**COURSE STRUCTURE**

**AND**

**DETAILED SYLLABUS**

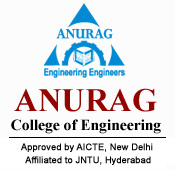
**III & IV – B.TECH – I & II - SEMESTERS**

**CHEMICAL ENGINEERING**

**FOR**

**B.TECH FOUR YEAR DEGREE COURSE**

**(Applicable for the batches admitted from 2014-15)**

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**VENKATAPUR, GHATKESAR, HYDERABAD – 500 088, TELANGANA STATE.**

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**III YEAR I SEMESTER COURSE STRUCTURE**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Subject Code** | **Subject Name** | **Lectures** | **T/P/D** | **Credits** |
| A55028 | Chemical Engineering Thermodynamics-II | 4 | 1 | 4 |
| A55029 | Chemical Reaction Engineering-I | 4 | 1 | 4 |
| A55030 | Mass Transfer Operation-I | 4 | 1 | 4 |
| A55031 | Process Heat Transfer | 3 | 1 | 3 |
| A55032 | Inorganic Chemical Technology | 3 | 1 | 3 |
| A55033  A55034  A55035 | **Open Elective-1**  Technology of Pharmaceuticals and Fine Chemicals  Intellectual Property Rights  Nanotechnology | 3 | 1 | 3 |
| A55215 | Advanced English Communication Skills Lab | 0 | 3 | 2 |
| A55216 | Process Heat Transfer Lab | 0 | 3 | 2 |
|  | **Total** | **21** | **12** | **25** |

**III YEAR II SEMESTER COURSE STRUCTURE**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Subject Code** | **Subject Name** | **Lectures** | **T/P/D** | **Credits** |
| A56039 | Process Modeling and Simulation | 4 | 1 | 4 |
| A56040 | Mass Transfer Operation-II | 4 | 1 | 4 |
| A56041 | Chemical Reaction Engineering-II | 4 | 1 | 4 |
| A56042 | Instrumentation | 3 | 1 | 3 |
| A56043 | Organic Chemical Technology | 3 | 1 | 3 |
| A56044  A56045  A56046 | **Elective-2**  Material Science for Chemical Engineers  Corrosion Engineering  Plastic Materials | 3 | 1 | 3 |
| A56214 | Mass Transfer Operation Lab | 0 | 3 | 2 |
| A56215 | Chemical Reaction Engineering Lab | 0 | 3 | 2 |
|  | **Total** | **21** | **12** | **25** |

**IV YEAR I SEMESTER COURSE STRUCTURE**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Subject Code** | **Subject Name** | **Lectures** | **T/P/D** | **Credits** |
| A57053 | Transport Phenomena | 4 | 1 | 4 |
| A57054 | Process Dynamics and Control | 4 | 1 | 4 |
| A57055 | Chemical Process Equipment Design | 4 | 1 | 4 |
| A57056 | Biochemical Engineering | 3 | 1 | 3 |
| A57057 | Industrial Safety and Hazard Management | 3 | 1 | 3 |
| A57058  A57059  A57060 | **Elective-3**  Design and Analysis of Experiments  Petroleum and Petrochemical Technology  Environmental Biotechnology | 3 | 1 | 3 |
| A57215 | Process Dynamics and Control Lab | 0 | 3 | 2 |
| A57216 | Simulation Lab | 0 | 3 | 2 |
| A57217 | Industry oriented Mini Project | 0 | 0 | 2 |
|  | **Total** | **21** | **12** | **27** |

**IV YEAR II SEMESTER COURSE STRUCTURE**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Subject Code** | **Subject Name** | **Lectures** | **T/P/D** | **Credits** |
| A58045 | Industrial Pollution Control Engineering | 3 | 1 | 3 |
| A58046 | Plant Design and Economics | 3 | 1 | 3 |
| A58047  A58048  A58049 | **Elective-4**  Optimization of Chemical Process  Polymer Technology  Bioprocess Engineering | 3 | 1 | 3 |
| A58217 | Seminar | 0 | 6 | 2 |
| A58218 | Comprehensive Viva | 0 | 0 | 2 |
| A58219 | Project work | 0 | 15 | 10 |
|  | **Total** | **09** | **24** | **23** |

Note: All End Examinations (Theory and Practical) are of three hours duration.

**T – Tutorial P – Practical D – Drawing**

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

**4 1/- 4**

**(A55028)CHEMICAL ENGINEERING THERMODYNAMICS-II**

**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 ", 7th ed, Mc Graw Hill, 2005.

**References:**

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

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

**4 1/- 4**

**(A55029)CHEMICAL REACTION ENGINEERING-I**

**COURSE OBJECTIVE:**

* 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 CA and XA, 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:**

* Describe the algorithm that allows the student to solve chemical reaction engineering problems through logic rather than memorization.
* 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.
* Work together to solve both open-ended and closed-ended reaction engineering problems.
* Use relevant theory to describe the molecular basis for elementary chemical reaction rates.

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

**4 1/- 4**

**(A55030) MASS TRANSFER OPERATION-I**

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

**3 1/- 3**

**(A55031)PROCESS HEAT TRANSFER**

**COURSE OBJECTIVE:**

* 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:**

* Student able to understand the basic concepts and laws of the three modes of heat transfer
* Student can apply analytical techniques to the solution of conduction heat-transfer problems
* Student will analyse the heat transfer processes involved in boiling and condensation
* 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.
3. Heat transfer: Principles and Applications. B.K. Dutta, PHI Learning, India, 2004
4. Process Heat Transfer by [Donald Q. Kern](http://www.goodreads.com/author/show/2335227.Donald_Q_Kern). McGraw-hill New York, 1950

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

**3 1/- 3**

**(A55032) INORGANIC CHEMICAL TECHNOLOGY**

**COURSE OBJECTIVES**

* To learn Process technology and Unit operations.
* To learn various ferrous and non-ferrous industry products and its process technology.
* To learn Process technology of glass, ceramic and cement industry.
* To learn about manufacturing procedures of fertilizers and other common chemicals.

**UNIT - I**

Basic concepts of Unit Operations and Unit Processes. Water Conditioning using Ion Exchange and Lime Soda Process. Classification of Ferrous and Non-Ferrous metals. Metallurgy of Iron, Steel, Copper and Aluminium. Composition of various types of Steels

**UNIT -II**

Manufacture of Porcelain, composition and uses of Enamel products. Manufacture of Port Land Cement. Composition and uses of special Cements. Miscellaneous Calcium Compounds.Magnesium Compounds.

Manufacture of Glass and uses of special Glasses. Properties and manufacture of refractories.

**UNIT - III**

Manufacture and uses of Fuel gases - Producer gas - Water Gas - Substituted natural Gas -Manufacture of Industrial gases –Carbondioxide, Hydrogen, Oxygen and Nitrogen by Liquefaction and rectification of air.

**UNIT - IV**

Manufacture of Common salt, Soda ash, Caustic Soda and Chlorine. Manufacture of Sulphuric Acid, Hydrochloric Acid and some other Chemicals-Aluminium sulphate and alum, Barium salts rare earth compounds - Nitric Acid - Phosphoric Acid

**UNIT - V**

Manufacture of Ammonia -Urea – Ammonium Chloride-DiAmmonium Phosphate - Super Phosphate and Complex fertilizers. Manufacture of activated Carbons and Graphite’s and their applications in Chemical Industry

**COURSE OUTCOMES:**

* Able to differentiate Process Technology and engineering design of unit operations, water conditioning methods and Metallurgical Industries.
* Able to Understand of Process Technology of Cement, Porcelain and Glass industries.
* Able to Understand of Cryogenic and Industrial gases.
* Student exposed to important inorganic chemicals such as acids, bases, salts and N, P, K fertilizers.

**TEXT BOOKS**:

1. Outlines of Chemical Technology by Charles E.Dryden, 2nd Edition, M.Gopal Rao and M.Sittig(Editors), Wiley Eastern 2001
2. Chemical Process Industries – V Edition by Shreve’s. Austin (Editor), McGraw Hill, 1985.

**REFERENCES:**

1. Chemical Technology, V.Sujatha, P. Rajendra Prasad and V.M. Mohan, Scitech Publications (India) Pvt Ltd.2010.

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

**3 1/- 3**

**(A55033)TECHNOLOGY OF PHARMACEUTICALS AND FINE CHEMICALS**

**Open Elective-I**

**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,

Manufacture with flowsheets, properties uses and testing of the following ferric ammonium citrate, pthallic anhydride and phenol flourobenzene process and benzene sulfate process.

**Unit VI:**

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

**Unit V:**

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

**COURSE OUTCOMES:**

Students will be equipped with the knowledge of:

* 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.
2. Industrial Chemicals by Faith, Kayes and Clark, John Wiley & Sons, 3rd Ed. 1965.

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

**3 1/- 3**

**(A55034) INTELLECTUAL PROPERTY RIGHTS**

**(Open Elective 1)**

**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 transfer.

**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, 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, Patents, Trade secrets.
* Learn the legalities of intellectual property to avoid plagiarism and other IPR relates crimes like copyright infringements, etc
* Get knowledge of new developments of intellectual property.

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

**3 1/- 3**

**(A55035) NANOTECHNOLOGY**

**(Open Elective 1)**

**COURSE OBJECTIVES:**

This course will address the most exciting, novel and interdisciplinary issues in nanoscale science and engineering. Demonstrate a working knowledge of nanotechnology principles and industry applications

**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:**

- Gain knowledge of

* Growth techniques of nanomaterials.
* Investigating and manipulating 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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**B.Tech CHEM III Year I-Semester L T/P C**

**0 -/3 2**

**(A55215)ADVANCED ENGLISH COMMUNICATION SKILLS LAB**

**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.

**4. Minimum Requirement**:

The English Language Lab shall have two parts:

i) The Computer aided Language Lab for 60 students with 60 systems, one master console,

LAN facility and English language software for self- study by learners.

ii) The Communication Skills Lab with movable chairs and audio-visual aids with a P.A System, a T.

V., a digital stereo –audio & video system and camcorder etc.

System Requirement ( Hardware component):

Computer network with Lan with minimum 60 multimedia systems with the following specifications:

i) P – IV Processor

a) Speed – 2.8 GHZ

b) RAM – 512 MB Minimum

c) Hard Disk – 80 GB

ii) Headphones of High quality

**5. 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.

* 1. Management Shapers Series by Universities Press(India)Pvt Ltd., Himayatnagar, Hyderabad 2008.
  2. Communication Skills by Leena Sen, PHI Learning Pvt Ltd., New Delhi, 2009.
  3. Handbook for Technical Writing by David A McMurrey & Joanne Buckely CENGAGE Learning 2008.
  4. Job Hunting by Colm Downes, Cambridge University Press 2008.
  5. Master Public Speaking by Anne Nicholls, JAICO Publishing House, 2006.
  6. English for Technical Communication for Engineering Students, Aysha Vish hwamohan, Tata Mc Graw-Hil 2009.
  7. Books on TOEFL/GRE/GMAT/CAT/ IELTS by Barron‘s/DELTA/Cambridge University Press.
  8. International English for Call Centres by Barry Tomalin and Suhashini Thomas, Macmillan Publishers, 2009.

DISTRIBUTION AND WEIGHTAGE OF MARKS:

Advanced Communication Skills Lab Practicals:

1. The practical examinations for the English Language Laboratory practice shall be conducted as per the University norms prescribed for the core engineering practical sessions.

2. For the English Language lab sessions, there shall be a continuous evaluation during the year for 25 sessional marks and 50 End Examination marks. Of the 25 marks, 15 marks shall be awarded for day-to-day work and 10 marks to be awarded by conducting Internal Lab Test(s). The End Examination shall be conducted by the teacher concerned with the help of another member of the staff of the same department of the same institution.

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

**0 -/3 2**

**(A55216)PROCESS HEAT TRANSFER LAB**

**COURSE OBJECTIVE:**

* To gain knowledge and apply it in profession in which student is and to know the relation between theory and laboratory equipment.

(Atleast **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

1. Determination of natural convection heat transfer coefficient for a vertical tube.

Major equipment-Natural convection heat transfer apparatus.

1. Determination of critical heat flux point for pool boiling of water.

Major equipment-Pool boiling apparatus

1. Determination of forced convective heat transfer coefficient for air flowing through a pipe.

Major equipment-Forced convection heat transfer apparatus

1. Determination of overall heat transfer coefficient in double pipe heat exchanger.

Major equipment-Double pipe heat exchanger apparatus

1. Study of the temperature distribution along the length of a pin-fin under natural and forced convections.

Major equipment-Pin-fin apparatus

1. Determination of Thermal Conductivity of Insulating powder.

Major equipment: Insulating Powder Apparatus.

1. Determination of Stefan-Boltzmann constant.

Major equipment-Stefan-Boltzmann apparatus

1. Determination of emissivity of a given plate at various temperatures.

Major equipment-Emissivity determination apparatus.

1. Obtain Temperature Profile under Transient (unsteady) conditions

Major Equipment-Transient Heat Conduction Apparatus

1. Determination of Capacity and Economy by Single Effect Evaporator

Major Equipment- Evaporator.

1. Study the drop wise and film wise condensation and determine heat transfer coefficient

Major equipment- Drop wise and Film wise condensation apparatus.

**COURSE OUTCOMES**

* To design and develop of solutions of complex engineering problems and design system component or processes that meet the needs
* Conduct investigation of complex problems in heat transfer equipment
* To select and apply modern techniques and tools for modeling to complex engineering problems in practice.

**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.
3. Heat transfer: Principles and Applications. B.K. Dutta, PHI Learning, India, 2004
4. Process Heat Transfer by [Donald Q. Kern](http://www.goodreads.com/author/show/2335227.Donald_Q_Kern). McGraw-hill New York, 1950

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

**4 1/- 4**

**(A56039)PROCESS MODELING AND SIMULATION**

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

**4 1/- 4**

**(A56040)MASS TRANSFER OPERATION-II**

**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 Book:**

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

**4 1/- 4**

**(A56041)CHEMICAL REACTION ENGINEERING-II**

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

**3 1/- 3**

**(A56042)INSTRUMENTATION**

**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 Book:**

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

**3 1/- 3**

**(A56043) ORGANIC CHEMICAL TECHNOLOGY**

**COURSE OBJECTIVES:**

The students will

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

2. To impart knowledge on various aspects of production engineering and enable the students to understand the practical methods of production in a chemical factory.

**UNIT - I:**

Petroleum processing: - Constituents of petroleum, various unit operations and unit processes of refining, products of refining. Introduction to Thermal Cracking, Catalytic cracking, Partial Oxidation and steam reforming.

Petrochemicals:- Manufacture and uses of Chloromethanes, Ethanolamines, Acrylonitrile, Phenols, Formaldehyde, Vinyl Chloride and vinyl acetate, Ethylene and Acetylene.

**UNIT - II:**

Polymer Industry: - Polymerization and methods of polymerization.

Classification of plastics; Manufacture of phenol formaldehyde resin and polyvinyl resins (PVC & PVA), Manufacture of Poly ethylene LDPE and HDPE, Poly propylene.

Rubbers: Classification, natural rubber, monomers for synthetic rubber. Manufacture of S.B.R

**UNIT - III:**

Synthetic fibres: Classification, manufacture of Nylon - 66, Polyester fiber, Viscose Rayon Fibre.

Pulp and Paper Industry: Methods of pulping production of sulphates and sulphite pulp. Recovery of chemicals from black liquor. Production of paper. Varieties of paper. Additives of paper.

**UNIT - IV:**

Sugar and Starch Industry: Manufacture of cane sugar, production of starch from maize and uses of starch and sugar.

Fermentation industry: Manufacture of industrial alcohol from molasses. Manufacture of Penicillin and its uses.

**UNIT - V:**

Oils, Soaps, Detergents: - Definitions, constituents of oils, Extraction and expression of vegetable oil. Refining and Hydrogenation of oils.

Continuous process for the production of Fatty acids, glycerin and Soap.

Detergents: comparisons with soap, manufacture of commercial detergents. Classification of surfactants and types of paints and Varnishes, manufacture of paint and varnishes, ingredients and composition of paints and varnishes

**COURSE OUTCOME**:

* Ability to understand the manufacturing of various organic chemicals.
* The students can classify the chemical process industry into industrial categories of base, intermediate end-products and specialty chemicals manufacturers.
* Ability to understand the process flow diagram and various process parameters.
* Ability to identify and solve engineering problems during production.

**Text Books**:

1. Out lines of Chemical Technology by Charles E.Dryden, 2nd Edition, M.Gopal Rao and M.Sittig (Editors), Willy Eastern 2001
2. Chemical Process Industries – V Edition by Shreve’s. Austin (Editor), McGraw Hill, 1985.

**Reference:**

1. Chemical Technology, V.Sujatha, P. Rajendra Prasad and V.M. Mohan, Scitech Publications(India) Pvt Ltd.2010.

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

**3 1/- 3**

**(A56044) MATERIAL SCIENCE FOR CHEMICAL ENGINEERS**

**(Elective-2)**

**COURSE OBJECTIVES:**

* To provide students with a strong foundation in materials science with emphasis on the fundamental scientific and engineering principles which underlie the knowledge and implementation of material structure, processing, properties, and performance of all classes of materials used in engineering systems.

**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.

Assignment 1: Alloys and other metals used in chemical industry

**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:**

* an ability to apply advanced science (such as chemistry and physics) and engineering principles to materials systems.
* an ability to integrate the understanding of the scientific and engineering principles underlying the four major elements of the field (structure, properties, processing, and performance) related to materials systems appropriate to the field.
* Able to design and conduct experiments to study the microstructure, properties, processing and performance of materials and to analyze and interpret the experimental results.
* Able to identify materials-related problems and formulate plans to solve such problems

**TEXT BOOK:**

1. Materials Science and Engineering; V. Raghavan.; Prentice Hall of India Pvt. Ltd., New Delhi, 2009.

**REFERENCES:**

1. Science of Engineering Materials Vol. 1 &2; Manas chanda; McMillan Company of India Ltd.1981.
2. Elements of materials science, Van Vlack, L.R. 1989.

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

**3 1/- 3**

**(A56045) CORROSION ENGINEERING**

**(Elective-2)**

**COURSE OBJECTIVES:**

* To introduce the principles of corrosion and important common corrosion forms to get clear idea about the corrosion.
* To study different methods for corrosion control and their implementation for different industries.
* To study the material selection to reduce corrosion cost and predicting corrosion behaviour 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 inCorrosion 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 properDesigning, 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 behaviour:** Effect of oxidisers, 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 solve corrosion problems

**TEXT BOOK**:

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

**3 1 / - 3**

**(A56046) PLASTIC MATERIALS**

**(Elective-2)**

**COURSE OBJECTIVES:**

To enable the students

* To learn basics of plastics and their properties and different additives and their functioning
* To learn about the general methods of preparation of individual class of plastic materials
* To study about the general properties, processing behaviour and applications of different specialty of plastic materials

**UnitI** **Introduction:** Fed stock of polymers- naphtha, liquefied petroleum gas, cracking of naphtha, etc., polymer structure and its effect on polymer properties: Strength, Plastic deformation, Physical state of polymer, Chemical resistance, Crystallinity of polymer, Effect of light, moisture, gases, chemicals and heat on polymers. **Additives:** introduction to additives and their function — fillers, plasticizers, colorants, heat stabilizers, antioxidants, UV absorber, antistatic agents, flame retardant, blowing agent, lubricants.

**UnitII** **Properties, application and processing of commodity plastics-l:** Polyolefins — Low density polyethylene (LDPE), linear low density polyethylene (LLDPE), high density polyethylene (HDPE), high molecular high density polyethylene (HMHDPE), Ultra high molecular weight polyethylene (UHMWPE). Manufacturing process of PE by Ziegler Natta, HDPE by low pressure process. nylon and poly vinyl chloride.

**UnitIII Properties, application and processing of commodity plastics-II:** polypropylene (PP), polypropylene copolymers, vinyl polymers — polyvinyl acetate (PVA), polyvinyl chloride (PVC), acrylic plastics -- poly methyl methacrylate (PMMA). Introduction to properties and application of polyvinyl dichloride (PVDC), polyvinyl alcohol (PVOH), ethyl vinyl acetate (EVA) and ethyl cellulose.

**UnitIV** **Properties, application and processing of commodity plastics-III:** Cellulosics — cellulose acetate (CA), cellulose acetate butyrate (CAB), cellulose nitrate (CN), ethyl cellulose. Styrene polymers — polystyrene (PS), high impact polystyrene (HIPS), acrylonitrile butadiene styrene (ABS), styrene acrylonitrile (SAN), expanded polystyrene (EPS).

**UnitV** **Properties, application and processing technique of engineering plastics:** polyamides — nylon 6, nylon 6:6, nylon 11, nylon 6:10, nylon 6:12, polyesters — poly butylenes terephthalate (PBT), poly ethylene terephthalate (PET), polycarbonate, polyacetal, poly tetra fluoroethylene (PTFE). **Properties, application and processing of thermosets materials:** phenol formaldehyde, urea formaldehyde, melamine formaldehyde, epoxy resin, polyurethane.

**COURSE OUTCOMES**:

* Students will have the knowledge of different types of plastics, their properties and different additives and their functioning.
* They will be equipped with knowledge on various methods of preparation, structure and properties of different speciality plastics.
* They will gain knowledge about various processing techniques suitable for particular end use applications.
* They can also select the individual plastic materials based on end use applications.

**TEXTBOOK:**

1. Polymer Science, V.R. Gowariker, New Age International, 1986.

**REFERENCES:**

1. Plastics Materials, WA. Brydson, 7th edition, Butterworth- Heinemann 1999.

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

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**(A56214)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

1. Determination of Steam distillation Temperature

Major equipment-Steam distillation unit

1. Verification of Rayleigh’s Equation by differential distillation.

Major equipment- Differential Distillation unit

1. Packed Towers, HETP evaluation.

Major equipment-Packed column unit

1. Vapor-Liquid Equilibria.

Major equipment-VLE apparatus

1. Batch Drying.

Major equipment-Tray dryer

1. Evaluation of mass transfer coefficients-Wetted wall column.

Major equipment-Wetted wall column unit

1. (a)Liquid-Liquid Equilibria(Tie line data) (b)Ternary Liquid Equilibia (binodal curve).

Major equipment-LLE setup

1. Solid Liquid Equilibria: Calcium carbonate and water
2. Solubility characteristics.
3. 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. McCabe, W.L., Smith, J.C., and Harriot, P., “Unit Operations in Chemical Engineering”, McGraw-Hill VII Edn., 2004.

**REFERENCES:**

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

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

**0 -/3 2**

**(A56215)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

1. Determination of the rate constant and to find the temperature dependence using Arrhenius form of equation.

Major Equipment – Batch Reactor

1. Determination of the kinetic parameters (order, reaction rate constant) of given reactor system

Major Equipment – CSTR Apparatus

1. Determination of the kinetic parameters (order, reaction rate constant) of given reactor system

Major Equipment – PFR Apparatus

1. To Determine the effect of Residence time on conversion and to determine the rate constant using a CSTR

Major Equipment – CSTR Apparatus

1. TO determine the RTD and axial dispersion number in a tubular column using a tracer.

Major Equipment – Tubular Reactor Apparatus

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

Major Equipment – Packed Bed Reactor Apparatus

1. To determine the mass transfer coefficient with and without chemical reaction for a solid –liquid system

Major Equipment – Beaker, stirrer

1. To determine the mass transfer coefficient with and without chemical reaction for a liquid –liquid system

Major Equipment – Beaker, stirrer

1. To compare the performance of mixed flow reactor in series with that of an ideal reactor.

Major Equipment – CSTRs in series Apparatus

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

4 1/- 4

**(A57053)TRANSPORT PHENOMENA**

**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:** Reynold’s analogy in heat and momentum transfer. Reynolds’s – Colbun 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 BOOK:**

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

4 1/- 4

**(A57054)PROCESS DYNAMICS AND CONTROL**

**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 BOOK:**

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

4 1/- 4

**(A57055)CHEMICAL PROCESS EQUIPMENT DESIGN**

**Course Objective:**

The objective of this course is to acquire basic understanding of design parameter, complete knowledge of design procedures for commonly used process equipment and their attachments (e.g. internal and external pressure vessels, tall vessels, high pressure vessels, supports etc.), and different types of equipment testing methods.

**UNIT I :**

**Introduction to 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 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 BOOK:**

1. Chemical Engineering: 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, 1982.
6. Chemical Engineering Hand Book, Perry, 8th Ed., Mc GrawHill, New York, 2008.

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

3 1/- 3

**(A57056)BIOCHEMICAL ENGINEERING**

**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 down stream 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 catatlyzed 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 KL 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, Ultrafiltration and reverse osmosis); Chromatographic separation-Gelpermeation 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.

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

3 1/- 3

**(A57057)INDUSTRIAL SAFETY AND HAZARD MANAGEMENT**

**Course Objective:** 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 equipments

**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, 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 relief’s 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 BOOK:**

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.

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

3 1/- 3

**(A57058)DESIGN AND ANALYSIS OF EXPERIMENTS**

**Elective - 3**

**COURSE OBJECTIVES:**

1. To learn the DAE in chemical engineering.
2. To identify different factors or levels for the laboratory experiments.
3. To analyze the factors.
4. To fit regression line models for the chemical experiment.

**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 2k factorial designs.

Analysis of 22, 23 and 24factorial design [Concept of ANOVA table Problems].

Confounding in Factorial Designs, confounding in 23 and 24 factorial design.

**UNIT IV:**

Concept/Theory of Analysis of 3k factorial design.

Analysis of 32 and 33 factorial design [Concept of ANOVA table Problems].

Confounding in 33 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:**

* Able to relate statistics concepts for analyzing data from experiments.
* Student will be able to identify advantages of factorial methods over BGA, OFAT.
* Student will be able to apply Factorial experiments to chemical engineering experiments.
* Student will be able to apply linear regression models for real time experiments.

**TEXT BOOK:**

1. Design of Experiments for Engineers and Scientists, Jiju Antony, Elsevier.

**REFERENCES:**

1. Design of Experiments in Chemical Engineering, Zivorad R. Lazic, Wiley.
2. Design and analysis of experiments, 2nd ed., D.C.Montgomery, John Wiley and sons, New York, 2003.
3. 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.
4. Experimental Design and Data Analysis for Biologists, Gerry P. Quinn and Michael J. Keough, Cambridge University Press.
5. Statistical Analysis of Designed Experiments, Third Edition, Helge Toutenburg and Shalabh, Springer.

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

3 1/- 3

**(A57059)PETROLEUM AND PETRO CHEMICAL TECHNOLOGY**

**Elective – 3**

**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-** feedstock.

**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.
* Treatment techniques of chemical from petroleum.
* 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, 4th ed., B.K Bhaskara Rao, Oxford & IBH Publishing, 2002.

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

3 1/- 3

**(A57060)ENVIRONMENTAL BIOTECHNOLOGY**

**Elective – 3**

**COURSE OBJECTIVE:**

* This course focuses on fundamentals of molecular biology and biotechnology for environmental applications. The major topics include activated sludge processes, stoichiometry, bioenergetics, anaerobic digestion, biological nitrogen and phosphorus removal, molecular microbiology tools, biofouling, antibiotic resistance, and biofuels.

**UNIT I**

**ENVIRONMENTAL MONITORING:** Sampling: physical chemical and biological analysis, recombinant DNA technology, determination of biodegradable organic material, monitoring pollution, bio indicators, biomarkers, toxicity testing using biological material, biosensors.

**Natural resources recovery:** oil recovery, recovery of metals.

**UNIT II**

**Biological sewage treatment:** pollution caused by biodegradable material, function of waste water treatment system, sewage treatment methods, modifications to existing processes , removal of nitrogen and phosphorous ,sludge treatment and disposal , anaerobic digestion agricultural waste and industrial waste.

**UNIT III**

**Bioremediation:** synthetic compounds, petrochemical compounds, Inorganic wastes, bioremediation strategies, bioremediations techniques in situ and ex situ, Phytoremediation, metals and gaseous bioremediation, biochemical pathways of biodegradation.

**Agricultural biotechnology:** detection and diagnostics, micro propagation, somatic cell genetics, production and transgenic plants, safety and transgenic crops, transgenic plants and animals, disease control, germplasm and biodiversity.

**UNIT IV**

**Biotechnology and sustainable technology:**

Provision of bulk and fine chemicals, microbial polymers and plastics, Industrial processes and clean technology.

**Biotechnology of the marine environment:** pharmaceuticals, molecular biology products, polymers, enzymes and transgenic organisms, micro-algae and marine population.

**UNIT V**

**Biofuels**: Finite supply of fossil fuels ,emissions from fuels, Greenhouse gaeses,natural sources of green house gases ,ozone, sulfur dioxide ,effects of industrial activity, remediation of the emissions from fossil fuels, alternative non-fossil energy sources, biological energy sources, combustion of biomass , biogas , biodiesel, ethanol, hydrogen, Introduction to microbial fuel cells.

**COURSE OUTCOMES:**

1. 1.Describe the role of microorganisms in processes such as biofilm formation, biocorrosion, mineral leaching, composting, clean drinking water
2. Explain how environmental conditions can be manipulated to enhance or retard the above processes
3. Summarize the significance of the biorefinery concept and explain how plant biomass can be converted to fermentable substrates and subsequently microbially transformed into biochemicals, biopolymers and biofuels
4. Critically analyze relevant journal articles and investigate industrial application of the above concepts

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

0 -/3 2

**(A57215)PROCESS DYNAMICS AND CONTROL LAB**

**COURSE OBJECTIVE:**

* 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.
* To determine experimentally the methods of controlling the processes including measurement using process simulation techniques
* Students perform computer-simulation based laboratory experiments to relate the learned mathematical concepts to real world processes and also to learn team based problem solving

**Experiments**

1. Calibration and determination of time lag of various first order instruments.

Major equipment: First order equipment like Mercury-in- Glass thermometer.

1. Calibration and determination of time lag of various second order instruments.

Major equipment: Second order equipment like Mercury-in- Glass thermometer with Thermal well.

1. Experiments with single and two capacity systems without interaction.

Major equipment: Single tank system, two tank systems

1. Experiments with single and two capacity systems with interaction.

Major equipment: Single tank system, two tank systems

1. Estimation of damping coefficient for U-tube manometer.

Major equipment: U-tube manometer.

1. Level Control Trainer.

Major equipment: Level control trainer setup with computer.

1. Temperature Control Trainer.

Major equipment: Temperature control trainer setup with computer.

1. Pressure Control Trainer.

Major equipment: Pressure control trainer setup with computer.

1. Experiments on proportional, reset, rate mode of control etc.

Major equipment: PID control Apparatus.

1. Control valve Characteristics.

Major equipment: Control valve setup.

**COURSE OUTCOMES**: students will be able to:

* Understand and be able to describe quantitatively the dynamic behavior of process systems
* Develop the ability to use computer software to help describe and design control systems.
* Design and tune feedback controllers on real systems as well as simulated systems
* Have knowledge on the development and use of right type of control dynamics for process control under different operative conditions.

**TEXT BOOK:**

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

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

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**(A57216)SIMULATION LAB**

**COURSE OBJECTIVES**

* Understanding Basic Simulation techniques using Common Mathematical Principles.
* Implementation of Force balance equations for transportation of fluids in closed pipes using C/C++ simulink with MATLAB.
* Implementation of Total continuity, Component continuity, Energy balance equations for common unit operations like Heat transfer equipment, Reactors, Tanks in series using C/C++ simulink with MATLAB.
* Understanding P, V, T behavior of Binary system using thermodynamic principles.

(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.
* Student will be able to apply of Force balance equations for transportation of fluids in closed pipes using C/C++ simulink.
* Student will be able to apply Total continuity, Component continuity, Energy balance equations for common unit operations like Heat transfer equipment, Reactors, Tanks in series using C/C++.
* Student will perform analysis of P, V, T behavior of Binary system using thermodynamic 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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**B.Tech CHEM IV Year II-Semester** L T/P C

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**(A58045)INDUSTRIAL POLLUTION CONTROL ENGINEERING**

**Course Objective:**

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 S02, 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 Ozones, 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:**

1. Student will know about the different types of wastes generated in an industry, their effects on living and non-living things.
2. Student will learn about environmental regulatory legislations and standards and climate changes.
3. Students will able to Understand the different unit operations and unit processes involved in conversion of highly polluted water to potable standards.
4. Student can analyze and quantify hazardous and nonhazardous solid waste, 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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**(A58046)PLANT DESIGN AND ECONOMICS**

**COURSE OBJECTIVE:**

* 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.
* 4.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.

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**(A58047)OPTIMIZATION OF CHEMICAL PROCESSES**

**Elective – 4**

**COURSE OBJECTIVE:**

* To provide students to understanding of different optimization techniques like linear programming, genetic algorithm and different search techniques and apply it in the design of process.
* To apply the optimization techniques to design heat transfer equipment, mass transfer equipment, reactor, bio reactor and fluid mechanics.

**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 Hessain 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, chemostat, optimization of thermal cracker using linear programming.

**COURSE OUTCOMES:**

* Translate a verbal description of the chemical engineering problem into mathematical description
* Formulate unconstrained or constrained objective functions of chemical engineering problems
* To gain exposure to application of optimization techniques in case of various Petrochemical processes.
* Understand how the problem formulation influences its solvability, solve the optimization problem, interpret the results of optimization and present the insights.

**TEXT BOOK:**

1. Optimization of chemical processes by T.F.Edgar and Himmelblau D.M. Mc- Graw. Hill. New York, 2001.

**REFERENCES:**

1. Optimization for Engineering Design, Kalyan Moy Deb, PHI Pvt Ltd, New Delhi, 2000.

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**(A58048) POLYMER TECHNOLOGY**

**Elective – 4**

**COURSE OBJECTIVE:**

* 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 emerits 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
* Quantitative determination of degree of polymerization and molecular weight distribution
* 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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**(A58049) BIOPROCESS ENGINEERING**

**Elective – 4**

**COURSE OBJECTIVE:**

* 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 PH 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 BOOK:**

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.