

B.Tech (Chemical Engineering) Semester –III (Second Year)

Code		Category	Course Title	Scheme of Instruction, Hrs/Week				Credits	Scheme of Evaluation, Marks		Total Marks
Department	University			L	T	P	Total		CIE	SEE	
CH1301C	7-1-3-01R25	MA-BS	Complex Analysis & Partial Differential Equations	3	0	0	3	3	40	60	100
CH1302C	7-1-3-02R25	CH-PC	Chemical Technology	3	0	0	3	3	40	60	100
CH1303C	7-1-3-03R25	CH-PC	Chemical Process Calculations	3	0	0	3	3	40	60	100
CH1304C	7-1-3-04R25	CH-PC	Momentum Transfer	3	0	0	3	3	40	60	100
CH1305C	7-1-3-05R25	CH-PC	Chemical Engineering Thermodynamics - I	3	0	0	3	3	40	60	100
CH1306C	7-0-3-01R25	MG-HS	Managerial Economics and Financial Accountancy	3	0	0	3	3	40	60	100
CH1307L	7-1-3-R25P1	CH-PC	Momentum Transfer Lab	0	0	3	3	1.5	40	60	100
CH1308L	7-1-3-R25P2	CH-PC	Chemical Analysis Lab	0	0	3	3	1.5	40	60	100
CH1309S	7-1-3-R25S1	CH-SC	Computer Skills	1	0	2	3	2	100	0	100
CH1310M	7-0-3-R25M1	CH-MC	Constitution of India	2	0	0	2	0	100	0	100
TOTAL				21	0	8	29	23	520	480	1000
All interested students are advised to register for Minors degree or Honors degree at the end of this semester by submitting filled in registration form available from the Head of the Department /Chair person, Board of Studies (UG) of the parent department.											


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COMPLEX ANALYSIS AND PARTIAL DIFFERENTIAL EQUATIONS**Credits: 3****Assessment: 40+60**

Semester	L-T-P	Course Code	Branches
III	3-0-0	7-1-3-01R25	CH, CE, ME,

Course Educational Objectives:

1. This course aims at providing the student to acquire the knowledge on the calculus of Functions of complex variables.
2. To understand power series and expansion of analytic function, poles, singular points, Residue Theorem and its applications
3. To familiarize the students with the techniques of Fourier series and evaluating improper integrals
4. The aim is to analyze the solutions of partial differential equations.
5. To discuss the boundary value problems, one dimensional wave equation, heat equation And Laplace Equation.

UNIT – I

Complex analysis - I: Analytical functions - Cauchy-Reimann equations – Construction of Analytic functions- Complex integration - Cauchy's theorem - Integral formula - Evaluation of integrals.

UNIT - II

Complex analysis - II: Sequences, series, convergence tests, Taylor's and Laurents' series- Singularities - Poles - Residues - Residue theorem – Contour integration- Evaluation of real integrals

UNIT – III

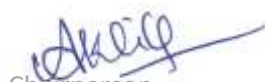
Fourier series: Fourier series-even and odd functions, periodic functions-half range sine and cosine Series- Gamma and Beta functions

UNIT – IV

Partial differential equations - I : Formation of differential equations - Classification - First order linear partial differential equations – Lagranges' linear equation - Method of multipliers - first order non-linear partial differential equations by Charpit's method.

UNIT- V

Partial differential equations - II: Method of separation of variables - One dimensional wave equation - Heat equation – Laplace's equation.


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Text Books:

1. Grewal B S, Higher Engineering Mathematics, 42th Edition, Khanna Publications, 2007.
2. Venkataraman M K, Engineering Mathematics, National Publishing Company, 1995.
3. Kreyszig E, Advanced Engineering Mathematics, 8th edition, Wiley, 1998.
4. Mathematics-III by T.K.V.Iyenger, B. Krishna Gandhi et al, S. Chand & Company Ltd
5. Mathematical Methods by T.K.V.Iyenger, B. Krishna Gandhi et al, S. Chand & Company Ltd

Course Outcomes: At the end of the course, students will be able to

1. After the completion of course, students will be able to understand the analyticity of complex functions and apply Cauchy's integral formula and Cauchy's integral theorem to evaluate improper integrals along contours.
2. Compute the residue of a function and use the Residue Theory to evaluate a contour integral or an integral over the real line.
3. Find the Fourier Series to represent function as a series of constants sine and cosine Functions of different intervals and evaluate certain improper integrals to make them simple with introduction of Gamma and Beta functions.
4. Formulation/solve/classify the solutions of Partial differential equations ,Identify linear And Nonlinear PDE by different methods.
5. Apply Variables separable methods to solve boundary value problems and find the solution of one dimensional wave equation, heat equation and Laplace equation.

Mapping of Course Outcomes with Program Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	2	1	1	1	1	2	1	3	1	3
CO2	3	3	3	3	1	2	2	1	1	2	1	3	1	3
CO3	3	2	2	3	2	1	2	1	1	2	1	3	1	3
CO4	3	2	2	3	2	1	1	1	1	2	1	3	1	3
CO5	3	3	3	2	2	1	1	1	1	2	1	3	1	3

1 – Slightly; 2 - Moderately; 3 – Substantially


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CHEMICAL TECHNOLOGY**Credits: 3****Assessment: 40+60**

Semester	L-T-P	Course Code	Branches
III	3-0-0	7-1-3-02R25	CH

Course Educational Objectives:

1. To know the difference between unit operations and unit processes.
2. To learn principles of different unit operations like screening, filtration, size reduction, mixing.
3. To learn how to draw flow sheet for a process.
4. To know the industrial production of cements, industrial gases, nitrogen, sulphur phosphorous, glass and ceramic industries.
5. To learn the thermodynamic considerations, engineering problems and economic factors in the production.

UNIT-1:

Fuel & Industrial gases: Natural gas, LPG, CO₂, H₂, N₂ and Synthesis gas Water Technology: Sources of water - Methods of treating freshwater -Desalination - Activated sludge process. Chlor-Alkali Industry: Manufacture of Caustic Soda and chlorine, Soda ash. Manufacture of elemental Sulphur and sulphuric acid.

UNIT-II:

Cement and Paints: Cement types and manufacture. Manufacture of Paints – Pigments. Pulp and Paper Industry: Methods of pulping, Production of sulphate & Sulphite pulp, production of paper - Wet process. Sugar and Starch Industry: Manufacture of Cane Sugar, Production of starch from Maize.

UNIT-III :

Fertilizers: Nitrogen Industries - Synthetic Ammonia, Urea, Nitric acid Phosphorus Industries: Phosphoric acid, Super phosphate & Triple Super Phosphate. Potassium: Manufacture of Potassium chloride.

UNIT-IV:

Industrial Microbial Processes and Edible oils. Oils, fats and waxes: Extraction of vegetable oils – Hydrogenation of Oil Methods of production of essential oils. Fermentation processes for the production of ethyl alcohol, acetone, acetic acid, butanol and antibiotics. Manufacture of soaps, detergents & Glycerine.


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UNIT-V:

Rubbers: Classification, Monomers of Synthetic Rubber Manufacture of SBR. Fibers: Manufacture of Viscose Rayon, Nylon 6, 6., Manufacture of polyester fibers.

Plastics: Classification – Types of Synthetic resins and plastics and their manufacture- Thermoplastics – Thermosetting resins.

TEXT BOOK:

1. Chemical Process Industries by R.N. Shreve and J.A. Brink Jr. McGraw Hill 5th ed.

REFERENCE:

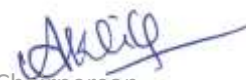
1. Dryden's Outlines of Chemical Technology by Gopal Rao and Marshall sitting. – Boca Raton

Course Outcomes:

1. Able to differentiate unit operations and unit processes. To know the basic principles of different unit operations. Able to know the constituents of petroleum, and the extraction of petroleum compounds like petrol and diesel.
2. Can understand the raw materials and production of ammonia, urea, and phosphorus industries.
3. Can understand the raw materials, pulp and paper industry, reactions involved, and the production of sugar and starch.
4. Get knowledge about alcohol, soaps, edible oils, hydrogenation of oils, and extraction of vegetable oils.
5. Can understand the difference between paints and varnishes and their production. Know the classification of plastics, industrial production of plastics, and rubbers.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1	1	2	3	3					
CO2	2	2	2	2	2							
CO3	3	3	2	3	2	1						
CO4	2	1		2								
CO5	1	2	2	2	1							

1 – Slightly; 2 - Moderately; 3 – Substantially


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CHEMICAL PROCESS CALCULATIONS**Credits: 3****Assessment: 40+60**

Semester	L-T-P	Course Code	Branches
III	3-0-0	7-1-3-03R25	CH

Course Educational Objectives:

1. To understand different representations of mixture compositions and reaction stoichiometry. To understand the ideal gas law and its applications.
2. To learn the concepts of vapor pressure and different representations of vapour presence in gas mixtures.
3. To understand and apply the law of conservation of mass.
4. To understand and apply the law of conservation of energy.
5. To analyse combustion operations, from a material and energy perspective.

UNIT I

Stoichiometry: Introduction, Units and Dimensions- Graphical Integration and differentiation- use of log-log, semi-log and triangular graphs, conversion of units. Basis of Calculation, Methods of expressing composition of mixture and solutions, density and specific gravity, Baume and API gravity scales. Behaviour of Ideal gases: Kinetic theory of gases, application of ideal gas law, gaseous mixtures.

UNIT II

Vapour pressure: Liquefaction and liquid state, vaporization, boiling point, effect of temperature on vapour pressure, vapour pressure plots, vapour pressure of immiscible liquids and solutions, Raoult's law, Non-volatile solutes. Humidity and Saturation: Humidity, Absolute humidity, Relative and Percentage saturation, dew point, humid heat, wet and dry bulb temperatures, use of humidity charts.

UNIT III

Material Balance: Yield, conversion, Tie substance, limiting reactant, excess reactant, mass balance calculations for unit operations like distillation, absorption, extraction, dissolution, crystallization, drying and evaporation. Mass balance with chemical reactions: Processes involving recycle, Purge and By-pass.

UNIT IV

Energy Balance Thermo Physics: Energy, energy balances, heat capacity of gases, liquid and mixture solutions. Kopp's rule, latent heats- heat of fusion and heat of vapourization, Trouton's ratio, Kistyakowski equation. Thermo chemistry: calculation and applications of heat of reaction, combustion, formation, Hess law.


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UNIT V

Fuels and Combustion: Introduction, fuels, calorific value of fuels, air requirement and flue gases, combustion calculations. Heating value, Calculations of theoretical and actual flame temperatures.

TEXT BOOK:

1. Chemical Process Principles part - I, Material and Energy Balances by Hougen, O.A., Watson, K.M. and Ragatz, R.A. John Wiley and sons, 2nd ed.
2. Chemical Process Calculations - David Himmelblau

REFERENCES:

1. Stoichiometry (3rd edition) - Bhatt and Vora , tata-McGraw-Hill Publication.
2. Elementary Principles of Chemical Process , 3rd edition – Richard M.Felder & Ronald W. Rousseau, Wiley – Eastern
3. Process Calculations by K. V. Narayanan and Lakshmi Kutty.

Course Outcomes:

1. To understand the dimension-unit systems and their interrelationships, to be able to represent mixture compositions in different forms and to be able to make calculations using reaction stoichiometry.
2. To be able to make mass balance calculations for different operations, without reaction, its mathematical form and its application to different operations and reactions.
3. To be able to make mass balance calculations for different operations, with reaction, its mathematical form and its application to different operations and reactions.
4. To have learnt the significance of vapour pressure and its dependence and to have learnt different representations of partial saturation and to apply the ideal gas law in conjunction with variation in levels of saturation.
5. To be able to estimate parameters like oxygen requirement, flue gas analysis, and energy.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	3	2	2				2	2	1	1
CO2	3	1	3	2	2				2	2	1	1
CO3	3	1	3	2	3				2	2	1	1
CO4	3	1	3	2	3				2	2	1	1
CO5	3	1	3	2	3				2	2	1	1

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MOMENTUM TRANSFER**Credits: 3****Assessments: 40+60**

Semester	L-T-P	Course Code	Branches
III	3-0-0	7-1-3-04R25	CH

Course Educational Objectives:

1. To learn dimensional analysis, fluid statics and its applications.
2. To understand the important phenomena observed in flowing fluids, basic quantitative laws and equations of fluid flow.
3. To form a firm idea of the flow of incompressible and compressible fluid flow through pipes and in thin layers.
4. To understand the flow past solid surfaces, through packed bed and in fluidized beds, settling characteristics of particles through fluids.
5. To learn the working and performance of pumps and valves and understand the construction and operation of flow measuring devices.

UNIT - I:

Introduction: Units, Dimensions and Dimensional analysis: Rayleigh Method – Buckingham theorem. Fluid statics and its applications: Nature of fluids - Hydrostatic Equilibrium – Applications of Fluid Statics.

UNIT - II:

Fluid flow phenomena: Velocity field - Laminar flow, Shear rate and Shear stress - Rheological Properties of fluids – Turbulence – Boundary layers. Basic equations of fluid flow - Continuity equation – Momentum Balance Equation - Bernoulli's equation and its applications.

UNIT - III:

Flow of incompressible fluids in Pipes and Channels: Shear stress and Skin friction in pipes - Laminar and turbulent flows in pipes and channels - Universal velocity distribution - friction factor chart - effect of Sudden Expansion, sudden contraction, fittings and valves. Flow of compressible fluids: Continuity equation - mechanical and total energy balances - velocity of sound - ideal gas equation - stagnant temperature.

UNIT - IV:

Flow past immersed bodies: Drag force and drag coefficient - Flow through bed of solids - Motion of particles through fluids - Free and hindered settling - Mechanism and pressure drop of fluidization - Types of fluidization and its applications.


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UNIT - V:

Transportation and metering of fluids: Fluid moving machinery – Pipe, Fittings and valves - selection and specifications - Classification and performance of pumps and compressors - Measurement of flowing fluids - Storage and handling.

TEXT BOOKS:

1. Unit operations of Chemical Engineering (7th edi) Warren L. McCabe, Juliane Smith and Peter Harriott, McGraw Hill.

REFERENCES:

1. A Text Book of Fluid Mechanics and Hydraulic Machines by R.K.Bansal, Laxmi Publishing Private Limited, New Delhi, 2010.
2. Solved Examples in Chemical Engineering by G.K.Roy
3. Chemical Engineering Vol.I by Coulson and Richardson, Pergamon Press.
4. "Fluid Mechanics" 2nd edition by Noel de Nevers, Mc Graw Hill

Course Outcomes:

1. Perform dimensional analysis of fluid flow problems and develop pressure drop equations for fluid static equipments.
2. Have the knowledge on different types of flow regions in fluid flow, rheological properties of fluids, turbulence and boundary layers.
3. Carry out macroscopic mass, momentum and energy balance to solve engineering problems related to fluid flow.
4. Analyze the formation and calculation of fluid friction in pipes and conduits.
5. Analyze flow past solid surface through packed bed and determine the minimum fluidization velocity and terminal velocity of the fluid in Stokes and Newton's law regions.
6. Analyze fluid flow measuring devices like Orifice meter, Venturimeter, Rotameter and Pitot tube.
7. Understand the working of Centrifugal and reciprocating pumps and also give the knowledge on different types of valve, selection of pipe and fittings.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	2	2				2	2	1	1
CO2	3	2	2	2	2				2	2	1	1
CO3	3	2	2	2	3				2	2	1	1
CO4	3	2	2	2	3				2	2	1	1
CO5	3	2	3	2	3				2	2	1	1

1 – Slightly; 2 - Moderately; 3 – Substantially


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CHEMICAL ENGINEERING THERMODYNAMICS –I**Credits: 3****Assessment: 40+60**

Semester	L-T-P	Course Code	Branches
III	3-0-0	7-1-3-05R25	CH

Course Educational Objectives:

1. To understand the concepts of energy, forms of energy, equilibrium and reversibility
2. To learn and apply the laws of thermodynamics
3. To understand the P-V-T behavior of pure fluids & to study the feasibility of processes
4. To learn the concept of entropy and to apply second law of thermodynamics
5. To learn thermodynamic analysis of refrigeration and different flow processes

UNIT - I:

Introduction –Scope, Dimensions and Units – Mass, mole, volume, force, temperature, pressure, work, energy, heat, internal energy.

The first law of thermodynamics, Energy balance for closed systems, Thermodynamic state and state functions, equilibrium, The phase rule, The reversible process, enthalpy, heat capacity, Mass and energy balances for open systems, Energy balances for steady state flow processes

UNIT - II:

Volumetric properties of pure substances: P-V-T behavior, Virial expressions, the ideal gas, Applications of Virial equations, Cubic equations of state - Vander walls and Redlich - Kwong equations, Theorem of corresponding states, generalized correlation – Pitzer correlation.

UNIT - III:

Heat effects– Sensible and latent heat effects, Standard heats of reaction formation, and combustion, Temperature dependence, heat effects of industrial reactions.

UNIT - IV:

Second law – Statement, Heat engine, Thermodynamic Temperature scale, concept of entropy, mathematical statement of second law, Entropy changes of an ideal gas, Calculation of ideal work and lost work The Third Law of Thermodynamics

UNIT- V:

Property relations for homogeneous phases-Residual properties, Residual properties by equations of state. Two phase systems, Thermodynamic diagrams - Tables of thermodynamic properties – generalized property correlations for gases.


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TEXT BOOK:

1. J.M.Smith , H C Van Ness and M.M.Abbott - Introduction to Chemical Engineering Thermodynamics 6th ed. Tata McGraw-Hill Publishing Company .

REFERENCES:

1. Chemical Engineering Thermodynamics by Thomas E. Daubert
2. Chemical Engineering Thermodynamics, YVC Rao, University publications.

Course Outcomes:

1. Apply the first and second laws of thermodynamics to chemical processes.
2. Compute the properties of ideal and real mixtures using equations of state and generalized correlations.
3. Understand thermodynamic properties of fluids
4. Estimate heat and work requirements for industrial processes.
5. Determine the efficiency of processes involving heat into work, refrigeration and liquefaction.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	3	2	2				2	1
CO2	3	3		2							1	1
CO3	2		3	2							1	1
CO4	2			2							1	1
CO5	2			2	2	2	2				1	1

1 – Slightly; 2 - Moderately; 3 – Substantially


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MANAGERIAL ECONOMICS AND FINANCIAL ACCOUNTANCY**Credits: 3****Assessment: 40+60**

Semester	L-T-P	Course Code	Branches
III	3-0-0	7-0-3-01R25	CH

Course Educational Objective:**Managerial Economics objectives**

1. Decision-making: To enable managers make optimal decisions to maximize a firm's profitability and success by integrating economic theory with business practices.
2. Analysis: To help in the analysis of business situations by providing insights into demand, supply, production functions and costs.
3. Problem-solving: To provide the tools to find optimal solutions for business problems such as those related to pricing, production, capital management, and profit planning.
4. Economic Concepts: To develop understanding of concepts like consumer behaviour, production and cost analysis and market structures.

Financial Accountancy objectives

5. Financial Analysis: To introduce students to financial accounting and analysis techniques, including the use of ratios like liquidity, activity, and profitability.
6. Historical Reporting: To understand how financial accounting records and reports on past performance through final accounts (income statement, balance sheet).
7. Financial Health Assessment: To provide a method for analysing and interpreting financial statements to understand a company's financial position and performance.
8. Informed Decisions: While primarily historical, the objective is to provide the information necessary for management and external stakeholders like investors to make informed decisions, even if it's for future forecasting.

Unit -I

Managerial Economics: Definition, Characteristics and Scope – Basic economic tools in Managerial Economics. Managerial Economics and its relation with other subjects – Demand and Supply: Concept and Analysis – Time value of money, Cash flow and Time Diagrams – Choosing among alternative investment proposals: Methods of Economic analysis (Pay Back, ARR, NPV, IRR and B/C ratio)

Unit -II

Depreciation and methods of calculating depreciation (Straight line, Sum of the years digit method, Declining balance method, Annuity method, Sinking fund method)– National income accounting, Methods of estimation, Various concepts of National Income, Significance of National income Estimation and limitations.


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Unit -III

Types of Industrial Organization: Characteristics of Industrial organization, Features and evaluation of Sole Proprietorship, Partnership, Joint Stock Company, State/Public Enterprises and their types – The Business cycles and their relevance to decision making – Inflation: Definition, Process of inflation and measure of controlling inflation – New Economic Policy 1991 (Industrial Policy, Trade Policy, Fiscal Policy). Its Impact on Industry.

Unit -IV

Accounting Principles, procedure, Double entry system, Journal, Ledger, Trial balance, Cashbook – Preparation of Trading account and Profit and Loss account, Balance sheet.

Unit –V

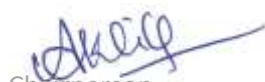
Cost Accounting: Introduction, Classification of costs, Methods of costing, Techniques of costing – Cost sheet and preparation of cost sheet – Break-even Analysis: Meaning, its application and Limitation.

Text Books

1. Gupta, G.S. (2018), Managerial Economics (2e), McGraw Hill Education (India) Pvt. Ltd., Chennai.
2. Dewett. K.K. (2006), Modern Economic Theory, Sultan Chand and Co., New Delhi.
3. Agarwal A.N. (2019), Indian Economy, New Age International Pvt. Ltd., New Delhi.
4. Jain and Narang (2011), Accounting Part-I, Kalyani Publishers, New Delhi.
5. Arora, M.N. (2012), Cost Accounting: Principles and Practice (12e), Vikas Publication, New Delhi.

Reference Books

1. Henry Malcom Steiner (1996), Engineering Economics Principles (2e), McGraw Hill Education.
2. Leland Blank and Anthony Tarquin (2012), Engineering Economy (7e), McGraw Hill, New York


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Course Outcomes: After the completion of the course the student will be able to;

- CO1** Understand the concepts of financial management and smart investment.
- CO2** Identify various cost elements of the product and its effect on decision making.
- CO3** Understand Economic and regulatory environment of the business and its impact on enterprises.
- CO4** Prepare the Accounting records and interpret the data for Managerial Decisions.
- CO5** Identify various cost elements of the product and its effect on financial decision making.

Mapping of Course outcomes with program outcomes:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1	2	1	2	1	1	2	1	3
CO2	3	3	2	2	1	2	2	1	1	2	1	3
CO3	3	2	1	1	1	1	1	1	1	2	1	3
CO4	3	2	2	1	1	1	1	1	1	2	1	3
CO5	3	3	3	2	2	1	1	1	1	2	1	3

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MOMENTUM TRANSFER LABORATORY**Credits: 1.5****Assessment: 40+60**

Semester	L-T-P	Course Code	Branches
III	0-0-3	7-1-3-R25P1	CH

Any 10/12 experiments on

- Flow Through Straight Pipe,
- Frictional losses Due To Fittings,
- Venturi meter,
- Orifice meter,
- Flow Through Helical Coil,
- Characteristics Of Centrifugal Pump,
- Flow Through Annulus,
- Frictional Loss Due To Sudden Expansion,
- Bernoulli's Experiment,
- Flow Through Packed Bed,
- Fluidization.


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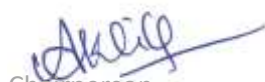

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CHEMICAL ANALYSIS LABORATORY**Credits: 1.5****Assessment: 40+60**

Semester	L-T-P	Course Code	Branches
III	0-0-3	7-1-3-R25P2	CH

10 / 16 Experiments from

- Chemical Analysis -Water(Hardness & total chlorides),
- Estimation of Chromium,
- Analysis of Bleaching Powder,
- Estimation of Phenol, Estimation of Sugars,
- Analysis of Vegetable Oils,
- Analysis of Soda Ash,
- Analysis of Pyrolusite,
- Analysis of Urea
- Instrumental Analysis-Fluorometer,
- Refractometer, Polarimeter,
- Conductometric Titration,
- Viscosity and Flash Point Determination,
- Measurement of pH,
- Colorimeter,
- Potentiometric Titration,
- Fuel Characterization-Calorific Value,
- Flash and Cloud Points.



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COMPUTER SKILLS**Credits: 2****Assessment: 100+0**

Semester	L-T-P	Course Code	Branches
III	1-0-2	7-1-3-R25S1	CH

Course Educational Objective (CEOs)

1. Identify basic terms, concepts, and functions of computer system components.
2. To enable the student to use MSWORD.
3. To acquaint with MSEXCEL and MSPowerPoint
4. To familiarize with browsing the INTERNET and EMAIL

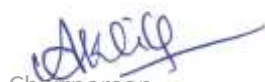
Detailed Syllabus

- MS WORD: Text Basics, Text Formatting and saving file, working with Objects.
- MS WORD: Header & Footers, Working with bullets and numbered lists, Tables.
- MS WORD: Styles and Content, Merging Documents, Sharing and Maintaining Document
- MS WORD: Sharing and Maintaining Document, : Proofing the document, Printing
- MS EXCEL: Introduction to Excel, Formatting excel work book
- MS EXCEL: Perform Calculations with Functions, Sort and Filter Data with Excel
- MS EXCEL: Create Effective Charts to Present Data Visually, Analyze Data Using PivotTables and Pivot Charts, Protecting and Sharing the work book
- MS EXCEL: Use Macros to Automate Tasks, Proofing and Printing, Preparation of various data collection forms, Mathematical Calculations using Spreadsheet
- MS POWER POINT: Setting Up PowerPoint Environment, creating slides and applying themes, working with bullets and numbering, Working with Objects, Slide show option and print
- INTERNET AND EMAIL: What is Internet, Types of internet networks, Receiving Incoming Messages, Sending Outgoing Messages, Email addressing, Email attachments, Browsing, Search engines, Text chatting, Job Searching.

Course Outcomes (COs)

After completion of the course the student will:

- a) The study and use of MS WORD, MS EXCEL, POWER POINT AND Google Forms with their utilization in Chemical engineering project works and personal works


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CONSTITUTION OF INDIA**Credits: 0****Assessment: 100+00**

Semester	L-T-P	Course Code	Branches
III	2-0-0	7-0-3-R25M1	CH,CE, ME,EE,EC,CS

Course Educational Objectives (CEOs):

Students will learn:

1. To understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.
2. To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism.
3. To address the role of socialism in India after the commencement of the Bolshevik Revolution in 1917 and its impact on the initial drafting of the Indian Constitution.

Unit-I

History of Making of the Indian Constitution: History, Drafting Committee, (Composition & Working) Philosophy of the Indian Constitution: Preamble Salient Features

Unit-II

Contours of Constitutional Rights & Duties: Fundamental Rights, Right to Equality, Right to Freedom, Right against Exploitation Right to Freedom of Religion, Cultural and Educational Rights, Right to Constitutional Remedies, Directive Principles of State Policy, Fundamental Duties.

Unit-III

Organs of Governance: Parliament, Composition, Qualifications and Disqualifications, Powers and Functions Executive, President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualifications, Powers and Functions

Unit-IV

Local Administration: District's Administration head: Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation. Pachayati raj: Introduction, PRI: Zilla Panchayat. Elected officials and their roles, CEO Zilla Panchayat: Position and role. Block level: Organizational Hierarchy (Different departments), Village level: Role of Elected and Appointed officials, Importance of grass root democracy

Unit-V

Election Commission: Election Commission: Role and Functioning. Chief Election Commissioner and Election Commissioners. State Election Commission: Role and Functioning. Institute and Bodies for the welfare of SC/ST/OBC and women.


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TEXT BOOKS/REFERENCES:

1. The Constitution of India, 1950 (Bare Act), Government Publication.
2. Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, 2015.
3. M. P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis, 2014.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

Course Outcomes (COs):

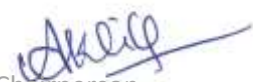
Students will be able to:

1. Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
2. Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.
3. Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
4. Discuss the passage of the Hindu Code Bill of 1956.

CO-PO Mapping

PO&PSO/ CO	PO (1)	PO (2)	PO (3)	PO (4)	PO (5)	PO (6)	PO (7)	PO (8)	PO (9)	PO (10)	PO (11)	PO (12)
CO1	2	2	-	-	2	1	2	-	-	2	1	1
CO2	2	1	1	-	1	1	-	-	-	1	1	1
CO3	2	2	-	-	2	1	2	-	-	2	1	1
CO4	-	-	-	-	2	1	2		-	2	1	1

1 - Slightly; 2 - Moderately; 3 – Substantially


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B.Tech. (Chemical Engineering) Semester IV (Second Year)

Code		Category	Course Title	Scheme of Instruction, Hrs/Week				Credits	Scheme of Evaluation, Marks		Total Marks
Department	University			L	T	P	Total		CIE	SEE	
CH1401C	7-1-4-01R25	MA-BS	Numerical Methods, Probability & Statistics	3	0	0	3	3	40	60	100
CH1402C	7-1-4-02R25	CH-PC	Particle and Fluid Processing	3	0	0	3	3	40	60	100
CH1403C	7-1-4-03R25	CH-PC	Chemical Engineering Thermodynamics - II	3	0	0	3	3	40	60	100
CH1404C	7-1-4-04R25	CH-PC	Heat Transfer	3	0	0	3	3	40	60	100
CH1405C	7-1-4-05R25	CH-PC	Mass Transfer Operations - I	3	0	0	3	3	40	60	100
CH1406M	7-0-4-R25M1	CE-MC	Environmental Science	2	0	0	2	0	100	-	100
CH1407L	7-1-4-R25P1	CH-PC	Particle and Fluid Processing Lab	0	0	3	3	1.5	40	60	100
CH1408L	7-1-4-R25P2	CH-PC	Heat Transfer Lab	0	0	3	3	1.5	40	60	100
CH1409S	7-1-4-R25S1	CH-SC	Python Programming	1	0	2	3	2	100	-	100
CH1410N		CH-NG	NCC/NSS/NSO	0	0	0	0	0	0	0	0
TOTAL				18	0	8	26	20	480	420	900
All students shall mandatorily register for NCC/NSO/NSS and complete 60 hours of activities beginning from the 1 st semester but to be completed before 4 th semester in one of these three options to earn Non-graded (NG) Credits as core requirement. Grade shall be awarded as Satisfactory or Unsatisfactory by the concerned HoD on the basis of participation, attendance, performance and behaviour. If a student gets an unsatisfactory Grade, he/she shall repeat the above activity in the subsequent years, in order to complete the degree requirements.											
All interested students shall register for Minors degree or Honors degree just before or at the time of commencement of this semester by submitting filled in registration form available from the Head of the Department /Chair person, Board of Studies (UG) of the parent department.											
Students shall undergo Community Service Project (CSP) for a duration of six to eight (6-8) weeks during the summer vacation by completing 45 – 60 hours of work with at least 75% attendance, to be evaluated and reflected in 5 th semester.											


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NUMERICAL METHODS, PROBABILITY & STATISTICS**Credits: 3****Assessment: 40+60**

Semester	L-T-P	Course Code	Branches
IV	3-0-0	7-1-4-01R25	CH,CE, ME

Course Educational Objectives:

1. This course aims at providing the student with the knowledge on Various numerical methods for
Solving transcendental equations,.
2. To acquaint the students with different types of numerical methods to interpolate the polynomials, numerical derivatives and integrals.
3. To provide suitable and effective methods called Numerical Methods, for differential equations.
4. To provide knowledge of discrete and continuous distributions and problems on Binomial, Poisson, Normal Distributions. Interpret the association of characteristics and through correlation and regression tools.
5. To acquaint the students with different types of large and small sample tests

Unit I :

Error analysis, Curve fitting by the method of least squares, Fitting of (i) Straight line (ii) Second degree parabola (iii) Exponential curves, Solutions of Algebraic & Transcendental Equations: Determination of roots of non - linear equations by iterative methods - Falsi position method - bisection method - Newton Raphson method .

Unit-II :

Numerical Interpolation, Integration & Differentiation - Newton's forward & backward interpolation formula - Lagrange's interpolation formula. Numerical differentiation with forward and backward differences, Numerical Integration with Trapezoidal rule, Simpson's 1/3 rule and Simpson's 3/8 rule.

UNIT - III:

Solution Of Ordinary Differential Equations - Taylor series method - Euler's method - Euler's modified method - Runge Kutta second & fourth order methods - Milne's predictor and corrector methods for first order equations.

UNIT - IV:

Random variables, Discrete and Continuous distributions, expectation, variance. Distributions: Binomial, Poisson, Normal and Exponential Properties and applications. Correlation – Rank Correlation - Regression analysis.


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UNIT - V:

Testing of Hypothesis –Large & Small samples-Null and alternate hypothesis, level of significance and critical region-Z-test for single mean and difference of means, single proportion and difference of proportions - t-test for single mean and difference of means - F-test for comparison of variances, Chi-square test for goodness of fit.

TEXT BOOK: 1. Higher Engineering Mathematics – B.S.Grewal.

1. Numerical methods by E. Balagurusamy, Tata McGraw-Hill Publishing Co.
2. Numerical Methods for Scientific and Engineering Computation 3rd edition by Jain, New Age International.
3. S P Gupta, Statistical Methods, 38th Edition, Sultan Chand & Sons Educational Publishers, 2009.
4. T. K. V Iyengar et al, Probability and Statistics 2nd Edition, S. Chand & Company Ltd, 2010.
5. S. C. Gupta and V K Kapur, Fundamentals of Applied Statistics, 3rd Edition, Sultan Chand & Sons Educational Publishers.

Course Outcomes: At the end of the course, students will be able to

1. To apply numerical methods to solve the Solution of Linear and Non-Linear Algebraic Equations and curve fitting problems iterative methods.
2. Derive interpolating polynomials using interpolation formulae Test and evaluate the accuracy of Differentiation and integrals numerically.
3. Using numerical methods we find solution of Ordinary differential equations.
4. Evaluate discrete and continuous probability distributions and able to solve problems on Binomial, Poisson, Normal Distributions. Interpret the association of characteristics and through correlation and regression tools.
5. Design the components of a classical hypothesis test. Infer the statistical inferential methods based on small and large sampling tests.

Mapping of Course Outcomes with Program Outcomes:														
COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	3	3	2	1	1	1	1	2	1	3	1	3
CO2	3	3	3	3	2	2	2	1	1	2	1	3	1	3
CO3	3	2	2	3	2	1	2	1	1	2	1	3	1	3
CO4	3	2	2	3	1	1	1	1	1	2	1	3	1	3
CO5	3	3	3	3	2	1	1	1	1	2	1	3	1	3

1 - Slightly; 2 - Moderately; 3 – Substantially


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PARTICLE AND FLUID PROCESSING**Credits: 3****Assessment: 40+60**

Semester	L-T-P	Course Code	Branches
IV	3-0-0	7-1-4-02R25	CH,CE, ME

Course Educational Objectives:

1. To gain a comprehensive understanding of solids, including their characterization, handling, mixing and transportation of bulk solids.
2. To provide students with the importance of size reduction, actions involved, and parameters affecting size reduction and industrial size-reduction equipment.
3. To develop knowledge of techniques for separating solid mixtures.
4. To gain the techniques involved in solid-liquid separation.
5. To understand techniques and impact of liquid agitation and mixing.

UNIT - I: Properties, Handling of Particulate Solids

Particle size and shape, particle size distribution, properties of particulate masses, storage, transportation and mixing of solids, types of mixers, mixers for cohesive solids, mixers for free-flowing solids.

UNIT - II: Principles - Equipment of Comminution and Size Reduction

Principles of comminution, computer simulation of milling, Operations size reduction equipment -crushers, grinders, ultra fine grinders, cutting machines, equipment and operation.

UNIT - III: Screening and Particle Separation Processes

Screening, screening equipment, Separations based on motion of particles through fluids, gravity settling processes and centrifugal settling processes, Gas cleaning. Flotation

UNIT – IV: Filtration Processes

Thickeners, gravity separation and classification of Filtration – Cake filters centrifuge and cyclones, principles of cake filtration and clarifying filters, liquid clarification, principles of clarification, cross flow filtration,

UNIT - V: Agitation and Mixing of Liquids and Multiphase Systems

Agitation of liquids, circulation velocities, power consumption in agitated vessel, blending and mixing - suspension of solid particles, dispersion operation.


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TEXT BOOK:

1. Unit operations of Chemical Engineering (5th ed) Warren L. McCabe, Juliane Smith and Peter Harriott, McGraw Hill.

REFERENCE:

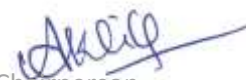
1. Chemical Engineering Vol. I & II, Coulson and Richardson, Pergamon Press.
2. Mechanical Operations for Chemical Engineers by Narayanan & Bhattacharya, Khanna Publishers

Course Outcomes:

1. To be able to determine the Volume surface mean diameter, mass mean diameter, number of particles and types of mixers.
2. To be able to calculate the screening effectiveness.
3. To be able to find the power requirement using three crushing laws.
4. To have the knowledge of different types of Crushers, grinders, ultrafine grinders, cutters.
5. To have understood settling processes and flotation technique.
6. To develop the rate equations for constant pressure and constant volume filtration techniques and also to solve the problems related to these techniques.
7. To have acquired the construction and operation of different filtration, settling and clarifying equipment.
8. To understand the functioning of agitated vessels and to calculate the power consumption.
9. To have the knowledge on different types of turbines, blending and mixing.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	3	2	2				2	1
CO2	3	3		2							1	1
CO3	2		3	2							1	1
CO4	2			2							1	1
CO5	2			2	2	2	2				1	1

1 - Slightly; 2 - Moderately; 3 – Substantially


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CHEMICAL ENGINEERING THERMODYNAMICS - II**Credits: 3****Assessment: 40+60**

Semester	L-T-P	Course Code	Branches
IV	3-0-0	7-1-4-03R25	CH

Course Educational Objectives:

1. To develop frame work to estimate thermodynamic properties of fluids
2. To systematize the synthesis of mixture properties from pure component properties
3. To develop equilibrium criterion and examine its various forms
4. To study phase equilibria
5. To study chemical reaction equilibria

UNIT-I: Solution thermodynamics:

Fundamental property relations-Chemical potential as a criterion for phase equilibrium- Partial properties –Ideal gas mixtures - Fugacity and fugacity coefficient for pure species and component in solutions-Generalized Correlations for the Fugacity Coefficient-Ideal solutions – Excess properties, Liquid phase properties from VLE data, models for excess Gibbs energy, property changes of mixing and Heat Effects of Mixing Processes

UNIT-II: Thermodynamic properties of fluids:

Application of Thermodynamics of flow processes- Duct flow of Compressible fluids – turbines – compression process. Production of power from heat– The steam power plant, Internal combustion engines, Rocket Engine, Jet engines. Refrigeration: The Carnot refrigerator, The vapor compression cycle, choice of refrigerant, absorption refrigeration, Heat pump, Liquefaction process.

UNIT-III: VLE at low to moderate pressures:

Nature of equilibrium-Phase rule, Duhem's theorem, qualitative behavior, the gamma/phi formulation of VLE, Simplifications: Raoult's Law, Modified Raoult's Law, and Henry's Law - Dew point and Bubble point calculations, flash calculations.


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UNIT-IV: Topics in Phase Equilibrium:

VLE from cubic equations of state, VLE from k-value correlations -Equilibrium and stability- liquid-liquid equilibrium (LLE), vapor-liquid-liquid equilibrium (VLLE) and Residual Properties by Cubic Equations of State

UNIT-V: Chemical Reaction Equilibria:

Reaction coordinate-application of equilibrium criterion to chemical reactions - standard Gibb's energy change and the equilibrium constant - effect of temperature on equilibrium constant- Evaluation of equilibrium constant- relation to composition- equilibrium conversion for single reactions - phase rule- Duhem's theorem for reacting systems and multi reaction equilibria

Text Book:

1. J.M.Smith and H C VanNess, Introduction to Chemical Engineering Thermodynamics 5th ed. McGraw Hill 1996.

REFERENCES:

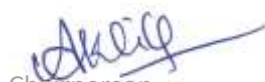
1. Chemical Engineering Thermodynamics by Thomas E. Daubert
2. Chemical Engineering Thermodynamics, Y V C Rao, University publication

Course Outcomes:

1. To be able to develop and use expressions for property estimation
2. To have learn the concepts of residual, excess, partial molar properties and property changes of mixing
3. To have understood concepts of ideal solutions, fugacity and activity coefficient
4. To have learnt the concepts of LLE and VLLE
5. To be able to estimate equilibrium conversion of single and simple multiple reactions

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	3	2	2				2	1
CO2	3	3		2							1	1
CO3	2		3	2							1	1
CO4	2			2							1	1
CO5	2			2	2	2	2				1	1

1 - Slightly; 2 - Moderately; 3 – Substantially


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HEAT TRANSFER**Credits: 3****Assessment: 40+60**

Semester	L-T-P	Course Code	Branches
IV	3-0-0	7-1-4-04R25	CH

Course Educational Objectives:

1. To understand different modes of heat transfer and their characterization
2. To describe formulae for steady/unsteady state of heat transfer and heat transfer in fluids with and without phase change
3. To teach how to estimate heat transfer coefficients for different flow regimes and equipments.
4. To understand the principles of radiation, radiation shields and estimation of emissivity
5. To explain working and design of heat exchange equipment.

Unit I: Heat transfer by conduction and Convection:

Basic Law of Conduction- steady state conduction- compound resistances in series, Heat flow through a cylinder, plain wall, sphere, Unsteady-State Conduction Heat flow with variable surface temperature-Total heat Transferred - critical thickness of insulation - semi infinite solid, infinite slab.

Natural Convection, Heating and cooling of fluids in forced convection outside tubes.

Unit II: Principles of Heat Flow in Fluids:

Heat exchange equipment – parallel and countercurrent flow – Energy Balances – calculation of Heat Flux and Heat Transfer Coefficients-(Overall and Individual) – Log Mean Temperature Difference – Fouling Factors – Effective Coefficients for Unsteady State conduction – NTU & Effectiveness Methods. Concept of boundary layers hydrodynamic and thermal boundary layers, Prandtl Number.

Unit III: Heat transfer to fluids without phase change:

Heat Transfer by Forced Convection in laminar flow: Laminar flow heat transfer to flat plate and in tubes, Graetz and Peclet numbers, Fully Developed Flow, Correction for heating and cooling, effect of inserts on heat transfer, Heat transfer to non-Newtonian liquids in laminar flow.


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Heat Transfer by Forced Convection in Turbulent Flow: Dimensional Analysis Method, Empirical Equations, Effect of tube length, Average value of h_i in turbulent flow, Estimation of T_w , cross sections other than circular, effect of roughness, heat Transfer at High velocities.

Transfer by Turbulent Eddies and Analogy between Transfer of heat and momentum: Eddy diffusivity and analogy equations, Heat transfer in transition region between laminar and turbulent flow, heat Transfer to liquid metals.

Unit IV: Heat transfer to Fluids with Phase Change & Radiation:

Heat transfer from condensing vapors -drop wise and film wise condensation- Coefficients for film type condensation for vertical and horizontal tubes, practical use of Nusselt equations – Condensation of superheated vapors & mixed vapors, effect of non-condensables- heat transfer to boiling liquids

Fundamentals of Radiation: Emission of Radiation, Absorption of radiation by opaque solids. Radiation between surfaces, Radiation to semitransparent materials. Combined heat transfer by conduction-convection and radiation – radiation shields.

Unit -V: Heat Exchange Equipment:

Heat Exchangers: Shell and Tube, Plate Type Heat exchangers, Extended Surface Equipment, scraped surface exchangers, Condensers and vaporizers. Heat transfer in agitated vessels, heat transfer in packed beds, Regenerators and Types of Reboilers.

Evaporation : Types of evaporators –Performance of tubular evaporators, material and energy balances in single and multiple effect evaporators – methods of feeding & vapor recompression.

Text book

1. Unit Operations of Chemical Engineering by Warren L. McCabe and Julian C. Smith, Peter Harriott, 7th edition

Reference Book

1. Heat Transfer by J.P. Holman, McGraw-Hill Publications


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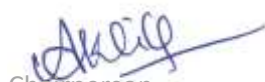

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Course Outcomes:

1. To be able to calculate the heat transfer flux in one-dimensional heat conduction
2. To have learnt the concepts of turbulence, boundary layer and analogies
3. To be able to calculate heat flux in natural convection and forced convection
4. To have understood the concepts of black body, view factors and to be able to calculate radiation heat flux
5. To have understood the construction and flow patterns in heat exchange equipment and To be able to design heat exchangers, condensers and evaporators

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	3	2	2				2	1
CO2	3	3		2							1	1
CO3	2		3	2							1	1
CO4	2			2							1	1
CO5	2			2	2	2	2				1	1

1 - Slightly; 2 - Moderately; 3 – Substantially


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MASS TRANSFER OPERATIONS – I**Credits: 3****Assessment: 40+60**

Semester	L-T-P	Course Code	Branches
IV	3-0-0	7-1-4-05R25	CH

Course Educational Objectives:

1. To impart the basic concepts of molecular and eddy diffusion in fluids, mass transfer coefficients and analysis of different mass transfer processes.
2. To appraise different types of equipment and their operation for gas-liquid separations.
3. To develop the frame work for the design of mass transfer equipment for absorption, stripping, drying and humidification.
4. To learn the construction, operation and inoperable conditions in humidification and dehumidification process.
5. To understand the equilibrium considerations in the drying.

UNIT - I:

Mass Transfer Operations - Classification of Mass Transfer Operations - Choice of Separation method - Methods of conducting Mass Transfer Operations - design principles, unit systems. Molecular Diffusion In Fluids : The equation of continuity , Steady state molecular diffusion of Fluids at rest and in laminar flow - Molecular Diffusion in gases – steady state diffusion of A through non diffusing B, Steady-state equimolar counter diffusion, steady-state diffusion in multi component mixtures, Diffusivity of gases and liquids - Applications of molecular diffusion.

Mass transfer coefficients - Mass transfer coefficients in laminar flow and turbulent flow ,mass transfer theories - Mass, Heat and Momentum Transfer Analogies - Mass Transfer data for simple situations.

UNIT - II:

Inter Phase Mass Transfer: Equilibrium, Diffusion between phases, Overall mass transfer coefficients, Material Balances - steady state Co-current and Countercurrent processes Stages. Equipment for gas-liquid contact – Description of continuous and stage wise contact equipment – packing for packed columns liquid distribution – mass transfer coefficients in packed columns - inoperable conditions – stage , ideal stage, Point, tray and column efficiency – comparison of tray and packed towers.

UNIT - III

Gas Absorption: Equilibrium solubility of gases in liquids - choice of solvent for absorption- Co-current and Counter current flow (one component transferred) – material balance, Minimum liquid - gas ratio for absorbers, Dilute gas mixtures, Absorption factor – Kremser-Brown equations - Determination of number of transfer units and height of transfer unit.


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UNIT - IV:

Humidification : Vapor - liquid Equilibrium and Enthalpy of vapor- gas mixtures, Air-water system, Adiabatic saturation curves, Psychrometric charts , humidification and dehumidification, Operating lines and design of packed humidifiers and dehumidifiers , cooling towers ,spray chamber , Evaporative cooling.

UNIT - V:

Drying: Equilibrium – definitions, Insoluble solids -Soluble solids, classification of Drying Operations - Batch Drying and Continuous Drying -Equipment, Mechanisms of Batch drying, drying through Circulation Drying, Rate of drying.

TEXT BOOK:

1. Mass Transfer Operations - Robert E.Treybal (3rd Ed.) McGraw Hill, Kogakusha.

REFERENCE :

1. Principles of Mass transfer and Separation Processes – B. K.Datta - PHI

Course Outcomes :

1. To be able to calculate the flux in cases involving diffusive transfer. To appreciate the contribution of turbulence to transfer and to calculate coefficients and from them, the flux.
2. To be able to estimate the process parameters like solvent requirement, number of theoretical stages, height and diameter of columns.
3. To understand equilibrium relevant to absorption and to calculate the number of stages, number and height of transfer units.
4. To understand the equilibrium concerned to humidification, various methods of conducting the operation and to design a cooling tower.
5. To understand the mechanism of drying operations and to calculate the time, rate of drying.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1	1	1	1						2
CO2	2	1	1	2		1	2					1
CO3	2	1			1	1						2
CO4	2	1		1				1	1			1
CO5	2	1								1		1

1 - Slightly; 2 - Moderately; 3 – Substantially


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ENVIRONMENTAL SCIENCE**Credits: 0****Assessment: 100+0**

Semester	L-T-P	Course Code	Branches
IV	2-0-0	7-0-4-R25M1	CH

Course Educational Objectives (CEOs):

1. Introduce the scope and importance of environmental resources and their sources.
2. Impart knowledge on Ecosystem and Biodiversity.
3. Impart knowledge on causes and consequences of Environmental pollution its Global effects.
4. Familiarize with environmental issues and their management.
5. Outline different social issues and the guidelines formulated for protection of environment.

UNIT I: Environmental Studies and Natural Resources

Definition, Scope and importance of Environment, Environmental studies, Need for public awareness

Components of Environment- Atmosphere, Hydrosphere, Lithosphere.

Renewable and Non-Renewable Resources and associated problems

Water resources: Use and over utilization of surface and ground water, floods, drought, conflicts over water, dams benefit and problems.

Forest resources: Use and over exploitation, deforestation, case studies. Timber extraction, mining, dams and their effects on forests and tribal people.

Land resources: Land as a resource, land degradation, Man induced landslides, soil erosion and desertification.

Mineral resources: Use and overexploitation, Environmental effects of extracting and using mineral resources, case studies.

Food resources: World food problems, changes caused agriculture and overgrazing, effects of modern agriculture, fertilizer – pesticide problems, water logging, salinity, Case studies.

Energy resources: Growing energy needs, renewable and non renewable energy sources, use of alternate energy sources. Case studies.

Role of an individual in conservation of natural resources.

UNIT II: Ecosystem and Biodiversity

Ecosystem - Concept of an ecosystem. Structure and functions of an ecosystem. Producers, consumers and decomposers. Energy flow in the ecosystem. Ecological succession. Food chains, food webs and ecological pyramids. Introduction, types, characteristic features, structure and function of the following ecosystem.(a)Forest ecosystem. (b) Grassland ecosystem(c)Desert ecosystem. (d) Aquatic ecosystem (ponds, streams, lakes, rivers, oceans, estuaries)


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Biodiversity and its conservation:

Definition, genetic species and ecosystem diversity. Biogeographically classification of India. Value of biodiversity: consumptive use, productive use, social, ethical, aesthetic and option values. Biodiversity at global, National and local levels. India as a mega-diversity nation. Hot-spots of biodiversity. Threats to biodiversity: habitat loss, poaching of wildlife, man – wildlife conflicts. Conservation of biodiversity: in-situ and ex-situ conservation of biodiversity.

UNIT – III**Environmental pollution and Global Effects**

Definition, Causes, Effects, and control measures of (a) Air pollution (b) Water pollution (c) Soil pollution (d) Marine pollution (e) Noise pollution (f) Thermal pollution (g) Nuclear hazards.

Solid waste Management: Causes, effects and control measures of urban and industrial wastes. Role of an individual in prevention of pollution. Pollution case studies. Disaster management: Floods, earthquakes, cyclone, landslides, Tsunami. Climate change-Global warming, Acid rain, Ozone depletion.

UNIT – IV**Environment Issues and Management:**

Environment and Human health – Epidemic diseases, HIV/AIDS, Aviation Flue, Water Borne Diseases. Environmental Impact Assessment, Sustainable Development, Clean Production and Clean Development Mechanisms

Environment Legislation: Environmental Protection Act, Water Act, Air Act, Wild Life Protection Act, Forest Conservation Act, Public Liability & Insurance Act, Issues involved in Enforcement of Environmental legislation.

UNIT – V**Social Issues and the Environment**

Population growth, Population Explosion, Population Control, Women and Child welfare. Urbanization, Industrialization, Development projects, Resettlement and Rehabilitation of people – Problems concerned, Case studies.

Consumerism and Waste Products Conservation, Public Awareness, Water Conservation, Rain water harvesting, watershed management, Wasteland reclamation, Human Rights, Value education, Environmental ethics- Issues and possible solution. Role of information Technology in Environment and Human Health.


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Text Books / Reference Books:

1. Anubha Kaushik & C P Kaushik, Environmental studies, New age International Publishers, 2008
2. Benny Joseph, Environmental studies, Tata McGraw-Hill Publishers, 2005
3. M Chandra Sekhar, Environmental Science, Hi-Tech Publishers, 2004
4. Keerthinarayana and Daniel Yesudian, Principles of Environmental Sciences and Engineering, Hi-Tech Publishers, 2005
5. Amal K. Datta, Introduction to Environmental Science and Engineering, Oxford & IBH Publishing Co. Pvt. Ltd, 2000
6. Santhosh kumar Garg, Rajeshawri Garg and Rajni Garg, Ecological and Environmental studies, Khanna publishers, 2006
7. Gilbert M, Introduction to Environmental Engineering and Science, Masters Publication by Prentice –Hall of India Private Ltd., 1991
8. William P Cunningham and Mary Ann Cunningham, Principles of Environmental Science, Tata McGraw Hill Publishing Co. Ltd, 2002

Course Outcomes(Cos):

At the end of the course, students will be able to

1. Acquire knowledge in diverse components of environment and natural resources.
2. Understand ecosystem and biodiversity and its conservation methods.
3. Identify and resolve the issues related to sources of different types of pollution and its global effects
4. Provide solutions to individuals, industries and government for sustainable development of natural resources
5. Apply environmental ethics in resolving social issues for protection of diversified ecosystems.

PO & PSO / CO	PO(1)	PO(2)	PO(3)	PO(4)	PO(5)	PO(6)	PO(7)	PO(8)	PO(9)	PO(10)	PO(11)	PO(12)	PSO(1)	PSO(2)
CO1						3		3	2	1	2	3	3	2
CO2								3	2	1	2	3	3	2
CO3								3	2				3	2
CO4								3	2				3	1
CO5								3	2				3	1

1 - Slightly; 2 - Moderately; 3 – Substantially


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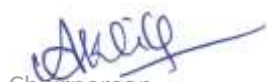
PARTICLE AND FLUID PROCESSING LAB**Credits: 1.5****Assessment: 40+60**

Semester	L-T-P	Course Code	Branches
IV	1-0-2	7-1-4-R25P1	CH

Only 10 for 11 Experiment

EXPERIMENTS:

1. Sieve Analysis
2. Roll Crusher
3. Ball Mill
4. Rod Mill
5. Pulverizer
6. Cyclone Separator
7. Crystallizer
8. Plate And Frame Filter Press
9. Leaf Filter
10. Hydro Classifier
11. Motion Of Particles Through A Fluid



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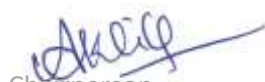
HEAT TRANSFER LABORATORY**Credits: 1.5****Assessment: 40+60**

Semester	L-T-P	Course Code	Branches
IV	0-0-3	7-1-4-R25P2	CH

Only 10 for 12 Experiment

List of Experiments:

1. Thermal Conductivity of Insulating Powder.
2. Heat Transfer through Natural Convection
3. Heat Transfer through Forced Convection.
4. Double Pipe Heat Exchanger,
5. Heat Transfer through Composite Wall.
6. Heat Transfer from Pin Fin Apparatus.
7. Critical Heat Flux Apparatus.
8. Heat Transfer in Agitated Vessel Equipment.
9. Condensation of Steam on Vertical Copper Tube,
10. Natural Convection and Radiation heat Transfer.



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PYTHON PROGRAMMING**Credits: 1.5****Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
IV	1-0-2	7-1-4-R25S1	CH

Course Educational Objectives:

The objective of the course is to impart to the students:

1. Python syntax and semantics and be fluent in the use of Python flow control and functions.
2. The concepts of Object-Oriented Programming as used in Python.
3. Exposure to various problems solving approaches of computer science in various Domains.
4. Various data structures like lists and dictionaries using python.
5. Introduce Python third- Party Tools for various domains.

UNIT I: Introduction to Python: Features and History of Python, Print and Input Functions, Variables, Keywords, Comments

Types: Numerical Types (int, float, complex), Strings, Boolean, Type Conversion Operators: Arithmetic, Relational, Logical, Bitwise, Assignment, Identity, Membership.

Control Flow: Indentation, if-elif-else, while, for, break, continue, pass, else-with loops.

UNIT II: Functions:

Introduction, Required Arguments, Default Arguments, Keyword Arguments, Variable Number of Arguments, Variable Scope and Lifetime, Global Variables, Lambda Functions, Command Line Arguments.

Object-Oriented Programming: Classes and Objects, Built in Class Methods and Attributes, Self, Constructor, Destructor, Inheritance, Data Hiding, Overriding Methods and Overloading Operators.

UNIT III: Data Structures, Files and Exception Handling:

Lists, Nested Lists, List Comprehensions, Tuples and Sequences, Sets, Dictionaries. File I/O: Opening, Closing, Reading and Writing Handling Exceptions, Multiple Except Blocks, Multiple Exceptions in a Single Block, Except Block without Exception, The Else Clause, Raising Exceptions, Built-in and User-Defined Exceptions, The Finally Block.

UNIT IV: Modules, Packages and Standard Library:

Introduction Modules, Import and From-Import, Packages in Python, Used Defined Modules and Packages, PIP. The Python Standard Library: Numeric and Mathematical Modules, String Processing, Date & Time, Calendar, Operating System, Web Browser.


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Python Third- Party Tools: Survey of The Most Common 3rd Party Packages: Requests, Numpy/Scipy, Matplotlib/ Pyplot, Pandas, Pillow, Flask/Django/Twisted, Pep8, Scikit-Learn/Nltk, Stanford-CoreNlp, Bcrypt, Beautiful Soup, and More.

UNIT V: GUI, Graphics and Applications:

GUI Design with Tkinter: Button, Canvas, Check Button, Entry, Frame, Label, List Box, Menu, Menu Button, Message, Radio Button, Scale, Scrollbar, Text Graphics with Turtle: Motion Control, Pen, Colour, Fill, Multiple Turtles, Reset and Clear.

Course Outcomes

Having successfully completed this course the students will be able to:

- a) Understand the structure, syntax, and semantics of the Python language.
- b) Interpret the concepts of Object-Oriented Programming as used in Python.
- c) Demonstrate proficiency in handling Strings and File Systems.
- d) Implement desktop/Web-based applications using the Python programming language.
- e) Boost hireability through innovative and independent learning.

Text Books:

1. Reema Thareja, Python Programming using problem solving approach, First Edition, Oxford University Press, 2017
2. Mark Lutz, Learning Python, fifth Edition, O'Reilly, 2016

Reference Books:

1. Mark Lutz, Programming Python, Fourth Edition, O'Reilly Media, 2010.
2. John V. Guttag, Introduction to Computation and Programming Using Python with Application to Understanding, PHI.
3. Allen Downey, Think Python: How to think like a Computer Scientist, Green Tea Press.
4. Paul Barry, Head First Python: A Brain-Friendly Guide, Second Edition, O'Reilly.
5. The Python Standard Library, Python 3.6.5 documentation (Web Resource) <https://docs.python.org/3/library/>.


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B.Tech. (Chemical Engineering)
Semester V (Second Year)

Code		Category	Course Title	Scheme of Instruction, Hrs/Week				Credits	Scheme of Evaluation, Marks		Total Marks
Department	University			L	T	P	Total		CIE	SEE	
CH1501C	7-1-5-01R25	CH-PC	Mass Transfer Operations -II	3	0	0	3	3	40	60	100
CH1502C	7-1-5-02R25	CH-PC	Chemical Reaction Engineering -I	3	0	0	3	3	40	60	100
CH1503C	7-1-5-03R25	CH-PC	Process Dynamics and Control	3	0	0	3	3	40	60	100
CH1504C	7-1-5-R25E1	CH-PE	Professional Elective-I	3	0	0	3	3	40	60	100
CH1505C	7-1-5-R25E2	CH-PE	Professional Elective-II	3	0	0	3	3	40	60	100
CH1506L	7-1-4-R25P1	CH-PC	Mass Transfer Operations Lab	0	0	3	3	1.5	40	60	100
CH1507L	7-1-4-R25P2	CH-PC	Process Dynamics & Control Lab	0	0	3	3	1.5	40	60	100
CH1508S	7-1-4-R25S1	CH-SC	Computational Techniques Lab	1	0	2	3	2	100	0	100
CH1509M	7-1-5-09R25	CH-MC	Professional Ethics in Engineering	2	0	0	2	0	100	0	100
CH1510I	7-0-5-R25CS	CH-CI	Community Service Project (CSP)	0	0	0	0	2	100	0	100
TOTAL				18	0	8	26	22	580	420	1000


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CHEMICAL ENGINEERING

PROFESSIONAL ELECTIVE COURSES

Elective List	University Code	Subject Name
Professional Elective-I: (V- Semester)	7-1-5-R25E11	Fuel Cell Systems
	7-1-5-R25E12	Energy Engineering
	7-1-5-R25E13	Industrial Effluent Treatment
Professional Elective-II: (V- Semester)	7-1-5-R25E21	Process Instrumentation
	7-1-5-R25E22	Polymer Science & Engineering
	7-1-5-R25E23	Fundamentals of Nanotechnology
Professional Elective-III: (VI- Semester)	7-1-6-R25E11	Petroleum Refining Processes
	7-1-6-R25E12	CO ₂ Capture and Utilization
	7-1-6-R25E13	Water Conservation & Management
	7-0-6-R25CE1	Introduction to Semiconductor Manufacturing
Professional Elective-IV: (VII- Semester)	7-1-7-R25E11	Fluidization Engineering
	7-1-7-R25E12	Process Modeling & Simulation
	7-1-7-R25E13	Fundamentals of Microelectronic Material Processing
Professional Elective-V: (V-II Semester)	7-1-7-R25E21	Computational Fluid Dynamics
	7-1-7-R25E22	Membrane separations
	7-1-7-R25E23	Bio Process Engineering


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MASS TRANSFER OPERATIONS – II**Credits: 3****Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
V	3-0-0	7-1-5-01R25	CH

Course Educational Objectives:

1. To understand VLE and to learn the different types of distillation operations.
2. To understand the design of continuous fractionating columns in distillation operations.
3. To understand LLE and to learn the design of staged columns for liquid-liquid and solid-liquid extraction and also to learn the construction and operation of different equipment for the said operations.
4. To get a fundamental understanding of membrane separations and solid –liquid leaching operations.
5. To understand the mechanism of adsorption and ion exchange processes

UNIT-I: Distillation –I

Vapor-Liquid Equilibria-P-x-y and t-x-y diagrams – x-y and H-x-y diagrams - ideal solutions - Raoult's Law, Relative volatility-positive and negative deviations from ideality, Minimum and Maximum boiling azeotropes-Types of distillation column- Steam distillation-Simple distillation-Flash distillation- Multicomponent simple and flash distillation -Differential distillation – batch distillation with reflux.

UNIT-II: Distillation –II

Continuous Fractionation -Binary systems, Multistage towers-The method of Ponchan and Savarit- The method of McCabe-Thiele-Location of the feed tray, total reflux, minimum reflux ratio, optimum reflux ratio, use of open steam, multiple feeds, partial and total condensers – Reboilers- Packed bed distillation. – Principles of azeotropic and extractive distillation-comparison-Continuous differential contact packed tower distillation. Various steps involved in the determination of the height of the tower-low pressure distillation-molecular distillation.

UNIT-III: Liquid –Liquid Extraction

Liquid Extraction-Applications-Liquid Equilibria-Equilateral Triangular coordinates– system of three liquids-one pair partially soluble-two pair partially soluble-Rectangular coordinates - Effect of temperature and pressure-Rectangular coordinates on solvent free basis – factors influencing the choice of solvent .Single stage extraction -Multistage crosscurrent extraction and continuous countercurrent multistage extraction with out and with reflux –Steps involved in the determination of number of stages- Minimum solvent requirement-Insoluble liquids – cross and counter current operations- Equipment for solvent extraction- agitated vessels, Emulsions and Dispersions, Mixer –settler cascades, sieve tray towers. Continuous contact (Differential)contactors –Spray towers- packed towers-Mechanically agitated counter current extractors, Rotating Disc contactors, centrifugal Extractors and York-Scheibel column extractor.


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UNIT-IV: Leaching

Preparation of the solid –Temperature of Leaching- unsteady - state operation - in- place Leaching, Heap leaching, percolation tanks - Counter current multiple contact (the shanks system), percolation in closed vessels, Filter- press leaching Agitated vessels. –Batch settling - Steady - stage (continuous) operation - Leaching during grinding, Agitated vessel, Thickeners, continuous counter current Decantation, Hydro cyclones ,continuous leaching of coarse solids, classifiers, leaching of vegetable seeds. Basics of Membrane Separations–classification–capillary and solution diffusion models – retention coefficient – concentration polarization – fouling – membranes (operational requirement – structure and preparation) – components of a typical membrane separation plant – micro filtration – ultra filtration – reverse osmosis – dialysis – electro dialysis - pervaporation

UNIT – V: Adsorption

Adsorption-Applications-Types of adsorption-Nature of Adsorbents-Adsorption equilibrium and adsorption kinetics –single gases and vapors, vapor and gas mixtures, and liquids. Adsorption operations – Stage wise operation – Multistage cross current and counter current operation, types of two parameter adsorption isotherms-applications of the Langmuir Freundlich equation and BET adsorption isotherm- Equipment's-continuous - Agitated vessels, Fluidized beds, Steady state fixed bed absorbers, adsorption wave, Ion Exchange – Principles of ion exchange, Techniques and applications, Equilibrium Rate of ion exchange.

Text Book:

Mass Transfer Operations–Robert E Treybal (3rded.) Mc Graw Hill, Kogakusha.

Reference Books:

- 1.Bio Separations–Principles and Techniques–B. Sivasankar
- 2.Principles of Mass transfer and Separation Processes–B.K. Datta-PHI


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Course Outcomes:

1. To be able to analyze different phase diagrams – p-x-y, t-x-y, h-x-y, bimodal solubility curve and N-x-y representations. To be able to calculate flash calculations. To be able to apply Rayleigh's equation (differential distillation).
2. To be able to calculate the number of ideal stages using Ponchon-Savarit and McCabe-Theile procedures. To acquire a fundamental understanding of azeotropic and extractive distillation.
3. To be able to calculate the solvent requirement and number of stages for different contacting patterns like single stage, cross current and countercurrent modes
4. To be familiar with different constructions of equipment suitable for extraction and leaching.
5. To be able to explain the equilibrium of adsorption and to calculate and number of stages for different contacting schemes.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1			2			1			3
CO2	1	1	1	1	1	2		1	1			2
CO3	1	1	1	1	1	2		1	1			1
CO4	1	1	1	1	1	2		1	1			2
CO5	1	1	1	1	1	2		1	1			3

1 - Slightly; 2 - Moderately; 3 – Substantial


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CHEMICAL REACTION ENGINEERING – I**Credits: 3****Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
V	3-0-0	7-1-5-02R25	CH

Course Objectives:

1. To provide knowledge on different types of reactions, reaction rate and mechanism
2. To provide knowledge on collection and analysis of batch reactor data for homogeneous reactions
3. To provide knowledge of different types of ideal reactors and to derive their design equations
4. To teach about different reactor configurations, their selection and performance analysis and to provide a foundation on deriving rate expressions for single and multiple reactions.
5. To teach about the heat effects during the reaction and finding the rate of reaction

UNIT - I:

Introduction: Performance equation, Classification of Reactions, Variables affecting the rate of reaction, Definition of Reaction rate.

Kinetics of Homogeneous Reaction: Concentration dependent term of a rate equation - Temperature dependent term of Rate equation - Searching for a mechanism.

UNIT - II:

Interpretation of Batch Reactor Data: Constant Volume Batch Reactor - Integral method and differential method of Analysis of Data - Varying Volume Batch Reactor - differential and integral methods of analysis of Data.

Single Ideal Reactor Design - Ideal Batch Reactor - Steady state mixed flow Reactor - Steady state plug flow Reactor - Space time, Space velocity, holding time in flow systems.

UNIT - III:

Design for Single Reactions: Size comparison of Single Reactions - Batch Reactors - Mixed Vs. Plug flow Reactors, First and Second order Reactions - Variations of Reactant ratio for second order reactions - General graphical procedure. Multiple Reactor systems: Plug flow Reactors in series and/ or in parallel - Equal size mixed flow Reactors in series - Mixed flow reactors of different sizes in series - Reactors of different types in series - Recycle reactor (omit auto catalytic reactions).

UNIT - IV:

Design for Parallel Reactions: Qualitative and quantitative discussion about product distribution and reactor size – The selectivity.


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Design for Series Reactions: Qualitative discussion about product distribution for irreversible first order reactions - Quantitative treatment, Plug flow or batch reactor - Quantitative treatment, Mixed flow reactor - First order followed by zero order reaction - zero order followed by first order reaction - Successive irreversible reactions of different orders - Reversible reactions – Qualitative discussion and Quantitative treatment of irreversible series-parallel reactions.

UNIT - V:

Temperature and Pressure Effects: Single Reactions - Heats of Reactions from Thermodynamics, Equilibrium constant from Thermodynamics - General Graphical Design Procedure - Optimum temperature progression - Heat effects - Adiabatic and Non-adiabatic operations - Exothermic Reactions in Mixed Reactors - A special problem.

TEXT BOOK:

1. Chemical Reaction Engineering by Octave Levenspiel, 3rd Edition, John Wiley & Sons

REFERENCES:

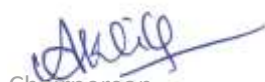
1. Chemical Engineering Kinetics (3rd ed) J M Smith.
2. Elements of Chemical Reaction Engineering (2nd) - H.Scott Fogler

Course Outcomes: At the end of the course, student will be able to

1. Write rate expressions for elementary and non-elementary reactions and to study the temperature dependence of reactions.
2. Apply analytical procedures (integral, differential, half life) to convert batch reactor data in to kinetic expression and derive performance equation for ideal reactors.
3. Make performance analysis of multiple reactor systems – PFR in series and parallel, CSTRs in series and in parallel, different reactors in series and recycle reactor.
4. Analyse multiple reactions – series, parallel and series-parallel and suggest reaction controls for desired product distribution.
5. Estimate heat effects of chemical reactions, suggest optimum temperature progression and have the knowledge on adiabatic and non-adiabatic operations.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1			2			1			3
CO2	1	1	1	1	1	2		1	1			2
CO3	1	1	1	1	1	2		1	1			1
CO4	1	1	1	1	1	2		1	1			2
CO5	1	1	1	1	1	2		1	1			3

1 - Slightly; 2 - Moderately; 3 – Substantially


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PROCESS DYNAMICS AND CONTROL**Credits: 3****Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
V	3-0-0	7-1-5-03R25	CH

COURSE DESCRIPTION:

This course is designed for chemical engineering students to understand the transfer functions for different types of systems in process industries, able to identify different controller elements used in process industries, can draw the block diagrams for control systems and able to learn the stability of systems in process industries. Frequency response of control systems can be studied. Different types of controller arrangements and controller tuning methods are studied.

Course Educational Objectives:

1. To introduce the fundamental principles of system dynamics and response, with emphasis on process systems
2. To introduce the basic features of different controllers and control elements
3. To develop and analyses feedback control loops for stability
4. To introduce the features of advanced control strategies
5. To train the students in the basic approach of modelling a physical process

UNIT I:

Laplace transforms - properties of Laplace transform, solution of linear differential equations using Laplace transform techniques. Block diagrammatic representation: Block diagram of control system, Summing point, Take-off point and block diagram algebra. Response of first order systems: Derivation of transfer functions for first order systems, Mercury thermometer, liquid level process, Mixing process and Heating process. linearization of nonlinear systems, interacting and non-interacting systems.

UNIT II: : Response of second order systems: Characteristics, Derivation of transfer functions for Second order system, Transient response, natural frequency, damping factor, overshoot, decay ratio, rise time and settling time, transportation lag.

Control systems: Control system, components of a feedback control system, Types of Control systems. Types of Feedback control system.

UNIT III: Controllers, Types of Controllers, P, PD, PI and PID controller, overall transfer function of closed loop control systems, regulator and servo problems, and final control elements, **Stability:** Concept of Stability, Stability criterion, Routh test for stability.


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UNIT - IV: Root locus: concept of root locus, rules for plotting the root locus diagram, Application of root locus to control systems. Bode diagrams Control systems design by frequency response: Bode stability criterion, Gain and Phase margins.

UNIT – V:

Advanced control strategies: Cascade control, feed forward control and ratio control. Controller tuning and process identification, control valves.

TEXT BOOK:

1. D.R. Coughanowr and S. E. LeBlanc, 'Process Systems Analysis and Control', Mc Graw Hill, III Edition, 2009.
2. D. E. Seborg, T. F. Edgar, D. A. Millichamp and F.J. Doyle III, 'Process Dynamics and Control', Wiley, IV Edition, 2017.
1. Process Control: Designing Processes and Control Systems for Dynamic Performance, 2nd Ed, TE Marlin (2000).
2. 2. Essentials of Process Control, WL Lubyen and ML Luyben (1997). McGraw Hill: New York.

REFERENCES:

1. Essentials of Process Control, WL Lubyen and ML Luyben (1997). McGraw Hill: New York.
2. Chemical Process Control by G. Stephanopolous, Prentice Hall 1998.
3. Process Control: Designing Processes and Control Systems for Dynamic Performance, 2nd Ed, TE Marlin (2000).
4. Computer Control of Industrial Processes, Emenule, S.Savas, McGraw-Hill, London.

Course Outcomes:

1. To be able to model physical systems/processes like thermometer / level systems / manometer. To have acquired the ability to study the response behavior of systems.
2. To be able to suggest an appropriate controller for an application. To develop feedback control loops and reduce it to single block representation for further analysis.
3. To be able to construct and analyse Routh array.
4. To be able to obtain the locus of roots of a characteristic equation. To be able to make stability analysis-based frequency response (Bode plots) approach.
5. To have learnt the basics of advanced control strategies. To have learnt controller tuning rules.


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	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	2	1	2				3			3
CO2		1	3	1	2				2			3
CO3	1	1	1	2	2				1			3
CO4	1	1	1	2	1				1			2
CO5		1	1	1	1				1			1

1 - Slightly; 2 - Moderately; 3 – Substantially


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PE-I - 1 FUEL CELL SYSTEMS**Credits: 2****Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
V	3-0-0	7-1-5-R25E11	CH

Course Educational Objectives:

1. To understand the development of electrochemistry and the fundamentals of electrode–electrolyte interfaces.
2. To acquire knowledge of electrochemical technologies and their practical applications.
3. To learn the fundamental principles of fuel cells.
4. To understand the electro catalytic processes involved in fuel cell reactions.
5. To study modeling techniques and analytical methods related to electrochemical systems.

UNIT-I**Fuel Cells and Electrochemical Energy Conversion**

What is a fuel cell, brief history, types of fuel cells, how does it work, why do we need fuel cells, Fuel cell applications, Fuel cell basic chemistry and thermodynamics, heat of reaction, theoretical electrical work theoretical electrical, potential, theoretical fuel cell efficiency

Electrochemistry – Thermodynamic Aspects of Electrochemical (EC) Energy Conversion – Theoretical Efficiency of Heat of a Reaction to Mechanical Energy – Efficiency of EC Energy Conversion – Factors Affecting Efficiency of EC Energy Conversion Electrode Kinetics of EC Energy Conversion

UNIT-II**Alkaline Fuel Cells and Molten Carbonate Fuel Cells**

Hydrogen, Hydrocarbon fuels, effect of impurities such as CO, S and others. electrode kinetics, types of voltage losses, polarization curve, fuel cell efficiency, Tafel equation, exchange currents, Advancements – System Issues – Ammonia as AFC Fuel Molten Carbonate Fuel Cells – General Principle – Cell Components – Mechanisms of Electrode Reactions- Status

UNIT-III**Phosphoric Acid and Solid Oxide Fuel Cells**

Phosphorus Acid Fuel Cells- Technology- Electrode Materials and Manufacturing – Stacks and Systems Solid Oxide Fuel Cells – History – Advantages and Limitations- Cell Components – Electrode Materials – Interconnects – Fuel – Configuration and Performance – Environmental Impact – Applications


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UNIT-IV**Direct Methanol Fuel Cell Technology**

Direct Methanol Fuel Cells – Technology Evolution – The Noble Metal Issue- The Catalyst – Electro-oxidation of Methanol – The Electrolyte – Non-Catalytic Aspects – Methanol Cross over to DMFC – catalyst Optimization and Scale up – Engineering Aspects.

UNIT-V**Comprehensive Study of Proton Exchange Membrane Fuel Cells**

Proton Exchange Membrane Fuel Cells – Basic Scientific aspects- Challenges – Technology Development – Fuel Processing – Modeling Studies of PEMFC Performance – Applications – Challenges to High Temperature Operations – Technological and Economic Challenges

Text Book :

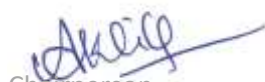
1. Fuel Cell : Principles and Applications – B.Viswanathan and M. AuliceScibioh – Universities Press - 2006

Course outcomes: At the end of the course the student

1. Have the knowledge on electrode and electrolyte interfaces
2. Able to implement various electrochemical technologies
3. Will have an idea on fuel cell principles and able to implement the principles
4. Acquire basic knowledge on electrolysis of fuel cell reactions
5. Will have a good knowledge on modeling analysis of fuel cell systems and Can give particular attention to half cell systems

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1			1	1	1			1	1			2
CO2			1	1	2			1	2			1
CO3			2	1	1			1	1			1
CO4			1	2	2			1	1			1
CO5			1	1	1			1	1			1

1 - Slightly; 2 - Moderately; 3 – Substantially


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PE-I – 2 ENERGY ENGINEERING**Credits: 3****Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
V	3-0-0	7-1-5-R2E12	CH

Course Educational Objectives:

1. To understand the present situation of energy supply and consumption rate in the world and India.
2. Make the students to have knowledge on alternative energy sources like solar energy, nuclear energy resources, and hydrogen energy and non-conventional energies like gobar gas plants, wind energy, ocean energy and geothermal energy.
3. To understand the importance of fuel cell and their working
4. To understand the renewable energy sources like wind energy.
5. Students will learn principles of conservation and audit, to get knowledge on economic concept of energy.

UNIT - I:

Scenario – Energy Consumption as a measure of prosperity – World energy future – Energy Consumption(world & India) Energy Sources and its availability. Fossil fuels -Coal and coke Occurrence, preparation, classification, Petroleum and natural gas - Constitution, occurrence, sources and production. Processed fuels - Water gas, Producer gas, Refinery gas, LPG.

UNIT - II:

Solar energy– Solar radiation at earth's surface – Solar energy collectors – Flat plate collectors, Concentrating collectors, non concentrating collectors Storage systems – Solar pond, extraction of thermal energy, applications. Applications of Solar Energy and conversion methods.

UNIT - III:

Chemical energy sources – Fuel Cells – Classification – Types – Applications. Nuclear energy Uranium as Energy source, types of reactors – sources in India, Nuclear Fuel Complex, Hydrogen energy – Introduction – Storage – Transportation – Utilization of Hydrogen gas –Hydrogen as an alternative fuel.


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UNIT - IV:

Other non-conventional energy sources –Gobar gas plants - Principle, construction and working–

KVIC Plant - Impact on rural development -Wind energy - Introduction – Wind energy

Conversion system – classification - advantages & disadvantages – applications –storage

Ocean energy – Ocean Thermal electric conversion – open cycle, closed cycle –

Utilization Geothermal energy Introduction– Geothermal sources – hydrothermal sources advantages& disadvantages – applications.

UNIT – V:

Energy conservation - Economic concept of energy – Principles of conservation and audit cogeneration – heat recuperators – regenerators – heat pipe – heat pump.

REFERENCE:

1. Conventional Energy Technology – Fuels and Chemical Energy by S.B.Pandya, TMH
2. Energy Resources, Demand and Conservation (with special reference to India) by ChamanKashkari, TMH (1975).
3. Solar Energy Utilization, G.D.Rai, Khanna Pub. (1984).
4. Non-conventional Energy Sources G.D.Rai, Khanna publications.
5. Energy Conservation and Utilization by JerroldH.Krentz, Allyn and Bacon Inc 1976.
6. Elements of Energy Conservation by Rused C.K, McGraw-Hill

Course outcomes

1. Students will be able to understand present situation of energy resources
2. Students will be able to get knowledge on solar energy collectors ,Students will come to know applications of solar energy and conversion methods .
3. Able to understand utilization of Hydrogen energy, Have the knowledge on fuel cells
4. Able to implement principles and working knowledge of Gobar plants, Will have the knowledge on wind energy and its applications, Acquired knowledge on ocean thermal electric conversion.
5. Acquired basic knowledge on economic concept of energy and principles of conservation and audit.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1					1		1	1	1			1
CO2					1							1
CO3					1		1		1			1
CO4					1		1		1			1
CO5					1				1			1


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PE-I – 3 INDUSTRIAL EFFLUENT TREATMENT**Credits: 3****Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
V	3-0-0	7-1-5-R25E13	CH

Course Educational Objectives:

1. To illustrate the importance of Environment and society to engineering professional students.
2. To impart the causes and preventive measures against Air, water, Land and noise pollution.
3. Describe the preventive methods of different types of pollution.
4. To understand the importance of waste water treatment
5. To learn about solid and hazard waste treatment

UNIT - I:

Types of pollution-Sources, causes and effects–Pollution Control Aspects. Industrial Emissions-Liquids& Gases. Classification and properties of air pollutants, Emission sources, effects and their effect on vegetation and materials. Environmental legislation-standards and guidelines, water act 1974, air act 1981.

Meteorological Aspects of Air Pollutant Dispersion: Temperature Lapse Rates and Stability, Plume Behaviour.

UNIT - II

Air Pollution Sampling and Measurement: Types of pollutant Sampling and measurement, Ambient air Sampling, Stack Sampling Analysis of Air pollutants

Air Pollution Control Methods and Equipment:

Control Methods, Source correction Methods, Cleaning of gaseous effluents and Particulate Emission Control with equipment, Control of gaseous emissions (without design)

UNIT – III

Waste water sampling and analysis- Domestic, municipal and industrial- characterization-treatment requirements, Sampling, methods of analysis of pollutants-Determination of organic matter- DO, BOD, COD, TOC. Determination of inorganic substances.


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Waste Water Treatment - Primary, Secondary and Advanced Waste

water Treatment, Primary Treatment: Screening, Sedimentation, flotation, neutralization. Secondary Treatment: Removal of BOD- Activated Sludge Process and Design, Trickling Filter Stabilization pond, Aerobic and Anaerobic Treatments, Advanced waste water treatment: Removal of suspended solids, Coagulation and Filtration, Removal of Dissolved solids- adsorption, ion exchange, reverse osmosis, electro dialysis.

UNIT -IV: Pollution Control For Specific Pollutants – Removal of Chromium, phenolic effluents, particulate matter, sulfur dioxide, oxides of nitrogen, Removal of Organic vapor from effluent gases, pollution Control aspects of fertilizer industries, petroleum Refinery and petrochemical units.

UNIT - V:

Solid waste management–Sources and Classification, public health aspects, methods of collection, Disposal and potential Methods.

Hazardous Waste Management: Definition, Sources, properties of hazardous waste .Classification, Hazardous Waste Management Strategy, treatment methods and Disposal methods.

Text Books:

1. Pollution control in Process Industries, Mahajan by C.S.Rao Wiley Eastern Ltd., (1992).
2. S.P. Mahajan ,Pollution Control in process Industries Tata McGraw Hill

REFERENCES:

1. E.B.Beseheivre, M. Schwartz, Treatment of Industrial Wastes McGraw Hill.
2. Environmental pollution control Engg by C.S.Rao Wiley Eastern.
3. Industrial Effluent Treatment Vol.1 J.K.Walters and A.Wint. Applied Science publishing Ltd. London.
4. Industrial Effluent Treatment Vol.2 J.K.Walters&A.Wint
5. Treatment of Hazardous wastes Noyes Data corp. NJ (1983).


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COURSE OUTCOMES:

1. An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability.
2. Understand the atmospheric dispersion of air pollutants, their effect on vegetation, control methodologies for air pollution. Characteristics of municipal solid waste and, for hazard waste treatments
3. An ability to recognition of the water treatment processes and control methods
4. An ability to design the equipment for removal of particulate matter from effluent gases.
5. Indentify the main sources and control methods to reduce the pollution control aspects from fertilizer industries, petroleum refineries.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1						1			
CO2	2	3	1						1			
CO3	2	2	1						1			
CO4	2	2	1						1			
CO5	2	2	1						1			1


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PE-II- 1 - PROCESS INSTRUMENTATION**Credits: 3****Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
V	3-0-0	7-1-5-R25E21	CH

Course Description:

This course is designed to chemical engineering students to understand various instruments used in process industries to measure the parameters like temperature, pressure, level, composition of various mixtures.

Course Educational Objectives:

1. To learn basic structure and characteristics of measuring elements and construction, working and features of instruments suitable for temperature measurement
2. To have knowledge on Composition analysis techniques
3. To learn construction and operation of pressure measuring instruments.
4. To learn construction and working of liquid-level measuring instruments.
5. To have knowledge about recording, indicating, signaling type instruments.

UNIT - I:

Elements of instruments, static and dynamic characteristics, basic concepts of response of first order type instruments,

Temperature Measurement : mercury in glass thermometer, bimetallic thermometer, pressure spring thermometers, static accuracy and response of thermometers, thermoelectric temperature measurement, resistance thermometer bulbs and circuits, radiation receiving elements, radiation, photoelectric and optical pyrometers.

UNIT- II:

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

UNIT - III:

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


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UNIT - IV:

Head density and specific gravity: direct measurement of liquid level, pressure measurement in open vessels, level measurements in pressure vessels, measurement of interface level, density measurement, level of dry materials.

UNIT - V

Flow measurement: Measurement of Head flow meters, area flow meters, open channel meters, viscosity meters.

Recording instruments, indicating and signaling instruments, transmission of instrument reading, control centre, instrumentation diagram, process analysis.

TEXT BOOK

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

REFERENCE

1. Principles of Industrial instrumentation by Patranabis, TMH

Course Outcomes:

2. Can understand the basic for measuring device of temperature
3. Can able to measure the composition of the mixture with different analytical instruments.
4. Can understand different instrument for pressure measurement of different liquid and elements of pressure measuring device.
5. Can Can understand the flow measuring device and various system of control unit in various plant

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	1		1			1			
CO2	3	3	1	1		1			1			
CO3	3	2	1			1			1			
CO4	3	2	1	1		1			1			
CO5	3	2	1	1		1			1			1


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PE-II – 2 - POLYMER SCIENCE AND ENGINEERING**Credits: 3****Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
V	3-0-0	7-1-5-R25E22	CH

Course Description;

This course is designed for chemical engineering students to understand various types of polymer materials, various methods for the preparation of polymer components

UNIT - I:

Classification of Polymers, Functionality, Mechanisms of Polymerization, Chain Polymerisation - Free radical, Ionic and cationic Polymerisation - Step polymerization methods. Stereoisomerism in Polymers, Chemicals and Geometrical structures in Polymers. Block and Graft Polymers. Molecular weight of Polymers - weight average, number average and viscosity average molecular weight. Principles and calculations for determination of the molecular weights - Osmometry, Ebulliometry, Light scattering, ultracentrifugation, End group Analysis and viscosity methods.

UNIT II:

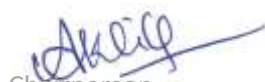
Thermodynamics of Solubility of polymers. Transition in polymers. Crystalline in Polymers. Polymer Degradation method. Kinetics of Polymerization Reactions— Free radical, Ionic Polymerization and step polymerization reactions. Derivation of rate equations and related numerical problems.

UNIT-III:

Polymerization Methods - Bulk, solution, suspension and emulsion polymerization. Comparison of Polymerization methods. Fabrication methods - Compounding Injection molding, Extrusion blow, blow extrusion, calendaring, Rotational molding, Thermoforming and vacuum forming. Polymer processing and Rheology: Non-Newtonian flow, Viscosity of Polymer solutions and suspensions, Constitutive, equations; Capillary Rheometer, Couette Rheometer, Cone and Plate Rheometer, Rheometric characterization of polymer solution and melts.

UNIT-IV:

Brief description of individual polymers. Reaction equations, brief process description with a schematic flow sheet, physical properties and uses of the following polymers. Individual Polymers: Thermosets: Phenol Formaldehyde, Urea formaldehyde, Polyester and epoxy resins, Polyurethane. Thermo plastics: Polyethylene, Polypropylene, PVC, Polystyrene, and Copolymers, PMMA, Polycarbonates.


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UNIT-V:

Applications of Polymers: Membrane Separations: Membrane Applications for Polymeric materials, mechanisms of transport and membrane preparation: Biomedical Applications: Artificial organs, Controlled drug delivery, hemodialysis and hemo filtration; Electronics: Electrically conductive polymers, electronic shielding, encapsulation, photonic polymers.

Reference Books:

1. Polymer Science, V.R.Gowariker, M.V.Viswanthan, Jaidev Sridhar, Wiley eastern Ltd, 1988.
2. Plastics engineering – R.J.Crawford, Butterworth Heinemann
3. Rubber and Plastic Technology – R.Chandra and S.Mishra, CBS Publishers
4. Outlines of Polymer Technology: Manufacture of Polymers by R.N.Sinha, Prentice Hall India.
5. J R Fried – Polymer Science and Technology, Prentice Hall of India Pvt., New Delhi, Eastern Economy Edition, 2000.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1						1			1			
CO2						1			1			
CO3						1			1			
CO4						1			1			
CO5						1			1			1


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PE-II – 3 - FUNDAMENTALS OF NANOTECHNOLOGY**Credits: 3****Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
V	3-0-0	7-1-5R25E23	CH

Unit – I:

Introduction: Importance of Nanotechnology emergence of nanotechnology, size range of nano particles - Thermodynamics and properties of nano scale materials, classification of nano structured materials - Bottom-up and top-down approaches- challenges in nanotechnology. Future of nanotechnology in chemical and Biochemical engineering.

Unit – II:

Synthesis of nano particles and processing: Methods for creating nano structures – processes for producing ultra fine powders – Mechanical grinding – wet chemical synthesis of nano materials – sol-gel emulsion processes-liquid-solid reactions- Gas phase synthesis of nano materials – Furnace, flame assisted ultra sonic spray pyrolysis – Gas condensation (CVC) – cold plasma methods- particle precipitation aided CVD.

Unit – III:

Characterization of nano systems: Sample preparation and characterization techniques of nano structured materials – scanning electron microscopy (SEM) – Transition electron microscopy and X-Ray photo electron and Auger electron spectroscopy (XPS, AES) – Scanning tunneling microscopy (STM), atomic force microscopy (AFM) – powder X-ray diffractometry (XRD).

Unit – IV:

special nano materials: Carbon fullerenes and nanotubes – onions – carbonfullerence-formation, properties and uses – Porous silicon preparation methods-Nano particles of SiC, alumina and zirconia and their sintering techniques – Wafer preparation, wafer cleaning techniques – lithography – etching – Mechanical attrition and nano composites.


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Unit – V:

Nano – Engineering applications: Micro electromechanical systems (MEMS) and nano electromechanical systems (NEMS), sensors, microfluidic devices – nano pump – molecular motors – Nano bots – nano medicine – drug delivery systems – catalysis by gold nano particles – wear resistance coatings – weapons – battery and fuel cell electrodes – thermal management – automotive and aerospace components. Environmental impact of nano-particles – ethical, legal and social issues.

Text Books:

1. Introduction to nanotechnology, by Charles P. Poole and Frank Jowens, John Wiley (2003)
2. Nanotechnology Research and perspectives, MIT Press (1992)

References:

1. Understanding of Nano science and technology, Poori Dutta & Sushmita Gupta, Global vision, New Delhi – (2006)


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MASS TRANSFER OPERATIONS LAB**Credits: 1.5****Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
V	3-0-0	7-1-4-R25P1	CH

List of Experiments:

1. Diffusion In Still Air
2. Diffusion Through Porous Wall
3. Surface Evaporation
4. Wetted Wall Column
5. Vapour- Liquid Equilibrium
6. Liquid-Liquid Equilibrium
7. Humidification/Dehumidification in Packed Column
8. Continuous Drying
9. Differential Distillation
10. Absorption in Bubble Column
11. Spray Extraction Column
12. Ion-Exchange Column
13. Absorption in Packed Tower


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PROCESS DYNAMICS AND CONTROL LAB**Credits: 1.5****Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
V	3-0-0	7-1-4-R25P2	CH

List of Experiments:

1. Characteristics of Control Valves
2. Dynamics of Liquid Filled Manometer
3. Dynamics of Mixing Process
4. Study of Two Interacting Liquid Level Systems
5. Characterization of Liquid Level System
6. Dynamics of Stirred Tank with Heat Transfer
7. Study of Temperature Control Loop
8. Characteristics of I/P Converter
9. Response of Pressure Vessels
10. Dynamics of Thermometer


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COMPUTATIONAL TECHNIQUES LAB**Credits: 2****Assessment: 100 + 0**

Semester	L-T-P	Course Code	Branches
V	3-0-0	7-1-4-R25S1	CH

List of Computer Programming:

Exposure to MAT Lab with the following

1. Euler's Method
2. Runge-Kutta Fourth Order Method
3. Regular Falsi Method
4. Newton Raphson Method
5. Newton Raphson Multiple Roots Method
6. Newton Forward Interpolation Method
7. Newton Backward Interpolation Method
8. Lagranges Interpolation Method
9. Jacobi Iteration Method
10. Gauss-Siedel Iteration Method


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PROFESSIONAL ETHICS IN ENGINEERING**Credits: 0****Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
V	2-0-0	7-1-5-09R25	

COURSE EDUCATIONAL OBJECTIVES:

1. To understand the core values that shape a professional character, such as integrity, work ethic, and civic virtue.
2. To create awareness about engineering ethics and theories of moral development (Kohlberg & Gilligan).
3. To instil a sense of responsibility regarding safety, risk assessment, and the experimental nature of engineering projects.
4. To educate students on their rights and responsibilities in a workplace, including Intellectual Property Rights (IPR) and confidentiality.
5. To broaden the perspective on global issues, such as environmental ethics, computer ethics, and the role of engineers as managers and consultants.

UNIT-I**HUMAN VALUES**

Morals, values and Ethics – Integrity – Work ethic – Service learning – Civic virtue – Respect for others – Living peacefully – Caring – Sharing – Honesty – Courage – Valuing time – Cooperation – Commitment – Empathy – Self Confidence – Character – Spirituality – Introduction to Yoga and meditation for professional excellence and stress management.

UNIT-II**ENGINEERING ETHICS**

Senses of Engineering Ethics – Variety of moral issues – Types of inquiry – Moral dilemmas – Moral Autonomy – Kohlberg's theory – Gilligan's theory – Consensus and Controversy – Models of professional roles – Theories about right action – Self-interest – Customs and Religion – Uses of Ethical Theories.

UNIT-III**ENGINEERING AS SOCIAL EXPERIMENTATION**

Engineering as Experimentation – Engineers as responsible Experimenters – Codes of Ethics – A Balanced Outlook on Law.


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UNIT-IV SAFETY, RESPONSIBILITIES AND RIGHTS

Safety and Risk – Assessment of Safety and Risk – Risk Benefit Analysis and Reducing Risk – Respect for Authority– Collective Bargaining – Confidentiality– Conflicts of Interest – Occupational Crime – Professional Rights – Employee Rights – Intellectual Property Rights (IPR) – Discrimination.

UNIT V**GLOBAL ISSUES**

Multinational Corporations – Environmental Ethics – Computer Ethics – Weapons Development – Engineers as Managers – Consulting Engineers – Engineers as Expert Witnesses and Advisors – Moral Leadership – Code of Conduct – Corporate Social Responsibility.

COURSE OUTCOMES:

1. Apply holistic human values, such as integrity, honesty, and empathy, to their personal and professional lives to maintain harmony.
2. Apply ethical theories (like Utilitarianism or Duty ethics) to resolve moral dilemmas and distinguish between ethical and unethical professional behavior.
3. Analyze engineering projects as social experiments, demonstrating an understanding of codes of ethics and the need for responsible experimentation.
4. Assess safety and risk in engineering practices and defend professional rights and responsibilities, including intellectual property and whistle blowing.
5. Evaluate global challenges—such as environmental degradation, computer ethics, and weapons development—and apply ethical principles to multinational corporate scenarios.

TEXTBOOKS:

1. Mike W. Martin and Roland Schinzinger, Ethics in Engineering, Tata McGraw Hill, New Delhi, 2003.
2. Govindarajan M, Natarajan S, Senthil Kumar V.S, Engineering Ethics, Prentice Hall of India, New Delhi, 2004.


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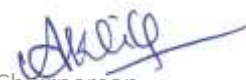

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REFERENCES:

1. Charles B. Fleddermann, —Engineering Ethics, Pearson Prentice Hall, New Jersey, 2004.
2. Charles E. Harris, Michael S. Pritchard and Michael J. Rabins, —Engineering Ethics – Concepts and Cases, Cengage Learning, 2009.
3. John R. Boatright, —Ethics and the Conduct of Business, Pearson Education, New Delhi, 2003
4. Edmund G. Seebauer and Robert L. Barry, —Fundamentals of Ethics for Scientists and Engineers, Oxford University Press, Oxford, 2001.
5. Laura P. Hartman and Joe Desjardins, —Business Ethics: Decision Making for Personal Integrity and Social Responsibility Mc Graw Hill education, India Pvt. Ltd., New Delhi, 2013.

PO & PSO CO	PO(1)	PO(2)	PO(3)	PO(4)	PO(5)	PO(6)	PO(7)	PO(8)	PO(9)	PO(10)	PO(11)	PO(12)	PSO(1)	PSO(2)
CO1						2		3	3			3	1	2
CO2						2		3	2			2	1	1
CO3						3	1	3	2			2	2	1
CO4						3		3	2	1		2	2	2
CO5						2	3	3	1			2	1	2

1 - Slightly; 2 - Moderately; 3 – Substantially


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FACULTY OF ENGINEERING
S. V. U. COLLEGE OF ENGINEERING
TIRUPATI-517 502

**B.Tech. (Chemical Engineering)
Semester VI (Third Year)**

Code		Category	Course Title	Scheme of Instruction, Hrs/Week				Credits	Scheme of Evaluation, Marks		Total Marks
Department	University			L	T	P	Total		CIE	SEE	
CH1601C	7-1-6-01R25	CH-PC	Transport Phenomena	3	0	0	3	3	40	60	100
CH1602C	7-1-6-02R25	CH-PC	Chemical Reaction Engineering-II	3	0	0	3	3	40	60	100
CH1603C	7-1-6-03R25	CH-PC	Optimization Techniques	3	0	0	3	3	40	60	100
CH1604C	7-1-6-R25E1	CH-PE	Professional Elective-III	3	0	0	3	3	40	60	100
CH1605C	7-1-6-R25O1	CH-OE	Open Elective-I (MOOCS)	0	0	0	0	3	0	100	100
CH1606C	7-1-6-R25O2	CH-OE	Open Elective-II (MOOCS)	0	0	0	0	3	0	100	100
CH1607C	7-0-6-R25M1	CH-BS	Elements of Quantum computing	2	0	0	2	2	100	0	100
CH1608K	7-1-6-R25MK	CH-IK	Indian Science, Engineering & Technology (IKS – Mandatory)	2	0	0	2	0	100	0	100
CH1609L	7-1-6-R25P1	CH-PC	Reaction Engineering Lab	0	0	3	3	1.5	40	60	100
CH1610S	7-1-6-R25S1	CH-SC	Process Simulation Lab	1	0	2	3	2	100	0	100
TOTAL				17	0	5	22	23.5	500	500	1000
Students shall undergo summer Industrial Internships for a duration of six to eight (6-8) weeks during the summer vacation by completing 45 – 60 hours of work with at least 75% attendance, to be evaluated and reflected in 7 th semester.											
Students shall ensure that IKS MOOKS and IKS Mandatory courses are not same either in title and/or in syllabi.											


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CHEMICAL ENGINEERING

PROFESSIONAL ELECTIVE COURSES

Elective List	University Code	Subject Name
Professional Elective-I: (V- Semester)	7-1-5-R25E11	Fuel Cell Systems
	7-1-5-R25E12	Energy Engineering
	7-1-5-R25E13	Industrial Effluent Treatment
Professional Elective-II: (V- Semester)	7-1-5-R25E21	Process Instrumentation
	7-1-5-R25E22	Polymer Science & Engineering
	7-1-5-R25E23	Fundamentals of Nanotechnology
Professional Elective-III: (VI- Semester)	7-1-6-R25E11	Petroleum Refining Processes
	7-1-6-R25E12	CO₂ Capture and Utilization
	7-1-6-R25E13	Water Conservation & Management
	7-0-6-R25CE1	Introduction to Semiconductor Manufacturing
Professional Elective-IV: (VII- Semester)	7-1-7-R25E11	Fluidization Engineering
	7-1-7-R25E12	Process Modeling & Simulation
	7-1-7-R25E13	Fundamentals of Microelectronic Material Processing
Professional Elective-V: (V-II Semester)	7-1-7-R25E21	Computational Fluid Dynamics
	7-1-7-R25E22	Membrane separations
	7-1-7-R25E23	Bio Process Engineering


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TRANSPORT PHENOMENA**Credits: 3****Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
VI	3-0-0	7-1-6-01R25	CH

COURSE DESCRIPTION:

This course is designed to chemical engineering students to understand the fluid flow dynamics in different conduits. Students are able to apply the fundamental mass, energy, and momentum balance equations to identify the flow conditions. They can able to apply boundary conditions for any flow system.

Course Objectives

1. Study the fluid dynamics, heat transfer and mass transport together at the introductory level.
2. Carry out micro and Macroscopic mass, momentum and energy balance to solve engineering problems.
3. Develop the general transport equations and perform time smoothed operations.

UNIT – I: Viscosity and mechanism of momentum transport: Newton's law of viscosity - pressure and temperature dependence of viscosity of liquids and gases, molecular theory of gases at low density. Thermal conductivity and mechanism of energy transport: Fourier's law of heat conduction - effect of temperature and pressure on thermal Conductivity, theory of thermal conductivity of gases at low density. Diffusivity and mechanism of mass transport: Fick's law of binary diffusion, temperature dependence of diffusivities, theory of diffusion in gases at low density -definition of concentrations, velocities and mass and molar fluxes.

UNIT – II: Shell momentum balances and Velocity distributions in laminar flow: shell momentum balances and boundary conditions, flow of a falling film - flow through circular tube and annulus - adjacent flow of two immiscible liquids – Creeping flow around sphere. Macroscopic mass, momentum and mechanical energy balances: Estimation of friction loss - pressure rise and friction loss in a sudden expansion, performance of a liquid - liquid ejector - power requirements for pipe line flow.

UNIT – III: Shell energy balances and Temperature distributions in solids and in laminar flow: Shell energy balances and boundary conditions - heat conduction with an electrical heat source –Nuclear heat source - viscous heat source - heat conduction through composite wall, addition of resistances - Heat conduction in a cooling fin - forced convection - free convection.


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UNIT – IV: Concentration distributions in solids and in laminar flow: shell mass balances, boundary conditions - diffusion through a stagnant gas film- diffusion with a heterogeneous chemical reaction - diffusion with a homogeneous chemical reactions - Diffusion into falling liquid film (Gas Absorption).

The equations of change for isothermal systems: Equations of continuity - Equation of motion - Equations of energy.

UNIT – V: Application of equation of change to solve flow problems: Flow through circular tube - falling film with variable viscosity –operation of coquette viscometer - shape of the surface of a rotating liquid –Transpiration cooling. The equation of continuity for a multi component mixture. Introduction to turbulent flow: fluctuations and time smoothed quantities - time smoothing of equations of change for incompressible fluids and time smoothing equation continuity for species A.

Text Books:

1. Transport Phenomena by R.B.Bird, Warren E. Stewart and Edwin N. Lightfoot, Wiley International Editors, II Edition, Chemical Engineering Series. 2005

Course Out comes: At the end of the course, student will be able to

1. Have the knowledge of transport of momentum, heat, mass and their mechanism.
2. Analyze the momentum transfer problems with shell balance and performance of liquid – liquid ejector, sudden expansion and pipe flow.
3. Analyze the Energy transport problems to derive heatflux distributions and also temperature distributions for various systems.
4. Understand diffusion shell balance and analyze the problems related to mass transfer.
5. Solve continuity, Navier-Stokes and energy equations to analyze engineering problems related to Newtonian laminar flow and time smoothed operations

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1	2								1
CO2	1	2	3	2	2							1
CO3		2	2	3		1						1
CO4		1	3	2								1
CO5		2	2	2	1							1

1 - Slightly; 2 - Moderately; 3 – Substantially


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CHEMICAL REACTION ENGINEERING – II**Credits: 3****Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
VI	3-0-0	7-1-6-02R25	CH

Course Educational Objects:

1. To develop a general methodology of combining reaction chemistry and chemical engineering concepts,
2. To optimize variety of systems where modeling or engineering of reactions is needed.
3. To understand the suitability and performance characteristics of different types of reactors like packed bed reactors mixed reactors
4. To teach various types of flows like Ideal flow, Non-Ideal flow and mixing of fluids
5. To understand the mechanism of solid Catalyzed reactions and fluid–fluid reactions

UNIT-I: Non Ideal Flow

Residence time Distribution of fluid in Vessels - E curve, the age distribution of fluid leaving in vessel, Experimental methods, the relations among E, C and F curves, mean time for closed vessels, useful mathematical tools, ways of using Age distribution information. Conversion directly from Tracer information - linear process. Models for Non ideal flow –Segregation model, Dispersion Model and Tank in series Model, Correlations for Axial Dispersion. Chemical reaction and dispersion. Mixing of fluids - self mixing of a single fluid and Mixing of two miscible fluids.

UNIT-II: Heterogeneous processes, catalysis and adsorption:

Heterogeneous Processes - Global Rates of Reaction, types of heterogeneous reactions. Catalysis - The nature of catalytic reactions, the mechanism of catalytic reactions.

Adsorption - Physical adsorption and Chemical Adsorption, Desorption, Applications- Adsorption Isotherms and Adsorption kinetics. Solid catalysis - Determination of physical properties - Surface Area, Void volume, solid density and pore volume distribution. Classification of catalysts - Catalyst preparation - promoters and inhibitors, non-isothermal reactors; kinetics of heterogeneous catalytic reactions; diffusion effects in catalysis; rate and performance equations for catalyst deactivation.

UNIT-III: Solid -Catalyzed Reactions:

The Rate Equation for Surface Kinetics, Rate of equations in terms of Fluid-phase concentrations at the catalyst surface - film resistance controls, surface phenomenon controls, qualitative analysis of rate equation, qualitative predictions from Active-site theory, Quantitative interpretation of kinetic data, pore diffusion resistance important, diffusion in single cylindrical pores, diffusion in porous catalysts, heat effects during reaction, combination of resistances for isothermal particles. Product Distribution in Multiple Reactions

Different Experimental methods or finding rates for solid catalyzed reactions.


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UNIT-IV: Fluid-Fluid Reactions:

The rate equation, kinetic regimes for Mass Transfer and Reaction, Rate equations for instantaneous fast, slow, intermediate and infinitely slow reactions. Significance of Hatta number and enhancement factor for first order reactions and tower reactor design.

UNIT-V: Fluid particle non-catalytic reactions;

Selection of a model - unreacted core model for spherical particles of unchanging size - diffusion through gas film controls - diffusion through ash layer controls - chemical reaction controls - rate of reaction for shrinking spherical particles - chemical reaction controls - gas film diffusion controls - Stokes regime - extensions - Limitations of the Shrinking Core Model - Stokes regime - Application to design - Determination of the rate-controlling step

Text Books:

1. Levenspiel O Chemical Reaction Engineering 3rd ed. John Wiley
2. Smith J.M. Chemical Engineering Kinetics 3rd ed. M c Graw Hill New York

Reference Books:

Elements of Chemical Reaction Engineering by H Scott Fogler, 2nd ed. PHI 1992

Course Outcomes:

1. Residence time distribution of fluid in vessels, the F and C curve relations. Formulate a residence time distribution from tracer experiment results and use it to predict conversion in a non-ideal reactor.
2. Write reaction rate equations for common types of homogeneous and heterogeneous reactions. Adsorption - Types and Isotherms.
3. Identify the mechanisms involved in a heterogeneous reaction and formulate an effective rate equation.
4. Calculate the impact of changing solid (or fluid) properties on the conversion of a heterogeneous reaction.
5. Fluid particle non-catalytic reactions. Unreacted core model for spherical particles, chemical reaction controls.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1	1	2							1
CO2	2	2	2	2	2							1
CO3	2	1	2	2	2							1
CO4	1	1	1	2	3							1
CO5	2	1	3	1	3							1

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OPTIMIZATION TECHNIQUES**Credits: 3****Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
VI	3-0-0	7-1-6-03R25	CH

Course Educational Objectives:

1. To teach the best design finding with the available resources is the goal of design optimization. Many of the design problems in aerospace systems (and also other areas) can be cast as optimization problems.
2. To teach the problems can then be solved using the optimization techniques.
3. One can model the problems well only with a good understanding of the theory behind optimization.
4. In this course we will deal with continuous optimization methods with emphasis upon nonlinear programming.
5. Application of optimization techniques for various operations.

UNIT I :

Introduction to optimization, scope and hierarchy of optimization, applications of optimization, general procedure for solving optimization problems. Formulation of objective function, fitting models to data, Continuity of functions, classification of functions, unimodal & multi modal functions, Convex and Concave functions, convex region, Necessary and sufficient conditions for an extremum of an unconstrained function.

UNIT II :**Optimization of unconstrained single variable functions:**

Numerical methods: Newton Raphson Method and Secant method. Region elimination methods: Interval halving method, Fibonacci search, Golden section search. Polynomial approximation methods- Quadratic interpolation, Cubic interpolation. Applications of one-dimensional search methods to chemical engineering problems.

UNIT III:**Unconstrained multivariable optimization:**

Direct search methods: random search, grid search, univariate search and pattern search methods. Indirect search methods: steepest descent method and conjugate gradient methods.


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Unit-IV:**Linear and non-linear programming**

Linear programming: Basic concepts in linear programming, Standard LP form, Graphical solution and Simplex method.

Non-linear programming: Lagrange multiplier method, , Iterative linearization and Quadratic programming method.

Unit –V: Applications of optimization

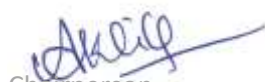
Optimizing recovery of waste heat, optimal pipe diameter, Determination of optimal reflux ratio for staged distillation column, optimization of multiple effect evaporator, optimization of shell and tube heat exchanger, optimal residence time for maximum yield in an ideal batch reactor, optimal residence time for maximum yield in chemist at and optimization of a thermal cracker using linear programming.

Text Book :

1. Optimization of Chemical Processes, T.F. Edgar and D.M. Himmelblau, McGraw-Hill, New York, 2001.
2. Optimization for Engineering Design, Kalyan Moy Deb, PHI Pvt. Ltd., New Delhi, 2000
3. Optimization Theory and Applications by S.S. Rao, 2nd Edition, Wiley Eastern Limited.

References:

1. Reklaitis, G.V., Ravindran A., Ragsdell K.M. Engineering Optimization, John Wiley, NY1980
2. Bile, W.E., Swain J.J., Optimization and Industrial Experimentation, Inter Science, NY 1980
3. Seinfeld J.H., Lapidus L., Process Modeling, Estimation and Identification, Prentice Hall, Engelwood Cliffs, New Jersey, 1974
4. Beveridge, C.S., Schechter, R.S., Optimization Theory and Practice McGraw Hill, NY1970
5. Plant Design & Economics for Chemical Engineers, 5 th Ed – Max S. Peters, Klaus D. Timmerhaus and Ronald E. West, McGraw Hill 141


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Course Outcomes:

1. An ability to apply knowledge of mathematics, science, and engineering, An ability to design and conduct experiments, as well as to analyze and interpret data.
2. Become familiar with optimization methods Mathematical modeling of optimization problems
3. Implementation of the algorithms discussed and solve realistic design problems, The student should master most of the issues in numerical optimization.
4. Develops ability to obtain data and information necessary to formulate and to solve problems related to Chemical Engineering with or without the support of software.
5. This course introduces you to the optimization theory and tells you how it can be applied to solve design problems

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1	1	2							1
CO2	2	2	2	2	2							1
CO3	2	1	2	2	2							1
CO4	1	1	1	2	3							1
CO5		1	3	1	3							1

1 - Slightly; 2 - Moderately; 3 – Substantially


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PE-III - 1 - PETROLEUM REFINING PROCESSES**Credits: 3****Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
VI	3-0-0	7-1-6-R25E11	CH

Course Educational Objectives:

1. Learn the formation, refining of crude oil and products of refinery.
2. Understand the means of processing data including thermal properties, important products characteristics.
3. Develop skills in drawing neat flow diagrams of different petroleum refining processes. (Cracking/reforming/alkylation/ isomerization / hydro cracking etc.,) that are aimed at producing high value/demand products.
4. Identify important testing methods for important petroleum products.
5. Have idea on Indian standards for major petroleum products.

UNIT I:

Origin, Formation and Composition of Petroleum: Origin and Formation of Petroleum, Reserves and Deposits of World, Petro Glimpses and Petroleum Industry in India, Composition of Petroleum Petroleum Processing Data: Evaluation of Petroleum, Thermal Properties of Petroleum Fractions.

UNIT II:

Important Products, Desalting of crude, pipe still furnaces, preflashing operation, Atmospheric and vacuum distillation units, different types of Reflux arrangements, Calculation of tray requirement for ADU column. Test methods and specifications: Distillation, Aniline point, Reid vapour pressure, Smoke point, flash point fire point, Carbon residue, viscosity and viscosity index, refractive index.

UNIT III:

Fractionation of Petroleum: Dehydration and Desalting of Crudes, Heating of Crude- Pipe Still Heaters, Distillation of Petroleum, Blending of Gasolines.

UNIT IV:

Treatment Techniques: Fractions-Impurities, Gasoline Treatment, Treatment of Kerosene, Treatment of Lubes, Wax and Purification.


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UNIT V:

Thermal and Catalytical Processes: Cracking, Catalytic Cracking, Catalytic Reforming- Introduction and Theory, Naptha Cracking, Coking, Hydrogen Processes, Alkylation, Isomerization Processes, Polymer Gasolines. Asphalt Technology: Source of Asphalt , Air Blowing of Bitumen, Upgradation of Heavy Crudes

Coking: Types of petroleum coke-Properties and uses process description of delayed coking - Flexicoking and fluid coking – Yields.

Text Book

1.Modern Petroleum Refining Processes by B.K.Bhaskara Rao

Reference Books:

1. Petroleum Refining and Petrochemicals by N.K Sinha
2. Petroleum Refinery Engineering by Nelson, McGraw Hill.
3. Petroleum Refining: Technology and Economics, J.H. Gary and G. E. Handwerk, 4th Edition, Marcel Dekkar, Inc., New York, 2001.

Course Outcomes:

At the end of the course, student will be able to:

1. Describe the formation of crude oil, its refining techniques.
2. Describe the chemical composition and physical properties of crude oil
3. Understand various processes employed in petroleum refinery such that we can meet customer demand in terms of quality & quantity.
4. Demonstrate the different methods available for removal of impurities from crude and products manufacture.
5. Understand, draw and describe the process flow diagrams of various refinery processes like distillation, cracking and reforming etc.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1					1		1	1	1			1
CO2					1							1
CO3					1		1		1			1
CO4					1		1		1			1
CO5					1				1			1

1 - Slightly; 2 - Moderately; 3 – Substantially


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PE-III - 2 - CO₂ CAPTURE and UTILIZATION**Credits: 3****Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
VI	3-0-0	7-1-6-R25E12	CH

Course Educational Outcomes:

1. To learn the carbon capture and storage techniques.
2. To learn various technologies available for carbon capture.
3. To learn CO₂ storage and its sequestration.
4. To learn various utilisations of CO₂.
5. To learn the life cycle assessment of CO₂.

UNIT-1:

Introduction: Global climate change, Green House Gases (GHG) emission, Policy and Regulatory interventions in abatement of carbon footprint, Carbon cycle, Carbon capture, storage and utilization (CCS&U).

UNIT-II:

CO₂ capture technologies from power plants and industrial processes: Post-combustion capture, Pre-combustion capture, Oxy-fuel combustion, chemical looping combustion CLC, Calcium looping combustion. **CO₂ capture agents and methods:** Capture methods, CO₂ capture agents, adsorption, Absorption, ionic liquids, metal organic frame works.

UNIT-III:

O₂ storage and sequestration: O₂ storage methods, Geological Carbon sequestration methods, Biomimetic carbon Sequestration.

UNIT-IV:

CO₂ Utilization: CO₂ derived fuels for energy storage, Enhanced Coal bed methods, CO₂ based solvents, CO₂ to oxygenated organics, Conversion into higher carbon fuels, High temperature catalysis.

UNIT-V:

Environmental assessment of CO₂ capture and utilization: Need for assessment, Life Cycle Analysis, Environmental assessment tools, Green chemistry, ISO standardization of Life Cycle Analysis (LCA), Method of conducting an LCA for CO₂ capture and Utilization.


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Text Books:

1. Carbon dioxide utilization: Closing the Carbon Cycle, Peter Styring, Elsje Alessandra Quadrelli, Katy Armstrong, Elsevier, 2015, 1st Edition.
2. Carbon Capture, Storage and, Utilization: A Possible Climate Change Solution for Energy Industry, Goel M, Sudhakar M, Shahi RV, TERI, Energy and Resources Institute, 2015, 1st Edition.
3. Carbon Capture and Storage, CO₂ Management Technologies, Amitava Bandyopadhyay, CRC Press, 2014, 1st Edition.

Reference Books:

1. Calcium and Chemical Looping Technology for Power Generation and Carbon Dioxide (CO₂) Capture, Fennell P, Anthony B, Woodhead Publishing Series in Energy: No. 82, 2015, 1st Edition.
2. Developments in Innovation in Carbon Dioxide Capture and Storage Technology: Carbon Dioxide Storage and Utilization, Mercedes Maroto-Valer M, Vol 2, Woodhead Publishing Series in Energy, 2014, 1st Edition.
3. Fundamentals of Enhanced Oil and Gas Recovery from Conventional and Unconventional Reservoirs, Alireza Bahadori, Elsevier Inc., 2018, 1st Edition.

Online Resources:

1. <https://nptel.ac.in/courses/103/107/103107157/>
2. <https://sequestration.mit.edu/>
3. <https://climate.mit.edu/explainers/carbon-capture>

Course Outcomes: At the end of the course the student will be able to

1. Know the CO₂ capture and its importance
2. Know various capture technologies available for CO₂ and its storage
3. Know Geological sequestration methods of CO₂
4. Know various utilization of CO₂
5. Know life cycle assessment of CO₂

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	1	2	3	1	1	1			
CO2	3	2	3	1	2	3						1
CO3	3	2	3	1	2	3	1		2			2
CO4	3	2	3	1	2	3	1		1			1
CO5	3	2	3	1	2	3			1			1

1 - Slightly; 2 - Moderately; 3 – Substantially


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PE-III - 3- WATER CONSERVATION AND MANAGEMENT**Credits: 3****Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
VI	3-0-0	7-1-6-R25E13	CH

Course Description:

The program is designed to help chemical engineering students gain a thorough understanding of the essential role of water in various industrial and practical applications. It includes topics such as water storage systems, evaluation of water quality, efficient water management practices, techniques to minimize water wastage, and different auditing methods used to support water conservation in industries.

Course Educational Objectives:

1. To understand water quality parameters and various water storage techniques.
2. To gain knowledge of water conservation practices in different workplaces.
3. To study methods and instruments used for measuring water flow.
4. To learn water preservation strategies and techniques to reduce water evaporation losses.
5. To develop an understanding of water auditing procedures implemented in various workplaces.

Unit I:

Water Resources and Management : Hydrologic cycle, recycling and distribution of water, water storage, water quality is safe for drinking, agriculture, and industrial use.

Unit II:

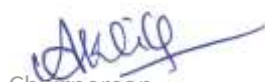
Water Conservation: water conservation in homes; water conservation in the work place.

Unit III:

Water Management: Water Quality Management, Controlling Use and Quality of Water, Water Flow Measurement

Unit IV:

Water Quality Control: Testing Water Salinity, Preserving Water Quality, Minimising Evaporation, Water Sanitation


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Unit V:

Water Conservation in Various Sectors: Water Audits, Water Conservation in Agriculture, Water Conservation in Process Industry Water Conservation in Construction Industry, Water Conservation in Service Industry

Course Outcomes: At the end of the course the student will able to

- 1 To know the importance of water and its storage techniques
- 2 To know water conservation techniques at various levels
- 3 To know water management at various stages
- 4 To know water quality and water testing methods
- 5 To know water conservation audits at various places

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1					1		1	1	1			1
CO2					1							1
CO3					1		1		1			1
CO4					1		1		1			1
CO5					1				1			1

1 - Slightly; 2 - Moderately; 3 – Substantially


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PE-III - 4 - INTRODUCTION TO SEMICONDUCTOR MANUFACTURING**Credits: 3****Assessment: 40 + 60**

Semester	L-T-P	Course Code (7-0-1-01R25)	Branches
VI	3-0-0	7-0-6-R25CE1	CH,CE,EE,EC,ME,CS (All Branches)

Course Objective(s):

1. To explain the physics of semiconductor materials and devices.
2. To discuss the processes involved in semiconductor manufacturing.
3. To understand the ecosystem of semiconductor manufacturing.
4. To get knowledge of safety aspects in the semiconductor industry.
5. To design systems and equipment for semiconductor manufacturing.

UNIT – 1:**Semiconductor materials (Si, Ge, GaAs, GaN, SiC):**

Electrical classification of solids (metals, semiconductors and insulators), intrinsic and extrinsic semiconductors, crystal structure and defects, band gap and Fermi level, doping effects on electrical conduction in semiconductors, direct and indirect bandgap semiconductors.

UNIT – 2:**Semiconductor wafer manufacturing and characterization:**

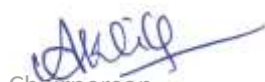
Thermal and chemical processes involved in converting pure sand into electronic grade polycrystalline silicon, pure silicon crystal growth from polysilicon, silicon wafer fabrication and polishing.

UNIT – 3:**Thin film fabrication and characterization:**

Vacuum-based thin film deposition techniques for metals, semiconductors and dielectrics; Physical Vapour Deposition (PVD); Chemical Vapour Deposition (CVD); analytical characterization techniques (XRD, SEM, TEM, XPS etc.); plasma, lasers and ion beams for semiconductor manufacturing.

UNIT – 4:**Semiconductor Device Manufacturing Techniques:**

Introduction to IC-chip manufacturing, oxidation, lithography, etching, doping, diffusion, ion-implantation and metallization, realization of on-chip resistor, diode, capacitor and inductor, bonding and packaging.


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UNIT – 5:**Semiconductor ecosystem, safety and applications:**

Clean room aspects, gas handling systems in semiconductor manufacturing, safety aspects in device fabrication (electrical, chemical and vacuum), clean water and pure chemical requirements, CMOS-based IC chips for computers and mobiles, semiconductor-based solar cells and displays, lab-grown diamonds for semiconductor applications.

Textbooks:

1. Sze SM and Lee MK, **Semiconductor Devices: Physics and Technology**, 3rd Edition, Wiley India (2016).
2. Swami Nathan P, **Semiconductor Materials, Devices and Fabrication**, Wiley (2019)

References:

1. Neaman D, **Semiconductor Physics and Devices**, 4th Edition, McGraw Hill (2017).
2. MKS Handbook: **Semiconductor Devices and Process Technology**, 2nd Edition (2017).
3. Gandhi S.K, **VLSI Fabrication Principles: Silicon and Ga-As**, 2nd Edition, Wiley (2008).

Course Outcomes: After completing this course, students will be able to

1. Understand the basic properties and behavior of semiconductor materials used in electronic devices.
2. Learn how semiconductor wafers are manufactured from raw materials to finished silicon wafers.
3. Gain knowledge of thin-film deposition methods and basic material characterization techniques.
4. Understand the main steps involved in semiconductor device and IC fabrication processes.
5. Become familiar with the semiconductor manufacturing ecosystem, safety practices, and major applications of semiconductor devices.

Mapping of course outcomes with program outcomes:

PO/ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	-	-	-	-	-	-	-	-	-	1	3	2
CO2	3	2	-	2	-	-	-	-	-	-	-	1	3	1
CO3	2	2	-	3	3	-	-	-	-	-	-	1	2	2
CO4	2	2	3	2	2	-	-	-	-	-	-	1	1	1
CO5	1	-	-	-	-	3	2	2	2	1	-	2	2	2


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ELEMENTS OF QUANTUM COMPUTING**Credits: 2****Assessment: 100 + 0**

Semester	L-T-P	Course Code	Branches
VI	2-0-0	7-0-6-R25M1	CH,CE,EE,EC,ME,CS

Prerequisites: Physics**Course Objectives**

1. To introduce the basic principles of quantum mechanics relevant to computing.
2. To differentiate between classical and quantum computation models.
3. To understand qubits, superposition, entanglement, and quantum gates.
4. To study basic quantum algorithms and their real-world applications.

UNIT – I:

Evolution of computation: classical to quantum paradigm, Limitations of classical computation, Basic principles of quantum mechanics relevant to computation. Introduction to Quantum Computing: Bits Vs Qubits, Classical Vs Quantum logical operations

UNIT - II

Quantum states and qubits, Superposition principle and quantum measurement. Quantum entanglement and its importance. Quantum gates: Pauli, Hadamard, Phase, CNOT, Toffoli. Bloch sphere representation of qubit states.

UNIT - III

Qubit: Physical implementations of Qubit. Qubit as a quantum unit of information. The Bloch sphere Quantum Circuits: single qubit gates, multiple qubit gates, designing the quantum circuits. Bell states.

UNIT - IV

Quantum Algorithms: Classical computation on quantum computers. Relationship between quantum and classical complexity classes. Deutsch's algorithm, Deutsch's-Jozsa algorithm, Shor's factorization algorithm, Grover's search algorithm.

UNIT - V

Noise and error correction: Graph states and codes, Quantum error correction, fault-tolerant computation. Quantum Information and Cryptography: Comparison between classical and quantum information theory. Quantum Cryptography, Quantum teleportation


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TEXT BOOKS:

1. Nielsen M. A., Quantum Computation and Quantum Information, Cambridge

REFERENCE BOOKS:

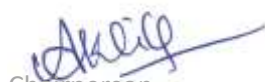
1. Quantum Computing for Computer Scientists by Noson S. Yanofsky and Mirco A. Mannucci.
2. Benenti G., Casati G. and Strini G., Principles of Quantum Computation and Information, Vol. I: Basic Concepts, Vol II
4. Basic Tools and Special Topics, World Scientific. Pittenger A. O., An Introduction to Quantum Computing Algorithms

Course Outcomes

1. Understand basic principles of quantum mechanics relevant to computation.
2. Understand basics of quantum states, Qubit and gates.
3. Understand physical implementation of Qubit
4. Understand Quantum algorithms and their implementation
5. Understand The Impact of Quantum Computing on Cryptography

Mapping of Course Outcomes with Program Outcomes:														
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1			1	2	1	1		1	1	1	2
CO2	1	2	2	1	1	1	2		1	1	1	2		
CO3	2	1	3	3	1	1	1				1	3	1	3
CO4	1	2	3	3	1	1	1	1		1	1	3	1	3
CO5	2	2	2	2	2	1	1	1	1		1	3	1	3

1 – Slightly; 2 - Moderately; 3 – Substantially


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INDIAN SCIENCE, ENGINEERING & TECHNOLOGY (IKS MANDATORY)

Credits: 0**Assessment: 100 + 00**

Semester	L-T-P	Course Code	Branches
VI	3-0-0	7-1-6-R25MK	CH

Course Objectives

- To familiarize learners with major sequential development in Indian science, engineering and technology.
- To review & strengthen the ancient discovery and research in physics, chemistry, maths, metallurgy, astronomy, architecture, textile, transport, agriculture and Ayurveda etc.
- To help students to trace, identify and develop the ancient knowledge systems to make meaningful contribution to development of science today
- To help to understand the apparently rational, verifiable and universal solution from ancient Indian knowledge system for the scientific, technological and holistic development of physical, mental and spiritual wellbeing.

Unit-I: Indian Traditional Knowledge; Science and Practices

Introduction to the Science and way of doing science and research in India, Ancient Science in Intra & Inter Culture Dialogue & co evolution. Traditional agricultural practices, Traditional water-harvesting practices, Traditional Livestock and veterinary Sciences Traditional Houses & villages, Traditional Forecasting, Traditional Ayurveda & plant based medicine, Traditional writing Technology

Unit- II: Ancient Indian Science (Physics, Chemistry, Maths)

Physics in India: Vaisheshika darshan Atomic theory & law of motion, theory of panchmahabhoota, Brihath Shathaka (divisions of the time, unit of distance), bhaskaracharya (theory of gravity, surya siddhanta & sidhanta shriomani), Lilavati (gurutvakashan Shakti). Chemistry in India Vatsyayana, Nagarjuna, Khanda, Al-Biruni, Vagbhata – building of the ras-shala (laboratory), working arrangements of ras-shala, material and equipment, Yaśodhara Bhaṭṭa-process of distillation, apparatus, saranasamskara, saranataila Mathematics in India: Baudhayana's Sulbasutras, Aryabhata, Bhaskaracharya I, Severus Sebokht, Syria, Brahmagupta, Bhaskaracharya-II, Jyēsthadeva


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UNIT-III: Ancient Indian Science (metallurgy, Astronomy, Architecture)

Metallurgy in India: Survarṇa(gold) and its different types, prosperities, Rajata(silver), Tamra(copper), Loha(iron), Vanga(tin), Naga / sisa(lead), Pittala(brass) Astronomy in India Vedang Jyotish, aryabhatta siddhanta, Mahabhaskariya, Laghubhaskariya, vatesvarasiddhanta, Sisyadhivrdhida, Grahashyay, Goladhyaya, Karabakutuhala (Aryabhata, Varahamihira, Brahmagupta, Vatesvara, Bhaskara, Paramesvara, Nilakantha Somayaji, Jyesthadeva, Sankara Varman) Architecture in India: Nagara (northern style), Vesara (mixed style), and Dravida (southern style), Indian vernacular architecture, Temple style, cave architecture, rock cut architecture, kalinga architecture, chandels architecture, rajput architecture, jain architecture, sikh architecture, Maratha architecture Indo Islamic architectural, Indo-Saracenic revival architecture, Greco Buddhist style.

UNIT-IV: Ancient Indian Science (Textile, Agriculture, Transport)

Textile Technology in India: Cotton (natural cellulose fiber), silk, wool (natural protein fibers), bast and leaf fibers, mridhudhautadhupitambaram (meaning a practice of fumigating the fabric with incense smoke before use as a part of the finishing process), sitadhautavasana yugala (bleached white—a finishing process); suchhastah, sutradharah (needle and thread – tools for stitching). dyeing, washing spinning and weaving technology, Agriculture in India: krishisuktas, Krishiparashara, Brihatsamhita, Types of crops, Manures, Types of land- devamatraka, nadimatraka, use of animals in warfare, animal husbandry, Animals for medicines. Ancient transport in India

UNIT-V: Ancient Indian Science (Ayurveda & Yoga)

Ayurveda for Life, Health and Well-being: Introduction to Ayurveda: understanding Human body and Pancha maha bhuta, the communication between body & mind, health regimen for wellbeing, introduction to yoga (raja yoga, astang yoga, gyan yoga), understanding of Indian psychological concept, consciousness, tridosha & triguna.

References:

1. Textbook on IKS by Prof. B Mahadevan, IIM Bengaluru.
2. Kapur K and Singh A.K (Eds) 2005). Indian Knowledge Systems, Vol. 1. Indian Institute of Advanced Study, Shimla. Tatvabodh of sankaracharya, Central chinmay mission trust, Bombay, 1995.
3. Nair, Shantha N. Echoes of Ancient Indian Wisdom. New Delhi: Hindology Books, 2008.
4. SK Das, The education system of Ancient hindus, Gyan publication house, India


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5. R P Kulkarni, Glimpse of Indian Engineering and Technology (Ancient & Medieval period, Munshiram Manoharlal Publishers Pvt. Ltd. 2018
6. AK Pathak, Science and Technology in India, Anshika prakashan pratapgarh, 2016
7. PB Sharma, S. Narain, Doctors Scientists and Engineers of Ancient India, Kalpaz Publications 2017
8. NVP, Unithiri, Indian Scientific Traditions (Professor K.N. Neelakantan Felicitation Volume), publication division unieristy of Calicut, 2006
9. Anonyms, History of Science in India- Volume-I Part-I (Physics, Mathematics and Statistics)
10. the national academy of science, India & the ramkrishna mission institute of culture, 2014
11. R N Basu, T K Bose, CS, Cakraborty History of Science in India – Agricultural Science
12. (Volume V), the national academy of science, India & the ramkrishna mission institute of culture 2014
13. A Gosh, History of Science in India (Volume-I Part-II Astronomy), the national academy of science, India & the ramkrishna mission institute of culture, 2014
14. Dharmpal, Indian science and technology in the eighteen century, rashtrottahana sahitya, 1983
15. S Biswal, B L ray, vedic Science and technology, DK Print world, 2009
16. A.K Bag, Histroy of technology in Indian (Set 3 vol), Indian Nation Science Academy, 1997.
17. AR vasudev Murty, Science and Technology in Ancient India as Reflected in the Mahabharat, Sanskrit bharati, 2019.

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REACTION ENGINEERING LAB**Credits: 1.5****Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
VI	3-0-0	7-1-6-R25P1	CH

List of Experiments:

1. Study of Temperature Dependence of Reaction
2. Kinetics Study under Pseudo Behaviour Conditions
3. Kinetics Study in a Mixed Flow Reactor
4. Kinetics Study in Adiabatic Batch Reactor
5. Modeling of a Mixed Flow Reactor
6. Flow Characterization of a Plug Flow Reactor
7. Modeling of a Packed Bed Reactor
8. Residence Time Distribution in Tanks in Series Assembly
9. Kinetics of Saponification in a Batch Reactor
10. Effect of Mass Transfer on Reaction


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PROCESS SIMULATION LABORATORY**Credits: 2****Assessment: 100 + 0**

Semester	L-T-P	Course Code	Branches
VI	3-0-0	7-1-6-R25S1	CH

Course Educational Objectives:

1. To evaluate chemical engineering problems & understand basic concepts of steady state process model equations.
2. To understand various models of Simulation and flow sheeting concepts.
3. To understand the fundamental concepts of DWSIM.
4. To develop steady state simulation of VLE data using DWSIM software.
5. To develop steady state simulation of distillation column, reactors and heat exchangers a using DWSIM software.

Lis of Experiments:

1. Introduction of Software packages.
2. Setting up models for simulation.
3. Flow sheeting concepts.
4. DWSIM
5. Creating a material stream.
6. Steady state simulation for generation of VLE data.
7. Steady state simulation for Bubble point and dew point calculations.
8. Steady state simulation for shortcut distillation column,
9. Steady state simulation of Plug flow reactor.
10. Steady state simulation of heat exchangers.


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**B.Tech. (Chemical Engineering)
Semester VII (Fourth Year)**

Code		Category	Course title	Scheme of Instruction, Hr/Week				Credits	Scheme of Evaluation, Marks		Total Marks
Department	University			L	T	P	Total		CIE	SEE	
CH1701C	7-1-7-01R25	CH-PC	Plant Design & Process Economics	3	0	0	3	3	40	60	100
CH1702C	7-1-7-02R25	CH-PC	Industrial Safety & Hazard Analysis	2	0	0	2	2	40	60	100
CH1703C	7-1-7-R25E1	CH-PE	Professional Elective – IV	3	0	0	3	3	40	60	100
CH1704C	7-1-7-R25E2	CH-PE	Professional Elective - V	3	0	0	3	3	40	60	100
CH1705C	7-1-7-R25O1	CH-OE	Open Elective-III (MOOCS)	0	0	0	0	3	0	100	100
CH1706C	7-1-7-R25O2	CH-OE	Open Elective – IV (MOOCS)	0	0	0	0	3	0	100	100
CH1707S	7-1-7-R25S1	CH-SC	Process Equipment Design & Drawing	1	0	2	3	2	100	0	100
CH1708K	7-1-7-R25KS	CH-IK	IKS – MOOCS	2	0	0	2	2	0	100	100
CH1709I	7-0-7R25CS	CH-SI	Summer Industrial Internship	0	0	0	0	2	100	0	100
TOTAL				14	0	2	16	23	400	500	900
Students shall ensure that IKS MOOCS and IKS Mandatory courses are not same either in title and/or in syllabi.											


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CHEMICAL ENGINEERING

PROFESSIONAL ELECTIVE COURSES

Elective List	University Code	Subject Name
Professional Elective-I: (V- Semester)	7-1-5-R25E11	Fuel Cell Systems
	7-1-5-R25E12	Energy Engineering
	7-1-5-R25E13	Industrial Effluent Treatment
Professional Elective-II: (V- Semester)	7-1-5-R25E21	Process Instrumentation
	7-1-5-R25E22	Polymer Science & Engineering
	7-1-5-R25E23	Fundamentals of Nanotechnology
Professional Elective-III: (VI- Semester)	7-1-6-R25E11	Petroleum Refining Processes
	7-1-6-R25E12	CO ₂ Capture and Utilization
	7-1-6-R25E13	Water Conservation & Management
	7-0-6-R25CE1	Introduction to Semiconductor Manufacturing
Professional Elective-IV: (VII- Semester)	7-1-7-R25E11	Fluidization Engineering
	7-1-7-R25E12	Process Modeling & Simulation
	7-1-7-R25E13	Fundamentals of Microelectronic Material Processing
Professional Elective-V: (V-II Semester)	7-1-7-R25E21	Computational Fluid Dynamics
	7-1-7-R25E22	Membrane separations
	7-1-7-R25E23	Bio Process Engineering


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PLANT DESIGN AND PROCESS ECONOMICS**Credits: 3****Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
VII	3-0-0	7-1-7-01R25	CH

Course Description:

This course is designed for chemical engineering students to understand the concepts of plant design, layout and safety majors to be taken in chemical industries. Students are able to identify piping patterns in industries. Can be able to calculate the cash flow patterns by using different methods. Students can learn the various replacement methods used to identify the cost of equipments.

Course Educational Objectives:

1. To understand the general overall design considerations and practical design considerations
2. To understand the plant location, plant layout, plant operation and control and patent considerations
3. To understand the process design development
4. Gives an idea on time value of money and cash flow patterns
5. It gives an idea on analysis of cost estimation and to determine profitability, alternative investments and replacements

UNIT - I :

Introduction – Chemical Engineering Plant Design-General Overall Design Considerations – Practical Considerations in Design - Engineering Ethics
General Design Considerations – Health and Safety hazards – Loss Prevention – Environmental Protection Plant Location – Plant Layout – Plant Operation and Control – Patent Considerations

UNIT - II :

Process Design Development – Development of Design database – Process Creation – Process Design – Process Flow Diagrams – Piping and Instrumentation Diagrams – Vessel and Piping layout – Equipment Design and Specifications

UNIT - III :

Interest, Time Value of Money, Taxes, and Fixed Charges – Interest – Cost of Capital – Time Value of Money – Cash Flow Patterns – Compounding and Discounting factors – Income taxes – Fixed Charges


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UNIT - IV:

Analysis of Cost Estimation – Cash flow for industrial Operations – Factors affecting investment and production costs – capital investment – Estimation of capital investment – Cost Indexes – Cost components in Capital Investment – Methods for estimating capital investment – estimation of revenue – Gross Profit, Net profit and cash flow - contingencies.

UNIT - V:

Profitability, Alternative investments and Replacements – Profitability Standards – Methods for calculating Profitability – Alternative Investments – Replacements – Practical factors in alternative investment and replacement analysis

Text Books:

Plant Design and Economics for Chemical Engineers , 5 th Ed. – Max S.Peters and Klaus D. Timmerhaus and Ronald E.West – McGraw Hill

References :

1. Chemical Engineering Plant Design by Vilbrandt and Dryden, McGraw Hill Intl.
2. Process Engineering Economics by H.E. Schwyer McGraw Hill Co.

Course Outcomes:

1. Students will have knowledge to understand design considerations and engineering ethics. Students able to understand plant location, plant lay out, plant operation and control in a profitable way.
2. Students able to design process flow diagrams, piping and instrumentation diagrams and vessel and piping layout.
3. Students will have the knowledge on interest, time value of money and cash flow patterns useful for cost estimation.
4. Students will have an idea on analysis of cost estimation involves capital investments, estimation of revenue, and cost indexes, students will come to know factors affecting investment and production costs.
5. They will able to find out the alternate investments and replacements, it will also helps the students to understand profitability standards and methods for calculating profitability.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1		1	2			1			1
CO2	1			2	2	1			2			1
CO3			2	3	1	1			1			1
CO4		1		2	1	2			1			1
CO5			2	2	1	1			1			1

1 - Slightly; 2 - Moderately; 3 – Substantially


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INDUSTRIAL SAFETY & HAZARD ANALYSIS**Credits: 3****Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
V	3-0-0	7-1-7-02R25	CH

Course Objectives

1. To learn about accident and loss statistics, safety concepts
2. To educate about industrial hygiene, evaluation and control of toxic releases
3. To give knowledge about fire and explosions, prevention methods and designs
4. To know about relief systems like types, relief sizing for different services
5. To educate about hazards identification and different hazop studies.

UNIT – I:

Introduction: Safety concepts and programs, Engineering ethics – Accident and loss statistics
 Acceptable risk public perceptions – Nature of the accident process and inherent safety.
 Toxicology: Methods of entry of toxins in to biological organisms and their effects –
 Elimination of toxicants from Biological organisms – Toxicological studies – Thresh hold limits
 – models for dose and response curves.

Unit – II:

Industrial Hygiene: Government regulations – process safety and risk management. Plan –
 Industrial hygiene identification, evaluation and control toxic release and dispersion models;
 important source models dispersion models of puff with no wind and wind puff with no wind
 and with source on ground - pasquill – Gifford model – worst case conditions – effect of release
 momentum and Buoyancy and release mitigation.

Unit – III:

Fires and Explosions : The fire triangle – distinction between fires and explosions – definitions –
 Flammability characteristics of liquids and vapors – Flam mobility diagram ignition energy –
 Auto ignition and adiabatic compression – ignition sources – sprays and mists - explosions and
 their characteristics – damage to people and property – fires explosion - prevention methods
 and designs.

Unit – IV:

Relief concepts – definitions – location of relieves – Relief types, scenarios data for sizing and
 relief systems relief-sizing for liquid and gas services – rupture disc relieves – two-phase flow
 during run away reaction relieves – deflagration venting for dust and vapor explosions – venting
 for fires external to process vessels – venting for thermal expansion of process fluids.


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Unit – V:

Hazard Identification - Check lists – Surveys HAZOP and HAZAN Studies – safety reviews
 Review of probability theory – Event trees – Fault trees – QRA and LOPA analysis
 Accident Investigations with typical case histories.

Text Book:-

D.A. Crowl and J.F. Louvar – Chemical process safety (Fundamentals with applications)
 Printice Hall (2002)

References:-

1. H.H. Fawcett and W.S. Wood – Safety and accident prevention in chemical operations, 2nd edn, John Wiley and sons, 1982.
2. Coulsion and Richardson – Chemical Engineering – R.K. Sinnott, Vol-6, Butterworth – Heinmann Ltd., 1996.

Course Outcomes: At the end of the course, student will be able to

1. Knows about different types of accidents and loss statistics, risk to public life and safety measures to be taken
2. Is able to understand about government regulations of industrial hygiene, identification of hygiene evaluation and control of toxic releases
3. Able to learn difference between fire and explosion, flammability characteristics of liquids and vapors
4. Knows about relief definition, types, relief sizing for liquid and gas services and about rupture disc relieves
5. Have knowledge about hazard, surveys of hazard and different hazop studies and Can understand QRA and LOPA analysis, event trees, fault trees, accident investigations

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1									
CO2	1			2	2							
CO3			2	1		1						
CO4		1		2								
CO5			2	2	1							

1 - Slightly; 2 - Moderately; 3 – Substantially


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PE-IV - 1 - FLUIDIZATION ENGINEERING**Credits: 3****Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
VII	2-0-0	7-1-7-R25E11	CH

Course Objectives :

1. To learn on different types of fluidizations, their advantages and disadvantages. Characterization of particles, analyze the various types of distributors used for fluidized beds and its design.
2. Study the classification of particles; carry over particles in fluidization and pneumatic transport of solids.
3. Give the knowledge of Transport Disengaging Height (TDH) and its significance in entrainment and to understand elutriation from fluidized beds and Elutriation constants
4. This course will help to learn solid circulation systems for fast fluidized operations and flow patterns of gas-solid mixtures flowing in horizontal and vertical pipes.
5. This subject focuses on the industrial applications of fluidized beds and spouted beds with examples.

UNIT- I

Introduction: The Phenomenon of fluidization, Liquid like Behavior of a fluidized Bed, Comparison with other Contacting Methods, Advantages and Disadvantages of Fluidized beds for Industrial Operations, Fluidization Quality, Selection of a Contacting Mode for a given Application, Overall Plan. Fluidization and mapping of regimes.: Fixed beds of particles: Characterization of particles, fixed beds- One size of particles, fixed beds- Solid with a Distribution of sizes, Determination of the effective Sphericity from Experiment. Fluidization without Carryover of particles Minimum Fluidizing Velocity, μ_{mf} , Pressure Drop-verses-Velocity Diagram, Effect of Pressure and Temperature on Fluidized Behavior, Sintering and Agglomeration of Particles at High Temperature.

UNIT-II

Types of Gas Fluidization without carryover – The Geldart classification of particles; Fluidization with carryover particles – Terminal velocity of particles, u_t — Turbulent and Churning Fluidization – Pneumatic Transport of solids – Fast Fluidization – Voidage Diagrams for All Solid Carryover Regimes; The Mapping of Fluidization Regimes. The Dense Bed: Distributors, Gas Jets, and Pumping Power: Distributor Types – Ideal Distributors – Perforated and Multiorifice Plates – Tuyeres and Caps – Pipe Grids and Spargers; Gas Entry Region of a Bed; Gas Jets in Fluidized Beds; Pressure Drop Requirements across distributors; Design of Gas Distributors Power Consumption.


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UNIT – III

Entrainment and Elutriation From Fluidized Beds: Freeboard Behavior – Origin of Solids Ejected in to the Freeboard – experimental Findings; Location of the Gas Outlet of a Vessel – Estimation Of the TDH; Entrainment from Tall Vessels: $H_f > TDH$ – Procedure of Zenz et al. [21,8] – The Elutriation Constant Approach – Relationship between k and G_s – Experimental Methods for finding k and k^* - Experimental Findings for k^* - Entrainment from Short Vessels: $H_f < TDH$ – Freeboard – Entrainment Model.

UNIT – IV

High – Velocity Fluidization: Turbulent Fluidized Beds – Experimental Findings; Fast Fluidization - Experimental Findings; The Freeboard – Entrainment Model Applied to Fast Fluidization – Design Considerations; Pressure Drop in Turbulent and Fast Fluidization. Circulation systems: Circuits for the Circulation of Solids – Classification of Circulation Loops – Pressure Balance in a Circulation loop; Finding Require Circulation Rates - Circulation Rate for Deactivating Catalysts – Circulation Rate for a Require Heat Removal Rate.

UNIT – V

Industrial Applications of Fluidized Beds: Coal Gasification – Gasoline from other Petroleum Fractions – Gasoline from natural and Synthesis Gases - Synthesis Reactions – Metallurgical and Other Processes; Physical Operations – Heat exchange – Solidification of a Melt to make Granules – Coating metal objects with plastic – Drying of Solids - Coating of Objects and Growth of Particles – Adsorption; Synthesis Reactions – Phallic Anhydride – Fischer – Tropsch Synthesis – acrylonitrile by the Sohio Process- Maleic anhydride - Other Catalytic Reactions – Comments – Polymerization of Olefins; Cracking of Hydrocarbons – Fluid catalytic Cracking (FCC) – Fluid Cooking and Flexi – Coking – Thermal cracking; Combustion and Incineration – Fluidized Combustion of coal – Incineration of Solid Waste; carbonization and gasification – Gasification of Coal and coke – Activation of Carbon – Gasification of Solid waste; Cacination; Reactions Involving Solids – roasting Sulfide Ores – Silicon for Semiconductor and Solar cell industries - Chlorination and Fluorination of Metal Oxides – Reduction of Iron oxide; Biofluidization.


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Text Book :

1. Fluidization Engineering by Diazo Knuizz & D. Leveaspiel John Wiley.

References :

1. Fluidization by Davidson JF & Harison B, Academic Press.
2. Fluidization and Fluid Particle systems Zenz PA & Othmer D F, Reinhold Pub. Co

Course Out comes:

At the end of the course, student will be able to:

1. Know the advantages, disadvantages, and different types of fluidization and can understand the comparison and selection of contacting methods.
2. Determine the minimum fluidization velocity and terminal velocity and able to design gas distributors and calculate power consumption for fluidized beds.
3. Have the knowledge of characterization of particles and determination of effective sphericity from experiment.
4. Experimental findings of entrainment, Estimation of TDH, and determination of elutriation constants and understand the fast fluidization, application of entrainment models to fast fluidization and solid circulation systems for fluidized beds.
5. Have the knowledge of FCC, Combustion and Incineration of coal and Chlorination and Fluorination of Metal Oxides.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	1	1			1	1			
CO2	3	2	1	1	2			1	2			
CO3	3	2	2	1	1			1	1			
CO4	3	2	1	2	2			1	1			
CO5	3	2	1	1	1			1	1			

1 - Slightly; 2 - Moderately; 3 – Substantially


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PE-IV - 2 - PROCESS MODELING AND SIMULATION**Credits: 3****Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
VII	2-0-0	7-1-7-R25E12	CH

Course Description:

This course is designed for students to understand the fundamental laws used for the development of mathematical models for chemical engineering systems. Various examples of chemical engineering systems are discussed for mathematical modeling. Numerical methods are also discussed for solving differential equations. Some of the examples are also discussed for simulation.

Course Educational Objectives:

1. To understand the concepts of model, development of model, algebraic equations and linearization.
2. To educate about the development of model in the field of chemical engineering.
3. To have the knowledge on classification of models with examples.
4. To learn about the numerical methods, computer programming and simulation methods.
5. To acquire abilities to propose, solve and simulate simple chemical process, unit operation and control system models in the chemical industry.

UNIT - I:

Mathematical models of Chemical Engineering systems. - Fundamentals - Introduction - Fundamental laws. Principles of formation, review of algebraic, ordinary and partial differential equations, solutions of the above equations. Linearization, probabilization models, development of models by experiment and statistic, regression and correlation analysis.

UNIT -II:

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

UNIT - III:

Introduction to Matrix models, lumped parameter model, distributed parameter model. Examples of single component vaporizer, batch reactor, reactor with mass transfer, ideal binary distillation column, batch distillation with holdup.

UNIT - IV:

Computer simulation, numerical methods, computer programming, iterative convergence methods, numerical integration of ODEs. Discrete even and continuous simulation.


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UNIT - V:

Computer simulation, examples gravity flow tank, three CSTRs, in series, binary distillation column, batch reactor, VLE, dew point & bubble point calculations, counter current heat exchanger. Simulation in process control.

Text Book:

1. Process Modeling, Simulation and Control for Chemical Engineering by W.L.Luyben, 2nd ed. McGraw Hill (1990).
2. Ramirez, W: Computational Methods in Process Simulation, Butter worths publishers, New York, 1989
3. Lorentze T. Biegler, Ignacio Grossmann and Arthur W. Westerberg – Systematic Methods of Chemical Process Design – Prentice Hall International, 1997

Reference Book:

1. Edgar, T.F; Himmelblau, D.M; Optimisation of Chemical Processes, McGraw-Hill Book Co; New York.
2. Gaikwad R.W. and Dharendra – Process Modeling and Simulation – Central Techno Publications, Nagpur, 2004
3. Morton M. Denn – Process Modeling – Longman Scientific & Technical, 1987
4. A.W. Westerberg, H.P. Hutchinson, R.L. Motard and P. Winter – Process Flowsheeting – Cambridge University Press, 1985

Course outcomes: At the end of the course the student will able

1. To understand the use of mathematical model, principles of formulation and fundamental laws and develop models by experiment and correlation analysis,
2. To develop mathematical models of chemical engineering systems like two heated tanks, constant volume CSTRs and gas pressurized CSTR.
3. To have the knowledge of different types of models like lumped parameter, distributed parameter and matrix models.
4. To write the computer programming, learn the simulation of numerical methods, iterative convergence methods, and discrete even and continuous methods.
5. Ability to design, manage and operate chemical process simulation, control and instrumentation procedures.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1			1	1	1			2	1			2
CO2			2	1	2			1	2			1
CO3			1	1	1			2	1			2
CO4			2		2			1	1			1
CO5			1	1	1			1	1			1

1 - Slightly; 2 - Moderately; 3 – Substantially


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PE-IV - 3 - FUNDAMENTALS OF MICROELECTRONIC MATERIAL PROCESSING**Credits: 3****Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
VII	2-0-0	7-1-7-R25E13	CH

Course Educational Objectives :

- 1) To have a fundamental knowledge about Integrated Circuits and its fabrication.
- 2) To learn the basic units of Integrated Circuits and Microelectronics processing.
- 3) To study in detail regarding Incorporation and Transport of Dopants.
- 4) To learn the Chemical rate processes and Kinetics of Micro processing and o Chemical Vapor deposition reactors and its design.
- 5) To study in detail regarding to physical and physicochemical rate process and its reactors.

UNIT - I: Integrated circuits and fabrication : Integrated circuits - Semiconductors and charge carriers - Basic relationships and conductivity - Basic units of Integrated circuits - Microelectronics processing.

Silicon Refining and other Raw Materials: Metallurgical Grade Silicon and source Gases - Electronic Grade silicon - Metal organic compounds.

UNIT - II: Bulk Crystal Growth: Introduction - Crystal structures and defects - Crystal Growth and Impurity distribution (Czochralski Technique) - Oxygen precipitation.

Incorporation and Transport of Dopants - introduction - - nature of diffusion in solids - dopant incorporation - radiation damage and annealing - dopant redistribution and autodoping - lithography.

UNIT - III: Chemical Rate Processes and Kinetics: Introduction - Growth processes of films of crystalline structure - homogenous reactions - heterogeneous reactions and deposition kinetics - gas - solid reactions - photochemical reactions - selective deposition

UNIT - IV: Chemical Vapor Deposition Reactors : CVD reactors - regimes of fluid flow - free convection and flow stability - intrinsic kinetics and transport effects - reactor design (isothermal, non isothermal, molecular flow reactors) and further considerations.

UNIT - V: Physical and Physicochemical Rate Processes and Apparatus : Introduction - Evaporation and physical vapor deposition - plasma - Physical sputtering - plasma deposition and gas - solid reactors - plasma etching - PVD apparatuses - plasma reactors.

Text Book:

1. Fundamentals of Microelectronics Processing – Hong H.Lee, McGraw-Hill


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Course Outcomes :

1. To be able to design an Integrated Circuit. Able to have knowledge on Integrated Circuit processing.
2. Able to learn the nature of Diffusion in solids, Incorporation of dopants and dopant redistribution, to learn the concept of Lithography.
3. Able to have knowledge on Homogenous and Heterogenous reactions involving in process.
4. Able to design a Chemical Vapor deposition reactor.
5. Able to design a Physical Vapor deposition apparatus and plasma reactors

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1						1	1	1		1	
CO2	1				1			1	1			
CO3	1				1			1	1			
CO4	1				1			1	1		1	
CO5	1				1			1	1			1

1 - Slightly; 2 - Moderately; 3 – Substantially


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PE-V - 1 - COMPUTATIONAL FLUID DYNAMICS**Credits: 3****Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
VII	3-0-0	7-1-7R25E21	CH

Course Educational Outcomes:

1. To learn the importance of computational fluid dynamics in developing the models in fluid dynamics
2. To learn the classification of partial differential equations
3. To learn the various discretization techniques
4. To learn the generation of grid with suitable boundary conditions
5. To learn simple computational fluid dynamics techniques

Unit I :

Philosophy of CFD – CFD - CFD as a research tool – CFD as a design tool – Examples
Governing Equations of Fluid Dynamics – Introduction – Models of Flow – The sustainable derivative- Divergence of Velocity – Continuity Equation – Momentum Equation – Energy Equation – Physical boundary conditions – Forms of Governing equations suited to CFD

Unit II :

Mathematical Behaviour of Partial Differential Equations (PDEs) – Classification of quasi linear PDEs – General Method of determining the classification of PDEs – General Behavior of different classes of PDEs

Unit III :

Discretization – Basic aspects – Finite Differences – Difference equations – Explicit and Implicit approaches – Errors and analysis of stability

Unit IV :

Grids with appropriate transformations – General transformation of equations – Metrics and Jacobians – Form of governing equations suited to CFD – Stretched grids – boundary fitted coordinate systems – adaptive grids – modern developments in grid generation, finite volume mesh


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Unit V :

Simple CFD Techniques - The Lax – Wendroff Technique – MacCormack's technique - Viscous Flows, Conservation form and space marching – Relaxation Technique – Aspects of numerical dissipation and dispersion – Alternating – Direction- Implicit technique – Pressure correction technique

Text Book :

1. CFD : The Basics with Applications – John D. Anderson Jr. TMH Publication

Reference

1. Introduction to CFD – PradipNiyogi, S K Chakrabarthy, M K Laha , Pearson Edu.:

Course outcomes: At the end of the course the student will able to

1. Understand the importance of computational fluid dynamics in fluid dynamics
2. Classify the partial differential equations for computational fluid dynamics
3. Use various discretization techniques
4. Apply boundary condition with the generation grids for fluid flow systems
5. Apply computational fluid dynamics techniques for fluid flow systems

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1			1	1	1			1	1			
CO2			2	1				1	2			1
CO3			1	1	1			2	1			2
CO4			1		2			1	1			1
CO5			1	1	1			1	1			1

1 - Slightly; 2 - Moderately; 3 – Substantially


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PE-V - 2 - MEMBRANE SEPARATIONS**Credits: 2****Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
VII	3-0-0	7-1-7-R25E22	CH

COURSE OBJECTIVES

1. To learn classification and principles of membrane separation processes.
2. To know the applications of membrane separation processes.
3. To get knowledge about ideal separations on capabilities of membrane processes and secondary phenomena occurring in membrane processes.
4. To know about the equipments of membrane processes.
5. To understand the design of membrane systems.

UNIT- I

Introduction to Membrane Separation Processes: Classification of separation process – separating agents – principles of gas permeation, reverse osmosis, ultra-filtration, pervaporation, dialysis, electro-dialysis.

Unit II :

Applications of membrane separation processes - separation of hydrogen or acid gases, Oxygen – nitrogen separation starting from air,- stability of membrane processes for waste water treatment, applications in pulp and paper, electroplating and electro-coating industries – applications in food industry – denaturing of liquid foods , cheese making and whey production.

Unit III :

Ideal separations on capabilities of membrane processes – separation factor, rejection factor, expressions for ideal separation factors

Secondary phenomena in membrane processes: secondary physical and transport phenomena in membrane processes, concentration polarization


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Unit IV :

Equipment for membrane processes: Flat sheet, tubular, spiral wound and hollow fiber, membrane modular designs, single entry and double entry separating elements, separation stage, flow configuration.

Unit V:

Design of membrane systems: Design equations for perfect mixing and cross flow configuration, separation stages for gas permeation, reverse osmosis and ultra-filtration. Design equations for perfect mixing and parallel flow dialyze, simple design equations for electro-dialytic stacks

Reference Books:

- 1) Membranes in Separation – S.T.Hwang and K.Mammermeyer, Wiley-Interscience, Newyork (1975).
- 2) Transport Processes and Unit Operations – Christie J.Geankoplis, Prentice Hall of India Pvt.Ltd (2000).

Course Out comes

1. Able to understand overall view of membrane separation processes. Able to learn different processes in reverse osmosis, ultra filtration, dialysis, electro dialysis.
2. have the knowledge on applications of membrane separation processes
3. To have a knowledge on separation factor, expressions for ideal separation factor. to have a knowledge on transport phenomena in membrane processes
4. Able learn knowledge on membrane modular designs, single and double entry separating elements.
5. Can understand design equations for mixing and cross flow configurations. Able to design equation for perfect mixing and parallel flow dialyze. To develop the design equation for electro dialytic stacks

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		1	1	1				1	1			
CO2		2	1	1				2	1			
CO3		1	1	1		2	1	1	1			
CO4		2	1	1				2	1			
CO5		2	2	1				1	1			

1 - Slightly; 2 - Moderately; 3 – Substantially


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PE-V - 3 - BIO PROCESS ENGINEERING**Credits: 3****Assessment: 40 + 60**

Semester	L-T-P	Course Code	Branches
VII	3-0-0	7-1-7-E25E23	CH

Course Educational Objectives:

1. To study the mechanism of catalytic action and study production of enzymes
2. To have a view on cell growth
3. To study the operation and cultivation method of cells in bio reactors
4. To have a view on selection and control of bio-reactors
5. To have a knowledge on recovery and purification of products

Unit I :

Enzymes: Introduction –Classification-Importance-Mechanistic models for simple enzyme kinetic— Enzyme kinetics – Experimentally Determining Rate Parameters for Michaelis–Menten Type Kinetics-Immobilized enzyme systems–Methods of Immobilization–large scale production of enzymes– Medical and Industrial utilization of enzymes and enzyme deactivation.

Unit II:

Cells: Microbial diversity-Types of cell-viruses-Cell nutrients– Nucleic Acids-lipids-vitamins-DNA and RNA-DNA Replication-Transcription-Translation: Message to Product-metabolic regulation– How the Cell Senses Its Extracellular Environment-Major Metabolic Pathways-transport of small molecules across cellular membrane - Cell Growth – batch growth – Quantifying cell growth – cell growth in continuous culture.

Unit III:

Bioreactors–I:Operating considerations: Choosing the cultivation method–Modifying Batch and Continuous Reactors–Chemostat with Recycle, Multistage Chemostat Systems, Fed-batch Operation and Perfusion Systems. Immobilized cell systems- Active Immobilization of Cells, Passive Immobilization-Biological Films, Diffusional Limitations in Immobilized Cell Systems-Bioreactor Considerations in Immobilized Cell Systems– Solid State Fermentations.


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Unit IV:

Bioreactors–II: Selection, Scale-up and its difficulties-Instrumentation for Measurements of Active Fermentation - Using the Information Obtained, Bioreactor instrumentation and its control, Sterilization of Process fluids-Introduction and the Kinetics of Death -Sterilization of Liquids - Sterilization of Gases.

Unit V:

Recovery and Purification of Products: Product recovery strategy and Purify Products, Separation of insoluble products – Filtration, Centrifugation and Coagulation & Flocculation, cell disruption – Mechanical Methods and Non mechanical methods, Separation of Soluble Products –Liquid Liquid Extraction, Aqueous Two phase Extraction, Precipitation, Adsorption, Dialysis, Reverse Osmosis, Ultrafiltration and Microfiltration, Cross-flow ultrafiltration & microfiltration, Chromatography , Electrophoresis and Electrodialysis, Finishing steps for purification – Crystallization-Drying, Integration of Reactor and Separation

Text Book:

1. Bioprocess Engineering–Basic Concepts by Michael L.Shuler and Fikret Kargi, Prentice Hall of India Pvt. Ltd.,

References:

1. Bio chemical Engineering Fundamentals by J.E.Bailey and D.O.Ollis (McGraw-Hill)
2. Bio chemical Engineering by S.Aiba ,Humphrey and Millis.

Course Outcomes:

1. Able to analyze kinetics of enzymes and immobilized enzyme systems
2. Able to have knowledge on medicinal and industrial utilization of enzymes can learn microbial diversity Have knowledge on cell growth in batch and continuous reactors
3. Able to choose different cultivation methods
4. Have knowledge on bioreactor instrumentation and its control
5. Can understand the strategies of product recovery and separation of soluble and insoluble product.


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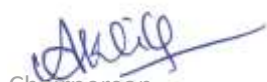

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PROCESS EQUIPMENT DESIGN & DRAWING**Credits: 2****Assessment: 100+ 40**

Semester	L-T-P	Course Code	Branches
VII	1-0-2	7-1-7-R25S1	CH

Introductory topics like PFD & PID, welding symbols, materials of construction, headers and closures, nozzles and supports .

Design calculations and preparation of Engineering drawing of Process equipment like Heat exchangers, Plate Columns, Packed Columns, Evaporator, Reactor, Dryer, Storage Vessels etc.,


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**B.Tech. (Chemical Engineering)
Semester VIII (Fourth Year)**

Code		Category	Course title	Scheme of Instruction, Hr/Week				Credits	Scheme of Evaluation, Marks		Total Marks
Department	University			L	T	P	Total		CIE	SEE	
CH1801PI	7-0-8-R25PS	CH-PWSI	Project-Work and Full Semester Internship	0	0	0	0	12	50	50	100
			TOTAL	0	0	0	0	12	50	50	100

In the final semester, the student should mandatorily undergo full semester internship and parallelly he/she should work on a project with well-defined objectives. At the end of the semester the candidate shall submit an internship report and its completion certificate in the department. Student is permitted to submit report on the work carried out during the internship as project report provided the internship work is in the discipline of his B.Tech. Program. Internship programs offered by AICTE/APSSDC/NSDC/SWAYAM PLUS /Any State or Central Government organizations involving Industry experts and approved by the concerned BoS/Head/Head of the Institution are also considered equivalent to full semester Internship provided it involves 90 – 120 hours of work. The Internship work area can be in his own discipline or inter-disciplinary (One discipline being his own) or other discipline also. The project work shall be either in the discipline of his own or inter-disciplinary.


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EXIT OPTIONS FOR B.TECH CHEMICAL ENGINEERING

**Two months internship in industry or bridge courses mentioned below of 6 to 8 credits
on NPTEL – SWAYAM Platform**

Semester	Exit Option	Credits	Additional Credits for exit students	List of exit courses
Sem I & II	U.G Certificate	41	6-8	1. Chemical Process Instrumentation 2. Mat Lab Programming for numerical Computation 3. Membrane Technology 4. Momentum Transfer in Fluids 5. Physio-chemical Processes for waste water Treatment 6. Polymer Reaction Engineering 7. Process Equipment Design 8. Transport Processes 9. Renewable Energy Engineering: Solar, Wind and Biomass Energy systems 10. Polymeric Bio Materials- Structure, Properties, function Performance 11. Modeling Stochastic Phenomena for engineering applications-Part-1 12. Material And Energy Balances 13. Fundamentals Carbon capture utilization and Storage 14. Chemical Process Utilities 15. Chemical Process Technologies 16. Aspen Plus- Simulation software- A Basic Courses for Beginners 17. Basic Principles and Calculations in Chemical Engineering 18. Heat and Mass transfer


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Sem III & IV	U.G Diploma	43	6-8	1. Fundamentals in bioprocess engineering 2. Fluid and particle mechanics 3. Polymers: concepts, properties, uses and sustainability 4. Aspen plus: simulation software – an advanced course 5. Introduction to polymer physics 6. Chemical process safety 7. Polymer process engineering 8. Advanced reaction engineering 9. Chemical process intensification 10. Organic chemical technology 11. Thermal processing of foods 12. MAT lab- based programming lab in chemical engineering 13. Enhanced oil recovery techniques 14. Advanced heat conduction 15. Petroleum formation evaluation 16. Advanced Reaction Engineering 17. Chemical Engineering Thermodynamics 18. Nano-Technology in Chemical Engineering
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