Selection Based on given conditions, Family – Based Puzzles, Jumbled Problems.
Assertions and Reason – Logical Venn Diagrams – Alpha Numeric Sequence Puzzle. Cubes and Dice – Analytical Reasoning.

UNIT IV

Logical Deduction: Logic, Statement – Arguments, Statement – Assumptions, Statement – Conclusions, Deriving Conclusions from Passages.
Clocks & Calendar.
Simple Interest : Effect of change of P, R and T on Simple Interest – Compound Interest: Conversion Period, Difference between Compound Interest and Simple Interest – Time and Work – Time and Distance.

UNIT V

Mensuration: Area of Plane Figures, Volume and Surface Area of solid figures.
Data Interpretation: Tabulation, Bar Graphs, Pie Charts, Line Graphs.

COURSE OUTCOMES:

On successful completion of this course, it is expected that the students will be able to,

- Develop knowledge of general aptitude and logical reasoning
- Improve the knowledge of arithmetical reasoning data sufficiency
- Sharpen the brain in puzzle tests and jumbled problems

TEXT BOOKS:

1. Verbal and Non Verbal Reasoning by R.S.Agarwal.
2. Quantitative Aptitude by R.S.Agarwal.
3. Quantitative Aptitude by Abhijit Guha.

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III-Year B.Tech-CHEM - I-Semester **L T/P C**
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(A55214)ADVANCED ENGLISH COMMUNICATION SKILLS LAB

(Common for all Branches)

1. Introduction

The introduction of the English Language Lab is considered essential at 3rd year level. At this stage the students need to prepare themselves for their careers which may require them to listen to, read, speak and write in English both for their professional and interpersonal communication in the globalised context.

The proposed course should be an integrated theory and lab course to enable students to use ‗good' English and perform the following:

Gather ideas and information, to organize ideas relevantly and coherently.

Engage in debates.

Participate in group discussions.

Face interviews.

Write project/research reports/technical reports.

Make oral presentations.

Write formal letters.

Transfer information from non-verbal to verbal texts and vice versa.

To take part in social and professional communication.

2. Objectives:

This Lab focuses on using computer-aided multimedia instruction for language development to meet the following targets:

To improve the students' fluency in English, through a well-developed vocabulary and enable them to listen to English spoken at normal conversational speed by educated English speakers and respond appropriately in different socio-cultural and professional contexts.

Further, they would be required to communicate their ideas relevantly and coherently in writing.

3. Syllabus:

The following course content is prescribed for the Advanced Communication Skills Lab:

1. **Vocabulary Building** – synonyms and antonyms, Word Roots, One-Word Substitutes, Prefixes and Suffixes, Study of Word Origin, Analogy, Idioms and Phrases.

2. **Reading Comprehension –** Reading for Facts, Guessing meanings from context, Scanning, Skimming, Inferring Meaning, and Critical Reading.

3. **Writing Skills** –Structure and presentation of different types of writing - Resume Writing /E-Correspondence/Statement of Purpose.
4. **Technical Writing**- Technical Report Writing, Research Abilities/Data Collection/Organizing Data/Tools/Analysis.

5. **Group Discussion** – Dynamics of Group Discussion, Intervention, Summarizing, Modulation of Voice, Body Language, Relevance, Fluency and Coherence.

6. **Presentation Skills** – Oral presentations (individual and group) through JAM sessions/Seminars, Written Presentations through Projects/ PPTs/e-mails etc.

7. **Interview Skills** – Concept and Process, Pre-Interview Planning, Opening Strategies, Answering Strategies, Interview through Telephone and Video-Conferencing.

3. Suggested Software:

The software consisting of the prescribed topics elaborated above should be procured and used.

Suggested Software:

- Clarity Pronunciation Power – part II
- Oxford Advanced Learner‘s Compass, 7th Edition
- DELTA‘s key to the Next Generation TOEFL Test: Advanced Skill Practice.
- TOEFL & GRE(KAPLAN, AARCO & BARRONS, USA, Cracking GRE by CLIFFS)

The following software from train2success.com‘

Preparing for being interviewed, Positive Thinking, Interviewing Skills, Telephone Skills, Time Management, Team Building, Decision making

English in Mind, Herbert Puchta and Jeff Stranks with Meredith Levy, Cambridge

Books Recommended:

1. Technical Communication by Meenakshi Raman & Sangeeta Sharma, Oxford University Press 2009.
2. Advanced Communication Skills Laboratory Manual by Sudha Rani, D, Pearson Education 2011.
3. English Language Communication : A Reader cum Lab Manual Dr A Ramakrishna Rao, Dr G Natanam & Prof SA Sankaranarayanan, Anuradha Publications, Chennai 2008.
4. English Vocabulary in Use series, Cambridge University Press 2008.
5. Management Shapers Series by Universities Press(India)Pvt Ltd., Himayatnagar, Hyderabad 2008.
6. Communication Skills by Leena Sen, PHI Learning Pvt Ltd., New Delhi, 2009.
7. Handbook for Technical Writing by David A McMurrey & Joanne Buckely CENGAGE Learning 2008.
8. Job Hunting by Colm Downes, Cambridge University Press 2008.
9. Master Public Speaking by Anne Nicholls, JAICO Publishing House, 2006.
10. English for Technical Communication for Engineering Students, Aysha Vish hwamohan, Tata Mc Graw-Hil 2009.
11. Books on TOEFL/GRE/GMAT/CAT/ IELTS by Barron‘s/DELTA/Cambridge University Press.
12. International English for Call Centres by Barry Tomalin and Suhashini Thomas, Macmillan Publishers, 2009.

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III-Year B.Tech-CHEM - I-Semester **L T/P C**
0 -/3 2

(A55215)PROCESS HEAT TRANSFER LAB

COURSE OBJECTIVES:

- To gain knowledge and apply it in profession in which student is capable to understand the relation between theory and laboratory equipment models.

(At least **Ten** experiments should be performed)

1. Determination of total thermal resistance and thermal conductivity of composite wall
   Major equipment-Composite wall Assembly
2. Determination of thermal conductivity of metal rod.
   Major equipment-Thermal conductivity apparatus
3. Determination of natural convection heat transfer coefficient for a vertical tube.
   Major equipment-Natural convection heat transfer apparatus.
4. Determination of critical heat flux point for pool boiling of water.
   Major equipment-Pool boiling apparatus
5. Determination of forced convective heat transfer coefficient for air flowing through a pipe.
   Major equipment-Forced convection heat transfer apparatus
6. Determination of overall heat transfer coefficient in double pipe heat exchanger.
   Major equipment-Double pipe heat exchanger apparatus
7. Study of the temperature distribution along the length of a pin-fin under natural and forced convections.
   Major equipment-Pin-fin apparatus
8. Determination of Thermal Conductivity of Insulating powder.
   Major equipment: Insulating Powder Apparatus.
9. Determination of Stefan-Boltzmann constant.
   Major equipment-Stefan-Boltzmann apparatus
10. Determination of emissivity of a given plate at various temperatures.
    Major equipment-Emissivity determination apparatus.
11. Obtain Temperature Profile under Transient (unsteady) conditions
    Major Equipment-Transient Heat Conduction Apparatus
12. Determination of Capacity and Economy by Single Effect Evaporator
    Major Equipment- Evaporator.
13. Study the drop wise and film wise condensation and determine heat transfer coefficient
    Major equipment- Drop wise and Film wise condensation apparatus.

COURSE OUTCOMES

- Designing and development of solutions for complex engineering problems for the processes that meet the needs of industry.
- Conduct trouble shooting & investigation of problems in heat transfer equipment.
- To select and apply modern techniques and tools for modeling rigorous engineering problems in practice.

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III-Year B.Tech-CHEM - II-Semester	**L**	**T/P**	**C**
	3	**1/-**	**3**

(A56055)PROCESS DYNAMICS AND CONTROL

PREREQUISITE: Mathematics-I, II, III and Process Instrumentation, Chemical Engineering Fluid Mechanics, Mass transfer Operations.

COURSE OBJECTIVES

- To represent dynamic systems by equations and by transfer functions in block diagrams and to obtain transient response to disturbances like step, impulse, ramp and sinusoidal forcing function.
- To estimate the stability limits for a system, with or without control.
- To calculate and use the frequency response of a system
- To analyze, design and tune feedback / feed forward, cascade and model based controllers in the context of various control strategies used to control chemical processes.

UNIT 1: Introduction to process Dynamics and control. Mathematical tools for modeling. Solutions of Ordinary Differential equations using Laplace transform. Inversion by partial fractions. Further properties of Transforms and Partial Fractions. Response of I order systems: Transfer Function, Transient response to step, impulse, ramp and sinusoidal forcing function. physical examples of first order systems: liquid level, mixing process, heating process. Concept of time constant. Linearization. Response of first order systems in series: interacting and non-interacting systems.

UNIT 2: Higher order systems: Second order system- Transient response of under damped, critically damped, over damped systems to step, impulse and sinusoidal forcing functions. Transporation lag. The Control System: Components of a control system, Negative and Positive feed back control systems, Servo and Regulatory control problems, Development of Block diagram, Controllers and final control elements. Reduction of physical control systems to block diagrams: Block diagram of a chemical reactor control system. Closed loop Transfer function. Overall Transfer functions for single loop control systems. Overall Transfer functions for multi loop control systems. Transient response of simple control systems.

UNIT 3: Stability: Concept of stability. Stability criterion. Routh Test for stability. Root Locus: concept of root locus, plotting of the root locus diagram for feedback control systems. Transient response from root locus. Application of root locus to control systems.

UNIT 4: Introduction to frequency response: Bode diagrams for first order, first order system in series, second order systems and for controllers and transportation lag. Bode stability criterion. Gain margin and phase margin. Control system design by frequency response. Nyquist Plots. Nyquist stability criteria.

UNIT 5: Advanced control strategies: Cascade Control. Feed Forward Control. Ratio Control. Smith Predictor. Dead time compensation. Internal Model Control. Controller tuning and Process Identification: ISE, ITAE, IAE, Ziegler – Nicholas and Cohen-Coon tuning methods, process identification by step, frequency and pulse testing. Control Valves: Construction sizing, Characteristics and valve Positioner.

COURSE OUTCOMES:

A student will be able to:

- Understand the dynamic behavior of different processes.
- Understand the operation of modern controllers and analyze different components of a control system.
- Analyze the stability of a control system and design basic control strategies.
- Understand and discuss the importance of process control in process operation and the role of process control engineers.

TEXT BOOKS:

1. Process System Analysis and Control, 3rd Ed., D.R. Coughanowr and Steven E. Le Blanc, Mc Graw Hill, 2009.

REFERENCES:

1. Chemical Process Control, G.Stephanopoulos, PHI learning Pvt Ltd., New Delhi, 2010.
2. Outlines of Chemical Instrumentation and Process Control, 3rd Ed., A. Suryanarayana, Khanna Publishers, New Delhi, 2010.
3. Process Control, B.Wayne Bequette, PHI learning Pvt Ltd., New Delhi, 2003.
4. Control system Engineering, 5th Ed, I.J.Nagrath and M. Gopal, New age International Pvt Ltd, 2007.

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III-Year B.Tech-CHEM - II-Semester	**L**	**T/P**	**C**
	3	**1/-**	**3**

(A56056)MASS TRANSFER OPERATION-II

PREREQUISITE: Mass Transfer-1

COURSE OBJECTIVES:

- The purpose of this course is to introduce the undergraduate students with the most important separation techniques in the process industry, and provide proper understanding of unit operations.

UNIT-I

Distillation: Fields of applications, VLE for miscible liquids, immiscible liquids, Positive and negative deviations from ideality, enthalpy-concentration diagrams, flash vaporization and differential distillation for binary and multi component mixtures, Azeotropic distillation, extractive distillation, steam distillation

UNIT-II

Continuous rectification-binary systems, multistage tray towers –method of Mc Cabe and Thiele, enriching section, exhausting section, feed introduction, total reflux, minimum and optimum reflux ratios, use of open steam, condensers, partial condensers, cold reflux, multiple feeds , tray efficiencies, continuous-contact equipment(packed towers)

Multistage (tray) towers –the method of Ponchon and Savarit, the enriching and stripping sections, feed tray location, total reflux, minimum and optimum reflux ratios, reboilers, use of open steam, condenser and reflux accumulators.

UNIT-III

Liquid-Liquid operations: fields of usefulness, liquid-liquid equilibrium, equilateral triangular co-ordinates, system of three liquids, choice of solvent, stage wise contact, multistage cross-current extraction, Multi stage counter current without reflux, extraction, Multi stage counter current with reflux, fractional extraction, Differential (continuous contact) extractors, spray towers, packed towers, mechanically agitated counter-current extractors, centrifugal extractors, dilute solutions, super critical fluid extraction.

Leaching: Fields of applications, preparation of solid for leaching, types of leaching, leaching equilibrium, single stage and multi stage leaching calculations, constant under flow conditions, equipment for leaching operation.

UNIT-IV

Adsorption: types of adsorption, nature of adsorbents, adsorption equilibrium, single gases and vapors, Adsorption Hysteresis, effect of temperature, Heat of adsorption, vapor and gas mixtures: One and both component adsorbed, Effect of change of temperature or pressure. Liquids, Adsorption of solute from dilute and concentrated solutions, stage wise operation, application of Freundlich equation to single and multistage adsorption (cross current & countercurrent).

Adsorption of vapor from a gas, fluidized bed, continuous contact, steady state moving bed adsorbers, unsteady state–fixed bed adsorbers, adsorption wave, elution, adsorption-desorption operations- thermal desorption of gases, rate of adsorption in fixed bed, principles of ion exchange, rate of ion exchange

UNIT-V

Introduction to Membrane Separation: Introduction and types of membrane separation processes, liquid permeation membrane processes, Solid permeation membrane processes, complete mixing models for gas separations by membranes and multi-component mixtures, cross flow model for gas separation by membranes, Derivation of equations for counter-current and co-current flow for gas separation for membranes, Reverese osmosis , Ultrafiltration, micro filtration membrane processes, Applications , equipment, models for reverse osmosis.

COURSE OUTCOMES:

- Understanding of modern separation technique in various applications and apply the mass transfer concepts in the design of separation columns.
- Ability to design and operate the unit operations like distillation, adsorption, liquid-liquid extraction, leaching
- Construct and analyze a multi-stage equilibrium separation processes
- Student can develop different flow model equations for membrane separation processes

TEXT BOOKS:

1. Mass transfer operations by R.E. Tryebal, 3rd ed. Mc Graw Hill, 1980.

REFERENCES:

1. Diffusion: Mass Transfer in Fluid System by E. L. Cussler, 2009.
2. Transport processes and Separation Process Principles 4th Ed., by Christie J. Geankoplis, PHI Learning Pvt. Ltd., New Delhi, 2009

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III-Year B.Tech-CHEM - II-Semester **L T/P C**
3 1/- 3

(A56057)CHEMICAL REACTION ENGINEERING-II

PREREQUISITE: Chemical Reaction Engineering-1

COURSE OBJECTIVES:

- To provide students through to understanding of reaction engineering applications and apply it to design a reactor, dispersion model, tank in series model.
- To identify the flow to be non ideal and causes of it and take in to account of non ideality in the design of reactor of any other system related to reaction engineering.

UNIT-I

Basics of non-ideal flow-E, the age distribution of fluid, the RTD, Conversion in Non-ideal flow reactors, diagnosing reactor ills (qualitative discussion only).The dispersion model-axial dispersion, correlation for axial dispersion, chemical reaction and dispersion.

UNIT-II

The tanks-in-series model-pulse response experiments and RTD, chemical conversion. The convection model for laminar flow-the convective model and its RTD, chemical conversion in laminar flow reactors.

Earliness of mixing, segregation and RTD-self mixing of a single fluid, mixing of two miscible fluids.

UNIT-III

Catalysis and catalytic reactors-catalysts, steps in catalytic reactions, synthesizing a rate law, mechanism and rate limiting step (From chapter-10 Fogler). Heterogeneous reactions-Introduction.

Solid catalyzed reactions-The rate equation for surface kinetics-Pore diffusion resistance combined with surface kinetics, Porous catalyst particles, Heat effects during reactions, Performance equations for reactors containing porous catalyst particles.

UNIT-IV

Solid catalyzed reactions-Experimental methods for finding rates, Deactivating catalysts-Mechanisms of catalyst deactivation, the rate and performance equations.

UNIT-V

Fluid-fluid reactions-Kinetics-the rate equation. Fluid particle reactions: Kinetics-Selection of a model, shrinking core model for spherical particles of unchanging size, rate of reaction for shrinking spherical particles, extensions, determination of rate controlling steps.

COURSE OUTCOMES:

- Develop rate laws for use in reactor design based on reaction data from a reactor or set of reactors.
- Make comparisons of ideal reactor types (batch, plug flow, mixed flow, etc.) and be able to determine the best choice for simple objectives when using a single reactor or a set of reactors.
- Predict reactor performance in situations where a reacting gas has a significantly changing density, including the case of variable pressure within an ideal plug flow reactor.
- Determine optimal ideal reactor design for multiple reactions for yield or selectivity

TEXT BOOK:

1. Chemical reaction engineering by Octave Levenspiel, 3rd ed. John Wiley and Sons, 1990.

REFERENCES:

1. Elements of Chemical reaction engineering by H.S. Fogler, 2nd ed.PHI, 1992.
2. Chemical engineering Kinetics by J.M. Smith, 3rd ed.Mc Graw Hill,1981.

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III-Year B.Tech-CHEM - II-Semester **L T/P C**
4 1/- 4

(A56058)MATERIAL SCIENCE FOR CHEMICAL ENGINEERS
Core Elective-3

PREREQUISITE: First Year Physics and Chemistry

COURSE OBJECTIVES:

- To provide students through to understanding of various materials used in chemical industry.

UNIT-I
INTRODUCTION: Engineering Materials – Classification – levels of structure.

CRYSTAL GOEMETRY AND STRUCTURE DETERMINATION:
Space lattice and Unit cell, Bravais lattices, crystal systems with examples, Lattice coordinates, Miller indices, Bravais indices for directions and places: crystalline and non crystalline solids; ionic, covalent and metallic solids; packing efficiency, ligancy and coordination number; structure determination by Bragg's X-ray diffraction and powder methods.

UNIT-II
CRYSTAL IMPERFECTION:
Point defects, line defects-edge and screw dislocation, Berger's circuit and Berger's vectors, dislocation reaction, dislocation motion, multiplication of dislocations during deformation , role of dislocation on crystal properties; surface defects, dislocation density and stress required to move dislocations.

UNIT-III
Basic thermodynamic functions; phase diagrams and phase transformation: Primary and binary systems-general types with examples; tie line& lever rules, non equilibrium cooling. Phase transformations in Fe-Fe3 C steels, Time-Temperature-Transformation (TTT) curves for eutectoid steels and plain carbon steels; effect of alloying elements on properties of steels; types of steels, phase diagrams of Pb-Sn, Cu-Ni systems.

UNIT-IV
Elastic, an-elastic and plastic deformations in solid materials; rubber like elasticity, visco-elastic behavior (models); shear strength of real and perfect crystals, work hardening mechanisms cold working, hot working; dynamic recovery, Brief description of heat treatment in steels.
DIFFUSION IN SOLIDS: Ficks law of diffusion, Solution of fick' s second law, Application based on second law of solution , Kirkendall effect, Atomic model diffusion, Briefly other diffusion processes.

UNIT-V

MAGNETIC MATERIALS: Terminology and classification, Magnetic moments due to electron spin, Ferro- magnetism and related phenomena, domain structure, hysteresis loop, soft and hard magnetic materials.

FRACTURE IN DUCTILE AND BRITTLE MATERIALS CREEP: mechanism of creep and methods to reduce creeping in materials, creep rates and relations. Fatigue mechanisms and methods to improve fatigue resistance in materials.

OXIDATION AND CORROSION:

Mechanisms of oxidation, Oxidation resistant materials, principles and types of corrosion, protection against corrosion.

COURSE OUTCOMES:

- Able to determine the best material to design reactors and other equipments.
- Determine the best material to use in industrial design and construction

TEXT BOOKS:

1. Materials Science and Engineering; V. Raghavan.; Prentice Hall of India Pvt. Ltd.,

REFERENCES:

1. Science of Engineering Materials Vol. 1 &2; Manas chanda; McMillan Company of India Ltd.
2. Elements of materials science, Van Vlack, L.R.

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III-Year B.Tech-CHEM - II-Semester **L T/P C**
4 1/- 4

(A56059)ADVANCED SEPARATION TECHNIQUES
Core Elective-3

PREREQUISITE: Mass Transfer-I, Mass Transfer-II, Mechanical Unit Operations

COURSE OBJECTIVE:
To understand the governing mechanisms and driving forces of various advanced separation processes and to perform process and design calculations for advanced separation processes.

UNIT I
BASICS OF SEPARATION PROCESS
Review of Conventional Processes, Recent advances in Separation Techniques based on size, surface properties, ionic properties and other special characteristics of substances, Process concept, Theory and Equipment used in cross flow Filtration, cross flow Electro Filtration, Surface based solid – liquid separations involving a second liquid.

UNIT II
MEMBRANE SEPARATIONS
Types and choice of Membranes, Plate and Frame, tubular, spiral wound and hollow fiber Membrane Reactors and their relative merits, commercial, Pilot Plant and Laboratory Membrane permeators involving Dialysis, Reverse Osmosis, Nanofiltration, Ultra filtration and Micro filtration, Ceramic- Hybrid process and Biological Membranes.

UNIT III
SEPARATION BY ADSORPTION
Types and choice of Adsorbents, Adsorption Techniques, Dehumidification Techniques, Affinity Chromatography and Immuno Chromatography, Recent Trends in Adsorption.

UNIT IV
INORGANIC SEPARATIONS
Controlling factors, Applications, Types of Equipment employed for Electrophoresis, Dielectrophoresis, Ion Exchange Chromatography and Eletrodialysis, EDR, Bipolar Membranes.

UNIT V
OTHER TECHNIQUES
Separation involving Lyophilisation, Pervaporation and Permeation Techniques for solids, liquids and gases, zone melting, Adductive Crystallization, other Separation Processes, Supercritical fluid Extraction, Oil spill Management, Industrial Effluent Treatment by Modern Techniques.

COURSE OUTCOMES:

- Able to determine the best separation techniques to use in every process industry.

TEXT BOOKS:

1. King, C. J., “Separation Processes”, Tata McGraw Hill, 1982.
2. Roussel, R. W., “Handbook of Separation Process Technology”, John Wiley, New York, 1987.

REFERENCES:

1. Nakagawal, O. V., “Membrane Science and Technology”, Marcel Dekkar, 1992.

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III-Year B.Tech-CHEM - II-Semester **L T/P C**
4 1/- 4

(A56060)PULP AND PAPER INDUSTRY
Core Elective-3

PREREQUISITE: Mechanical Unit Operation, Chemical Technology

COURSE OBJECTIVES:
To provide the basic concepts of pulp and paper manufacturing process to the chemical engineering students which will enable them to understand and acquire knowledge in pulp and paper sector

UNIT I
INTRODUCTION: Pulp and Paper Industry Scenario in India, Chronological development of pulp and paper technology, Definitions of pulp and paper, Flow sheet of complete pulp and paper manufacturing process

UNIT II
RAW MATERIAL SELECTION: Types of wood – softwood, hardwood and non-wood, composition of wood- cellulose, hemicelluloses, lignin, extractives, and inorganic components, comparison with other raw materials

UNIT III
PULPING PROCESS: Pulping processes – Mechanical Pulping, Kraft Pulping, Sulphite Pulping, Cooking equipment, washing, screening and thickening, Stock Preparation

UNIT IV
Chemical Recovery Black liquor oxidation, Recaustizing, Calcining, Alternate Kraft recovery systems

UNIT V
PAPER MACHINE: Introduction to paper machine, Wet and dry end operations, finishing, properties and testing of paper, end uses of paper

COURCE OUTCOMES:
Student be able to apply the knowledge of pulping process and paper

TEXT BOOKS

1. Smook. G. A, “Hand book for Pulp and Paper Technologists”, 7 th Edn., TAAPI Press 1989
2. Mc Donald. R. G,. and Franklin J. N. Pulp and Paper Manufacture” Vol 2. Mc Graw Hill. 1969.

REFERENCES

1. Gopala Rao .M and Marshall Sittig, Dryden's Outlines of Chemical Technology, 3rd Edn., East-West Press, New Delhi, 2004.
2. George. T, Austin, Shreve's Chemical Process Industries, 5th Edn., McGraw- Hill International Editions, Singapore, 1984

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III-Year B.Tech-CHEM - II-Semester	**L**	**T/P**	**C**
	4	**1/-**	**4**

(A56061)OPTIMIZATION OF CHEMICAL PROCESSES
Core Elective-4

Prerequisite: Mathematics-I, II, II, and Chemical Process Calculations

COURSE OBJECTIVES:
To provide students understanding of different optimization techniques like linear programming, genetic algorithm and different search techniques and apply it in the design of process.

Unit-I:
Nature and organization of optimization problems: what optimization is all about, why optimize, scope and hierarchy of optimization, examples and applications of optimization, the essential features of optimization problems, general procedure for solving optimization problems, obstacles of optimization, classification of models, how to build a model, fitting functions to empirical data, the method of least squares, factorial experimental design, fitting a model to data subject to constraints.

Unit-II:
Basic concepts of optimization: Continuity of functions, unimodal versus multimodal functions, convex and concave functions, convex region, necessary and sufficient conditions for an extremum of an unconstrained function, interpretation of the objective function in terms of its quadratic approximation.
Optimization of unconstrained functions: one-dimensional search: Numerical methods for optimizing a function of one variable, scanning and bracketing procedures, Newton's, Quasi-Newton's and Secant methods of uni-dimensional search, region elimination methods, polynomial approximation methods, how the one-dimensional search is applied in multi-dimensional problem, evaluation of uni-dimensional search methods.

Unit-III:
Unconstrained multivariable optimization: direct methods, random search, grid search, univariate search, simplex method, conjugate search directions, Powell's method, indirect methods-first order, gradient method, conjugate method ,indirect method-second order-Newton's method forcing the Hessian matrix to be positive definite, Movement in the search directions, termination, summary of Newton's method, relation between conjugate gradient and Quasi-Newton method.

Unit-IV:
Linear programming and applications: Basic concepts in linear programming, Degenerate LP's-graphical solution, natural occurrence of linear constraints, the simplex method of solving linear programming problems, standard LP form, obtaining a first feasible solution, the revised simplex method, sensitivity analysis, duality in linear programming, the Karmarkar algorithm, LP applications.

Genetic Algorithms: (Qualitative treatment) Working principles, differences between GAs and traditional methods, similarities between GAs and traditional methods, GAs for constrained optimization, other GA operators, real coded GAs, Advanced GAs.

Unit-V:

Optimization of unit operations-1: recovery of waste heat, shell and tube heat exchanger, evaporator design, liquid-liquid extraction process, optimal design of staged distillation column.

Optimization of unit operations-2: Optimal pipe diameter, optimal residence time for maximum yield in an isothermal batch reactor, chemo stat, optimization of thermal cracker using linear programming.

COURSE OUTCOMES:

Student will able to formulate unconstrained or constrained objective functions of chemical engineering problems. Gains exposure to application of optimization techniques in case of various petrochemical processes and understands how the problem formulation influences its solvability and interpretation of optimization results.

TEXT BOOKS:

1. Optimization of chemical processes by T.F.Edgar and Himmelblau D.M. Mc- Graw. Hill. New York, 2001.
2. Optimization for Engineering Design, Kalyan Moy Deb, PHI Pvt Ltd, New Delhi, 2000.

REFERENCES:

1. Elementary Principles of Chemical Processes, 4th Edition, Richard M. Felder, Ronald W. Rousseau, Lisa G. Bullard

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III-Year B.Tech-CHEM - II-Semester	**L**	**T/P**	**C**
	4	**1/-**	**4**

(A56062)NUMERICAL METHODS FOR CHEMICAL ENGINEERS
Core Elective-4

PREREQUISITE: Mathematics, Chemical Process Calculations

COURSE OBJECTIVES:

This course is designed to give an overview of computational techniques of interest to process engineer.

UNIT-1:

Introduction: Motivation and applications. **Computation and Error Analysis:** Accuracy and precision; Truncation and round-off errors; Binary Number System; Error propagation.

UNIT-2:

Computation and Error Analysis: Accuracy and precision; Truncation and round-off errors; Binary Number System; Error propagation. **Linear Systems and Equations**: Matrix representation; Cramer's rule; Gauss Elimination; Matrix Inversion; LU Decomposition; Iterative Methods; Relaxation Methods; Eigen Values.

UNIT-3:

Algebraic Equations: Bracketing methods: Bisection, Reguli-Falsi; Open methods: Secant, Fixed point iteration, Newton-Raphson; Multivariate Newton's method. **Algebraic Equations**: Bracketing methods: Bisection, Reguli-Falsi; Open methods: Secant, Fixed point iteration, Newton-Raphson; Multivariate Newton's method.

UNIT-4:

Regression and Curve Fitting: Linear regression; Least squares; Total Least Squares; Interpolation; Newton's Difference Formulae; Cubic Splines. **Numerical Differentiation**: Numerical differentiation; higher order formulae.

UNIT-5:

Integration and Integral Equations: Trapezoidal rules; Simpson's rules; Quadrature. **ODEs: Initial Value Problems**, Euler's methods; Runge-Kutta methods; Predictor-corrector methods; Adaptive step size; Stiff ODEs. **ODEs: Boundary Value Problems**: Shooting method; Finite differences; Over/Under Relaxation (SOR).

COURSE OUTCOME:

Adapting to Computational techniques to solve problems step-wise, repeated and iterative solution methods, which would otherwise be tedious or unsolvable by hand-calculations can be solved by using computer models. The development of fast, efficient and inexpensive Mathematical models increased the range of engineering problems that can be solved reliably.

TEXT BOOKS:

1. Numerical Methods for Engineers, Gupta S.K. (1995), New Age International.
2. Numerical Methods for Engineers, Chapra S.C. and Canale R.P. (2006), 5th Ed; McGraw Hill.

REFERENCES:

1. Numerical Methods for Engineers and Scientists by Joe D Hoffman, 2nd edition
2. Stochastic Numerical Methods: An Introduction for Students and Scientists by Raúl Toral, Pere Colet

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III-Year B.Tech-CHEM - II-Semester **L T/P C**
4 1/- 4

(A56063)ELECTROCHEMICAL ENGINEERING
Core Elective-4

PREREQUISITE: Chemical Process Calculations, Chemical Reaction Engineering, First Year Electrical Engineering

COURSE OBJECTIVES:

This course builds upon the underlying theory in thermodynamics, reaction kinetics, and transport phenomena, and applies these methods to electro synthesis and fuel cell applications.

UNIT- I:
Review basics of electrochemistry: Faraday's law C Nernst potential –Galvanic cells – Polarography The electrical double layer: its role in electrochemical processes – Electro capillary curve –Helmholtz layer – Guoy– Steven's layer – fields at the interface.

UNIT- II:
Mass transfer in electrochemical systems: diffusion controlled electrochemical reaction – the importance of convention and the concept of limiting current. Mass transfer over potential or concentration polarization. Secondary current distribution – the rotating disc electrode.

UNIT- III:
Corrosion: Introduction – Metallic surface preparation – Phosphating – Inhibitors in acid media – in engine cooling systems. Control measures, industrial boiler water corrosion control –protective coatings – vapor phase inhibitors – cathodic protection, sacrificial anodes – Paint removers.

UNIT- IV:
Batteries: Primary and secondary batteries – Lechlanche dry cell – alkaline manganese cell – Mercury cell – Reverse electrolyte cells like MgCCuCl2 , ZnCPbO2, Secondary cells like lead acid, NiCCd, NiCFe, AgoCZn, AgoCcd, sodium Csulphur, LiCS, Fuel cells.

UNIT- V:
Electrodes used in different electrochemical industries: MetalsC Graphite – Lead dioxide – Titanium substrate insoluble electrodes – Ironoxide – semi conducting type etc. Metal finishing: Electro deposition – electro refining – electroforming – electro polishing – anodizing – Selective solar coatings. Cell design.

COURSE OUTCOMES:

At the end of the course, students are expected to provide an in-depth analysis of electrochemical
Device operation, including a thermodynamic assessment of efficiencies, quantitative characterization of kinetic and transport limitations, as well as comparative evaluation of different electrochemical reactor configurations.

TEXT BOOKS:

1. Picket, "Electrochemical Engineering", Prentice Hall, 1977.
2. J.S. Newman, "Electrochemical systems", Prentice Hall, 1973.

REFERENCES:

1. Electrochemical engineering, C. Mantell, McGraw Hill, 1972.
2. Electrochemical Engineering, Christos Comninelllis, Gregory Foti, 2012
3. Electrochemical Engineering, Ivo Roušar, Karel Micka, Arnošt Kimla (in-depth transport analysis) ,1986

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III-Year B.Tech-CHEM - II-Semester	**L**	**T/P**	**C**
	3	**1/-**	**3**

(A56064) PETROLEUM AND PETRO CHEMICAL TECHNOLOGY
Core Elective-5

PREREQUISITE: Fluid Mechanics, Mechanical Unit Operations, Heat Transfer, Mass Transfer Operations.

COURSE OBJECTIVES:
Studying this subject the students will learn about the extraction and production of oil and gas to meet energy needs, as well as refining of crude oil for a wide spectrum of useful products such as petrochemicals, Chemicals, Plastics.

UNIT I:

Origin formation and composition of petroleum: Origin and formation petroleum, Reserves and deposits of world, Indian petroleum Industry.
Petrochemical industry- feedstocks.

UNIT–II:

Petroleum Processing data: Evaluation of petroleum, Thermal properties of petroleum Fractions, important products properties and test methods.
Fractionation of Petroleum: Dehydration and desalting of crudes, heating of crude pipes still heaters, distillation of petroleum, blending of gasoline.

UNIT III:

Treatment techniques: Fraction-impurities, treatment of gasoline, treatment of kerosene, treatment of lubes.

UNIT IV:

Thermal and catalytic processes: cracking, catalytic cracking, catalytic forming, Naptha cracking, coking, Hydrogenation processes, Alkylation processes, Isomerization Process.
Chemicals from Methane: Introduction, production of methanol, formaldehyde ethylene glycol, **PTFE,** methylamines.

UNIT V:

Chemicals from Ethane-Ethylene –Acetylene: Oxidation of ethane, production of Ethylene, Manufacture of Vinyl Chloride monomer, Vinyl Acetate manufacture, Ethanol from Ethylene, Acetylene Manufacture, Acetaldehyde from Acetylene.

COURSE OUTCOMES:

- Introduction with the petroleum refinery worldwide.
- Develop knowledge of different refining processes.
- To get acquainted with technologies used for manufacturing petroleum products at commercial scale.

TEXT BOOKS:

1. Petroleum Refining Engineering, 4th ed., WL Nelson, McGraw Hill, New York, 1958.
2. Modern Petroleum Refining Processes, 5th ed., B.K Bhaskara Rao, Oxford and IBH Publishing, 2007

REFERENCES:

1. Shreve's chemical Process industries, 5th ed., G.T Austin, Mc Graw –Hill, New York, 1984.
2. Chemical Technology of petroleum .W.S.Gruese and D.R Stevens, Mc Graw –Hill 1980.

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III-Year B.Tech-CHEM - II-Semester

L	T/P	C
3	1/-	3

(A56065)FLUIDIZATION ENGINEERING
Core Elective-5

PREREQUISITE: Fluid Mechanics

COURSE OBJECTIVES:
The course will enable the students to understand basic concepts of the fluidization phenomena, industrial applications of fluidized beds and their operational and design aspects.

UNIT-I
Introduction: The phenomenon of fluidization; liquid like behaviour of a fluidized bed; Comparison with other contacting methods; Advantages and disadvantages of fluidized beds.

UNIT-II
Industrial applications of fluidized beds: Coal gasification; gasoline from other petroleum fractions; Gasoline from natural and synthesis gases; Heat exchange; Coating of metal objects with plastics; Drying of solids; Synthesis of phthalic anhydride; Acrylonitrile; Polymerization of olefins; FCCU; Fluidized combustion of coal; incineration of solid waste; Activation of carbon; gasification of waste; bio-fluidization.

UNIT-III
Fluidization and mapping of regimes: Minimum fluidization velocity; Pressure drop vs. velocity diagram; effect of temperature and pressure on fluidization; Geldart classification of particles; terminal velocity of particles; turbulent fluidization; pneumatic transport of solids; fast fluidization; solid circulation systems; Voidage diagram; Mapping of regimes of fluidization.

UNIT-IV
Bubbles in dense bed: Single rising bubbles; Davidson model for gas flow at bubbles; Evaluation of models for gas flow at bubbles.
Bubbling Fluidized beds: Experimental findings; Estimation of bed porosities; Physical models: simple two phase model; K-L model.
High velocity Fluidization: Turbulent fluidized bed; Fast fluidization pressure drop in turbulent and fast fluidization.

UNIT-V
Solids Movement, Mixing, Segregation and staging: Vertical movement of solids; Horizontal movement of solids; Staging of fluidized beds.
Gas Dispersion and Gas interchange in Bubbling Beds: Dispersion of gas in beds; Gas interchange between bubble and emulsion; Estimation of gas interchange coefficients. Particle to Gas Mass Transfer**:** Experimental interpolation of mass transfer coefficients; Heat transfer; Experimental heat transfer from the bubbling bed model.

COURSE OUTCOMES:

- ✓ The students will enable to apply fluidization concept to design the fluidization bed reactors for chemical and allied industries.

TEXT BOOKS:

1. Fluidization Engineering, 2nd ed., D. Kunii and O. Levenspiel, Butterworth-Heinemann,
   London, 1999.

REFERENCES:

1 Gas Fluidization Technology, D. Geldart Ed., John Wiley Sons, 1986.
2 Gas-Liquid-Solid Fluidization Engineering, Liang-Shih Fan, Butterworths, 1989
3 Fluidization Idealized and Bubbleless, with Applications, Mosoon Kwauk, Science Press, 1992

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III-Year B.Tech-CHEM - II-Semester

L	T/P	C
3	1/-	3

(A56066)FERTILIZER TECHNOLOGY
Core Elective-5

COURSE OBJECTIVES:
The course will enable the students to understand basic concepts and manufacturing processes of synthetic fertilizers, and bio-fertilizers, organic manures.

UNIT-I
Overview: Development of fertilizer industry; Fertilizers production and consumption in India; Nutrient contents of fertilizers; Secondary nutrients; Feedstock and raw materials for nitrogenous, phosphatic and potassic fertilizers. Organic manures.

UNIT-II
Nitrogenous fertilizers: Ammonia from natural gas, associated gas, coke oven gas, naphtha, fuel oils; ammonium nitrate, calcium ammonium nitrate, ammonium chloride – their methods of production, characteristics and storage and handling specifications.

UNIT-III
Phosphatic fertilizers: single super phosphate, triple superphosphate potassic fertilizers: Potassium chloride, potassium sulphate.
Complex fertilizers: Ammonium phosphate, ammonium sulphate, MAP/ DAP, nitro phosphates, urea-ammonium phosphates - their methods of production, characteristics and storage and handling specifications.

UNIT-IV
Miscellaneous fertilizers: Organic Manures, Biofertilizers: N2 Fixing Biofertilizers, P solubilizing-biofertilizers, P-mobilizing-biofertilizers; liquid fertilizers, controlled release fertilizer. Design aspects of ammonia synthesis converters, urea autoclave, pipe reactors, prilling tower.

UNIT-V
Retrofitting, upgrading and modernization of existing plants. General fertilizer storage and handling; Corrosion problems in fertilizer industries; Fertilizer plants effluent treatment and disposal. Case study of selected fertilizer plants with environmental aspects.

COURSE OUTCOMES:
The students should enable to apply fertilizer concept to manufacture fertilizers and design the fertilizer industries equipment

TEXT BOKS:

1. "Handbook of Fertilizer Technology", Fertilizer Association of India, New Delhi
2. "Production of Fertilizers (Booklets 1 to 8)", European Fertilizer Manufacturers' Association.

REFERENCES:

1. "Mineral Fertilizer Production and the Environment (Part 1 & 2)", International Fertilizer Industry Association.
2. "Pollution Prevention and Abatement Handbook", The world Bank Group.
3. "Fertilizer Industry - An Introductory survey", M. G. Menon, Higginbothams (P) Ltd.
4. "Fertilizer Manual", United Nations Industrial Development Organization, United Nations, New York.

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III-Year B.Tech-CHEM - II-Semester	**L**	**T / P / D**	**C**
	2	-	-

(A56067)ENGLISH FOR LIFE SKILLS

1. **INTRODUCTION:**

It is a general observation that today's techno savvy student's interest in reading is decreasing considerably with which they fail to acquire a good sense of language. The 'Language Skills' have transformed into "Life Skills or Survival Skills" in the present global scenario from mere communication skills. Any skills that are useful in life can be considered as Life Skills. Life skills are not always taught directly but often learned indirectly through experience and practice.

2. OBJECTIVES:

a. To increase the understanding of the world around and equip the learner to cope up with the challenges of life.
b. To help the students to accomplish the Life Skills which are associated with managing and leading a better life.
c. To equip the students with a set of Life Skills and increase their abilities for adaptive and positive behaviour.

3. LEARNING OUTCOMES:

b. Enrichment of human skills through language and literature
c. Building up confidence to deal effectively with the demands and challenges of everyday life.
d. Acquisition of psychosocial competency.

UNIT-I

"**Education: Indian and American" by *Anurag Mathur*** from **English for Life Skills,** published by Orient Black Swan Private Limited, Hyderabad, India.

"Teamwork Skills" by *SP Dhanavel* from **English and Soft Skills,** published by Orient Black Swan Private Limited, Hyderabad, India.

UNIT-II

"Work" by *D.H.Lawrence* from **English for Life Skills,** published by Orient Black Swan Private Limited, Hyderabad, India.

"Emotional Intelligence Skills" by *SP Dhanavel* from **English and Soft Skills,** published by Orient Black Swan Private Limited, Hyderabad, India.

UNIT-III

"Learning Skills" by *SP Dhanavel* from **English and Soft Skills,** published by Orient Black Swan Private Limited, Hyderabad, India.

UNIT-IV

"Problem-solving Skills" by *SP Dhanavel* from **English and Soft Skills,** published by Orient Black Swan Private Limited, Hyderabad, India.

UNIT-V

"How Wealth Accumulates and Men Decay" by *G.B.Shaw* from **English for Life Skills,** published by Orient Black Swan Private Limited, Hyderabad, India.

"Adaptability Skills" by *SP Dhanavel* from **English and Soft Skills,** published by Orient Black Swan Private Limited, Hyderabad, India.

TEXTBOOKS:

1. "English for Life Skills" published by Orient Black Swan Private Limited, Hyd, India.
2. "English and Soft Skills" by SP Dhanavel published by Orient Black Swan Private Limited, Hyd, India.

REFERENCES:

1. Life and Language, An Anthology of English Prose and Poetry published by Oxford University Press, Delhi, India
2. Fluency in English II edited by Promodinivarma and Mukti Sanyal, published by Oxford University Press, Delhi, India
3. Essential life skills Form: I, II, III, IV by E.Wachira Et al published by Oxford University Press, Delhi, India.

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III-Year B.Tech-CHEM - II-Semester **L T/P C**
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(A56215) MASS TRANSFER OPERATION LAB

COURSE OBJECTIVES:

- To provide students complete understanding of mass transfer operations and apply in professional life there by communicating effectively.
- To learn modern estimation techniques to solve problems in mass transfer operation and equipment
- To solve industry related problems including design and to respond to changing impact of chemical engineering solutions at a global level and in society.

(Atleast **Ten** experiments should be performed)

List of experiments

1. Estimation of diffusivity coefficients.
   Major equipment-Diffusivity apparatus

2. Determination of Steam distillation Temperature
   Major equipment-Steam distillation unit

3. Verification of Rayleigh's Equation by differential distillation.
   Major equipment- Differential Distillation unit

4. Packed towers,HETP evaluation.
   Major equipment-Packed column unit

5. Vapor-Liquid Equilibria.
   Major equipment-VLE apparatus

6. Batch Drying.
   Major equipment-Tray dryer

7. Evaluation of mass transfer coefficients a) Surface Evaporation b)Wetted wall column.
   Major equipment-a) Surface Evaporation unit b)Wetted wall column unit

8. (a)Liquid-Liquid Equilibria(Tie line data) (b)Ternary Liquid Equilibia (binodal curve).
   Major equipment-LLE setup

9. Solid Liquid Equilibria: Calcium carbonate and water

10. Solubility characteristics.

11. specific gravity chart

COURSE OUTCOMES:

- ✓ The students should able to solve mass transfer operation problems and design equipment optimally
- ✓ The student shall able to analyze and solve the complex problem by simplifying it.
- ✓ The student shall able to design a complex system or equipment.

TEXT BOOKS:

1. Mass transfer operations by R.E. Treybal, 3rd ed. Mc Graw Hill, 1980.

2. Unit Operations in Chemical Engineering, McCabe, W.L., Smith, J.C., and Harriot, P., McGraw-Hill VII Edn., 2004.

REFERENCES:

1. Diffusion: mass transfer in fluid system by E. L. Cussler, 2nd Ed, 1997.
2. Transport processes and Separation Process Principles 4th Ed., by Christie J. Geankoplis, PHI Learning Pvt. Ltd., New Delhi, 2009
3. Principles of mass transfer and separation processes, Binay .K. Dutta, PHI Learning Pvt Ltd, India, 2007

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III-Year B.Tech-CHEM - II-Semester

L	T/P	C
0	-/3	2

(A56216)CHEMICAL REACTION ENGINEERING LAB

COURSE OBJECTIVES

- Determine the reaction order and specific reaction rate from experimental data.
- Develop rate laws for use in reactor design based on reaction data from a reactor or set of reactors.
- To impart knowledge on different types of chemical reactors, the design of chemical reactors under isothermal and non-isothermal conditions.
- To enable the students to learn the gas-solid catalytic and non-catalytic reactors and gas-liquid reactors.

(Atleast **Ten** experiments out of the following experiments should be performed)

1. Determination of the kinetic parameters (reaction rate constant and order) and analyzing the data by Differential method of analysis and Integral method of analysis.
   Major Equipment – Batch Reactor
2. Determination of the rate constant and to find the temperature dependence using Arrhenius form of equation.
   Major Equipment – Batch Reactor
3. Determination of the kinetic parameters (order, reaction rate constant) of given reactor system
   Major Equipment – CSTR Apparatus
4. Determination of the kinetic parameters (order, reaction rate constant) of given reactor system
   Major Equipment – PFR Apparatus
5. To Determine the effect of Residence time on conversion and to determine the rate constant using a CSTR
   Major Equipment – CSTR Apparatus
6. TO determine the RTD and axial dispersion number in a tubular column using a tracer.
   Major Equipment – Tubular Reactor Apparatus

7. To determine RTD and dispersion number (axial dispersion number) for a packed bed using a tracer.

   Major Equipment – Packed Bed Reactor Apparatus
8. To determine the mass transfer coefficient with and without chemical reaction for a solid –liquid system

   Major Equipment – Beaker, stirrer
9. To determine the mass transfer coefficient with and without chemical reaction for a liquid –liquid system

   Major Equipment – Beaker, stirrer
10. To compare the performance of mixed flow reactor in series with that of an ideal reactor.

    Major Equipment – CSTRs in series Apparatus
11. To determine RTD and dispersion number (axial dispersion number) for a given mixed flow reactors in series using a tracer.

    Major Equipment – CSTRs in series Apparatus

COURSE OUTCOMES.

Students will:

- Gain the ability to determine experimentally the kinetics and rate constants of reactions in different types of reactors. These studies have wide applications in various process industries.
- Gain knowledge on the selection of the reactor for the reaction and its design.
- Make comparisons of ideal reactor types (batch, plug flow, mixed flow etc) and be able to determine the best choice for simple objectives when using a single reactor or a set of reactors.
- Work together to solve both open-ended and closed-ended reaction engineering problems.

TEXT BOOK:

1. Chemical Reaction Engineering, 3rd Edition. O. Levenspiel, John Wiley and Sons, 1999.

REFERENCES:

1. Elements of Chemical reaction engineering by H.S. Fogler, 2nd ed.PHI, 1992.
2. Chemical engineering Kinetics by J.M. Smith, 3rd ed. Mc Graw Hill, 1981.

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IV-Year B.Tech-CHEM - I-Semester	**L**	**T/P**	**C**
	3	**1/-**	**3**

(A57059) TRANSPORT PHENOMENA

Prerequisite: Fluid Mechanics, Mass Transfer, Heat Transfer

COURSE OBJECTIVES:

1. To provide fundamentals of momentum, heat and mass transfer and to study analogy between momentum, heat and mass transfer
2. To be able to analyze various transport processes, develop model and to provide mathematical solution to the model developed

UNIT I:

Viscosity and the mechanisms of momentum transfer: Newton's law of viscosity (Molecular momentum transport), generalization of Newton's law of viscosity, pressure and temperature dependence of viscosity, molecular theory of the viscosity of gases at low density, molecular theory of viscosity of liquids.

Shell momentum balances and velocity distributions in laminar flow: shell momentum balances and boundary conditions, flow of a falling film, flow through a circular tube, flow through annulus, flow of two adjacent immiscible fluids.

UNIT II:

Momentum transfer in Turbulent flow

Comparison of laminar and turbulent flows. Mechanism of turbulence, intensity of turbulence, scale of turbulence, Reynolds stresses, the time smoothed velocity profile near the wall, Prandtle's mixing length model, Relationship between average velocity and maximum velocity in turbulent pipe flow.

Thermal conductivity and the mechanisms of energy transport: Fourier's law of heat conduction (molecular energy transport), pressure and temperature dependence of thermal conductivity, and theory of thermal conductivity of gases at low density.

UNIT III:

Shell energy balances and temperature distributions in solids and laminar flow: shell energy balances; boundary conditions, heat conduction with an electrical heat source, heat conduction with a nuclear heat source, heat conduction with a viscous heat source, heat conduction with a chemical heat source, heat conduction through composite walls, heat conduction in a cooling fin, forced convection and free convection.

Diffusivity and mechanisms of mass transport: Fick's law of binary diffusion (molecular mass transport), temperature and pressure dependence of diffusivities, theory of diffusion in gases at low density.

UNIT IV

Concentration distributions in solids and laminar flow: shell mass balances; boundary conditions, diffusion through a stagnant gas film, diffusion with a heterogeneous chemical reaction.

Diffusion with homogeneous chemical reaction, diffusion into falling liquid film (gas absorption), diffusion into a falling liquid film(solid dissolution), diffusion and chemical reaction inside a porous catalyst.

Interphase mass transfer and theoretical models: Film theory, surface renewal theory and film penetration theory, multi parameter and eddy diffusion model

UNIT V

The equation of change for isothermal systems: The equation of continuity, the equation of motion, the equation of mechanical energy, the equation of angular momentum. Partial time derivative, total time derivative, substantial time derivative. The equation of change in terms of the substantial derivative, use of equation of change to solve flow problems.

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Momentum, heat and mass transfer analogy: Reynolds' analogy in heat and momentum transfer. Reynolds's – Colburn analogy in heat and momentum transfer, mass transfer analogy

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COURSE OUTCOMES

1. Understand the analogy between heat, mass and momentum transfer
2. Formulate a mathematical representation of a flow, heat and mass transfer phenomena
3. Solve flow, heat, mass transfer problems either individually or coupled for simple geometries analytically
4. Identify the similarities among the correlations for the flow, heat and mass transfer at interfaces

TEXT BOOKS:

1. Transport Phenomena by Bird R.B, Stewart W.C, Lightfoot E.N, 2nd edition, John Wiley and Sons Inc, U.S.A reprinted in 2013

REFERENCES:

1. Introduction to Transport phenomena by Roy S.C and Guha C, Danpat Rai & Co. 2007
2. Introduction to Transport phenomena by Bodh Raj, PHI Learning Pvt Ltd, New Delhi – 110001, 2012

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IV-Year B.Tech-CHEM - I-Semester	**L**	**T/P**	**C**
	3	**1/-**	**3**

(A57060) PROCESS MODELING AND SIMULATION

Prerequisite: Fluid Mechanics, Mass Transfer, Heat Transfer, Chemical Process Calculations

COURSE OBJECTIVES

- To understand basics of theoretical modeling by the application of Fundamental laws.
- To get introduced to modeling and simulation of steady state and dynamic behavior.
- To train students in computer programming abilities for solving iterative problems.
- Develop the mathematical models and solutions by applying various numerical methods to the basic Chemical engineering problems in mass, heat and momentum transfer.

UNIT-I

Mathematical models for chemical engineering systems, fundamentals, introduction to fundamental laws.

Examples of mathematical models of chemical engineering systems, constant volume CSTRS, two heated tanks, and gas phase pressurized CSTR, non-isothermal CSTR.

UNIT –II

Examples of single component vaporizer, batch reactor, reactor with mass transfer, ideal binary distillation column, batch distillation with holdup

UNIT -III

Computer simulation, examples, gravity flow tank, three CSTRs in series, binary distillation column, batch reactor.

Simulation of Non-isothermal CSTR, VLE dew point, bubble point calculations, counter current heat exchanger

UNIT -IV

Mathematical formulation of the Physical Problems:

Application of the law of conservation of mass-Salt accumulation in a stirred tank- starting an equilibrium still-solvent extraction in two stages-Diffusion with chemical reaction.

Application of the law of conservation of energy-Radial heat transfer through a cylindrical conductor-Heating a closed Kettle.

UNIT -V

The difference operator-Properties of the difference operator-Difference tables and other difference operators. Linear Finite Difference Equations: Simultaneous linear differential equations-Calculation of Number of theoretical stages in Liquid Liquid Extraction column. Nonlinear Finite Difference Equations: Graphical Solution-Analytical solution--Calculation of the number of CSTR reactors for Specific Conversion--Calculation of the number of theoretical plates required for distillation column.

COURSE OUTCOMES:

students will be able to:

- Develop mass balance, energy balance and momentum balance equations for various chemical process systems.
- Develop various models for various systems such as reactors, distillation columns, heat exchangers and analyze their behavior.
- Solve various types of equations including linear, non-linear, ordinary and partial differential equations.
- Apply commercial softwares to simulate various processes of chemical industries.

TEXT BOOKS:

1. Process Modeling Simulation and Control for Chemical Engineers by W. L. Luyben, McGraw Hill, 2nd Ed., 1990.
2. "Mathematical Methods in Chemical Engineering" by Jenson, V.J. and G.V.Jeffereys, Academic Press. London and New York, 2nd Ed., 1977

REFERENCE:

1. Modeling and analysis of Chemical Engineering processes by K.Balu and K. Padmanabhan, IK International private limited, 2007

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IV-Year B.Tech-CHEM - I-Semester	**L**	**T/P**	**C**
	3	**1/-**	**3**

(A57061) CHEMICAL PROCESS EQUIPMENT DESIGN

Prerequisite: Heat Transfer, Fluid Mechanics, Mass Transfer, Chemical Process Calculations

Course Objective:

The objective of this course is to acquire basic understanding of various design parameters and to design various Chemical Engineering equipments.

UNIT I:

Introduction to Equipment Design

Introduction; development of flow and block diagrams from process description, Piping and instrumentation diagram ,material and energy balance, sizing of equipment, design preliminaries, design codes, Material of construction selection procedure, fabrication methods and testing methods, selection of equipments for gas, liquid and solid processes.

UNIT II:

Mechanical design of process equipment

Fundamentals principles and equations, General Design considerations of pressure vessels, Design of thin walled vessels under internal and external pressure, compensation for opening and braches, Design vessels subjected to combined loading, theories of failure, design of flange joints and supports, design of high pressure vessels, design of storage vessels for volatile and non volatile liquids.

UNIT III:

Design of shell and tube heat exchangers

Basic procedure and theory ,Overall heat transfer coefficient, fouling factors, Shell and tube exchanger construction details, mean temperature difference, General design considerations of shell and tube exchanger, tube side heat transfer coefficient and pressure drop ,shell side heat transfer and pressure drop.

UNIT IV:

Design of separation columns (Distillation, Absorption & extraction)

Continuous distillation basic principles and process description, Design variables in distillation column, Design methods for binary systems, plate efficiency, plate contractors, plate hydraulic design, packed columns.

UNIT V:

Design of reactor, evaporator

Introduction, material of construction, Agitation, classification of reactor vessels, reactor selection, Design considerations, Types of evaporators, Design considerations of evaporator, Optimum pipe diameter.

COURSE OUTCOMES:

- Knowledge of basics of process equipment design and important parameters of equipment design ,Mechanical properties of materials to be used as MOC.
- Ability to design internal pressure vessels and external pressure vessels ,special vessels (e.g. tall vessels) and various parts of vessels (e.g. heads) including various unit operation equipments
- Ability to Design heat transfer equipments and mass transfer equipments
- Ability to design cooling and heating systems of chemical reactors.

TEXT BOOKS:

1. Chemical Engineering Design: Vol.6, Coulson J.M. and Richardson J.F., Pergamon Press 1983.
2. Process Equipment Design, M.V. Joshi and V. V. Mahajani, 3rd Ed, Mac Millan India Ltd, 1996.

REFERENCES:

1. Process Design of Equipments, Dr. Shrikanth D. Dawande, Central Techno Publications, 2nd Ed, 2000.
2. Process Equipment Design-Vessel Design: Brownell L.E., Wiley Eastern Ltd.,1986.
3. Introduction to Chemical Equipment Design-Mechanical Aspects: Bhattacharya B.C., CBS Publishers, 1991.
4. Process Heat Transfer: Kern Q., McGraw Hill book Co. Inc., 1982.
5. Mass Transfer Operations: Treybal R.E., MGH Book Co.Inc, 3rd Ed., 1982.
6. Chemical Engineering Hand Book, Perry, 8th Ed., Mc GrawHill, New York, 2008.

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IV-Year B.Tech-CHEM - I-Semester	**L**	**T/P**	**C**
	3	**1/-**	**3**

(A57062) BIOCHEMICAL ENGINEERING

Prerequisite: Chemical Reaction Engineering, Chemical Process Calculations

COURSE OBJECTIVES:
To enhance skills in the areas of biochemical processes, to provide the fundamental background of biological systems, bio-chemical engineering, immobilized enzyme technology, and downstream processing.

UNIT 1
Introduction to microbiology: Biophysics and the cell doctrine, the structure of the cells, important cell types, from nucleotides to RNA and DNA, amino acids into proteins. Kinetics of enzyme catalyzed reaction: the enzyme substrate complex and enzyme action. Simple enzyme kinetics with one and two substrates, other patterns of substrate concentration dependence, modulation and regulation of enzyme activity. Other influences on enzyme activity.

UNIT 2
Immobilized Enzyme Technology: Enzyme immobilization. Industrial Processes. Utilization and regeneration of Cofactor. Immobilized enzyme Kinetics. Effect of External Mass Transfer resistance. Analysis of intraparticle diffusion and reaction.

UNIT 3
Kinetics of cellular growth in batch and continuous culture. Models for cellular growth. Unstructured, structured and cybernetic models. Thermal death kinetics of cells and spores. Introduction to metabolic pathways, Biosynthesis, transport across cell membranes, end products of metabolism, Stoichiometry of cell growth and product formation.

UNIT 4
Design and analysis of biological reactors: Batch reactors, fed batch reactors, enzyme catalyzed reactions in CSTR, CSTR reactors with recycle and wall growth, Ideal plug Flow reactors, Sterilization reactors, sterilization of gases, packed bed reactors using immobilized catalyst. Fermentation technology: Media formulation, design and operation of typical aseptic, aerobic fermentation process. Transport phenomena in bioprocess system: gas liquid mass transfer in cellular systems, determination of oxygen transfer rates, Overall K_L a estimates and power requirements for sparged and agitated vessels, Scaling of mass Transfer equipments, Heat Transfer.

UNIT 5: Downstream Processing: Strategies to recover and purify products; Separation of insoluble product-Filtration and centrifugation; Cell Disrution-Mechanical and Non-Mechanical methods; Separation of Soluble products: Liquid-liquid Extractions, Membrane separation (Dialysis, Ultra filtration and reverse osmosis); Chromatographic separation-Gel permeation Chromatography, Electrophoresis, final steps in purification-Crystallization and drying.

COURSE OUTCOMES:

- Student will understand the difference between bioprocesses and chemical processes.
- Student will be able to understand the biological systems and kinetics of enzymatic reactions.
- Student will be able to design equipments for handing biological processes.
- Student will understand Operations utilized in the purification of biological products enable them to recommend, install and easily learn to scaleup of the bioprocesses.

TEXT BOOKS:

1. Biochemical Engineering Fundamentals, 2nd Ed, J.E. Bailey and D.F. Ollis, Mc Graw Hill Publishers, Newyork, 1987.
2. Bioprocess Engineering, 2nd Ed, M.L.Shuler and F.Kargi, PHI learning Pvt Ltd, New Delhi, 2009.

REFERENCES:

1. Biochemical Engineering, J.M.Lee, Prentice Hall, New Jersey, 1992.
2. Bioprocess Engineering principles, P.M.Doran, Elseveir Gurgaon, 2005.
3. Introduction to Biochemical Engineering,D.G.Rao,Tata McGraw Hill,New Delhi,2005.

ANURAG GROUP OF INSTITUTIONS
(AUTONOMOUS)

IV-Year B.Tech-CHEM - I-Semester	**L**	**T/P**	**C**
	3	**1/-**	**3**

(A57063) PLANT DESIGN AND ECONOMICS

Prerequisite: Chemical Process Calculations, Process Modeling and Simulations

COURSE OBJECTIVES:
The objective of this course is to teach principles of cost estimation, feasibility analysis, management, organization and quality control that will enable the students to perform as efficient managers.

UNIT I
Introduction, Process design development, General design considerations, cost and asset accounting, in detail case study for nitric acid and sodium dodecylbenzene sulfonate. Cash flow for industrial operations, factors effecting investment and production cost, capital investments, estimation of capital investments, cost indices, cost factors in capital investment.

UNIT II
Organization for presenting capital investments, estimates by compartmentalization, estimation of total product cost direction, Production costs, fixed charges, plant over head costs, financing.

UNIT III
Interest and investment cost, types of interest, nominal and effective interest rates, continuous interest, present worth and discount annuities, cost due to interest on investment, source of capital, Taxes and insurances, type of taxes: Federal income taxes, insurance-types of insurances, Self insurance.
Depreciation: types of Depreciation, service life, salvage value, Present value, Methods for determining depreciation, single unit and group depreciation.

UNIT– IV
Profitability: Alternative investments and Replacements, profitability standards, Discounted cash flow, Capitalized cost, payout period, Alternative investments, analysis with small investments, increments and replacements.

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

COURSE OUTCOMES:

- Learn basics of Cost estimation, Working Capital and Capital Investment and understand the time value of money
- Study depreciation methods and learn tax calculation methods
- Learn the methods of estimation of profitability of an industry and procedures adopted for Replacement and Selection from Alternatives.
- Understand process equipment design concept perform various optimize various parameters such as heat duty of heat exchanger, production rate of various process plants.

TEXT BOOKS:

1. Plant Design and Economics for Chemical Engineering, 4th ed, M.S. Peters and K.D. Timmerhaus, Mc Graw-Hill, 1991.
2. Process Engineering Economics, H.E. Schweyer, Mc Graw Hill Co., New York, Kogakusha Co., Ltd., Tokyo. 1955.

REFERENCES:

1. Chemical Engineering plant Design by C.Vilbrandt and Dryden C.E. 4th Edition, Mc Graw Hill Book Co., 1959.

ANURAG GROUP OF INSTITUTIONS
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IV-Year B.Tech-CHEM - I-Semester

L	T/P	C
3	1/-	3

(A57064) DESIGN AND ANALYSIS OF EXPERIMENTS
Open Elective-1

Prerequisite: Process Equipment Design, Probability & Statistics

COURSE OBJECTIVES:
Students will learn importance of analyzing experimental data, disadvantages present in BGA, OFAT and will be taught how to apply techniques of Factorial experiments and of regression models.

UNIT I:
Introduction to Testing of Hypothesis [Definitions and Concepts/Theory only of Null Hypothesis & Alternative Hypothesis, tail test ***no problems***].
Introduction to Design of Experiment: Principles of an Experimental Design [Randomness, Replication and Local Control].
Design Terminology [Block, Degree of freedom, Confounding, Design, Effect, factor space, factor, Main effect, Interaction, Level].
Review of ANOVA [Basic assumptions, Concepts of ANOVA tables for one-way and two-way with problems]

UNIT II:
Factorial Experiment: [Definition and Concepts/Theory of Factor Effect, Fixed, Random Mixed Factor Effect].
Only Concepts/Theory of [Completely Randomized Design, RBD and LSD Recollection, Graeco-Latin Squares ***no problems***].

UNIT III:
Factorial design; Concept/Theory of analysis of 2^k factorial designs.
Analysis of 2^2, 2^3 and 2^4factorial design [Concept of ANOVA table Problems]. Confounding in Factorial Designs, confounding in 2^3 and 2^4 factorial design.

UNIT IV:
Concept/Theory of Analysis of 3^k factorial design.
Analysis of 3^2 and 3^3 factorial design [Concept of ANOVA table Problems].
Confounding in 3^3 factorial design.
Introduction to Balanced Incomplete Block Design. Analysis of Balanced Incomplete Block design BIBD [Concept of ANOVA table Problems].

UNIT V:
Regression analysis-[Simple Linear Regression, Interval Estimation in Simple Linear Regression, Analysis of Variance of Simple Linear Regression, Lack of Fit of the Simple Linear Regression. Multiple Regression, Polynomial Regression, Nonlinear Regression ***with Problems***].

Correlation [Definitions and Correlation in Linear and Multiple Regression].

COURSE OUTCOMES:

Student will have understanding of Analysis of variance with factorial design procedures, knowledge of implementing 2^k and 3^k factorial designs and Regression model to chemical engineering experimental problems.

TEXT BOOKS:

1. Design of Experiments in Chemical Engineering, Zivorad R. Lazic, Wiley.
2. Statistical Design and Analysis of Experiments With Applications to Engineering and Science, Second Edition, Robert L. Mason, Richard F. Gunst and James L. Hess, A John Wiley & Sons Publication.

REFRENCES:

1. Design and analysis of experiments, 2nd ed., D.C.Montgomery, John Wiley and sons, New York, 2003.
2. Experimental Design and Data Analysis for Biologists, Gerry P. Quinn and Michael J. Keough, Cambridge University Press.
3. Statistical Analysis of Designed Experiments, Third Edition, Helge Toutenburg and Shalabh, Springer.
4. Design of Experiments for Engineers and Scientists, Jiju Antony, Elsevier.

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IV-Year B.Tech-CHEM - I-Semester	**L**	**T/P**	**C**
	3	**1/-**	**3**

(A57065) INDUSTRIAL SAFETY AND HAZARD MANAGEMENT
Open Elective-1

Prerequisite: Environmental Engineering

COURSE OBJECTIVES:
This course will provide effective use of chemical industries utilities. This course also emphasis on the knowledge of loss prevention, personal safety, industrial safety, hazard analysis, toxicology and personal proactive equipment's.

UNIT I

Introduction:
Safety program, Engineering ethics, Accident and loss statistics, Acceptable risk, Public perception, Toxicology: How toxicants enter biological organisms, How toxicants are eliminated from biological organisms.

UNIT II

Industrial Hygiene:
Government regulations, Identification: material safety data sheets, Evaluation: evaluating exposures to volatile, Control: respirators, ventilation.

UNIT III

Fires and Explosions:
The fire triangle, Distinction between fire and explosions: Definitions, Flammability characteristics of liquids and vapors, MOC and inerting, ignition energy, Auto ignition, Auto oxidation, adiabatic compression, Explosions.

Designs to prevent fires and Explosions:
Inerting, Explosion proof equipment and instruments, Ventilations, Sprinkler systems. Hazards Identification: Process hazards checklists, Hazard surveys, and Hazop safety reviews.

UNIT IV

Introduction to Reliefs: Relief concepts: Definitions, Location of reliefs, Relief types, Data for sizing reliefs, Relief systems. **Relief Sizing**: Conventional spring operated reliefs in liquids, Conventional spring operated relief's in vapor or gas service, Rupture disc relief's in liquid, vapor or gas service.

UNIT V

Chemical Process Safety: Introduction, Chemical process in Hazardous operations, chemical reactors, Reaction Hazards, Operational Deviations and Technical Report.

Personal Protective Equipment: Introduction ,Legal Requirements , Selection guide lines, Head Protection, Eye and Face Protection , Hand Protection ,Foot and Leg Protection, Body Protection, Indian standards on Personal Protective Equipment.

COURSE OUTCOMES:

- Understanding of Safety principles.
- Ability to do Hazard analysis.
- Identify and take preventive measure of industrial hazards and accidents.
- Know and acquire knowledge of accident investigation and statistical analysis of accidents.

TEXT BOOKS:

1. Chemical Process Safety – (Fundamentals with applications), D.A.Crowl & J.F.Louvar Prentice Hall, New Jersey, 1990.
2. Industrial Hygiene and Chemical safety –M.H.Faulekar, I.K. International, 2006.

REFERENCES:

1. Safety and Accident Prevention in Chemical Operations, H.H.Fawcett and W.S.Wood, 2nd Edition, John Wiley and sons, New York, 1982.
2. Coulson and Richardson's – Chemical engineering – R.K.Sinnot, Vol.6, Butterworth-Heinmann Limited, 1996.

ANURAG GROUP OF INSTITUTIONS
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IV-Year B.Tech-CHEM - I-Semester

L	T/P	C
3	1/-	3

(A57066) INTRODUCTION TO NANOTECHNOLOGY
Open Elective-1

Prerequisite: Engineering Physics, Material Science for Chemical Engineers

COURSE OBJECTIVES:
This course will address the most exciting, novel and interdisciplinary issues in nanoscale science and engineering.

UNIT-I
Introduction: Background and definition of nanoscience and nanotechnology, possible applications of nanotechnology. Band structure and density of states at nanoscale: energy bands, density of states at low dimensional structures.

UNIT-II
Growth techniques of nanomaterials : Top-down versus bottom-up techniques, lithographic process and its limitations, non-lithographic techniques, plasma arc discharge, sputtering, film deposition in a glow discharge , thermal evaporation , e- beam evaporation.
Chemical vapor deposition, types of CVD Processes, pulsed laser deposition, molecular beam epitaxy, sol-gel technique, electrodeposition, other processes –ball-milling, chemical bath deposition and ion beam deposition.

UNIT-III
Investigating and manipulating materials in the nanoscale: Electron microscopies, scanning probe microscopies, optical microscopies for nanoscience and nanotechnology, other kinds of microscopies-secondary ion mass spectrometry (SIMS), photo electron spectroscopy (PES), X-ray diffraction.
Fullerenes: Synthesis and purification of fullerenes, mass spectrometry and ion/molecule reactions , chemistry of fullerenes in the condensed phase, endohedral chemistry of fullerenes , orientational ordering , conductivity and super conductivity in doped fullerenes , optical properties
.
UNIT-IV
Carbon nanotubes: Synthesis and purification, filling of nanotubes, mechanism of growth electronic structure, transport properties, mechanical properties, physical properties, applications, nanotubes of other materials.
Self assembled monolayers: Monolayers on gold, growth process, phase transitions, patterning monolayers , mixed monolayers, SAMS and applications.

UNIT-V: Monolayer-protected metal nanoparticles: Method of preparation, characterization, fuctionalized nanoparticles, applications. Core –shell nanoparticles: characterization, properties and applications. Nanoshells: properties, characterization and applications. An overview of nanobiology, nanosensors, nanomedicines, molecular nanomachines.

COURSE OUTCOMES:

- Understand what nanotechnology is about and how to use it. Growth techniques of nanomaterials. S
- Studying materials in the nanoscale.Fullerenes, Carbon nanotubes, self assembled monolayers and monoplayer-protected metal nanoparticles.Nanobiology, nano sensors, nanomedicines, molecular nanomachines.

TEXTBOOKS:

1. Introduction to Nanoscience and Nanotechnology, K.K Chattopadhyay and A.N. Banerjee, PHI learning Pvt.Ltd… New Delhi,2009.(Unit I to III)
2. Nano: The Essentials, T. Pradeep, Tata Mc. Graw Hill Education Pvt Ltd. New Delhi, 2007. (Unit IV to VIII)

REFERENCES:

1. Springer Handbook of Nanotechnology, Bhushan Bharat (Ed.), Springer International Edition 2004.

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IV-Year B.Tech-CHEM - I-Semester **L T/P C**
0 -/3 2

(A57218) PROCESS DYNAMICS AND CONTROL LAB

COURSE OBJECTIVES:

- To obtain transient response to disturbances like step, impulse , ramp and sinusoidal forcing function
- To analyze stability and performance of feedback loops using Laplace and frequency domain techniques.

Experiments:

1. Calibration and determination of time lag of various first order instruments.
   Major equipment: First order equipment like Mercury-in- Glass thermometer.

2. Calibration and determination of time lag of various second order instruments.
   Major equipment: Second order equipment like Mercury-in- Glass thermometer with Thermal well.

3. Experiments with single and two capacity systems without interaction.
   Major equipment: Single tank system, two tank systems

4. Experiments with single and two capacity systems with interaction.
   Major equipment: Single tank system, two tank systems

5. Estimation of damping coefficient for U-tube manometer.
   Major equipment: U-tube manometer.

6. Level Control Trainer.
   Major equipment: Level control trainer setup with computer.

7. Temperature Control Trainer.
   Major equipment: Temperature control trainer setup with computer.

8. Pressure Control Trainer.
   Major equipment: Pressure control trainer setup with computer.

9. Experiments on proportional, reset, rate mode of control etc.
   Major equipment: PID control Apparatus.
10. Control valve Characteristics.
    Major equipment: Control valve setup.

COURSE OUTCOMES:

- Understand and be able to describe quantitatively the dynamic behavior of process systems
- Have knowledge on the development and use of right type of control dynamics for process control under different operative conditions.

TEXT BOOKS:

1. Process System Analysis and Control, 3rd Ed., D.R. Coughanowr and Steven E. Le Blanc, Mc Graw Hill, 2009.

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IV-Year B.Tech-CHEM - I-Semester

L	T/P	C
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(A57219) SIMULATION LAB

COURSE OBJECTIVES

- Understanding Basic Simulation techniques using Common Mathematical Principles using various softwares.

(At least **Ten** experiments from the following syllabus should be performed)

1. Simulate the non-interaction system response for a step change
2. Simulate the interaction system response for a step change
3. Simulate velocity and height of the tank at various intervals for Gravity Flow Tank.
4. Simulate the Shell and tube exchanger for various case studies.
5. Simulate Batch Reactor for Concentration at various time intervals.
6. Simulate Plug Flow Reactor for Concentration at various time intervals.
7. Simulate Distillation Column for Binary Mixtures.
8. Write a program to evaluate bubble point temperature and vapor composition
9. Write a program to evaluate liquid composition and dew point temperature
10. Simulate three CSTR'S connected in series for concentration at various time intervals -Open loop.
11. Simulate three CSTR'S connected in series for concentration at various time intervals –Closed loop.
12. Simulate non-isothermal CSTR to find concentration, temperature, of reactor contents along with cooling jacket temperature and flow rate at various time intervals.

COURSE OUTCOMES

- Student will be able perform Basic Simulation techniques using Common Mathematical Principles.

TEXT BOOKS:

1. Process Analysis and Simulation in Chemical Engineering, **Gil Chaves,** I.D., **López,** J.R.G., **García Zapata,** J.L.,**Leguizamón Robayo**, A., **Rodríguez Niño**, G.
2. Process Simulation in Chemical Engineering, Chaves, Iván Darío Gil (et al.)

REFERENCES:

1. MATLAB Software
2. ASPEN Plus

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IV-Year B.Tech-CHEM - II-Semester	**L**	**T/P**	**C**
	3	**1/-**	**3**

(A58028) POLYMER TECHNOLOGY
Open Elective-2

Prerequisite: Engineering Chemistry, Chemical Technology

COURSE OBJECTIVES:
To enable the students to compute molecular weight averages from the molecular weight distribution, Condensation polymerization and transition in polymers.

UNIT-I
Introduction: definitions: Polymer& macro molecule, monomer, functionally, average functionally, co-polymer, polymer blend, plastic and resin's classification of polymers: based on resource, structure, applications thermal behavior, mode of polymerization. Concept of average molecular weight of polymers, molecular weight distribution, poly disparity index, determination of average molecular weights: End group analysis, Osmometry, light scattering techniques, viscometer, Gel permeation chromatography.

UNIT-II
Natural polymers: brief study of: Natural rubber, Shellac, Rosin, Cellulose, Proteins
Degradation of polymers, Role of the following additives in the polymers:
i) Fillers and reinforcing fillers ii) Plasticizers iii) Lubricants iv) Antioxidants and UV stabilizers v) Blowing agents vi) Coupling agents vii) Flame retardants viii) Inhibitors

UNIT-III
Mechanism and kinetics of: Addition or chain polymerization, free radical addition polymerization, ionic addition polymerization, coordination polymerization, coordination or step growth or condensation polymerization.
Compounding of polymer resins. Brief description of: I Compression and transfer moulding ii) Injection moulding iii) Extrusion IV) Blow moulding v) calendaring vi) Laminating and pultrusion.

UNIT-IV
Methods of polymerization: mass or bulk polymerization process, solution polymerization process, suspension polymerization process and emulsion polymerization method comparison of merits and demerits of these methods. Properties of polymers: crystalline and amorphous status, melting and glass transition temperature and their determination, effect of polymer structure on mechanical, physical chemical and thermal properties.

UNIT-V
Degradation of polymers, Role of the following additives in the polymers:

i) Fillers and reinforcing fillers ii) Plasticizers iii) Lubricants iv) Antioxidants and UV stabilizers v) Blowing agents vi) Coupling agents vii) Flame retardants viii) Inhibitors

Brief description of manufacture, properties and uses of:

i) Polyethylene (HDRP &LDPE) ii) Poly propylene iii) polyvinylchloride iv) polystyrene v) polytetra fluroethylene vi) poly methyl mehacrylate vii) polyvinyl acetate &polyvinyl alcohol.

COURSE OUTCOMES:

- Understand mechanism and mathematical modeling of different types of polymerizations
- Design of batch and continuous reactors for these polymerizations

TEXTBOOKS:

1. Polymer Science &Technology 2nd ed., J.R.Fried, PHI Learning Pvt. Ltd. New Delhi, 2009.
2. Plastic materials, J.A Bryson , Newnes-Butterworth (London), 1989.

REFERENCES:

1. Text book of polymer science, F.W. Jr.Bill Meyer , (3rd ed.,) John Wiley & sons 1984.
2. Introduction to plastics .J.H Brison and C.C Gosselin, Newnes-Butterworth , London 1968.

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IV-Year B.Tech-CHEM - II-Semester	**L**	**T/P**	**C**
	3	**1/-**	**3**

(A58029) ENERGY ENGINEERING
Open Elective-3

Prerequisite: Engineering Physics and Chemistry, Petroleum & Petrochemical Technology

COURSE OBJECTIVES

- To enable the students to understand the interaction between different parts of the energy system.

UNIT I

Sources of energy, types of fuels- energy and relative forms. Calorific value- gross and net value, calculation of calorific value from fuel analysis, experimental determination of calorific value, present and future energy demands with reference to India; Alternate sources of energy (with special reference to solar and Biomass).

UNIT II

Coal: origin, occurrence, reserves, petrography, classification, ranking, analysis, testing, storage, coal carbonization and byproduct recovery, liquefaction of coal, gasification of coal, burning of coal and firing mechanism, burning of pulverized coal.

UNIT III

Liquid fuels: petroleum: origin, occurrence, reserves, composition, classification, characteristics, fractionation, reforming, cracking, petroleum products, specification of petroleum products, burning of liquid fuels.

UNIT IV

Natural gas, coke oven gas, producer gas, water gas, LPG, burning of gaseous fuels, flue gas-analysis: orsat apparatus, steam distribution and utilization, combined heat and power systems. Waste heat recovery, sources of waste heat and potential application, various types of heat recovery systems, regenerators, recuperators, waste heat boilers

UNIT V

Energy auditing: short term, medium term, long term schemes, energy conversion, energy index, energy cost, representation of energy consumption, Sankey diagram, energy auditing.
Energy conservation: conservation methods in process industries, theoretical analysis, practical limitations

COURSE OUTCOMES:

- On completion of this course, the students would have the ability to apply the fundamentals of energy conversion and applications.

TEXT BOOKS

1. Fuels, furnaces and refractories by O.P.Gupta.
2. Fuels and combustion by Sami Sarkar 2nd edition orient Longman (1998).

REFERENCES

1. Non-conventional energy resources by G.D.Rai
2. Solar energy by S.P.Sukhathame.
3. Conventional energy technology, Fuel and chemical energy by Tata McGraw- Hill book Co.Ltd. (1987).
4. Fuel and energy by harker and Backhurst Academic press London 1981.
5. Fuel science- harker and Allen Oliver and Boyd 1972.
6. W.R.Murphy, G.Mc.Kay- Energy Management, 1st edition – Butterwolfer & Co.Ltd.(2001).
7. Energy management by Turner

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IV-Year B.Tech-CHEM - II-Semester	**L**	**T/P**	**C**
	3	**1/-**	**3**

(A58030) CORROSION ENGINEERING
Open Elective-2

Prerequisite: Engineering Physics and Chemistry, Material Science for Chemical Engineers

COURSE OBJECTIVES:
To introduce the principles of corrosion, common corrosion forms, corrosion control methods, and material selection to reduce corrosion cost and predicting corrosion behavior and its prevention.

UNIT – I
Introduction: Corrosion principles, Types of Corrosion, Acid Theory, Dry chemical corrosion, Wet theory or Electrochemical Theory, Electro- chemical aspects of Corrosion, - environmental effects, Pilling Bedworth Rule, Metallurgical aspects- corrosion rate expressions- methods of estimation of corrosion rates, Passivity.

UNIT –II
Types of corrosion: Forms of corrosion, uniform attack, galvanic corrosion, Examples of galvanic corrosion, Factors affecting galvanic corrosion, Crevice corrosion, Types of Crevice corrosion, pitting Corrosion: Principle and Theory, inter —granular corrosion, Knife line attack, selective leaching: Dezincification and Graphitization, Cavitation damage, Fretting Corrosion.

UNIT – III
Erosion- corrosion and some case studies, Factors affecting erosion- corrosion, stress corrosion cracking and Factors affecting stress corrosion.
Corrosion testing procedures: Introduction, Purpose of Testing, Steps involved in Corrosion testing, Standard expression for corrosion rate, NACE test, Slow stain rate test, Linear Polarization, Paint test, Seawater test, In vivo corrosion test (Field test).

UNIT – IV
Protection against Corrosion: Material selection, alteration of environment, Use of inhibitors, Protection by proper Designing, Modification of the properties of the metal, Cathodic Protection and Anodic Protection Units, Use of protective coatings -organic and inorganic coatings, Methods of application of metallic coatings, cladding.

UNIT–V:
Modern Theory: Principle, Thermodynamics: Free energy, Cell Potential, SHE and EMF series, Application of Thermodynamics to corrosion, Pourbaix Diagram. Electrode Kinetics: Exchange current density, Activation Polarization, Concentration Polarization, Combined Polarization, Mixed electrodes, Passivity with modern aspects.

Predicting corrosion behavior: Effect of oxidizers, Velocity effects, galvanic coupling, Alloy evaluation. Corrosion prevention: Anodic Protection and Noble-Metal Alloying.

COURSE OUTCOMES:

- Ability to understand electrochemical fundamentals
- Ability to understand corrosion preventing methods
- Ability to understand environmental induced corrosion
- Ability to corrosion problems

TEXT BOOKS:

1. Corrosion Engineering, 3rd ed., M.G. Fontana, Tata Mc Graw Hill, 2005.

REFERENCES:

1. Corrosion and Corrosion Control, H.H Uhlig, Wiley, 3rd edition, 2011.
2. Handbook of Corrosion Engineering, Pierre Roberge, Mc Graw- Hill, New York, 2000.

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IV-Year B.Tech-CHEM - II-Semester	**L**	**T/P**	**C**
	3	**1/-**	**3**

(A58031) INDUSTRIAL POLLUTION CONTROL ENGINEERING
Open Elective-3

Prerequisite: Industrial Safety & Hazard Management

COURSE OBJECTIVES:
The aim of this course is that the students will learn the essential principles used in industrial pollution in chemical industries and understand important issues in industrial pollution and pertinent environmental legislations

UNIT I
Introduction: Types of Emissions from Chemical industries: and effects of Environment, environment legislation, types of pollution, sources of Waste water, Effluent guide lines and standards. Characterization of effluent streams, oxygen demands and their determination (BOD,COD, TOC,) Oxygen sage curve, BOD curve mathematical, controlling of BOD curve, self purification of running streams, sources and Characteristics of pollutants in petroleum, paper & pulp fertilizer industry.

UNIT II
General methods of control and removal of $S0_2$, Oxides of nitrogen and organic vapors from gaseous effluent.
Air pollution sampling and measurement: Types of pollutant and sampling and measurement, ambient air sampling, collection of gaseous air pollutants. Collection of particulate air pollutants. Stack sampling: sampling system, particulate sampling and gaseous sampling. Analysis of air pollutants: sulphur dioxide, nitrogen oxides, carbon monoxide, oxidants and Ozone, hydrocarbons, particulate matter.

UNIT III
Air pollution control methods and equipments: Source collection methods, raw material changes, equipment modification. Cleaning of gaseous equipments particulate emission control: collection efficiency, control equipment like gravitational settling chambers, Cyclone separators, fabric filters, ESP and their constructional details and design.
Scrubbers: wet scrubbers, Spray towers, centrifugal scrubbers, packed beds and plate columns, venturi scrubbers, their design aspects .Control of gaseous emissions: Absorption by liquids and solids, absorption equipment and their design aspects.

UNIT IV
Introduction to waste water treatment: Biological treatment to waste water, bacterial and bacterial growth curve, aerobic processes, and suspended growth processes, activated aerated lagoons and stabilization ponds, Attached growth processes, trickling filters, rotary drum filters. Anaerobic process.

Methods of primary treatment: Screening sedimentation, flotation, neutralization, Methods of tertiary treatment: A brief Study of Carbon Absorption, Ion Exchange, Reverse Osmosis, Ultra filtration, Ozonation, treatment and disposal.

UNIT V

Hazardous Waste Management: Nuclear Wastes: health and environment effects, Sources and disposal methods. Chemical waste: health and environment effects.

Treatment and disposal: Treatment and disposal by industry, off site treatment and disposal, treatment practices in various countries. Biomedical Wastes: Types of wastes and their control.

COURSE OUTCOMES:

- Student will know about the different types of wastes generated in an industry, their effects on living and non-living things.
- Student will learn about environmental regulatory legislations and standards and climate changes.
- Students will able to Understand the different unit operations and unit processes involved in conversion of highly polluted water to potable standards.
- Student can analyze and quantify hazardous and nonhazardous solid waste and Wastes treatment and disposal.

TEXT BOOKS:

1. Environmental Pollution and Control Engineering, C.S.Rao – Wiley Eastern Limited, India, New Delhi, 1993.
2. Pollution Control in Process Industries , S.P. Mahajan, Tata McGraw-Hill , New Delhi, 1985

REFERENCES:

1. Waste water Treatment , M. Narayana Rao and A.K.Datta, Oxford and IHB PUBL, New Delhi

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IV-Year B.Tech-CHEM - II-Semester	**L**	**T/P**	**C**
	3	**1/-**	**3**

(A58032) INTELLECTUAL PROPERTY RIGHTS
Open Elective-2

Prerequisite: Nil

COURSE OBJECTIVES

To promote progress by exchanging limited exclusive rights for disclosure of inventions and creative works, society and the patentee/copyright owner mutually benefit and an incentive is created for inventors and authors to create and disclose their work. Get in detail knowledge about trademarks and trade secrets.

UNIT-I

Introduction to Intellectual property: Introduction, types of intellectual property, international organizations, agencies and treaties, importance of intellectual property rights.

Trademarks: Purpose and function of trademarks, acquisition of trade mark rights, protectable matter, selecting and evaluating trade mark, trade mark registration processes.

UNIT-II

Law of copy rights: Fundamental of copy right law, originality of material, rights of reproduction, rights to perform the work publicly , copy right ownership issues, copy right registration, notice of copy right, international copy right law.

Law of patents: Foundation of patent law. Patent searching process, ownership rights and transfers.

UNIT-III

Trade secrets: Trade secrete law, determination of trade secrete status, liability for misappropriations of trade secrets, protection for submission, trade secrete litigation

Unfair competition: Misappropriation right of publicity, false advertising.

UNIT-IV

New development of intellectual property:

New developments in trade mark law; copy right law, patent law, intellectual property audits.

UNIT-V

International overview on intellectual property, international- trade mark law, copy right law, international patent law, and international development in trade secrets law.

COURSE OUTCOMES:

- Get a holistic understanding of the complexities involved in the process of attributing intellectual property rights to people.
- Understanding in detail about Trademarks, Copy rights, Patent, Trade secrets.
- Learn the legalities of intellectual property to avoid plagiarism and other IPR relates crimes like copyright infringements, etc

TEXTBOOKS:

1. Intellectual Property Right, Deborah.E.Bouchoux, Cengage Learing, 3rd ed, 2008.
2. Intellectual Property Rights- Unleashing the Knowledge Economy, Prabuddha Ganguli, Tate Mc Graw-Hill Publishing Company, 4th ed, 2006.

REFERENCES:

1. Intellectual Property Rights, M Ashok Kumar, Serials Publications, 2008
2. Intellectual Property Rights: An introduction for scientists and technologists, Mohammed B.E Fayez, Islamic World Academy of Sciences, 2005

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IV-Year B.Tech-CHEM - II-Semester

L	T/P	C
3	1/-	3

(A58071) MANAGEMENT SCIENCE
Open Elective-3

Prerequisite: Nil

COURSE OBJECTIVES:

- To teach the fundamentals of the key elements of a business organization.
- To provide a critical perspective on theoretical knowledge and practical approach to various functional areas of management and decision making.
- To provide insights on management concepts and to built team work and leadership skills within them.

Unit-I

Introduction to Management: Entrepreneurship and organization – Nature and importance of Management, Functions of Management, Taylor's scientific Management Theory, Fayol's principles of management, Maslow's theory of Human Needs, Douglas Mc Gregor's Theory X and Theory Y, Herzberg's Two factor Theory of Motivation, Systems Approach to Management, Leadership Styles, Social Responsibilities of Management. Types of organization structures.

Unit-II

A) Operations Management: Principles and Types of Plant Layout-Methods of production(Job, batch and Mass production), Work Study – Basic procedure involved in Method Study and work measurement-Statistical Quality Control: X chart, R chart, C chart, P chart, (simple problems), Acceptance Sampling, Deming's contribution to quality.

b) Materials Management: Objectives, Need for Inventory control, EOQ, ABC Analysis, Purchase Procedure, Stores Management and Stores Records – supply chain management.

Unit –III

A) Human Resources Management (HRM): Evolution of HRM, Concepts of HRM, Basic functions of HR Manager: Manpower Planning, Recruitment, Selection, Training and Development, Placement, Wage and Salary Administration, Promotion, Transfer, Separation, Performance Appraisal, Grievance Handling and Welfare Administration, Job Evaluation and Merit Rating.

B) Marketing: Functions of Marketing, Marketing Mix, Marketing strategies based on Product Life cycle, Channels of distribution.

Unit –IV

Project Management(PERT/CPM): Network Analysis, Programme Evaluation and Review Technique (PERT), Critical Path Method(CPM), Identifying critical path, Probability of

Completing the project within given time, Project Cost Analysis, Project Crashing.(simple Problem)

Unit –V

Strategic & Contemporary Management Practices: Mission, Goals, objectives, policy, strategy, programmes, Elements of corporate planning process, Environmental Scanning, SWOT analysis, Steps in Strategy Formulation and Implementation, Generic Strategy alternatives. Basic concepts of Just-In-Time(JIT) system, Total Quality Management(TQM), Six Sigma and Capability Maturity Model(CMM) levels, Value chain Analysis, Enterprise Resource Planning(ERP), Performance management, Business Process Outsourcing(BPO), Business process Re-engineering 5S Model, Deming's PDCA, Kaizen, Poka-Yoke, Muda, Benchmarking, Balanced Score Card

COURSE OUTCOMES:

On completion of this course, the graduate should be able:

- To have the knowledge on various concepts of business management and approaches.
- To understand and analyze the interconnections between the development of key functional areas of business organization and the management thought process.
- To be ethically conscious and socially responsible managers, capable of contributing to the development of the nation and quality of life.

TEXT BOOKS:

1. Aryasri: Management Science, TMH, New Delhi, 2009

REFERENCES:

1. Kotler Philip & Keller Kevin Lane: Marketing Management PH, 2009.
2. Koontz, Weihrich & Aryasri: Principles of Management, TMH, 2009.
3. Stoner , Management, Pearson, 2009.
4. Thomas N. Duening & John M. Ivancevich Management-Principles and Guidelines, Cengage, 2009.
5. Kanishka Bedi, Production and Operations Management, Oxford University Press, 2009.
6. Memoria & S.V.Ganker, Personnel Management, Himalaya, 2009.
7. Schermerhorn: Management, Wiley, 2009
8. Parnell: Strategic Management, Biztantra, 2009.
9. L.S. Srinath: PERT/CPM, Affiliated East-West Press, 2009.
10. William J. Stevenson & Ceyhun Ozgur: Introduction to Management Science, TMH, 2007