NOTIFICATION

No. 72 /2022 Date : 20 /06/2022

Subject : Implementation of new Syllabi of Semester VII & VIII of B.Tech. (Chemical Engg.) & B.Tech. (Chem.Tech.) (Food, Pulp & Paper, Oil & Paint and Petrochemical Technology) (C.B.C.S.) as per A.I.C.T.E. Model Curriculum…

It is notified for general information of all concerned that the authorities of the University have accepted to implement new Syllabi of Semester VII & VIII of B.Tech. (Chemical Engg.) & B.Tech. (Chem.Tech.) (Food, Pulp & Paper, Oil & Paint and Petrochemical Technology) (C.B.C.S.) as per A.I.C.T.E. Model Curriculum to be implemented from the academic session 2022-23 onwards as per ñ**Appendix – A**ò as given below:

Sd/-
(Dr.T.R.Deshmukh)
Registrar

ñ**Appendix A**ò

SYLLABUS OF B.TECH. (CHEMICAL ENGINEERING) SEMESTER VII & VIII (CBCS)

SEMESTER: SEVEN

7CH01 CHEMICAL ENGINEERING OPERATION – III

SECTION - A

UNIT I: Liquid-liquid extraction: Liquid equilibria, Representation in equilateral triangular and rectangular coordinates, choice of solvent: Selectivity Distribution coefficient, Recoverability, Density, Determination of plait point liver rule, single and multistage extraction:

1) Cross current extraction
2) Counter current extraction, fractional extraction. Applications in petrochemical industries, extraction of nuclear fuels and recent advancements in applications. **(8)**

UNIT II: Continuous or differential extraction, Calculation of NTU & HTU, Classification of extraction equipments, stagewise:

i) The mixer settle, Baffle plate columns, Scheibel columns. Differential
ii) Spray column, Sieve Iray column, packed columns, pulsed columns, centrifugal extractors, and their applications, Design of continuous-contact towers. **(7)**

UNIT III: Principles of leaching, Types of equilibrium, Multistage cross- current, counter current leaching and their graphical and RAT representation. Continuous counter current decantation verify types of solid-liquid extractors, shank system, Rotocel, Ballmamn extractor, Extractor for cellular material, extraction of oil from cellular material, agricultural material and seeds. **(7)**

SECTION - B

UNIT IV: Distillation: Thermodynamics of vapour-liquid equilibrium, Relative volatility, partial pressures, Daltonôs, Raoultôs and Henryôs laws Methods of distillations: - Differential, Flash or equilibrium, Rectification and Batch distillations No. of plates by McCabe Thiele method. **(8)**

UNIT V: Panchon savarit, Lewis method, Reflux ratio, minimum reflux ratio, and Azeotroes, Antonic,Vanlaar. Consistency of system, Generation of Vapour-liq equilibria for unknown system Heringtonôs consistency test. **(7)**

UNIT VI: Introduction to multi component distillation Azeotroic distillation, extractive distillation, steam distillation of plate columns, Sieve trays, valve trays, plate efficiency, factors determining column performance, Bubble cap trays, Packed column : Packings, calculation of enrichment in packed column and design of distillation column. **(8)**

Text Books:

1) Unit Operation in Chemical Engineering: W.L. McCabe & J.C. Smith, Mc-Graw Hill.
2) Mass Transfer Operation: R.E. Treybal.
3) Mass Transfer by Pranav Datta.

Reference Books:

1) Mass Transfer: T K Sherwood, R.I.Pigford, McGraw Hill
2) Chemical Engineering Vol. II: Coulson & Richardson
3) Transport Phenomena and Unit Operations: Geankoplis.

7CH02 CHEMICAL REACTION ENGINEERING - I

SECTION - A

UNIT I: Classification of chemical reactions. Variables affecting the rates of reaction. Kinetics & Thermodynamics. Thermodynamics of chemical reactions. Classification of reactors. Order of reaction & rate constant. **(7)**

UNIT II: Rates of Homogeneous Reactions. Fundamentals of rate equation. Rate equations from proposed mechanism Analysis of simple & complex rate equation. Evaluation of rate equation from Laboratory data. (8)

UNIT III: Interpretation of rate data, Scale up and Design. Constant volume batch reactor. Variable volume Batch reactor. Temperature and reaction rate. **(7)**

SECTION – B

UNIT IV: Single ideal reactors. Ideal Batch Reactor. space time and space velocity, steady state mixed flow reactors, steady state plug flow reactor, Holding-time & space time for flow system. **(7)**

UNIT V: Design for single reactions Size comparison of single reactors Batch reactor, Mixed verses plug flow reactors Variation of reactant rates. General Graphical comparison. Autocatalytic reactions. **(8)**

UNIT VI: Design for multiple reactor system. Reactions in parallel & in series, series-parallel reactions. Batch recycle reactor, Flow recycle reactor. Temperature & pressure effects in single and multiple reactions. Optimum temperature profile. **(8)**

Text Books:

1) Chemical Reaction Engineering: Octane Levenspiel, Wiley Eastern Ltd.
2) Chemical Engineering Kinetics: Smith J.M. McGraw Hill.

Reference Books:

1) Reaction Kinetics for Chemical Engineers, Walas McGraw Hill
2) Elements of Chemical Reaction Engineering, H. Scott Fogler, Prentice Hall.

7CH03 PROCESS DYNAMICS AND CONTROL

SECTION - A

UNIT I : Transmit response of control systems, optimization. (7)

UNIT II: Stability, Root locus, Transient response. Application of root locus to control system. Frequency response methods. Design of Nyquist criteria. (8)

UNIT III: Process applications, Controller mechanisms. (7)

SECTION - B

UNIT IV: Development and control systems for various chemical industries case studies. (7)

UNIT V: Introduction on advanced control techniques as feed forward, control, cascade control, ratio control, adaquative control and digital computer control. (8)

UNIT VI: Dynamics and control of chemical equipments such as heat exchangers, distillation columns, absorption column, etc. (8)

Text Books:

1) Process Control: Pater Harriott, McGraw Hill, New York.
2) Process System Analysis and Control: Koppel Conghawoner McGraw Hill.

Reference Books:

1) Automatic Process Control: D.P. Eckman, Wiley
2) Chemical Process Control: George Stephanopoulos - Prentice Hall of India Pvt. Ltd.
3) Process Systems Analysis & Control: Donald R. Coughanour, McGraw Hill.

7CH04 PLANT DESIGN & PROJECT ENGINEERING

Objectives:

Learning fundamentals and applications of chemical engineering plant design, value engineering, optimization with emphasis on chemical engineering applications, fundamentals of engineering economics and the management decision making processes that are used in engineering problem solving. Understanding the concept of interest and equivalence, learning the methods of engineering economic analysis like present worth, rate of return, annual cash flow and benefit-cost ratio, depreciation, etc.

SECTION - A

UNIT I: Basic considerations in chemical engineering plant design, project identification, project identification, preliminary techno- economic feasibility, process selection, laboratory developments and its importance, pilot plant, scale-up methods, flow diagrams. Selection of process equipments: standard vs. Special equipments, materials of construction of process equipments, specification sheets. **(7)**

UNIT II: Plant Location: Objectives, levels of location problems, factors influencing location of a plant, locational analysis, selection criteria, significance, theories of plant location.

Plant Layout: Meaning of plant layout, design importance and scope, essentials, types of layout, factors influencing layout, dynamics of plant layout, planning for plant design. **(7)**

UNIT III: Cost estimation: equipment costs, cost indices, Williamôs point sixth rule, methods of estimation of fixed capital, product cost estimation. Interest formulae and their applications, time value of money, simple and compound interest, discrete, nominal and continuous rate of return and their relationships, issue and evaluation of bonds, concept of equivalence. **(8)**

SECTION - B

UNIT IV: Depreciation: Introduction, straight line method of depreciation, declining balance method of depreciation, sum of the years- digits method of depreciation, sinking fund method of depreciation/ Annuity method of depreciation, service output method of depreciation. **(8)**

UNIT V: Replacement and Maintenance analysis: Types of maintenance, types of replacement problem, determination of economic life of an asset, Replacement of an asset with a new asset, capital recovery with return and concept of challenger and defender, Simple probabilistic model for items which fail completely, practical factors in alternative and replacement investment. (8)

UNIT VI: Inventory control, scheduling a project using CPM/PERT, project management, optimum conditions, optimum production rates in plant operations, optimum conditions in cyclic operations, design reports. **(7)**

Text Books:

1. Max Peters, Plant design and economics for chemical engineers, McGraw Hill
2. Panneer Selvam, R, Engineering Economics, Prentice Hall of India Ltd, New Delhi, 2001.

Reference Books:

1. Chan S.Park, ñContemporary Engineering Economicsò, Prentice Hall of India, 2002
2. Donald G. Newman, Jerome.P.Lavelle, ñEngineering Economics and analysisò Engg. Press, Texas, 2002

7CH05 PROFESSIONAL ELECTIVE - III

(i) INDUSTRIAL WASTE TREATMENT

Objectives:

i) To impart the knowledge about disposal of effluents and the standards for disposal.
ii) To impart the knowledge about biological treatment methods and advanced treatment methods.

SECTION - A

UNIT I: Disposal Effects on Environment:

Effects of industrial wastes on streams, land, air - wastewater treatment plants - water quality criteria. Effluent standards - Process modification - Bioassay studies - Environmental legislation Pollutants Reduction: Waste minimization - House keeping - Volume and strength reduction - Material and process modifications - recycle, reuse and by-product recovery ï Environmental audit. **(7)**

UNIT II: Effluent Treatment:

Conventional methods of treatment and disposal of industrial wastes - Equalization and Neutralization - Separation of solids - Sedimentation and filtration - Coagulation and flocculation, absorption, chemical precipitation, chemical oxidation, Physiochemical treatment methods - Removal of dissolved impurities - Residue management - Combined treatment of industrial and municipal wastes. **(8)**

UNIT III: Biological Treatment Methods:

Principles and methods for removal of suspended impurities and organics - aerobic and anaerobic decomposition of organic matter, Stabilization ponds, activated sludge process, Oxidation ditch. **(7)**

SECTION - B

UNIT IV: Advanced Waste Water Treatment:

Nitrogen removal - Phosphorous removal - Removal of refractory Organics - Removal of dissolved inorganic substances - Chemical precipitation - ion exchange - Reverse Osmosis - Electro dialysis. **(8)**

UNIT V: Industrial Process and Waste Treatment – I:

Manufacturing process, waste water characteristics, composition, effects and appropriate treatment - flow sheets for chemical industries - Petro-chemical industries, Refineries, Pharmaceutical, Textiles - Apparel industries - Metallurgical industries - Steel plants, mines - Power industries - Fertilizer plants - Cement industry. **(8)**

UNIT VI: Industrial Process and Waste Treatment – II:

Manufacturing process, waste water characteristics, composition effects and appropriate treatment flow sheets for Pulp and paper industry - Agro-industries, Sugar - Distilleries, Food processing industry - meat packing, pickles, poultry dairy - Leather tanning. **(7)**

Text Books:

1. Rao.M.N. and Dutta, Waste Water Treatment, Oxford and IBH Publishing Ltd., Calcutta, 2008.
2. Eckenfelder, W.W., Industrial Waste Pollution Control, McGraw Hill Book Co., New Delhi, 2003.
3. S C Bhatia Managing Industrial Pollution.

Reference BookS:

1. Nemerow, N.L., Theory and Principles of Industrial Waste Treatment, Addison Wesley, Reading Mass, 1993.
2. Wastewater Engineering Treatment & Reuse Metcalf & Eddy Inc.

7CH05 PROFESSIONAL ELECTIVE - III
(ii) NEW SEPARATION TECHNIQUES

SECTION - A

UNIT I: Adsorption separations - Review of fundamentals, mathematical modelling of column contactors, pressure swing adsorption, ion chromatography, affinity chromatography, gradient chromatography, parametric pumping, counter-current, simulated counter-current and multidimensional chromatography. **(7)**

UNIT II: Membrane separation processes ï basic concepts, membrane modules, structure and characteristics of membranes. **(7)**

UNIT III: Design considerations of Reverse Osmosis, Ultra Filtration, Electro Dialysis, Gas permeation membranes, Pervaporation, Nano filtration and micro filtration. **(8)**

SECTION – B

UNIT IV: Detailed theories for membrane separations ï concentration polarization, gel formation and fouling, mathematical models for membrane systems with and without concentration polarization, Transport inside the membranes, solution diffusion membranes, porous membranes. **(8)**

UNIT V: Surfactant based separations - fundamentals of surfactants at surfaces and in solution, liquid membrane permeation, and foam separations, micellar separations. **(7)**

UNIT VI: Supercritical fluid extraction - Physicochemical principles, thermodynamic modelling, process synthesis and energy analysis. **(8)**

Text Books:

1. P. C. Wankat, ñLarge scale adsorption and chromatographyò, CRC Press, 1986
2. R.T. Yang, ñGas Separation by Adsorption Processesò, Imperial College Press, 1997.

Reference Books:

1. P.C. Wankat, ñRate Controlled Processesò, Springer Publications, 2005.
2. Seader, ñSeparation Process Principlesò, Wiley Publication, Second Edition, 2008.
3. R. W. Rousseau, ñHandbook of separation process technologyò, John Wiley and Sons, 1987.
4. M. C. Porter, ñHandbook of industrial membrane technologyò, Noyes Publication, Park Ridge, New Jersey, 1990.
5. J. F. Scamehorn and J. H. Harwell, ñSurfactant based separation processes, T. A. Hatton in Vol. 23 of Surfactant science seriesò, Marcel- Dekker., 1989
6. M. A. McHugh and V. J. Krukonis, ñSupercritical fluid extractionò, Butterworth, 1985.

7CH05 PROFESSIONAL ELECTIVE - III
(iii) OPTIMIZATION OF CHEMICAL PROCESSESS

SECTION - A

UNIT I: Nature and organization of optimization problems, fitting models to data, method of least squares, factorial experimental designs, formulation of objective functions. **(7)**

UNIT II: Optimization theory and methods - basic concepts of optimization, optimization of unconstrained functions, one dimensional search, multivariable optimization. **(8)**

UNIT III: Linear programming and applications, nonlinear programming with constraints, optimization of staged and discrete processes. (7)

SECTION – B

UNIT IV: Optimum recovery of waste heat, optimum shell and tube heat exchanger design, optimization of heat exchanger networks. **(7)**

UNIT V: Optimization of multistage evaporators, optimization of liquid- liquid extraction processes, optimal design and operation of staged distillation columns. **(8)**

UNIT VI: Optimal pipe diameter, minimum work of gas compression, economic operation of fixed bed filter, optimal design of gas transmission network, optimal design and operation of chemical reactors. **(8)**

Text Books:

1. T.F.Edger and D.M.Himmelblau, ñOptimization of Chemical Processesò, Mc.Graw Hill, 2001
2. G.S.Beveridge and R.S.Schechter, ñOptimization Theory and Practiceò, Mc.Graw Hill, 1970.

Reference Books:

1. Kalyanmoy Deb, ñOptimization for Engineering Designò, John Wiley, 1995
2. V.Kafarov, ñCybernetic Methods in Chemistry and Chemical Engineeringò, MIR Publishers, 1976.

7CH05 PROFESSIONAL ELECTIVE - III
(iv) SMART MATERIALS

SECTION - A

UNIT- I: **Introduction:** Closed loop and Open loop Smart Structures. Applications of Smart structures, Piezoelectric properties. Inchworm Linear motor, Shape memory alloys, Shape memory effect-Application, Processing and characteristics. **(7)**

UNIT- II:**Shape Memory Alloys:** Introduction, Phenomenology, Influence of stress on characteristic temperatures, Modelling of shape memory effect. Vibration control through shape memory alloys. Design considerations, multiplexing embedded NiTiNOL actuators. **(7)**

UNIT- III: **Electro rheological and Magneto rheological Fluids:** Mechanisms and Properties, Characteristics, Fluid composition and behaviour, Discovery and Early developments, Summary of material properties. Applications of ER and MR fluids (Clutches, Dampers, others). **(7)**

SECTION – B

UNIT- IV: Fibre Optics: Introduction, Physical Phenomenon, Characteristics, Fibre optic strain sensors, Twisted and Braided Fibre Optic sensors, Optical fibres as load bearing elements, Crack detection applications, Integration of Fibre optic sensors and shape memory elements. **(8)**

UNIT- V:Vibration Absorbers: Introduction, Parallel Damped Vibration Absorber, Analysis, Gyroscopic Vibration absorbers, analysis & experimental set up and observations, Active Vibration absorbers. Control of Structures: Introduction, Structures as control plants, Modelling structures for control, Control strategies and Limitations. **(8)**

UNIT-VI: Case Studies: MEMS Magnetic actuators, BP sensors, Microphone, Acceleration sensors, Gyro, MEMS Product development: Performance, Accuracy, Repeatability, Reliability, Managing cost, Market uncertainties, Investment and competition **(8)**

Text Books:

1. ñSmart Structures ï Analysis and Designò, A.V.Srin ivasan, Cambridge University Press, New York, 2001, (ISBN:0521650267).
2. ñSmart Materials and Structuresò, M.V.Gandhi and B.S.Thompson Chapmen & Hall, London, 1992 (ISBN:0412370107)
3. ñFoundation of MEMS, by Chang Liu. Pearson Educa tion. (ISBN:9788131764756)

Reference Books:

1. Banks HT, RC Smith, Y Wang ,Smart Materials and Structuresô, , Massow S A, Paris 1996.
2. Clark R L, W R Saunolers ,G P Gibss,ôAdaptive Structresô, Jhon Wiles and Sons, New York, 1998.
3. Esic Udd, An introduction for scientists and Engineersô, Optic Sensors : Jhon Wiley & Sons, New York, 1991 (ISBN : 0471830070.

7CH06 CHEMICAL ENGINEERING OPERATION–III (MASS TRANSFER-II) - LAB.

List of Experiments:

1. To prepare boiling point (B.P.) diagram and plot x-y data on the equilibrium diagram.
2. Verification of Rayleighôs equation for differential (Batch) distillation.
3. To construct equilibrium curve from vapour liquid equilibrium (VLE) data.
4. To find the composition of distillate and residue after distilling n- butanol-methyl alcohol mixture by simple distillation.
5. To determine vaporization efficiency and thermal efficiency in case of steam distillation.
6. To construct a ternary diagram for acetic acid ï water-benzene system.
7. To study the performance of sieve tray extraction column and compare it with packed column (or spray column).
8. To find out number of stages in multistage continuous counter current operation and in single stage multiple contact of operation for solid liquid extraction (Leaching).
9. To compare single stage with two stage cross current liquid-liquid extraction with partially miscible solvent.
10. To compare single stage with two stage cross current extraction for a system in which solvents are immiscible.

Note: The students should perform minimum EIGHT experiments from the list to complete the term. All experiments in this list shall be available in the laboratory. Additional experiments relevant to the syllabus may be added to the main list.

7CH07 CHEMICALREACTIONENGINEERING-I - LAB.

List of Experiments:

1. To determine the rate constant of saponification of ethyl acetate characterized by an acid like HCL.
2. To determine the activation energy of hydrolysis of an ester such as ethyl acetate.
3. To determine the kinetic of reaction between ethyl acetate and sodium hydroxide at room temperature using differential method of analysis.
4. To determine the kinetics of reaction between ethyl acetate and sodium hydroxide at room temperature by integral method.
5. Show that the decomposition of H2O2 in aqueous solution as first order reaction and determine value of rate constant.
6. To determine void volume porosity of catalyst particle.
7. To determine the RTD curve for packed bed reactor.
8. To determine the RTD curve for PFR.
9. To determine the RTD curve for mixed flow reactor.
10. Verification of performance equation of batch reactor.

Note: The students should perform minimum EIGHT (8) experiments from the list to complete the term. All experiments in this list shall be available in the laboratory. Additional experiments relevant to the syllabus may be added to the main list.

7CH08 PROCESS DYNAMICS AND CONTROL – LAB.

List of Experiments:

1. Sketch the response of the first order system for impulse change.
2. To find the response of a bare measuring thermometer. c) +ve step change d)-ve step change.
3. To find the response of mercury thermometer (kept in a thermal cell) for bare thermometer) +ve step change d)-ve step change.
4. To study under-damped response of manometer fluid with pressure change function.
5. To study the response of non-interacting system use in two tank for step change in flow rate.
6. To study the response level in one tank c) step change d) impulse change.
7. To verify efficiency of transportation lag when coupled with first order system.
8. To study a liquid level on-off controller.
9. To study the temperature control system.
10. To study the temperature control system.
11. To measure liquid level by bubbler system.

Note: The students should perform minimum EIGHT experiments from the list to complete the term. All experiments in this list shall be available in the laboratory. Additional experiments relevant to the syllabus may be added to the main list.

7CH09 PROFESSIONALELECTIVE - III - LAB.

Minimum EIGHT experiments based on the syllabus are to be performed.

7CH10 INDUSTRIAL TRAINING

During the course of study from III to VII semester each student is expected to undertake a minimum of two industrial visits and undertake a minimum of two weeks of industry/field training. The students are expected to submit a report, which shall be evaluated by an internal assessment committee at the end of VII semester for 50 marks.

07CH 11 PROJECT & SEMINAR

SEMINAR:
Each one of the students will be assigned a Seminar Topic in the current and frontier areas. The student has to conduct a detailed study/ survey on the assigned topic and prepare a report. The student will make an oral presentation followed by a brief question and answer session. The Seminar (presentation and report) will be evaluated by an internal assessment committee for 50 marks. The Seminar Report will be evaluated by external examiner appointed by the University along with the Project - Viva Voce examination at the end of VIII Semester.

PROJECT:
The objective of the project is to enable the students to work in groups of not more than four members in each group on a project involving analytical, experimental , design or combination of these in the area of Chemical Engineering. Each project shall have a guide. The student is required to do literature survey, formulate the problem and form a methodology of arriving at the solution of the problem. On completion of the work, a project report should be prepared and submitted to the department.

The evaluation is based on continuous internal assessment by an internal assessment committee for 75 marks by way of oral presentations. The university examination at the end of VIII Semester carries 75 marks will be a Viva Voce examination conducted by a committee of one external examiner appointed by the University and one internal examiner/Guide.

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SEMESTER: EIGHT

8CH01 TRANSPORT PHENOMENON

SECTION-A

UNIT-I : Transport properties and mechanism, Rate process, flux, types of fluids, phenomenological laws, Rheology of non-Newtonian fluids, flow through circular pipes, Mathematical foundation, types of time derivatives, Divergence, Operators. **(7)**

UNIT-II : Control Volume, Overall mass, momentum and energy balances, Extended Bernoulliôs equation, Reynoldôs transport equation, mass balance with chemical reaction. **(7)**

UNIT-III : Equation of change based on differential balance, equation of continuity, Navier-Stokes equation, energy equation, application of Narier-Stokes equations to various flows through different geometric shapes, applications of energy equation, potential streamline, creeping andideal flow. **(8)**

SECTION-B

UNIT-IV: Flow around submerged solids, flow past flat plate, boundary layer, Prandtl equation, expressions for viscous drag, thermal boundary layer. Von Karmonôs integral momentum equation, analysis of integral equation, displacement thickness. **(8)**

UNIT-V: Turbulent flow mechanism, intensity of turbulence, Reynoldôs sitresses, Prandtl mixing length, turbulent flow through circular pipes. Analogies of transfer processes, profiles of gradients, Reynoldôs Prandtl, Von Karmon, Chilton-Coulburn analogies, J factors, Dittus-Boelterôs equation. **(8)**

UNIT-VI : Review of classical mass transfer problems, mass transfer in binary systems with or without chemical reactions. Theories of interphase mass transfer. Mass transfer analogies. **(7)**

Text Books:

1) Transport Phenomenon: Bird, Stayward, Light Foot, John Wiley.
2) Momentum, Heat and Mass Transport: Benett and Mayers, McGraw Hill.

Reference Books:

1) Principles of Unit Operations: A.S. Foust, et-al, Wiley Toppan Int. Ed., Latest Edition
2) Fluid Dynamics and Heat Transfer: J.G. Kundsen and Katz, McGraw Hill, Latest Edition
3) Transport Phenomenon and Unit Operations: Geankoplis.

8CH02 CHEMICAL REACTION ENGINEERING-II

SECTION – A

UNIT-I: Residence time distribution. Models for non-ideal flow. (7)

UNIT-II: Mixing concept and models: Rate equation for Heterogeneous reactions, fluid particle Reactions. Determination of rate controlling step. Application to Design. **(8)**

UNIT-III: Fluid-Fluid reaction: The rate equation for different cases and application to design. **(7)**

SECTION - B

UNIT-IV: Heterogeneous processes, catalysis and adsorptional determination of surface area, void volume. Pore volume distribution catalyst preparation, promoters and inhabitation catalyst reactivation. **(8)**

UNIT-V: Rate equation for third solid catalytic, reactions. Internal External transport process in Heterogeneous Reactions. **(7)**

UNIT-VI: Design of Heterogeneous catalytic reactors, fixed broad reactors, isothermal and adiabatic fixed bed reactor, non- isothermal & non-adiabatic fixed bed rector. Fluidized bed, Drickle bed, slurry reactor. **(8)**

Text Books:

1. Chemical Reaction Engineering, Octave Levenspil, Wiley Eastern Ltd.
2. Chemical Engineering Kinetics, Smith J.M., McGraw Hill.

Reference Books:

1. Elements of Chemical Reaction Engineering - H. Scott Fogler, Prentice Hall.
2. Chemical Reactor Analysis & Design, Gilberth F. Froment & Kenneth B. Bischoof, John Wiley & Sons.
3. Chemical Reactor Design, Vol. I & II, M. W. Rase.

8CH03 SYSTEM MODELLING

SECTION – A

UNIT-I: Introduction: Models and model building, principles of model formulation, fundamental laws - continuity equation, energy equation, equations of motion, transport equations, equations of state, equilibrium and kinetics, classification of mathematical models. Numerical solutions of model equations ï Linear and non linear algebraic equations in one and more than one variables, ordinary differential equations in one and more than one variable. **(8)**

UNIT-II: Lumped Parameter Models: Formulation and solution techniques to be discussed for Vapour liquid equilibrium models, dew point and flash calculations for multi-component systems, boiling operations, batch and continuous distillation models, tank models, mixing tank, stirred tank with heating. **(7)**

UNIT-III: CSTR with multiple reactions. Non-isothermal CSTR - multiplicity and stability, control at the unsteady state. Non-ideal CSTR models - multi-parameter models with dead space and bypassing, staged operations **(7)**

SECTION - B

UNIT-IV: Distributed Parameter Models (Steady State): Formulation and solution of split boundary value problems - shooting technique, quasilinearization techniques, counter current heat exchanger, tubular reactor with axial dispersion, counter current gas absorber, pipe line gas flow, tubular permeation process, pipe line flasher. **(8)**

UNIT-V: Unsteady State Distributed Parameter Models: Solution of partial differential equations using finite difference method, convective problems, diffusive problems, combined convective and diffusive problems. Unsteady state conduction and diffusion, unsteady state heat exchangers, dynamics of tubular reactor with dispersion. Transfer function models for distributed parameter systems. **(8)**

UNIT-VI: Model Parameters Estimation: Introduction, method of least squares, curve fitting, parameter estimation of dynamic transfer function models ï step and impulse response models, Auto regressive Moving Average models, least square and recursive least square methods, parameter estimation of RTD models - moments method. **(7)**

Text Books:

1. Roger E. Franks, ñModelling and Simulation in Chemical Engineeringò, John Wiley and Sons, 1972.
2. W.F. Ramirez, ñComputational Methods in Process Simulationò, Butterworth Publishers, 1989.

Reference Books:

1. Seinfeld and Lapidus, ñMathematical Methods in Chemical Engineeringò, Prentice Hall, 1974.
2. W.L.Luyben,ò Process Modelling, simulation and Control for Chemical Engineersò, 1990.
3. Santosh Kumar Gupta, ñNumerical Methods for Engineersò, Tata McGraw Hill, 1995.

8CH04 PROFESSIONAL ELECTIVE - IV
(i) PETRO CHEMICAL TECHNOLOGY

SECTION-A

UNIT- I: General Introduction - History, economics and future of petrochemicals, energy crisis and petrochemical industry, sources and classification of petrochemicals, different feedstock,Types of cracking Process **(7)**

UNIT- II: First generation petrochemicals - alkanes - C1, C2, C3, C4 petrochemicals, alkenes -C2, C3, C4, petrochemicals, alkynes - C2, C3, C4 petrochemicals, B-T-X aromatics, diene based petrochemicals. **(7)**

UNIT- III: Second generation petrochemicals - synthesis gas, methanol, formaldehyde chloromethanes, ethanol, acetaldehyde, acetic acid, acetic anhydride, isopropyl alcohol, ethylene oxide, propylene oxide, acetone, vinyl chloride, phenol, aniline and styrene. **(8)**

SECTION - B

UNIT- IV: Third generation petrochemicals - plastics, rubbers and fibres, olefinic polymers, polyethylene, polypropylene, polyisobutylene, diene polymers - polybutadiene, neoprene, polyisoprene, SBR, synthetic fibres. **(7)**

UNIT- V: Miscellaneous petrochemicals - petroleum proteins, synthetic detergents, resin and rubber chemicals, explosives - TNT and RDX. **(8)**

UNIT- VI: Various technological forecasting of the petroleum and petrochemicals. **(8)**

Text Books:

1. S.Maiti, ñIntroduction to petrochemicalsò, Oxford and IBH publishing Co.,1992.
2. H.Steines, ñIntroduction to petrochemical Industryò, Pergamon, 1961.
3. I D Mall Petrochemical Process Technology.

Reference Books:

1. G.D.Hobson and W.Pohl, ñModern Petroleum Technologyò, Applied Science Publishers, IV Edition, 1975
2. Richard frank Goldsten and A.Lawrence Waddams, ñThe Petroleum Chemical Industryò, E&FN Spon Ltd., 1967
3. G.T.Austin, ñShreves Chemical Process Industriesò, McGraw Hill, V Edition, 1986

8CH04 PROFESSIONAL ELECTIVE -IV
(ii) INDUS1RIAL PIPING

SECTION - A

UNIT-I: Importance of piping in chemical industry. Classification of pipes: - Pipe codes and specification, Schedule numbers, BWG, NPS. **(7)**

UNIT-II: Material of construction of pipes. Pipe sizing: - Calculation of pipe diameter, thickness. Pipe fittings, advantages, calculation of frictional losses, and empirical correlations for flow of oil. Gasoline, hydrocarbons. **(8)**

UNIT-III: Criteria for selection of pipe joints, pipe joints for similar and dissimilar material, expansion effects and methods for reducing them. **(7)**

SECTION - B

UNIT-IV: Piping lay-out consideration, piping diagrams, types of pipe support, erection and maintenances of supporting, restraining and braing systems. Complex pipelines in series and in parallel. **(8)**

UNIT-V: Calculation of equivalent lengths. Pipeline storage capacity. Fundamental considerations in piping vibrations, types of vibrations, their prevention and control. Cryogenic piping. **(8)**

UNIT-VI: Single phase and two-phase flow. Piping for slurries. Insulation for piping systems. **(7)**

Text Books:

l. Piping Design for Process Plants by H. F. Rase, John Wiley.
2. Process Piping Systems, D. J. Deutsch, Chemical Engineering Magazine, McGrawHill.

Reference Book: Industrial Piping, C.T. Littleton, McGraw Hill.

8CH04 PROFESSIONAL ELECTIVE -IV
(iii) ENERGY & ENVIRONMENT ENGINEERING

SECTION - A

UNIT-I: **INTRODUCTION TO ENERGY SOURCES**: Global Energy, Environmental Resources, Energy necessity and energy crisis. Indian Energy Scenario: Energy Consumption, needs and crisis, energy sources and availability. **(7)**

UNIT-II: RENEWABLE SOURCES OF ENERGYAND ENVIRONMENT:

Biomass ï introduction, energy plantation, bio-mass conversion technologies (wet and dry process), photosynthesis, agricultural waste derived energy, urban waste derived energy.

BIOGAS: Generation, factors affecting bio-digestion, advantages of anaerobic digestion, classification of bio-gas plants. **(7)**

UNIT-III: HYDROPOWER: Site selection for hydroelectric power plants, classification of hydroelectric power plants, submergence, ecological imbalance, catchment area treatment, advantages and disadvantages of hydroelectric power plants. Submergence, Ecological Imbalance, Catchment Area Treatment **(8)**

SECTION - B

UNIT-IV: SOLAR ENERGY: Solar constants, solar radiation at earth surface, physical principles of conversion of solar radiation into heat. Concentrating collectors (focusing and non-focusing). **(7)**

UNIT-V: TIDAL ENERGY: OTEC (Ocean Thermal Electric Conversion), methods of ocean thermal electric power generation, site selection. Energy from tides ï basic principles of tidal power, components of tidal power plant.

WIND ENERGY: Introduction, basic principles of wind energy conversion. Site selection considerations. Basic components of wind energy conversion system. Wind energy collectors. Natural gas ï classification and comparison of different gas turbine power plants, Associated Environmental Effects. **(8)**

UNIT-VI: NUCLEAR ENERGY: necessity, general components of nuclear reactors, different types of reactors, breeding reactors, location of nuclear power plants, disposal of nuclear wastes, Associated Environmental Effects.

GEO-THERMAL ENERGY: introduction, nature of geothermal fields, geo-thermal sources, binary fluid geo-thermal power system and arrangement for hybrid plants. **(8)**

Text Books:

1. Rai, G.D , ñNon-conventional Energy Sourcesò, Khanna Publications.
2. Rao and Parulekar B.B., (1977), Energy Technologyï Non- conventional, Renewable and Conventionalò, 2nd Edition, Khanna Publishers.

Reference Books:

1. Mathur, A.N., and Rathore, N.S., ñRenewable Energy and Environmentò ï Proceedings of the National Solar Energy, Himanshu Publications, Udaipur
2. Saha, H., Saha, S.K., and Mukherjee, M.K., (1990), ñIntegrated Renewable Energy for Rural Developmentò, Proceedings of the National Solar Energy Convention, Calcutta, India,
3. Wilber, L.C., (1989), ñHandbook of Energy Systems Engineeringò, Wiley and Sons
4. The Energy Research Institute (TERI), New Delhi, Publications
5. Ministry of Environment and Forests, Government of India, Annual Reports.

8CH05 PROFESSIONAL ELECTIVE-IV - LAB.

Minimum EIGHT experiments based on the syllabus are to be performed by the students.

8CH06 CHEMICALREACTIONENGINEERING- II - LAB.

List of Experiments:

1. To determine the RTD in CSTR - pulse input.
2. To determine the RTD in PFR - pulse input.
3. To determine the RTD in Packed Bed Reactor - pulse input.
4. To determine the RTD in CSTR - step input.
5. To determine the RTD in PFR - step input.
6. To determine void volume porosity & solid density of catalyst.
7. To determine the Semi batch reactor.
8. To determine the solid fluid heterogeneous Catalytic reaction.
9. To determine the Adiabatic Batch Reactor.
10. To determine Study of adsorption isotherm of calculation of specific surface area of catalyst.

Note: The students should perform minimum EIGHT (8) experiments from the above list to complete the term. All experiments in this list shall be available in the laboratory. Additional experiments relevant to the syllabus may be added to the main list.

8CH07 PROJECT & SEMINAR:

The Seminar Report submitted by the student at the end of VII Semester will be evaluated by external examiner appointed by the University along with the Project - Viva Voce examination at the end of VIII Semester.

PROJECT:

The objective of the project is to enable the students to work in groups of not more than four members in each group on a project involving analytical, experimental , design or combination of these in the area of Chemical Technology. Each project shall have a guide. The student is required to do literature survey, formulate the problem and form a methodology of arriving at the solution of the problem. On completion of the work, a project report should be prepared and submitted to the department.

The evaluation is based on continuous internal assessment by an internal assessment committee for 75 marks by way of oral presentations. The university examination, which carries a **total of 150 marks**, will be a Viva Voce examination conducted by a committee of one external examiner appointed by the University and one internal examiner/Guide.

SYLLABUS OF B.TECH. (CHEMICAL TECHNOLOGY) (FOOD, PULP & PAPER, OIL & PAINT AND PETROCHEMICAL TECHNOLOGY) (C.B.C.S.)

SEMESTER VII & VIII (CBCS)

SEMESTER: VII

7CT01 MASS TRANSFER

Subject Code: 7CT01	Title: Mass Transfer	Credits = 4		
		L	T	P
Semester: VII	Total contact hours:	3	0	2

Course Objectives:

1. To learn basic concept of mass transfer, staged and continuous contact equipment design, gas absorption and distillation.
2. To learn basic knowledge of mass transfer equipments.
3. To design mass transfer equipments.
4. Unit operation based on mass transfers.

Course Outcomes: Students will be able to :

1. Explain the basic mechanism of mass transfer including diffusion and convective mass transfer.
2. Find the mass transfer coefficient and solve problems related to inter-phase mass transfer.
3. Explain the gas-liquid contacting process and solve related problems.
4. Solve problems on VLE and problems related to design calculation of distillation column.
5. Familiar with special distillation techniques such as steam distillation and azeotropic distillation.

SECTION - A

UNIT I : Introduction to mass transfer and applications, principles of molecular diffusion, Fickôs Law: Diffusivity, Diffusion in solids, Concepts of flux and derivation of flux equation, resistance, driving force, equilibrium, direction of mass transfer.

Convective mass transfer, inter-phase mass transfer, Theories of Mass Transfer, individual and overall of mass transfer coefficient for liquid and gas phase. Analogy between momentum, heat and mass transfer. Concept of stage wise contact processes, controlling phase concept, mass transfer in turbulent flow, empirical equations. Schmidtôs no, shearwood no, applications and problems.

UNIT II: Mechanism of absorption and stripping, equipment for Gas-Liquid contact. Calculation of no. of stages, Kremser equation, plate and packed tower internals, packed tower design, HETP, HTU, and NTU concepts, height of column based on conditions in the gas film, liquid film and overall coefficients. Plate type towers, number of plates, plate efficiency, absorption factor.

UNIT III: Types of distillation, relative volatility, azeotropes, enthalpy, concentration diagram, operating line equations, single flash vaporations and partial condensation. Differential distillation for binary systems.
Equilibrium curve for V-L system, fractionation McCabe-Thiele and Panchon-Savarit methods for multi stage operation. Reflux ratio, optimum reflux ratio and other operating parameters. Reboilers, total and partial condenser. Azeotropic and extractive distillation. Introduction of multicomponent distillation.

SECTION-B

UNIT IV: Extraction and Leaching: Ternary diagram, calculation of number of stages analytically and graphically, solvent selection, operating point, material balance of extraction for different solvent conditions (Miscible and immiscible). Introduction to solid liquid extraction, solid liquid equilibria, stage efficiency. Equipment for leaching, extraction, their sizing and design consideration.

UNIT V: Drying and Crystallization: Principles of drying, phase equilibrium, cross circulation drying, suspended particles drying, rate of drying curve, dryers for solids and pastes, dryers for solutions and slurries i.e. various types of dryers. Material balance across dryer.

Principles of crystallization, Equilibrium, calculation of yield, heat effects, crystal growth, properties of crystals nucleation, fractional crystallization, caking of crystals, various types of crystallizes and their applications.
Membrane separation process (microfiltration, ultra filtration, nano filtration, reverse osmosis)

Unit VI: Adsorption and Humidification: Adsorption equilibria, types of adsorption, properties of adsorbents, single and multi-stage adsorption, adsorption isotherms, principles of adsorption, break through curves, adsorption of liquids, basic equations, adsorption equipments and design aspect.
Humidification: Definitions, wet bulb temperature, dry bulb temperature, types of humidity, Adiabatic saturation temperature, study of temperature humidity chart, enthalpy-humidity charts, Determination of humidity and concept of dehumidification. Equipments for humidification operations.

7CT06 : Practicals: More than (6) six experiments expected

1. To study drying characteristics of a given material under a constant drying condition and determine critical equilibrium moisture content.
2. To measure tower characteristics parameter for various liquid for air flow rate in a counter current force draft cooling tower. To determine the effect of (L/G) and (KaV/L) and estimate the value of mass transfer coefficient Ka for value of (L/G).
3. To verify Reyleigh equation for simple distillation.
4. To estimate diffusivity of vapor in air.
5. Adsorption in packed column.
6. To analyze the performance of lab scale bubble cap column to obtain a desire separation of an alcohol waste product.
7. To determine thermal evaporative efficiency.
8. To determine reaction rate constant.
9. To steady the evaluation of HETP and HTU for separation of mixture into its component by distillation in packed column.

Recommended Books:

1. Principles of Mass Transfer and Separation Processes: Binay K. Dutta, 2nd edition, Prentice Hall of India, 2007.
2. Mass Transfer Operations: R. E. Treybal, 3rd edition, McGraw. Hill. 1983.
3. Heat & Mass Transfer: S. D. Dawande, Central Techno Pub., Nagpur
4. Unit Operation in Chemical Engineering: W. L. McCabe & J. C. Smith, McGraw. Hill.
5. Mass Transfer in fluid system: E.D. Cusseler, Cambridge.
6. Principles of Unit Operation: S. Foust 2nd edition, Wiley, New York 1980.
7. Separation Process Principles-Chemical and Biochemical Operations, J. D. Seader, Ernest J. Henley, D. Keith Roper, 3rd Ed., John Wiley & Sons, Inc.
8. Mass Transfer: T. K. Sherwood, R. I. Pigfor
9. Chemical Engineering: Coulson & Richardson.

Reference Book: Transport processes and Separation Process Principles, C.J. Geankoplis, Prentice Hall of India, 4th Ed. 2004.

7CT02 CHEMICAL REACTION ENGINEERING - I

Subject Code: 7CT02	Title: Chemical Reaction Engineering-I	Credits = 4		
		L	T	P
Semester: VII	Total contact hours:	3	0	2

Course Objectives:
1. Student will learn rate equation of homogeneous reaction
2. Students will understand the various methods to analyze the batch reactor data to study the kinetics of homogeneous reaction.
3. Students will learn the performance equation for ideal reactors.

Course Outcomes:
After successful completion of this course student will be able to:
1. Understand the kinetics of homogeneous reaction
2. Interpret batch reactor data to determine the kinetics of homogeneous reaction
3. Design the industrial reactor using kinetic data of pilot /lab scale reactor.
4. Determine the size and type of reactor.
5. Compare the size of various single and multiple ideal reactor system along with recycle reactor
6. Understand the kinetics and design for multiple reactions.
7. Understand the effect of temperature and pressure on conversion.

SECTION-A

UNIT I: Classification of chemical reactions, variables affecting the rates of reaction. Kinetics and Thermodynamics. Thermodynamics of chemical reactions. Classification of reactors. Order of reaction and rate constant. Rate of Reaction, Elementary and non-elementary homogeneous reactions, mechanism of reaction, temperature dependency from thermodynamics.

UNIT II: Rates of homogeneous reactions, fundamentals of rate equation, rate equations from proposed mechanism analysis of simple and complex rate equation. Evaluation of rate equation from laboratory data. Collision and activated complex theories.

UNIT III: Interpretation of rate data, scale up and design. Constant volume batch reactor, variable volume batch reactor, temperature and reaction rate, theories of reaction rates; kinetics of homogeneous reactions, interpretation of kinetic data. Integral and differential methods for analyzing kinetic data, interpretation of constant volume reactor, reversible reaction in parallel and series, catalytic reaction, auto catalytic reaction, reversible reactions. Interpretation of variable volume batch reactions for zero, first and second order reactions, design equation for batch, continuous stirred tank, plug flow reactors for isothermal reaction.

SECTION-B

UNIT IV: Single ideal reactors, ideal batch reactor. Space time and space velocity, steady state mixed flow reactors, steady state plug flow reactor, holding-time and space time for flow system.

UNIT V: Design for single reactions size comparison of single reactors Batch reactor, Mixed verses plug flow reactors Variation of reactant rates. General graphical comparison. Autocatalytic reactions.

UNIT VI: Design for multiple reactor system. Reactions in parallel and in series, series-parallel reactions. Batch recycle reactor, flow recycle reactor. Temperature & pressure effects in single and multiple reactions. Optimum temperature profile. Single and multiple reactions in ideal reactors.

7CT07 Practicals: More than six experiments expected:

1. To study the kinetics of given reaction in batch reactor
2. To study the kinetics of reaction between ethyl acetate and NaOH under ambient condition with excess of ethyl acetate
3. To determine the reaction rate and rate constant for saponification of ethyl acetate and NaOH at ambient condition in PFR
4. To determine the reaction rate and rate constant for saponification of ethyl acetate and NaOH at ambient condition in CSTR
5. To determine the reaction rate and rate constant for saponification of ethyl acetate and NaOH at ambient condition in Cascade CSTR
6. To determine the dispersion No. (D/lu) & N for CSTR using Pulse tracer (RTD in CSTR)
7. To determine the reaction rate constant for fluidized bed reactor
8. To study the effect of temperature on saponification of ethyl acetate and NaOH in batch reactor.

Recommended Books:

1. Momentum Transfer Operation: S .K. Gupta, TMC, Latest edition.
2. Unit Operations of Chemical Engineering: McCabe and Smith, TMC
3. Chemical Engineering Vol. I : Coulson & Richardson, Pergamon.
4. Chemical Reaction Engineering. : Octane Levenspiel, Wiley Eastern Ltd
5. Chemical Engg. Kinetics: Smith J.M. McGraw Hill.
6. Reaction Kinetics for Chemical Engineers: Walas. McGraw Hill.
7. Elements of Chemical Reaction Engineering: H. Scott Fogler, Prentice Hall.

7FT03 SPECIAL TECH - (IV) FOOD TECHNOLOGY

Subject Code: 7FT03	Title: Food Technology -IV	Credits = 4		
		L	T	P
Semester: VII	Total contact hours:	3	0	2

SECTION-A

UNIT I: Operation in food processing: Equipment for various operations like clearing, sorting, Grading, size reduction and separation, mixing, filtration, extraction, centrifugation, crystallization etc. Application of heat in concentration, chilling and refrigeration. Thermal processing of foods. preliminary operations, methods of heat sterilization and process time calculations. Food irradiation, Plant hygiene and water supply.

UNIT II: Process technology of cereals, legumes and oil seeds: Post-harvest storage and handling. Insect infection and its control. Mycotoxins incereals, oilseeds and their products. Milling of cereals and legumes. By products of milling industry. Oil extraction, refining. manufacture of margarine, salad Oils, cooking oils, shortening agents, lecithin, CMS etc. Processing of oil seeds for food uses.

UNIT III: Process technology of baking and baked Products: Selection of raw materials, Rheology of dough and dough testing methods. Changes during fermentation of dough, manufacture of bread, biscuits, crackers, cookies, cakes and other bakery products, manufacture of breakfast cereals, puffed cereals, fortified and enriched products, extrusion cooked products, Quality control.

SECTION-B

UNIT IV: Process Technology of Tea & Coffee: Composition and processing, flavor and aroma, methods of evaluation of quality.

UNIT-V: Process technology of cocoa, chocolate, candy and confectionary products: Raw materials, use of additives, Technology of processing of cocoa, Manufacture of chocolate candies and confectionary products. Quality control and standards.

UNIT VI: Special Foods: Weaning and baby foods, processed protein and cereal foods textured proteins, Nutraceuticals, intermediate moisture foods, organic food, novel food, proprietary food, supplementary food for diet and health, simulated milk products, Pre-cooked and instantized foods. Quality food management. Different ingredient and additatives.
Recent advances in the field.

7FT08 SPL. TECHNOLOGY-IV (PRACTICAL) FOOD TECHNOLOGY:

More than six experiments expected;

1. Physico-Chemical analysis of biscuit
2. Physico-Chemical analysis of wheat flour
3. Physico-Chemical analysis of whey powder.
4. Chemical and Instrumental analysis of tea/coffee.
5. Chemical analysis of honey

6. Chemical and Instrumental analysis of Jam, squash
7. Analysis of sodium chloride (purity, matter in soluble in water, water soluble matter other than sodium chloride)
8. Analysis of heavy metal in food stuff.
9. Determination of moisture content in spices and condiments by dean - stark method.
10. Determination of acidity of extracted fat in biscuit
11. Determination of acidity in skim milk powder.
12. Determination of germ oil content in wheat flour
13. Food fortification.
14. Salt content in butter and cheese.
15. Sedimentation value of wheat flour
16. Shelf life study of food products
17. Purity as acetone insoluble in lecithin.
18. Purity of ammonium bicarbonate.
19. Purity of citric acid monohydrate.
20. UHT processing curd making, cheese making, milk processing and standardization
21. Case study like veg. Pizzas.

BOOKS RECOMMENDED:

1. Fundamentals of Food Processing Operations by Jonslyn. M. A. and Heid, J.L.: AVI Publishing Co., Inc Westport, Connecticut.
2. Food Processing Operations, Vols. l,2 and 3 by Jonslyn, M.A. and Heid, J .L.: AVI Publ. Co., INC, Westport Connecticut, Latest Edition.
3. The Freezing Preservation of Foods, Vols., 1,2,3 & 4 Edited by Eople, M J. and Tressler, D. K.: AVI Publ. Co., INC, Westport Connecticut.
4. The Fundamentals of Food Engineering by Charu, S.E.: AVI Publ. Co., INC, Westport Connecticut.
5. Grain storage part of System. Edited by Sinha, R.N. and Muir W E.: AVI Publ. Co., Inc, Westport Connecticut.
6. Technology of cereals with Special reference to Wheat by Kent, N.L.: Pergamon Press, Oxford.
7. Cereal Technology by Matz, Samuel, A.: AVI Publishing Co., INC, Westport Connecticut.
8. Coffee Processing Technology, Vols.1 and 2 by Sivetz M.: AVI Publ. Co., INC, Westport Connecticut.
9. Food Dehyderation, Vol, I and 2 by Copley, M J. and Van Arsdel, W B.: AVI Publ. Co., INC, Westport Connecticut.
10. Modern Methods of Cocoa and Chocolate manufacture by Waters, H. W.: J. & A. Churchill, 40, Glouceter Place, Portman Square.
11. Wheat Chemistry and Technology, Edited by Pomeranz, Y.: American Association of Cereal Chemists, Incorporated St. Paul, Mannesota.
12. Modem Cereal Chemistry by Kent Jenos. D. W Amos, A J.: Foods Trade Press Ltd., 7, Garrick Street, WC. London.
13. Snack Food Technology by Matz, S.A.: AVI Publ. Co,INC, Westport Connecticut.
14. Bailey Industrial. Oil and Fat Products, Edited by Deniel Swern: Interscience Publishers, A division of John Wiley and Sons, New York.
15. Bakery Materials and Methods by Daniel, A.R.: Mac, Laren & Sons, Ltd., London.
16. The Manufacture of Biscuits, Cakes and Wafferôs by Fritsch, J. and Grospicrre: Sir. Issac Pitman and Sons Ltd., London.
17. Surgar Confectionary and Chocolate Manufacture by E. B Jackson and Less, R.: Leonard Hills Books, 24, Market Square, Aylesburry, Books.

7PT03 SPECIAL TECH (IV) PULP & PAPER TECHNOLOGY

Subject Code: 7PT03	Title: Pulp & Paper Technology- IV	Credits = 4		
		L	T	P
Semester: VII	Total contact hours:	3	0	2

SECTION-A

UNIT I: Bleaching of wood pulp, basic principles of chlorination and alkali extraction, oxidation bleaching agents-hypochlorite, chlorine dioxide, peroxide and other bleaching agents, reducing agents, acidification and combination stages, determination of bleach requirements.

UNIT II: Modern bleaching processes with following agents chlorine-dioxide, oxygen, ozone, peroxide per acids, enzyme and chelating agents. Their reactions, process variables, pulp properties, advantages disadvantages and equipment selections. Bio-bleaching, fundamentals and economics. Bleaching of post-consumer office waste and deinked newspaper.

UNIT III: Stock preparation, beating and refining, effect on fiber structure, theory of beating, factors affecting beating, stock preparation systems

SECTION-B

UNIT IV: Internal sizing of paper, rosin size and synthetic sizes, wax emulsions, asphalt emulsions, theory of internal sizing, various precipitants, alkaline sizing, fortified sizing.

UNIT V: Filling and loading: objectives, survey of filler properties, manufacture of fillers, preparation and addition of fillers, filler retention, adverse effects of fillers, commercial filling and loading materials, refractive index and scattering coefficient.

UNIT VI: Special additives for wet and dry strength, general considerations and properties, coloring, theory, terms used, dyes and pigments, fastness test, methods of coloring, coloring of special papers.

7PT08 SPL. TECHNOLOGY-IV (PRACTICAL) PULP & PAPER TECHNOLOGY:

More than (6) six experiments expected:

1. Determination of ash content of given paper.
2. Determination of moisture content in paper.
3. Determination of acidity / alkalinity by cold water extract.
4. Determination of acidity by hot water extract.
5. Determination of acidity / alkalinity of paper by pH meter.
6. Determination of water absorbency of paper by KELM absorbency method described the absorbency of paper by particular time interval.
7. Determination of sprit absorbency of paper by KELM absorbency method.
8. Determination of rosin size to given paper sample.

Books Recommended:

1. Pulp and Paper Science & Technology Vol. I & II by C. E. Libby
2. Pulp & Paper Manufacture Vol. I, II, III by MacDonald
3. Hand Book of Pulp and Paper Technology by K.W. Britt 2nd edition.

7OT03 SPECIAL TECH (IV) OIL & PAINT TECHNOLOGY

Subject Code: 7OT03	Title: Oil & Paint Technology - IV	Credits = 4		
		L	T	P
Semester: VII	Total contact hours:	3	0	2

(TECHNOLOGY OF SOAPS, DETERGENTS, ESSENTIAL OILS AND GLYCERINE)

SECTION-A

UNIT I: **Surfactants**: Concepts of surface activity, structure of surfactant molecules, hydrophil-lipophil balance, methods for measurement surface activity, mechanism of detergency. Typc of surfactants: Anionic, Cationic, nonionic and amphoteric. Biodegradation of surfactants.

UNIT II: Soaps: Raw materials for soap industry classification and selection of raw materials, properties of soap and soap solutions. Phase separation in soap boiling. Plants and process employed in soap manufacture. Various types of soaps and cleaning preparation.

UNIT III: Detergents: Classification, raw material, plants and process employed in manufacture of detergents, analysis of detergents.

SECTION-B

UNIT IV: Essential oils: Classification and chemical constituents of essential oils, methods of extraction, analysis of essential oils, natural and synthetic perfumery materials for industrial uses.

UNIT V: Glycerine : Manufacture of Glycerine from natural sources, sweet waters, properties spent lyes. Synthetic glycerin: Properties. analysis and utilization of glycerine.

UNIT VI: Application of Surfactants, analysis of soaps, LS.I. methods of testing of soaps and detergents, analysis of essential oils, analysis and utilization of glycerin, recent advances in the field.

7OT08 SPECIAL TECHNOLOGY-IV (PRACTICALS) OIL & PAINT TECHNOLOGY

More than six Experiments expected:

1. Producing fats and fat based products.
2. Mechanical expression of Oil from Oil seeds
3. Refining and hydrogenation of Oils.
4. Evaluation of bleaching Earths. Activated carbon and charcoal.
5. Preparation of soaps and detergents.
6. Preparation of various types of detergents.
7. Preparation and evaluation of wax formulations.

8. Preparation of metallic soaps.
9. Preparation of boiled oil, blown oils and stand oils and their evaluation.
10. Preparation of ester gum.
11. Fat splitting and separation of fatty acids.
12. Analysis of pigment. Oil absorption. hiding power etc.
13. Preparation of paints and its analysis, drying lime. gloss and shade matching.
14. Preparation of cosmetics.

BOOKS RECOMMENDED:

1. Soap: Their Chemistry and Technology: J.G.Khane.
2. Soap Manufacture: J. Davidson. lnerscience Publishers. New York. Latest Edition.
3. Sulphated Oils and Allied Products: D. Burton and G. F. Robertshaw. Chemical Publishing Co., New York, Latest Edition.
4. Surface active agents andõDetergents :A. M. Schwarttz. J. W. Perry and J. Berch, Interscience Publishers, New York.
5. Industrial oil and fat products: A.P.Bailley, Interscience Publishers. New York.
6. Technology of Laundry Soap Manufacture: Small Business Publications, New Delhi
7. House Hold & Industrial Surfactants : Small Business Publications, New Delhi.
8. The Technology of synthetic Detergent : Small Business. Publications, New Delhi.
9. Textiles Chemicals & Auxilaries: H.C. Speed and E. W. K. Schwartz, Reinhold Publications, New York.
10. The Manufacture of Glycerol :G.Martin
11. The Modern Soap Detergent Industries: G.Martin.

7PC03 SPECIAL TECH (IV) PETROCHEMICAL TECHNOLOGY

Subject Code: 7PC03	Title: Petrochemical Technology - IV	Credits = 4		
		L	T	P
Semester: VII	Total contact hours:	3	0	2

[REACTOR DESIGN ASPECTS IN PETROLEUM AND PETROCHEMICAL PROCESSES]

Course Objectives:

1. To know the utility and application of various refining processes.
2. To learn brief knowledge of petroleum refining.
3. To learn basic concept of equipment design for refining processes.

Course Outcomes:

1. Subject enriched the students about petroleum refining processes.
2. Subject enriched the students about mechanism and reactions involved, design aspect, material of construction.
3. Able to obtained optimum operating conditions.
4. Carry out the material balance across various refining processes.
5. Able to solve the troubleshooting occurs during processing.

SECTION-A

UNIT I: Design aspects of pipe still heaters, radiant and convection sections, calculation of heat flux, radius and number of pipes, band allowance. Capacity, number of plates, shell thickness, reflux ratio, pressure, temperature and composition calculations.

Type of furnaces, furnace for olefin synthesis, design aspect of furnace, effect of temperature, pressure, feed on product pattern. General processing of crude oil, crude distillation.

UNIT II: Capacity, role of feed stocks, desired product pattern, process variables, raw material for visbreaker, coker and catalytic cracker, deactivation in catalytic cracking, types, mechanism and kinetics.

UNIT III: Reactors for HDS (TBR) mass, transfer effects, various reactions, role of pressure. Characteristics of fluidized bed reactors, parameters, KL model, role of emission phase, wake, diameter of bubble, application of FBR for acrylonitrile production.

SECTION – B

UNIT IV: Details of loading capacities of different reactors in series for catalytic reforming, catalyst properties and composition, space time variation, variation of rates and extents of different reactions in different reforming, hydrocracking and isomerization reactors, problems associated with pressure and corrosion.

UNIT V: Packed bed reactors, multibed reactors, phthalic anhydride production in multi tubuler bed reactor, details of slurry bed reactor, heat and mass transfer, effects in slurry reactors, problems of catalyst and product separation.

UNIT VI: Reactor design aspects for production of styrene, problems of agitation, viscosity rise, mass transfer and heat transfer, power requirement, reactor design for alkylator, cooling systems, agitation and product separation.

Topic to be covered with study of material balance across various units, recent development in the field.

7PC08 SPL. TECHNOLOGY-IV (PRACTICAL) PETROCHEMICAL TECHNOLOGY - II

More than six Experiments expected:

1. General processing of petroleum and petroleum products.
2. Effect of blending agent/additive on performative study of various petroleum products (minimum study of 4 products).
3. Checking stability of various petroleum products during operations (minimum study of 4 products).
4. Various reactors and their performance.
5. Synthesis, characterization and performance of biofuels.
6. Determination of TFC, SFC, break power, break thermal efficiency of various types of petroleum fuel and bio-fuels.

Recommended Books:

1. Petroleum Processing Handbook, edited by John J. Meketta, Marcel Dekker Inc.
2. Robert A. Meyers, Handbook of Petroleum Refining Processes, McGraw Hill.
3. Richard A. Dawe, Modern Petroleum Technology, Volume II, Institute of Petroleum.
4. B. G. Deshpande, óThe World of Petroleumô, Wiley Eastern Ltd.
5. J. H. Gary, G. E. Handwert, Petroleum Refining Technology and Economics, Marcel Dekker Inc.
6. G. N. Sarkar, Advanced Petroleum Refining, Khanna Publisher.
7. J. M. Smith: Chemical Engineering Kinetics. 2nd Edn. McGraw Hill.
8. Octave Levenspiel: Chemical Reaction Engineering, Wiley Eastern.
9. C. G. Hill. Jr.: An Introduction to Chemical Engineering and Kinetics and Reactor Design. John Wiley.
10. J. J. Carbery: Chemical and Catalytic Reaction Engineering. McGraw Hill.
11. A. R. Cooper and G. V. Jeffreys L.: Chemical Kinetics and Reactor Design Oliver and Boyd. Edinburgh.
12. J. M. Coulson. J. F. Richardson and D. G. Peacock: Chemical Engineering. Vol. III, EIBS.
13. K. B. Denbig and IC. Turner: Chemical Reactor Theory. 2nd Edition, Cambridge University Press.
14. O. A. Houghen and K. M. Watson : Chemical Process Principles Part ï III Kinetics and Catalyst, John Wiley.

7CT04 PROFESSIONAL ELECTIVE-III : 1) CORROSION ENGINEERING

Subject Code: 7CT04	Title: Corrosion Engineering	Credits = 4		
		L	T	P
Semester: VII	Total contact hours:	3	0	2

Course Objectives:

1. To understand the needs for Corrosion Education, The Functions and Roles of an Engineer to prevent Corrosion.
2. Understanding of basic concepts of Corrosion, Corrosion in different materials, Corrosion Electrochemistry, Corrosion Thermodynamics, Kinetics and Applications.
3. To impart the interdisciplinary subject in which Chemical Engineering, Materials Engineering, Electrical Engineering, Civil Engineering and Metallurgy Engineering are involved.
4. Understand the Methodology, Methods and Materials to prevent the Corrosion.

Course Outcomes:

Upon completion of the course, the student should be able to:

1. Describe the Chemistry behind the corrosion, process of corrosion, different factors affecting the rate of corrosion.
2. Discuss Kinetics and different forms of corrosion and will able to recognize the corrosion occurring in the different materials.
3. Explain techniques of corrosion cells, Corrosion avoidance, corrosion failure and the various factors.
4. Students shall understand how to prevent the corrosion, selection of materials for corrosion prevention, how to alter the environment for minimal rate of corrosion, different protection techniques and coating to prevent corrosion.
5. Gain knowledge of corrosion by water, boilers feed water, cooling tower water and the scaling indices of water used in many processes. They will also learn about atmospheric corrosion, its tests as well as behavior and resistance to such corrosion.

SECTION-A

UNIT I: Study of corrosion-Needs for corrosion education, functions and roles of a corrosion engineer, corrosion engineers education, strategic impact and cost of corrosion damage, corrosion basics-why metals corrode, matter building blocks, acidity and alkalinity (pH), corrosion as a chemical reaction, corrosion in acids, corrosion in neutral and alkaline solutions.

UNIT II: Corrosion kinetics and applications of electrochemistry to corrosion-over potential. activation polarization, concentration polarization, ohmic drop, graphical presentation of kinetic data (evans diagrams), examples of applied electrochemistry to corrosion.

UNIT III: Eight forms of corrosion-recognizing corrosion, general or uniform attack, galvanic or two metal corrosion, crevice corrosion, pitting, inter-granular, selective leaching, erosion corrosion, stress corrosion, hydrogen damage.

SECTION-B

UNIT IV: Corrosion failures, factors, and cells- Introduction, information to look for, identifying the corrosion factors, examples of corrosion cells, corrosion avoidance, visualizing corrosion cells. **UNIT V:** Corrosion by water- Importance of water, corrosion and water quality and availability, types of water, cooling water systems, steam generating systems, water treatment, scaling indices.

UNIT VI: Atmospheric corrosion- Introduction, types of corrosive atmospheres, factors affecting atmospheric corrosion, measurement of atmospheric corrosivity factors, atmospheric corrosivity classification schemes, atmospheric corrosion tests, corrosion behavior and resistance.

7CT09 (i) Practicals: More than six experiments expected.

1. To measure the corrosion rate of two different metals
2. Applicability of copper corrosion test for corrosion tendency of liquid chemicals
3. Determination of corrosive tendency of light, middle distillate
4. Determination of corrosion tendency of HSD
5. Determination of corrosion tendency of lubricating oil.
6. Determination of corrosion tendency of engine oil
7. Comparative study of various petroleum and non petroleum oil for corrosion tendency.
8. Instrumental applicability for determination of corrosive components in given sample.
9. Determination of concentration effect on corrosive tendency of given sample.

Reference Books:

1. Pierre R. Roberge, Handbook of corrosion engineering, McGraw-Hill Publication.
2. Mars G. Fontana, corrosione, McGraw-Hill Book Company.
3. Pierre R. Roberge, corrosion engineering principles and practice, McGraw-Hill Publication.
4. Zaki Ahmad, principles of corrosion engineering and corrosion control, Butterworth-Heinemann Publication.
5. By Branko N. Popov, corrosion engineering: principles and solved problems, Elsevier Publication.

7CT04 PROFESSIONAL ELECTIVE-III: 2) POLYMER SCIENCE & ENGINEERING

Subject Code: 7CT04	Title: Polymer Science & Engineering	Credits = 4		
		L	T	P
Semester: VII	Total contact hours:	3	0	2

SECTION-A

UNIT I: Historical developments in polymeric materials, Basic concepts & definitions: monomer & functionality, oligomer, polymer, repeating unites, degree of polymerization, molecular weight & molecular weight distribution.

UNIT II: Natural polymers: Chemical & physical structure, properties, source, important chemical modifications, applications of polymers such as cellulose, lignin, starch, rosin, shellac, latexes, vegetable oils and gums, proteins etc.

UNIT III: Raw material for synthetic polymers: Manufacturing of various fractions of crude petroleum important for polymer industry for (a) Raw materials such as ethylene, propylene, butadiene, vinyl chloride, vinylidene dichloride, styrene, acrylic monomers like acrylic acid, acrylonitrile, methacrylic acid, methacrylates, acrylamide etc, (b) polyacids such as phthalic acid, terephthalic acid, isomers and anhydrides etc.

SECTION-B

UNIT IV: Classification of polymers thermoplastic/ thermoset, addition/ condensation, natural /synthetic, crystalline/amorphous, step growth /chain growth, specialty, homochain/heterochain, confirmation: homo & copolymers (detailed graft, block alt, ladder etc. & nomenclature), configuration cis/trans; tacticity, branched/ cross linked, classification of polymers based on end use etc.

UNIT V: Molecular weight and its distribution determination, carothers equation, states of polymers, transition temperatures such as Tg, Tc, Tm, solubility parameter, solution properties, temperature, good/ bad solvent.

UNIT VI: Addition, condensation polymerization mechanism, surface tension & contact angle measurements of different polymeric systems & their wetability with other substances.

7CT09 (ii) Practicals: More than **Six** experiments expected**.**

1. Determine the molecular weight of high polymer by Viscosity measurement
2. Preparation of Phenol-formaldehyde resin by acid catalyst.
3. Preparation of phenol formaldehyde resin by alkali catalyst.
4. Preparation of Urea-formaldehyde resin.
5. Determine the molecular weight of a given polymer by turbidimetry.
6. Preparation of Nylon.
7. Preparation of Polystyrene by free radical polymerisation.
8. Determination of melting point of plastic.
9. Determination of specific gravity of plastic.
10. Determination of acid value of plastic.
11. Identification of plastic by flame and solvent test.
12. Manufacture of product by casting (MMA/Polyester resin).
13. Manufacture of FRP sheet by hand layup method.

Recommended Books:

1. Raw Materials for Industrial Polymers by H Ulrich, Hanser Publication1989.
2. Principles of Polymer Science, by Bahadur and Sastry, Narosa Publishing House 2002.
3. Polymer Science by Gowarikar, Johan wiley and Sons 1986.
4. Encyclopedia of Polymer Science and Technology, Johan Wiley and Sons, Inc 1965.
5. Encyclopedia of Polymer Science and Engineering, Johan Wiley and Sons, Inc 1988.
6. Petrochemicals The Rise of an Industry by Peter H. Spitz, Johan Wiley and sons 1988.
7. Polymer Chemistry by Malcolm P. Stevens, Oxford University Press, Inc, 1990.
8. Text book of polymer Science, Billmeyer, John Wiley ans Sons 1984.
9. Principles of Polymer Systems, Rodriguez, Hemisphere Publishing Corpn, 1982.
10. Introduction to Polymer Science and Technology, H. S. Kaufman and J. J. Falcetta, Wiley ï Inter-science Publication, 1977
11. Polymer Science and Technology of Plastics and Rubbers, P. Ghosh.

7CT04 PROFESSIONAL ELECTIVE-III: 3) MANMADE FIBRE TECHNOLOGY

Subject Code: 7CT04	Title: Manmade Fiber Technology	Credits = 4		
		L	T	P
Semester: VII	Total contact hours:	3	0	2

SECTION-A

UNIT I: Introduction to technical textile, types of technical textiles, textiles used in industry such as filtration, filter fabric construction- woven, needle felt & knitted filter fabric, finishing treatment of filter fabric, thermal and chemical properties of filter fabric, essential requirements of good filter fabric.

UNIT II: Introduction of High performance fibres: Classification of high performance fibres, Comparison between apparel and high performance fibres, outline of characterization of high performance fibres.

UNIT III: Glass Fibres: Types and composition, manufactures processes, fibre structures, properties and applications. Poly ethylene fibres: types- HDPE, UHMWPE, mnufacturing process, properties and applications ceramic fibres: Classification and fibre formation, composition, structure, properties and application, basalt fibres.

SECTION-B

UNIT IV: Polyurethane elastomeric fibres: Manufacturing processes, fibre properties, application and future trends metallic compound fibres: Aluminium Oxide fibres and lead oxide fibres-preparation and processes, fibre structure, properties and application.

UNIT V: Chemically resistant fibres: PEEK (Polyether ether ketone fibre), PVDF and PTFE fibres, various physical and chemical fibre properties, heat and chemical resistance. Aramids & Co polyesters: fibres formation-fibre & structure properties, performance and application.

UNIT VI: Electro spun and speciality fibres: Basic concepts of electro spinning, fibers characteristics and various end applications. Photovoltaic fibres for energy harvesting, piezo electric fibres, photochromic fibres, hollow and noncircular cross section fibres.

7CT09 (iii) List of Practicals: More than **six** experiments expected**.**

1. Study of weaving preparatory and weaving processes
2. Study of loom drive, loom timing, passage of material and primary motions.
3. Study of precision winding machine
4. Study of drum winding machine.
5. Study of cheese winding machine.
6. Study of various types of yarn tensioners used in winding
7. Study of autoconer and its functions
8. Study of pirn winding machine
9. Study of sectional warping machine
10. Study of beam warping machine.

Recommended Books:

1. Tao X, Smart fibre, fabrics and clothing, Woodhead Publishing, 2001.
2. T. Hongu, P. Tatasuya, Glyn O, New fibres, (Ellis Horwood Series in Polymer Science and Technology), Ellis Horwood, New York, 1990.
3. M. Lewin. EM.Pearce, J. Preston, Hand book of fibre science and technology Vol.4, Marcel Dekkar, New York 1989.
4. Donnet J. B. Bansol R .C Carbon fibres, Marcel Dekkar, New York 1990.
5. Hearle J.W.S., High Performance Fibres, Textile Institute, Woodhead Publishing, 2001.
6. Mukhopadyay. S. K, High Performance Fibres, Textile progress Vol. 25, Textile Institute Manchester, 1993.
7. Characterization of Polymers and Fibres, 1st Edition, Authors: Mukesh Kumar Singh, Annika Singh, Woodhead Publishing, 2021.
8. Fibre Science and Technology, Akira Nakamura, Science Publishers, U.S, 2000.

7CT04 PROFESSIONAL ELECTIVE-III: (4) INDUSTRIAL WASTE TREATMENT

Subject Code: 7CT04	Title: Industrial Waste Treatment	Credits = 4		
		L	T	P
Semester: VII	Total contact hours:	3	0	2

SECTION-A

UNIT I : Environment, pollution, pollutant, Zero pollution, production waste, consumption waste, by product waste salvageable waste, types of pollution causes by wastes, greenhouse effect, Acid rains, Causes of acid rains, effects. Chloroflurocarbon, application of CFCôs in industry role of CFCôs in depletion atmospheric ozone. Other effects of air pollution. Agencies working on pollution control, their constitution, ageing of lakes and resvoirs, thermal stratification of lakes and reservoirs. Case study of wasteless processing.

UNIT II : Legislations of Environment protection, Indian standards for drinking water, effluent discharge, Indian standard codes for disposal of wastes, micro-organisms present in water, water sus-pended solids, turbidity, pH, conductivity, DO, BOD by direct method & dilution method, case sampling methods, Sampling procedures and precaution.

UNIT III: General Treatment: Screening and grease removal, Neutralization, proportioniry, chemical coagulation, sedimentation, filtration, biological treatment: Kinetics of biological growth, various suspended and attached growth processes for the treatment of industrial effluent. Advanced waste water treatment: Ion exchange, activated carbon adsorption, electro dialysis reverse osmosis.
Disinfection of Water: Sterilization and methods for disinfection. Sludge Disposal: Various alternatives for Sludge disposal.

SECTION-B

UNIT-IV : Solid waste management, land pollution, composting, land filling, incineration, types of hazardous waste, treatment of hazardous waste, sources of radioactive wastes, treatment of radioactive waste. Effects of radiations, rewashable and recyclable solid waste, recycling in chemical industries.

UNIT-V: Removal of particulate matter, comparative study of method employed e.g. cyclones, bag filters, precipitators, scrubbers, collectors etc, Pollutions control for fly ash, combustion and gasification plants. Various processes for reducing SOx, NOx emissions.

UNIT-VI: Waste management for industries like Food Industry, Dairy Industry, Sugar Mill, Fertilizer, Pulp and Paper, Sulphonic acid Cement, Tanneries, case studies and corrective measures taken in industry to prevent environmental hazards.

7CT09 (iv) Practicals: **More than six experiments expected.**

1. Determination of Sodium Hydroxide and sodium carbonate in the given alkali solution.
2. Determination of sodium bicarbonate and sodium carbonate in the given alkali solution.
3. Determination of temporary hardness of water sample by Hehnerôs method.
4. Determination of permanent hardness of water sample by alkali mixture i.e. ($NaOH + Na_2CO_3$).
5. Determination of permanent hardness of water sample by alkali mixture i.e. ($NaHCO_3 + Na_2CO_3$).
6. Determination of hardness of water sample by complexometric method using EDTA.
7. Determination of chlorine in water sample by Mohrôs method.
8. Determination of dissolved oxygen (DO) present in the water sample.
9. Determination of Chemical oxygen demand (COD) present in the water sample.
10. Determination of Biochemical oxygen demand (BOD) present in the water sample.
11. Determination of dissolved solids and suspended solids in sample (Wastewater/water)
12. To study the Turbidity of given water sample using Jackson Candle Turbidity meter.
13. To study the particulate pollution around the institute campus.
14. To determine the dose of coagulating agent for given water sample

Recommended Books:

1. Dr. S. P. Mahajan : Environmental Pollution Control.
2. Matcaff and Eddy : Wastewater Treatment.
3. Rao & Datta : Wastewater Treatment.
4. V. V. Kafaro: Waste less Chemical Processing.

7FT05: SPECIAL TECH (V) FOOD TECHNOLOGY

Subject Code: 7FT05	Title: Sp. Tech (V) Food Technology - V	Credits = 3		
		L	T	P
Semester: VII	Total contact hours:	3	0	0

SECTION A

UNIT I: Process Technology of fruits and vegetables: Pre and post-harvest changes in fruits and vegetables, storage, handing, and canning of fruits and vegetables and their products. Technology of fruits and vegetables juices, purees, concentrates, jams, jellies, marmalades, preserves fruit butters, candied fruits, pickles etc.

UNIT II: **Process Technology of meat and poultry**: Livestock and poultry preparations, slaughter, cutting dressing and grading, various cuts of meat. Post-mortem changes. Preservation and packing of meat, poultry and their products. Quality control in processed meat and poultry products, Microbiological standards. By products of meat and poultry processing industries. Process technology of eggs and their products.

UNIT III: **Process Technology of fish and other aquatic Foods**: Sources, methods offishing, handling and storage processing of fish and fish products, byproducts of fish processing. Fish oils, Standards of fish and fish products, processing of other aquatic foods like crabs, frogs, etc.

SECTION-B

UNIT IV: Process Technology of Milk and Milk products: Composition of milk, processing, storage and distribution of milk, manufacture of cream, ice cream, butter, ghee, evaporated, condensed and skimmed milk, whole and skimmed milk powder and other fermented milk products. Manufacture of cheese. Preparation of Indian milk products like khoa channa, curd and their products, Standards for milk products. Dynamic dairy technology.
Process Technology of Beverages: Carbonated beverages, fruit iuices and R.T.S. beverages, alcoholic beverages, quality control.

UNIT V: Packaging: Functions of packaging materials, rigid and flexible packages, metallic, glass and plastic containers. laminated packaging, requirement of packaging for specific products, aseptic packaging, controlled atmosphere packaging, modified atmosphere packaging. Testing of packaging materials, biodegradable packaging, label, artwork and nutrition table.

UNIT VI: Quality attributes of foods and their evaluation. Analytical methods use in food analysis flavour, aroma and texture of foods, food additives, spices and condiments. Contamination in foods. Mycotoxins.
Food adulteration and Food laws: FSSAI rule and regulations, ISI and Agmark standards, food safety, food quality control & quality assurance, HACCP, ISO 22000. Recent advances in the field.

RECOMMENDED BOOKS:

1. Preservation of Fruits and Vegetables by Girdharilal and Siddappa, G.S.Published by Indian Council and Agricultural Research (ICAR), New Delhi.
2. Fruits and Vegetable Juice Processing Technology Edited by Treassler, D.K. and Jonslyn, M.A., AVI Publishing Co., Inc. Westport, Connecticut.
3. Practical Canning by Lock A., Foods Trade Press Ltd., 7 Garrick Street, W.C.2, London.
4. The Meat Hand book by Levie A, AVI Publishing Co., Inc. Westport, Connecticut.
5. The Science of Meat and Meat Product, Edited by Price, J.F. and Schweigert, B.S: W.H. Freeman and Company, San Francisco.
6. Poultry Products. Technology by Mountney, G J., AVI Publishing Co., Inc. Westport, Connecticut.
7. Fishery By-products Technology by Brody, J., AVI Publishing Co., Inc. Westport, Connecticut.
8. Fish and Food Vols. I,II,III & IV Edited by Brog traom. G. : Academic Press, New York and London.
9. Processed Cheese Manufacture by Dr. Meyer A.: Food Trade Press, London.
10. Drying of Milk and Milk Products by Hall. C. W. and Hendrick, T. I.: AVI Publishing Co., Inc. Westport, Connecticut.
11. Modern Dairy Products by Lampert, I. M.: Eurasia Publishing House, (P) (Ltd.), Ram Nagar, New Delhi.
12. By products from Milk by Webb, B. H. and Whittier, E.O.,: A VI Publishing Co., Inc. Westport, Connecticut.
13. The Chemistry and Testing of Dairy Products by New Lander, J. H. and Atherton, H. V. : Olsen Publishing Co., Milwakee Wisconsis.
14. Food Adulteration by Jacob, T.: Mc-Millan & Co. of India, Ltd.
15. The Spice Handbook of Parry, J. W.: Chemical Publishing Co., New York.
16. Meat Technology by Gerrard F.: Deonord Hill, London.
17. Radiation Technology by Desrosier, N. W.: AVI, Publishing Co., INC, (1960)
18. Symposium: Processing Agricultural and Municipal Wastes, Editedby Inglett, C.E.: AVI Publishing Co., Inc.
19. Introduction of Waste Water Treatment Processes by Ramalho, R. S.: Academic Press, New York.
20. Processed Plant Protein Food Stuffs, Edited by Aultschul, A. M.: Academic Press, London.
21. Chemistry of Food Packaging by Swalam, C.M.: American Chemical Society, Washington D.C.
22. Packaging by Newbaner, R.G.: Van Nostrand, Reinhold Co., New York.

7PT05: SPECIAL TECH. (V) PULP AND PAPER TECHNOLOGY

Subject Code: 7PT05	Title: Sp. Tech (V) Pulp & Paper Technology	Credits = 3		
		L	T	P
Semester: VII	Total contact hours:	3	0	0

SECTION-A

UNIT I: Paper and paper board manufacture: Introduction auxiliary equipments, centricleaners, Sand traps, centrifugal separators and various screens.

UNIT II: Paper making machines: Fourdrinier machine, history and development of fourdrinier, modern fourdrinier machine approach flow system, head box slice, types of slices, drainage and formation on fourdrinier machine.

UNIT III: Advanced twin wire former, multi wire former and use of wet end chemistry in paper machine wet end.

SECTION-B

UNIT IV: Cylinder mold machine: Introduction, history of cylinder machine, vat, stock entries, and couch press, modern formers, cylinder machine felts.

UNIT V: Pick-up and press section: Suction picks-up, open draw and no draw, pressing theory, felts press section arrangements, suction rolls, crowning of press roll, swimming roll, modern press, extended nip press.

UNIT VI: Dryer section: Function of dryer section, theories of drying, cylinder drying, air drying, radiant drying, auxilliary equipment, operations and control, performance calculations. Cost and economics. Recent advances in the field.

BOOKS RECOMMENDED:

1. Advances in papermaking wet end chemistry application technologies, by Martin A. Hubbe and Scott Rosencrance
2. Paper and board grades, volume 18, by Hannu Paulapuro
3. Pulp and Paper Manufacture, 2nd edn., VoI.II, by B.Mac. Donald, Mc Graw-Hill.
4. Pulp and Paper Science & Technology Vol. I & II by C. E. Libby
5. Pulp & Paper Manufacture Vol. I, II, III by Mac Donald
6. Hand Book of Pulp and Paper Technology by K.W. Britt 2nd edition.

7OT05: SPECIAL TECH (V) OIL AND PAINT TECHNOLOGY

Subject Code: 7OT05	Title: Sp. Tech (V) Oil & Paint Technology	Credits = 3		
		L	T	P
Semester: VII	Total contact hours:	3	0	0

(TECHNOLOGY OF SURFACE COATINGS)

SECTION-A

UNIT I: Convertible and non-convertible coatings: Chemical nature of coatings and their properties. Various coating technology in Auto industries like CED, TOPCOAT, 3C1B, 3C2B etc.

UNIT II: Natural resins. Chemistry of drying, Semi-drying and non-drying oils, Chemistry and mechanism of heat and drying.

UNIT III: Manufacture of synthetic drying oils, Processes and Plants employed in refining of drying oils. Their manufacture and properties, solvents, diluents and thinners:

SECTION-B

UNIT IV: Chemistry and technology of synthetic resins.

UNIT V: Pigment and extenders: Pigmentary properties and evaluation of pigments. General outlines of the methods of the manufacture of pigments. Properties and uses of important pigments. Organic pigments and colors.
Color measurement through spectrophotometer considering LAB value, color theory munsell color system. Brief account of primary secondary color.

UNIT VI: Formulation of paints: Printing inks, lacquers, varnishes and. Methods of manufacture of paints, printing inks, and lacquers, I.S.1. Methods for evaluation of paints and printing inks. Application of paint through six axis robot and defects. Paint output parameter testing like gloss, DOI and brief about wave scan (appearance of coating) Recent advances in the field.

RECOMMENDED BOOKS:

1. Outline of Paint Tech: H. Hea
2. Organic Coating Tech.: H. R. Payne
3. Introduction to Drying Oil Tech.: A. R. MiIls
4. Paint and Varnish Manufacture: H. W. Chatfiels
5. Treatise on Coatings: Myas and Long.
6. Printing Inks: C.Ellis, Rainhold PbI., New York.
7. Nitrocellulose Ester Leaquers: F. Zimmer
8. Paint Film Defects: M. Hers
9. Paint and Varnishes: A. S. Khanna
10. O.C.C.I. Paint Technology Manual (5 Volumes)
11. Tech. of Writing and Printing Inks, Small Business Publ.

7PC05: SPECIAL TECH (V) PETROCHEMICAL TECHNOLOGY

Subject Code: 7PC05	Title: Sp. Tech (V) Petrochemical Technology	Credits = 3		
		L	T	P
Semester: VII	Total contact hours:	3	0	0

(PETROCHEMICAL INDUSTRY)

Course Objectives:

1. To know the importance of petrochemical industry.
2. To learn the brief knowledge of petrochemicals.
3. To learn the synthesis of various petrochemicals.
4. To know the applications of various petrochemicals.

Course Outcomes:

1. Students know about feed for petrochemical, impurities in it and techniques to deal with impurities.
2. Subject enriched the students about stochiometry reactions, mechanism and process flow involved.
3. Students know about various routes for synthesis of petrochemicals, economics and future trends.
4. Able to obtain optimum operating conditions.
5. Subject enriched the students about petrochemical processing, principles involved, engineering problems encountered and their solutions.

A state of the art account typically of the following with emphasis in increasing order of depth, wherever possible on (1) routes possible, (2) Stochiometry reaction, mechanism and flow sheet, (3) history, economics and future trends, (4) qualitative discussion of physic-chemical and chemical engineering principles involved and engineering problems encountered in the more favored route.

SECTION-A

UNIT I: Source materials for manufacture of chemicals from hydrocarbons, impurities in source materials and their removal, classification of petrochemicals, separation of individual constituents and mixture in brief.

UNIT II: Synthesis of major olefin building block, ethylene, propylene, butenes, etc. Details of steam cracking, future of ethylene production. Production of acetylene, petroleum and non-petroleum routes and its techno economical details, limitation of acetylene as feedstock.

UNIT III: Synthesis of commercial aromatics, BTX, details of chemical engineering principle involved in their separation, production of synthesis gas, its utility, various routes with its details, oxosynthesis.

SECTION-B

UNIT IV: Derivatives of methane, ethane, propane, butane, synthesis of methanol, formaldehyde, acetaldehyde, acetic acid, ethyl alcohol, halides of methane, halides of ethane, methyl amines, carbon disulphide, ethylene oxides, phenol, aniline, butadiene, ethyl oxides, ethyl benzene, etc. with their applications in various fields.

UNIT V: Synthesis of monomer, caprolactum, hexamethylene diamine, VCM, VAM, phthalic anhydride, acrylonitrile, Bisphenol A, styrene, isoprene, chloroprene, engineering plastics, Teflon, synthetic detergent, resin, explosive, synthetic rubber, raw material for synthetic rubber.

UNIT VI: Energy crises and petrochemical industry, impact of heavy feedstock on petrochemicals, ecology and energy crises, coal as an alternative to oil, natural fuels, synthetic fuels, applicability of saturate hydrocarbons for chemical synthesis, fuel for tomorrow.
Hydrogen, bio-fuels, bio-methane, bio-ethanol, biodiesel synthesis, characterization and application of bio-fuels, future trends in petrochemical industry.

RECOMMENDED BOOKS:

1. R. N. Shreve, J. A. Brink : Chemical Process Industries, 4th edition, Mc Graw Hill, Kogakusha.
2. J. A. Kent : Riegalôs Handbook of Industrial Chemistry, 7th ed., Van. Nostrand Reinhold Co.
3. Robert A. Meyers, Handbook of Petrochemicals Production Processes, McGraw Hill.
4. N. N. Lebedev, Chemistry and Technology of Basic Organic and Petrochemical Synthesis, Volume I and II, Mir Publication.
5. James G. Speight, óThe Chemistry and Technology of Petroleumô, CRC Press.
6. G. A. Purdy, óPetroleum Prehistoric to Petrochemicalsô, McGraw Hill Book Company Inc.
7. S. A. Miller: Acetylene, Vols. I & II, Ernest Benn. Publisher U.K.
8. S. A. Miller: Ethylene and its Industrial Derivatives, Ernest Benn., Publisher U.K.
9. E. G. Nancock: Propylene and its Derivatives, Ernest, Bean, Publisher U.K.
10. E. G. Nancock: Benzene and its Derivatives, Ernest Bean, Publisher U.K.
11. S. B. Chandlia: Oxidation of Hydrocarbons, Sevak Publication.
12. T. Dumas, W. Bulani: Oxidation of Petrochemicals, Chemistry and Technology, Applied Science.
13. R. Long: Production of Polymer and Plastic Intermediates from Petroleum, Butterworths.
14. Articles in Hydrocarbon Processing, Chemical Engineer, Oil and Gas Journal etc. as recommended during the academic session.

07CT 10 PROJECT & SEMINAR

SEMINAR:

Each one of the students will be assigned a Seminar Topic in the current and frontier areas. The student has to conduct a detailed study/ survey on the assigned topic and prepare a report. The student will make an oral presentation followed by a brief question and answer session. The Seminar (presentation and report) will be evaluated by an internal assessment committee for 50 marks. The Seminar Report will be evaluated by external examiner appointed by the University along with the Project - Viva Voce examination at the end of VIII Semester.

PROJECT:

The objective of the project is to enable the students to work in groups of not more than four members in each group on a project involving analytical, experimental , design or combination of these in the area of Chemical Engineering. Each project shall have a guide. The student is required to do literature survey, formulate the problem and form a methodology of arriving at the solution of the problem. On completion of the work, a project report should be prepared and submitted to the department.

The evaluation is based on continuous internal assessment by an internal assessment committee for 75 marks by way of oral presentations. The university examination at the end of VIII Semester carries 75 marks will be a Viva Voce examination conducted by a committee of one external examiner appointed by the University and one internal examiner/Guide.

8FT01: SPECIAL TECH (VI) FOOD TECHNOLOGY

Subject Code: 8FT01	Title: Sp. Tech (VI) Food Technology	Credits = 5		
		L	T	P
Semester: VIII	Total contact hours:	3	0	4

SECTION-A

UNIT I: Biochemical engineering and fermentation Technology: Metabolic pathways of micro organisms. Parameters for growth, energy, carbon and nitrogen. Sources requirements and biomass, estimation, surface, submergedand solid-state cultures. Kinetics of growth and structured growth models. Measurement of dissolved oxygen, mass transfer coefficient.

UNIT II: Effect of aeration and agitation, Kinetics of substrate utilization. Product yield and biomass production, batch, plug flow and chemostat cultures, Scale up in fermenter design. Types of fermenters. Design and operation of fermentation equipment.

UNIT III: Methods of aeration, agitation and sterilization. Control of contamination in fermenters. Antifoam devices, auxiliary equipment and instrumentation, Product recovery.

SECTION-B

UNIT IV: Fermentation technology of alcohol, alcoholic beverages, vitamins, antibiotics, vinegar, organic acids such as citric acid, lactic acid, solvents. Single cell protein, enzymes and othermiscellaneous products. Cultivation of algae, mushrooms and the starter culture.

UNIT V: Immobilised enzymes, methods of immobilization, properties an application of immobilized enzymes. Reactor design for immobilised enzyme Systems.

UNIT VI: Waste water treatment & water recycling, new special in fermentation technology.

8FT05: SPECIAL TECH. (VI) FOOD TECHNOLOGY - PRACTICALS

More than six experiments expected.

1. Preparation of fruit juices, squash, concentrate.
2. Preparation of jam, jellies, pickles etc.
3. Canning of fruits and vegetables and their evaluation.
4. Processing of meat, fish.
5. Preparation dairy products such as butter, cheese, ice cream.
6. Dehydration of fruits and vegetables and their evaluation.
7. Preparation of bakery products like bread, biscuits, cakes, crackers etc.
8. Preparation and evaluation of confectionery products like hard and soft boiled candies.
9. Preparation of fruit candies and chikkies
10. Preparation of beverages.
11. Evaluation of Michaelis - Menten constant.
12. Determination of BOD, COD and dissolved oxygen by chemical and instrumental methods.
13. Production, recovery and control tests of the fermentation products like alcohols.
14. Production, recovery and control tests organic acids, enzymes.

BOOKS RECOMMENDED:

1. Biochemical Engineering Fundamentals by Bailey, lame, E.: McGraw HiII Book Co.
2. Advances in Biochemical Engineering. Vols. 1 to 6 Edited by Bhose, T.K. and Ficchter, A : Springer Vorlag, Berlin, L Lcidelberg New York.
3. Biochemical and Biochemical Engineering, Science Vols. 1 to 2 Edited by Blakebrough : Academic Press, London and New York.

4. Industrial Fermentation, Vols. 1 & 2 By Under Kofler, L.A.: Chemical Publishing Co., INC, 212, Fifth Avenue, New York.
5. Immobilized Enzymes, Antigens, Antibodies and Peptides, Vols. 1& 2, 3 & 4 Edited by Weetal, H.H.: Marcel Decker, INC New York.
6. Industrial Microbiology by Presscot and Dunn: McGraw Hill Book Co., INC, New York.
7. Industrial Microbiology by Casida, L.E.: John Wiley and Sons, INC, New York.

8PT01: SPECIAL TECH. (VI) PULP & PAPER TECHNOLOGY

Subject Code: 8PT01	Title: Sp. Tech (VI) Pulp & Paper Technology	Credits = 5		
		L	T	P
Semester: VIII	Total contact hours:	3	0	4

[PULP AND PAPER TECHNOLOGY PROPERTIES AND TESTING OF PAPERS AND POLLUTION CONTROL]

SECTION-A

UNIT I: Finishing of paper and board: Operation and benefits of calendering, reeling and wrapping, winders, super calendaring, embossing, cutting of paper, packing of paper in ream and sheet form, dispatch of paper.

UNIT II: Surface treatment of paper and board: Definitions, objectives, general approaches, typical surface treatment processes- coating and surface sizing, factors controlling surface sizing, different types of sizing chemicals used, equipment used for application of surface sizing and coating on paper, preparation of coating colour, adhesives used for coating.

UNIT III: Manufacturing of insulating boards, hard boards, and particle board, raw material used, processing of different pulps, forming machines, and finishing of boards.

SECTION-B

UNIT IV: Energy conservation: Strategies to follow for conserving energy in digester, bleach plant, chemical recovery, boiler, stock preparation and in paper machine.

UNIT V: Analysis and testing: Introduction, test facilities, equipment, BIS, TAPPI and ISO standards used in analysis and testing, testing of pulp, wood, paper and converted products.

UNIT VI: Rag processing, manufacturing of hand made papers, and manufacturing and properties of speciality papers.

8PT05: SPECIAL TECH (VI) PULP & PAPER TECHNOLOGY PRACTICALS:

More than **six** experiments expected:

1. To find out basis weight of paper(gm/m^2)
2. To determine caliper of paper(Thickness)
3. To determine bulk of paper(Cobb value)
4. To determine folding endurance of paper.
5. To determine brightness and opacity of paper.
6. To determine tearing resistance of paper.
7. To determine bursting strength of paper.
8. Manufacturing of handmade paper.
9. Preparation of various GSM paper from semi automatic sheet former.

RECOMMENDED BOOKS:

1. Pulp and Paper Manufacture, 2nd Ed. Vol-II. by B. MacDonald, McGraw Hill
2. Winding machine mechanics and measurements by Dr. David Roisum and Dr. James K. Good
3. Pulp and Paper Science & Technology Vol. I & II by C. E. Libby
4. Hand Book of Pulp and Paper Technology by K.W. Britt 2nd edition.

8OT01: SPECIAL TECH (VI) OIL & PAINT TECHNOLOGY

Subject Code: 8OT01	Title: Sp. Tech (VI) Oil & Paint Technology	Credits = 5		
		L	T	P
Semester: VIII	Total contact hours:	3	0	4

[Technology of Waxes, Cosmetics and other Fat Based Products]

SECTION-A

UNIT I: Waxes: Natural sources classification, chemical composition, extraction refining and processing of waxes, their modification and formulation, synthetic waxes, properties.

UNIT II: Cosmetics: Classification, manufacture and evaluation of cosmetic, preparation such as shampoos, shaving creams, lotions, toileteries and perfumery materials.

UNIT III: Other fat based products: Manufacture and utilization of nitrogen, phosphorous and sulphur containing compounds.

SECTION-B

UNIT IV: Fatty acids: Theory and practice of fat splitting and purification of products, separation of fats and fatty acids and their applications in foods, pharmaceuticals, textile, plastics, leather and other industries. Recent development in the field.

UNIT V: Utilization, testing and evaluation of waxes, testing of cosmetic products, plasticizers and products obtained by inter exterification hydrogenation, oxidation and pyrolysis.

UNIT VI: Recent development in the field.

8OT05 SPECIAL TECH. (VI) OIL & PAINT TECHNOLOGY PRACTICALS:

1. Analysis of butter, ghee, margarine, vanaspati, soap stock, sulphonated and oil spent lyes.
2. Commercial fatty acids and glycerin. Evaluations of detergents.
3. Analysis of Cosmetics products.
4. Analysis of mixture of oils and fats.
5. Analysis of bye products and wastes obtained from oil & allied industries.
6. Preparation and, analysis of some industrially important fatty acids..
7. Analysis of natural & Synthetic Pigments
8. Analysis of raw materials for Paints & Paint products.

RECOMMENDED BOOKS:

1. The Chemistry and Technology of Waxes: A.H. Warth
2. Industrial Waxes: H.Benet (2 Volumes)
3. Fatty Acids and their Industrial Applications: E. S. Pattison
4. Industrial Oil and Fat Products: A. E. Bailey
5. Industrial Chemistry of Fats and Waxes: T. P. Hilditech.
6. Cosmetics Science and Tech.: W. Saggarin
7. Perfumes, Cosmetics and Soaps: W. A. Poucher (Vol.-I ,II, III)
8. Chemistry and Biochemistry of Natural Waxes: P. E. Kolattukudy.
9. Basics of Paint Technology, Part-I, V. C. Malshe, Meenal Sikchi, ICT, Mumbai.

8PC01: SPECIAL TECH (VI) PETROCHEMICAL TECHNOLOGY

Subject Code: 8PC01	Title: Sp. Tech (VI) Petrochemical Technology	Credits = 5		
		L	T	P
Semester: VIII	Total contact hours:	3	0	4

[PETROCHEMICAL ENGINEERING PROCESS ANALYSIS]

Course Objectives:

1. To know the importance of petroleum and petrochemical refining processes.
2. To learn basic principles and applied knowledge of petrochemical process analysis.
3. To learn the stochiometry reaction schemes, mechanism and its importance.
4. To learn mathematical equations for process analysis.

Course Outcomes:

1. Subject enriched the students about type of process, various operating parameters, chemical engineering principles involved, engineering problems encountered in the more favorable routes with their solutions.
2. Able to obtain optimum operating conditions.
3. Able to determine the óKô values for various processes.
4. Able to know the kinetics of reversible and irreversible exothermic reactions.
5. Students able to carry out material balance and mathematical modeling of process.
6. Able to carry out the qualitative discussion of physico-chemical processes.

SECTION-A

UNIT I: Irreversible exothermic catalytic reaction, comparative data of IECR carried in petrochemical industry, reactors for IECR, kinetic approach, simplification of reaction scheme, mechanism for heat control, factors influencing the operating conditions, finding optimum operating conditions. Mathematical modeling and its details, use of mathematical modeling for finding operating conditions, etc. Oxidation of naphthalene to phthalic anhydride, kinetics, thermodynamics, simple and complex model, fluidized bed versus fixed bed operations.

UNIT II: Reversible exothermic reaction, comparative data of RER carried in petrochemical industry, their important features, kinetic approach, effect of temperature, time on yield, optimization of reaction rate, flow pattern in various reactors, manufacture of ammonia, type of commercial reactors used for ammonia synthesis, kinetics and thermodynamics of ammonia formation, optimum temperature profile achieved in industrial reactors.

UNIT III: Steam cracking of hydrocarbons and petroleum fractions for production of olefins, aim, mechanism, technique uses, process conditions, reactors used, effect of various parameters like hydrocarbon to steam ratio, partial pressure of steam, nature of feedstock, temperature and residence time etc. on conversion.
Equations and relations for adiabatic conditions, isothermal conditions and its applications for calculations, acetylene manufacture and its kinetics.

SECTION-B

UNIT IV: Coal gasification, comparative data of various technology, steam reforming engineering aspects of steam reforming, reactivity of hydrocarbon, steam to hydrocarbon ratio, kinetics and thermodynamics, determination of equilibrium constant, shift reaction, kinetic relations for shift reaction, calculating steam required in shift reaction, material balance across shift converter, multistage shift converter.

UNIT V: Case study of physical process, adsorption isotherm, heat effect in adsorption, steady state and unsteady state adsorption, adsorption techniques, structure of adsorbent, regeneration of adsorbent, hypersorption, fluid char adsorption, cyclic adsorption, application of adsorption for natural gas processing in detail. For example, drying of natural gas, recovery of heavier hydrocarbon from natural gas, desulfurization of natural gas etc. as a complete case study with traditional and commercial routes and its comparison.

UNIT VI: Distillations and its applications, principles of working of following types:
Batch, continuous, primary, stabilization, re-run, vacuum, steam stripping, molecular, per fractionation, azeotropic, extractive. Discussion of above distillation type in petroleum refining and petrochemical industry with chemical engineering principles and engineering problem encountered. Catalyst in petroleum refining and petrochemical process, homogeneous and heterogeneous catalysis, catalyst morphology and activity, catalyst in hydrocarbon oxidation, polymerization, recent advances in industrial catalysis, role of polymers in catalysis.

Note: The paper is taught with necessary mathematical treatment and numerical problems illustrating the physico-chemical and chemical engineering principles, process equipment design, etc.
Topic to be covered with material balance across various units.

8PC05: SPECIAL TECH. (VI) PETROCHEMICAL TECHNOLOGY: PRACTICALS:

More than **six** experiments expected.

Petroleum Refining and Processing:

1. Study of various distillation unit with respect to simple, ASTM, vacuum and its comparative study.
2. TBP distillation of petroleum fraction, construction of property, midpercent, residue yield, distillate yield curve, verification of ASTM, TBP, EFV correlations.
3. Study of spray (bubble column), packed column, York Schibles (mixer settler) for extraction of acid from petroleum fractions into water, determination of efficiency, comparative study.
4. Break through phenomenon in adsorption, characterization curve.
5. Use of modern devices for petroleum and petrochemical analysis like Brookfield viscometer, Karl-Fisher autotitrator, UV spectrophotometer, ultrasonic interferometer, etc.

RECOMMENDED BOOKS:

1. Petroleum Processing Handbook, edited by John J. Meketta, Marcel Dekker Inc.
2. Robert A. Meyers, Handbook of Petroleum Refining Processes, McGraw Hill.
3. Richard A. Dawe, Modern Petroleum Technology, Volume II, Institute of Petroleum.
4. J. H. Gary, G. E. Handnert, Petroleum Refining Technology and Economics, Marcel Dekker Inc.
5. J. M. Smith: Chemical Engineering Kinetics. 2nd Edn. McGraw Hill.
6. C. G. Hill. Jr.: An Introduction to Chemical Engineering and Kinetics and Reactor Design. John Wiley.
7. J. J. Carbery: Chemical and Catalytic Reaction Engineering. McGraw Hill.
8. R. Cooper and G. V. Jeffreys L.: Chemical Kinetics and Reactor Design Oliver and Boyd. Edinburgh.
9. O. A. Houghen and K. M. Watson : Chemical Process Principles Part -III Kinetics and Catalyst, John Wiley.
10. J. A. Kent: Riegalõs Handbook of Industrial Chemistry, 7th ed., Van. Nostrand Reinhold Co., 1974.
11. N. N. Lebedev, Chemistry and Technology of Basic Organic and Petrochemical Synthesis, Volume I and II, Mir Publication.
12. S. A. Miller: Acetylene, Vols. I & II, Ernest Benn. Publisher U.K.
13. S. A. Miller: Ethylene and its Industrial Derivatives, Ernest Benn., Publisher U.K.
14. S. B. Chandlia: Oxidation of Hydrocarbons, Sevak Publication.
15. T. Dumas, W. Bulani: Oxidation of Petrochemicals, Chemistry and Technology, Applied Science.
16. Articles in Hydrocarbon Processing, Chemical Engineer, Oil and Gas Journal Etc. as recommended during the academic session.

8CT02: CHEMICAL REACTION ENGINEERING II

Subject Code: 8CT02	Title: Chemical Reaction Engineering II	Credits = 3		
		L	T	P
Semester: VIII	Total contact hours:	3	0	0

Course Objectives:

1. Student will understand the rate equation of Homogeneous reaction.
2. Students will understand the reactor design of heterogeneous system.

Course Outcomes:

After successful completion of this course student will be able to

1. Understand the basic aspects of non ideal flow
2. Determine the conversion in a non-ideal reactor using tracer information.
3. Develop the rate equation for heterogeneous reaction.
4. Design the reactor for fluid-fluid reactions
5. Design the reactor for fluid particle reaction
6. Design reactors for solid catalyzed reactions

SECTION-A

UNIT I: Residence time distribution. Models for non-ideal flow. Residence time distribution, single parameter model; non-isothermal reactors;

UNIT II: Mixing concept and models: Rate equation for heterogeneous reactions, fluid particle reactions. Determination of rate controlling step. Application to design, kinetics of enzyme reactions (Michaelis-Menten and Monod models), non-ideal reactors, kinetics of heterogeneous catalytic reactions; diffusion effects in catalysis; rate and performance equations for catalyst deactivation.

UNIT III: Fluid-Fluid reaction: Rate equation for different cases and application to design. Eight design.

SECTION-B

UNIT IV: Heterogeneous processes, catalysis and adsorption determination of surface area, void volume, pore volume distribution catalyst preparation, promoters and inhibition of catalyst reactivation.

UNIT V: Rate equation for third solid catalytic, reactions. Internal external transport process in heterogeneous reactions.

UNIT VI: Design of Heterogeneous catalytic reactors, fixed broad reactors, isothermal & adiabatic fixed bed reactor, non-isothermal & non-adiabatic fixed bed rector, fludized bed, trickle bed, slurry reactor.

BOOKS RECOMMENDED:

1. Chemical Reaction Engineering: Octove Levelspiel, 3rd Edn. J. Wiley Eastern Ltd.
2. Chemical Engineering Kinetics: Smith J.M., Mc Graw Hill, 3rd Edn. 1990.
3. Elements of Chemical Reaction Engineering: H. Scott Fogler, Prentice Hall 2016.
4. Chemical Reactor Analysis & Design : Gilberth F. Froment & Kenneth B. Bischoof, John Wiley & Sons.
5. Chemical Reactor Design: Vol I & II: M W.Rase
6. Chemical Kinetics: Keith J. Laidler, 3rd Edition, Pearson 2013.

8CT03: PLANT DESIGN AND PROJECT ENGINEERING

Subject Code: 8CT03	Title: Plant Design & Project Engineering	Credits = 3		
		L	T	P
Semester: VIII	Total contact hours:	3	0	0

SECTION-A

UNIT I : Project identification, Preliminary techno economic feasibility, Process design aspects selection of process, factors affecting process selection, importance of laboratory development pilot plant, scale up methods, safety factors, Types of flow diagrams.

UNIT II : Detection of process equipmentôs-standard *vs* special equipment, materials of construction for process equipmentôs, selection criteria, specification sheets.

UNIT III: Process auxiliaries - piping design, layout, supports for valves, process control & instrumentation control system design. Process utilities-process water, boiler feed water, water treatment, waste treatment & disposal, oils heating systems, chilling plant, compressed air & vacuum. Plant location & layout-Factors affecting both planning of layout. principles of plant layout, use of scale methods.

SECTION-B

UNIT IV: Cost estimation - factors involved in project cost estimation. Total capital investment, fixed capital & working capital. Methods of estimation of investment, estimation of equipment cost production factors, estimation of total product cost - factors involved in estimating. Depreciation - types of methods of depreciation, evaluation of depreciation methods.

UNIT V: Applied process design of fluid flow and ejectors, process planning, scheduling, flowsheet design, process safety and pressure-relieving devices.

UNIT VI: Economic considerations in process & equipment design, inventory control, scheduling a project using CPM/PERT methods, project management. Option design, general production rates in plant operation. Optimum conditions, optimum production rates in plant operation, optimum conditions in cyclic operation.

Recommended Books:

1. Plant Design & Economics for Chemical Engineering By M.S. Peters & K. D. Timmerhaus, McGraw Hill (Japan), 2nd Edition.
2. Applied Process Design for Chemical and Petrochemical plants, Ernest E. Ludwig, Gulf Professional Publishing (Volume 1).
3. Chemical Engg. Plant Design: F. C. Vibradant & C. E. Dryden, McGraw Hill (New York).

8CT04: PROFESSIONAL ELECTIVE-IV: (i) BIOCHEMICAL ENGINEERING

Subject Code: 8CT04	Title: Biochemical Engineering	Credits = 3		
		L	T	P
Semester: VIII	Total contact hours:	3	0	0

SECTION-A

UNIT I: Introduction: Biochemical Engineering- Interaction of two disciplines, comparison of chemical and biochemical process, role of biochemical engineers in development of modern formation industry, future development, applications of engineering advances.

UNIT II: Kinetics of enzyme catalyzed reactions: Simple enzyme kinetics with one and two substrates, determination of elementary step rate constant, substrate activation and inhabitation, multiple substrate, modulation and regulation of enzyme activity, enzyme deactivation, effect of pH, temperature, inhibitors on enzyme activity.

UNIT III: Design and analysis of biological reactors: Ideal bioreactors, reactor dynamics, microbial dynamics in chemostat culture, mass balance in a series vessel, mass balance with recycle, comparison between batch and continuous cultivation, sterilization reactors, animal and plant cell reactor technology, examples of design calculations, design and construction of fermenter, multiphase reactors.

SECTION-B

UNIT IV: Kinetics of substrate utilization: Ideal reactors for kinetics measurement, kinetics of balanced growth, transient growth kinetics, structured kinetics model, product formation kinetics.

UNIT V: Transport phenomena in microbial systems: Gas liquid mass transfer in cellular system, determination of OTR, mass transfer freely rising or falling bodies, forced convection mass transfer, estimation of overall kla, heat transfer correlation, mass transfer and microbial respiration, theories of diffusional mass transfer.

UNIT VI: Translation of laboratory culture results to plant operations, scale down, data translation, performance of shaker flask, fermentation technology, design and operation of typical aseptic, aerobial fermentation process.

Recommonded Books:

1. J.E. Bailley and D.F.Olis: Bio-chemical Engineering Fundamentals, McGraw Hill, New York, 1977.
2. S.Aiba, A.E. Humphrey and N.R. MHH:Bio-chemical Engineering, 2nd ed. Academic Press, 1973.
3. F.C. Web: Biochemical Engineering, Van Nostrand, 1964.
4. B. Atkinson: Biochemical Reactors, Plon Ltd., 1974.
5. Desai A.V.:Bio-energy, Willey Eastern Ltd. New Delhi, 1990.
6. Lehninger A.L.:Bio-Chemistry, Worth Publication, Inc., New York, 1972.
7. Bungay H.R.,Belfort G.: Advanced Bio-chemical Engineering, John Willey & Sons, New York, 1987.

8CT04: PROFESSIONAL ELECTIVE-IV: (ii) PETROLEUM PROCESSING ENGINEERING

Subject Code: 8CT04	Title: Petroleum Processing Engineering	Credits = 3		
		L	T	P
Semester: VIII	Total contact hours:	3	0	0

SECTION-A

UNIT I: Petroleum exploration production and refining of crude oils: Chemistry and composition (characteristics and constituents of crude oils, classification of crude oils).

UNIT II: Quality control of petroleum products classification of laboratory tests, distillation, vapour pressure, flash and fire points, octane number, performance number, cetane number, aniline point, viscosity index, calorific value, smoke point, char value, viscosity, viscosity index, penetration tests, cloud and pour points, drop point of grease, melting and settling points of wax, softening point of Bitumen, induction period of gasoline, thermal stability of jet fuels, gum content, total sulphur, acidity and alkalinity, copper strip corrosion test, Silver strip corrosion test for ATF, ash, carbon residue (Conradson method, Ramsbottom method) colour, density and specific gravity, Refractive index of hydrocarbon liquids, water separation index (modified) (WSIM), ductility.

UNIT III: Petroleum products: Composition, properties & specification of LPG, Naphthas, motor spirit, Kerosine, Aviation turbine fuels, Diesel fuels, Fuel oils, Petroleum hydrocarbon solvents, lubricating oils (automotive engine oils, industrial lubricating oils electrical insulating oils, Jute batching oils, white oils, steam turbine oils, metal working oils, etc.) petroleum waxes Bitumens, petroleum coke.

Crude oil distillation: Desalting of crude oils, atmospheric distillation of crude oil, vacuum distillation of atmospheric residue, thermal conversion process: thermal cracking reactions, thermal cracking, visbreaking, (conventional visbreaking and soaker visbreaking) coking (delayed coking, fluid coking, flexicoking), calcination of Green coke.

SECTION-B

UNIT IV: Catalytic conversion process fluid catalytic cracking; catalytic reforming; hydro cracking catalytic alkylation, catalytic isomerization; catalytic polymerization.

UNIT V: Finishing process hydrogen sulphide removal processes; sulphur conversion processes; sweetening processes (Caustic treatment, Solutizer process; Doctor treating process; Copper chloride sweetening; Hypochlorite sweetening ;Air and inhibitor treating process; Merox processes; Sulphuric acid treatment; Clay treatment); solvent extraction processes (Edeleanu process, Udex process, Sulfolane process), hydro treating processes.

UNIT VI: Lube oil manufacturing process evaluation of crude oils for lube oil base stocks, vacuum distillation, solvent deasphalting solvent extraction of lube oil fractions (Furfural, NMP and Phenol), solvent dewaxing, hydrofinshing, Manufacture of petroleum waxes (wax sweating, solvent deoiling) Manufacture of Bitumenôs selection of crude oil, methods of manufacture of bitumenôs, (distillation, solvent precipitation, air blowing).

RECOMMENDED BOOKS:

1. Nelson, W.L., Petroleum Refining Engineering, McGraw Hill.
2. Mall, ID, Petrochemical Process Technology, McMillan India.

Reference Book: Sarkar, G.N., Advance Petroleum Refining, Oscar Publication.

8CT04: PROFESSIONAL ELECTIVE-IV: (iii) FUEL TECHNOLOGY

Subject Code: 8CT04	Title: Fuel Technology	Credits = 3		
		L	T	P
Semester: VIII	Total contact hours:	3	0	0

SECTION -A

UNIT I: Comparison of various sources of energy. Alternatives to non-renewal sources. Characteristics and distribution, production and total deposits of coal and petroleum in India. Classification of fuels, classification of Coal, formation of Coal (colification process).

UNIT II: Analysis of coal, proximate and ultimate analysis. Significance of analysis. Rank of coal relation with moisture, ash, volatile matter. Reporting of coal analysis. Significance, composition of ash and mineral matter. Properties and testing of coal, calorific value (Gross and net), Bob calorimeter, Boy's gas calorimeter, weathenng index, swelling index, craking index. Grindability Index, specific gravity. Theoretical computations of calorific value.

UNIT III: Testing of oils, viscosity, flash point, pour point, aniline point, carbon residue, diesel index, octane and cetane number moisture content. Preparation of raw of mine coal, washing of coal, washability curves, methods of coal washing, coal washeries in India, Gravity seperation, float and sink rest efficiency of coal washing.

SECTION-B

UNIT-IV: Carbonisation, physical and chemical changes, high and low temperature carbonisation. Modern developments in design of coke ovens. Recovery of by products, Tar distillation. Blending of coals. Fuel economy in steel plants. Properties of metallurgical coke. Straight run distillation of crude oil Thermal transfer and catalytic cracking. Polymerisation alkylation.

UNIT-V: General principles of combustion. Combustion of grates, mechanical stokers, combustion of pulverised coal, Suspenaed bed and fluridised bed combustion. Problems in combustion based on mass and heat transfer with chemical reaction.

UNIT-VI: Gasification of coal, first and second generation gasifiers, design of gasifier, fixed and fluidised bed suspended gasifiers. Koppa Totrek, Lurgi Winker Hygas process. Orsat gas analysis, Gobour gas and sewage gas. Syntheis gas and its uses. Underground gasification of coal.

RECOMMENDED BOOKS:

1. Fuels and combustion: Samir Sarkar.
2. Fules fumaces and Refractories: O.P.Gupta
3. An introduction to study of fuel : JC Marrae.
4. Fuels: J Francis
5. Fuels and furnaces: Brame and King
6. Fuels : Huslam & Russel.

8CT06 PROJECT & SEMINAR

SEMINAR: The Seminar Report submitted by the student at the end of VII Semester will be evaluated by external examiner appointed by the University along with the Project - Viva Voce examination at the end of VIII Semester.

PROJECT:

The objective of the project is to enable the students to work in groups of not more than four members in each group on a project involving analytical, experimental , design or combination of these in the area of Chemical Technology. Each project shall have a guide. The student is required to do literature survey, formulate the problem and form a methodology of arriving at the solution of the problem. On completion of the work, a project report should be prepared and submitted to the department.

The evaluation is based on continuous internal assessment by an internal assessment committee for 75 marks by way of oral presentations. The university examination, which carries a **total of 150 marks**, will be a Viva Voce examination conducted by a committee of one external examiner appointed by the University and one internal examiner/Guide.