B.TECH. (CHEMICAL ENGINEERING)

&

B.TECH. + M.TECH. (CHEMICAL ENGINEERING)

(Effective from the admitted batch of 2015-16)

Scheme and Syllabi

DEPARTMENT OF CHEMICAL ENGINEERING
AU COLLEGE OF ENGINEERING (A)
ANDHRA UNIVERSITY
VISAKHAPATNAM

1/4 B.Tech (Chemical Engineering) - First Semester
&
1/6 B.Tech + M.Tech (Chemical Engineering) First Semester

ENG-1101   **ENGLISH**

OBJECTIVES:

Reading Skills
- ❖ Addressing explicit and implicit meanings of a text on current topics.
- ❖ Understanding the context.
- ❖ Learning new words and phrases.
- ❖ Using words and phrases in different contexts.

Writing Skills
- ❖ Using the basic structure of a sentence.
- ❖ Applying relevant writing formats to create paragraphs, essays, letters, emails, reports and presentations.
- ❖ Retaining a logical flow while writing.
- ❖ Planning and executing an assignment creatively.

Interactive Skills
- ❖ Analyzing a topic of discussion and relating to it.
- ❖ Participating in discussions and influencing them.
- ❖ Communicating ideas effectively.
- ❖ Presenting ideas coherently within a stipulated time.

Life Skills and Core Skills
- ❖ Examining self-attributes and identifying areas that require improvement: self-diagnosis and self-motivation.
- ❖ Adapting to a given situation and developing a functional approach to finding solutions: adaptability and problem solving.
- ❖ Understanding the importance of helping others: community services and enthusiasm.

OUTCOME:
- ❖ The overall performance of the students will be enhanced after the course; they will be in a position to make presentations on topics of current interests - politics, famous personalities, science and technology, tourism, work and business environment, with increased public speaking skills.

- ❖ Students will be able to read, listen, speak and write effectively in both academic and non-academic environment.

- ❖ The students will be updated with certain real life situations, which they can handle when come to face to face.

Syllabus:

1) **Vocabulary**: Word Search, Discuss and Note – Word Quiz – A List of 100 Basic Words – One Word Substitutes – 100 Difficult Words, Synonyms, Antonyms, Idioms, Technical terms.

2) **Grammar:** Types of Sentences, Verbs, Adverbs, Pronouns, Adjectives, Gerunds & Infinitives, Articles, Quantifier, Punctuation, Prepositions, Conjunctions, Exclamation.

3) **Reading:** Famous People – What is Personality, Personality Based on Blood Groups – News Report, Magazine Article, Mobile Towers and Health – An Excerpt from a Short Story, An Excerpt from a Biography – Open Letter to Prime Minister, Business Dilemmas: An Email Exchange – A
Review of IPL: The Inside Story, Marck Zuckerberg: World's Youngest Billionaire – Solar Power: The Way Forward, From the Very Small to the Very Large.

4) **Listening:** Life in a Hostel – Eating Away those Blues!, Meeting Carl Jung – A Documentary on the Big Cat – A Consultant Interviewing Employees – A Conversation about a Business Idea – An Interview with a Woman Engineer.

5) **Speaking:** Your favorite Holiday Destination – Describe yourself – Why we need to save Our Tigers-a Dialogue – Your First Interview – Pair Work: Setting up a New Business – Great Engineering Achievements.

6) **Scenario:** Sharing a Flat – Living in the Twenty-First Century – Global warming – Reality TV – Recession – The Sky-High Project.

7) **Writing:** Writing Sentences – Using your dictionary – Paragraph Writing, Arguing a Case – Essay, Formal Letters, Emails, Reports, and Presentations.

8) **Life Skills and Core Skills:** Self Awareness and Self Motivation – Communication, Adaptability – Motivation, Problem Solving – Personal Presentation Skills, Stress Management – Professionalism, Ethics – Innovativeness and Creativity.

Prescribed Text Book: *Life through Language: A Holistic Approach to Language Learning.*
Board of Editors, Pearson Publishers, India. 2013.

Life through Language: An Effective Learning Experience
> Life through Language has a systematic structure that builds up communicative ability progressively through the chapters. It will enable the learner to manage confusion; frame question for themselves and others; develop new ideas; support ideas with evidence; express themselves with poise and clarity; and think critically. Acquisition of skill leads to confidence.
> **Chapter-1**
> **People and Places:**-Word search - Ask yourself-Self-assessment-I -Self-assessment-II - Sentence and its types- A guidebook entry- Life in a hostel-Your favorite holiday destination-Designing a holiday-Writing sentences-Self-awareness- Self-motivation.

Chapter-2
Personality and Lifestyle:- Word quiz – Verbs-Adverbs- A big fat wedding- Wine and dine- Going places-Negotiations-Proving yourself- Meeting Carl Jung- Describing yourself- Living in the 21st century- Using your dictionary- Communication-Adaptability.

Chapter-3
Media and Environment: - A list of 100 basic words – Nouns- Pronouns- Adjectives-News report- Magazine article- User's Manual for new iPod- A documentary on the big cat- Why we need to save our tigers: A dialogue- Global warming- Paragraph Writing-Arguing a case- Motivation- Problem solving.

Chapter-4
Entertainment and Employment:- One word substitutes- Parts of speech- Gerunds and infinitives- An excerpt from a short story an excerpt from a biography- A consultant interviewing employees- Your first interview- Reality TV- Writing an essay-Correcting sentences- Integrity Sense of humor.

Capter-5
Work and Business:- A list of 100 difficult words- Articles, Quantifiers- Punctuation - Open letter to the Prime Minister Business dilemmas: An email exchange- A review of *IPL: The Inside Story,* Mark Zuckerberg: World's Youngest Billionaire- A conversation about a business idea- Pair work: Setting up a new business- Recession- Formal letters-Emails- Reports- Professionalism-Ethics.

Reference Books:
1. Basic Vocabulary. Edgar Thorpe, Showick Thorpe. Pearson P. 2008.
2. Quick Solutions to Common Errors in English, Angela Bunt. MacMillan P. 2008.
3. Know Your English (Volume 1&2), by Dr. S. Upendra, Universities Press, India 2012
4. Business Communication Strategies. Mathukutty Monippally. Tata Mc Grahill P. 2009.

ENG-1102   **MATHEMATICS-I**

OBJECTIVES:
To impart the knowledge of partial differentiation involving two or more variables, Euler's theorem, change of variables, Jacobins, Geometrical interpretation. To apply the concept of partial differentiation in finding the errors and approximations, maxima and minima of two variables, to introduce the Lagrange's method of undetermined constants and Leibnitz's rule. To solve the ordinary differential equations of first order and first degree, Bernoulli's equation, exact differential equations, and equations reducible to exact equations. To get knowledge about the applications of differential equations of first order like orthogonal trajectories, simple electric circuits, law of natural growth and decay. To solve the linear differential equations of higher order, also to impart the knowledge in convergence, divergence and oscillation of an infinite series.

OUTCOMES: By the end of the course, the student will be able to

1. Use the different methods to solve the partial differentiation involving two or more variables and acquire skills to find solutions of maxima and minima of functions of two variables.
2. Use the different methods to find solutions to ODEs of first order and first degree, orthogonal trajectories, simple electric circuits and law of natural growth and decay. Also acquire the skills to solve the higher order differential equations.
3. Calculate the convergence, divergence or oscillation nature of an infinite series, and apply different test techniques like comparison test, limit test, D Alembert's test and other tests.

SYLLABUS:
Unit-I
Partial Differentiation
Functions of two or more variables - Partial derivatives - Homogeneous functions – Euler's theorem - Total derivative - Change of variables – Jacobians - Geometrical interpretation: Tangent plane and Normal to a surface.
Unit-II
Application of Partial Differentiation
Taylor's theorem for functions of two variables - Errors and approximations – Total differential - Maxima and Minima of functions of two variables - Lagrange's method of undetermined multipliers - Differentiation under the integral Sign - Leibnitz's rules.

Unit-III
ORDINARY DIFFERENTIAL EQUATIONS OF FIRST ORDER and First degree
Formation of the ordinary differential equations(ODEs) - Solution of an ordinary differential equation - Equations of the first order and first degree - Linear differential equation - Bernoulli's equation - Exact differential equations - Equations reducible to exact equations.

Unit-IV
Applications of DIFFERENTIAL EQUATIONS OF FIRST ORDER
Orthogonal Trajectories - Simple Electric (LR & CR) Circuits - Newton's Law of Cooling - Law of Natural growth and decay.

Unit-V
LINEAR DIFFERENTIAL EQUATIONS OF HIGHER ORDER
Solutions of Linear Ordinary Differential Equations with Constant Coefficients - Rules for finding the complimentary function - Rules for finding the particular integral - Method of variation of parameters - Cauchy's linear equation - Legendre's linear equation - Simultaneous linear equations.

Unit-VI
Infinite Series
Introduction to Series – Convergence, Divergence and Oscillation of a Series - Comparison Test – Limit form - Integral Test - D Alembert's Ratio Test - Raabe's Test - Logarithm Test - Cauchy's Root Test - Alternating Series: Lebnitz Rule - Series of positive, negative terms: Absolute and Conditional Convergence-Uniform Convergence: Weirstrass M-Test. (All Tests without proofs)

TEXT BOOK:
   Scope and Treatment as in "Higher Engineering Mathematics", by Dr. B.S. Grewal, 43rd Edition, Khanna publishers.

REFERENCE BOOKS:
   1. Advanced Engineering Mathematics by Erwin Kreyszig.
   2. A text book of Engineering Mathematics, by N.P. Bali and Dr. Manish Goyal, Lakshmi Publications.
   3. Advanced Engineering Mathematics by H.K. Dass. S. Chand Company.
   4. Higher Engineering Mathematics by B.V. Ramana, Tata Mc Graw Hill Company.
   5. Higher Engineering Mathematics by Dr. M.K.Venkataraman.

ENG-1103   **MATHEMATICS-II**

OBJECTIVES: The students are introduced with matrix algebra, Laplace transforms and Special functions to enable them to use in their further studies.

In matrix algebra,
(i)   Consistency and inconsistency of system of equations by the use of rank of a matrix.
(ii)   Obtaining Eigen values and Eigen vectors of a square matrix and application of Cayley- Hamilton's theorem.
(iii)   Quadratic and canonical forms.
(iv)   Properties of complex matrices
(v)   Solution of system of equations by direct methods are thoroughly discussed.

In Laplace transforms,
(i)   Properties of Laplace transforms.
(ii)   Properties of Inverse Laplace transforms.
(iii)   Applications of Laplace transforms are presented.

Whereas in Special Functions,
(i)   Series solution of differential equations.
(ii)   Properties of Legendre polynomial.
(iii)   Properties of Bessel function are introduced to the students.

OUTCOME:

 The students comeout with a good knowledge of Matrix Algebra, Laplace Transforms and Special Functions and ready to use these mathematical techniques when required. And also, the students are able to discuss and apply all the contents mentioned in the objectives in their further study.

SYLLABUS:
Unit-I
Matrices I
Rank of a matrix- Echelon form, Normal Form - Solution of Linear System of Equations - Consistency of Linear System of Equations - Direct Methods: Gauss elimination method, LU Factorization method - Eigen Values and Eigen Vectors of a Matrix - Cayley-Hamilton theorem - Inverse and Powers of a Matrix using Cayley-Hamilton theorem.

Unit-II
Matrices II
Diagonalization of a Matrix - Quadratic Forms - Reduction of Quadratic Form to Canonical Form - Nature of a Quadratic Form - Complex Matrices: Hermitian, Skew-Hermitian and Unitary Matrices and their Properties.

Unit-III
LAPLACE TRANSFORMS
Introduction - Existence Conditions - Transforms of Elementary Functions - Properties of Laplace Transforms - Transforms of Derivatives - Transforms of Integrals - Multiplication by t^n - Division by t – Evaluation of integrals by Laplace Transforms - Laplace Transforms of Unit Step Function, Unit Impulse Function and Periodic Functions.

Unit-IV
LAPLACE TRANSFORMS
Inverse Laplace Transform - Convolution Theorem - Applications of Laplace Transforms to Ordinary Differential Equations, Simultaneous Linear Differential Equations with Constant Coefficients.

Unit-V
SPECIAL FUNCTIONS
Bessel's Equation - Bessel's Functions - Recurrence Formulae for Bessel's Function - Generating Function - Equations reducible to Bessel's equation - Orthogonality of Bessel's Functions.
Legendre's Differential Equation - General Solution of Legendre Equation - Legendre Polynomials - Rodrigue's Formula - Generating Function, Recurrence Formulae, Orthogonality of Legendre Polynomials.

TEXT BOOK:
    Scope and Treatment as in "Higher Engineering Mathematics", by Dr. B.S. Grewal, 43rd edition, Khanna publishers.

REFERENCE BOOKS:
1. Advanced Engineering Mathematics by Erwin Kreyszig.
2. A text book of Engineering Mathematics, by N.P. Bali and Dr. Manish Goyal. Lakshmi Publications.
3. Advanced Engineering Mathematics by H.K. Dass. S. Chand Company.
4. Higher Engineering Mathematics by B.V. Ramana, Tata Mc Graw Hill Company.

ENG-1104   **CHEMISTRY**

Objectives: The student will be able to:

1. appreciate the nature and scope of chemistry in engineering.
2. apply the knowledge of water, solid state of mater, polymers, corrosion, building material, fuels and lubricants as foundation for engineering discipline
3. apply key concepts from water chemistry, solid state chemistry for future society and industry needs
4. apply solid state chemistry in all major disciplines of engineering
5. apply the role of polymers, plastics and building materials and their properties for industrial and day to day use
6. apply the effects of corrosion on industrial scale and the measures for its control
7. apply fuels and lubricants and their properties for industrial and day to day use

Outcome:

The course introduces studentsto water chemistry, solid state chemistry, polymers, plastics, corrosion, building materials, fuels and lubricants for engineering applications, future materials and devices.

Syllabus:

Chapter 1: Water Chemistry   [8 Hrs.]

Sources of Water – Impurities and their influence on living systems – WHO Limits – Hardness and its Determination – Boiler Troubles and their removal – Water Softening Methods – Lime-Soda, Zeolite and Ion Exchange – Municipal Water Treatment – Break Point Chlorination – Desalination of Sea Water –Reverse Osmosis Method, Electrodialysis

Chapter 2: Solid State Chemistry: [8 Hrs.]

Solids: Classification of Solids – Types of Crystals – Fundamental Laws of Crystal Structure – X-Rays and Bragg's Law – Imperfections in Crystals – Band Theory of Solids – Chemistry of Semiconductors – Intrinsic, Extrinsic, Compound and Defects – Organic Semiconductors - Super Conductivity - Purification of Solids by Zone refining – Single Crystal Growth – Epitaxial Growth – Liquid Crystals

Chapter 3: Polymers and Plastics   [10 Hrs.]

Polymers: Definition – Types of Polymerisation (Addition & Condensation) – Mechanisms of Polymerisation - Radical and Ionic – Thermodynamics of Polymerisation Process

Plastics: Thermosetting and Thermoplastics - Effect of Polymer Structure on Properties of Plastics –Compounding of Plastics – Fabrication of Plastics – Preparation and Properties of Cellulose Derivatives – Vinyl Resins – Nylon (6,6), Bakelite, Reinforced Plastics – Conducting Polymers

Chapter 4: Corrosion   [10 Hrs.]

Corrosion: Origin and Theory – Types of corrosion: Chemical and Electrochemical; Pitting, Intergranular, Waterline, Stress – Galvanic Series – Factors Effecting Corrosion

Corrosion Controlling Methods: Protective Coatings: Metallic coatings Electroplating and Electroless Plating – Chemical Conversion Coatings – Phosphate, Chromate, Anodized, Organic coatings – Paints and Special paints.

Chapter 5: Building Materials   [10 Hrs.]

Portland Cement: Manufacture of Cement– Dry and Wet Processes – Chemical Composition of Cement – Setting and Hardening of Cement – Cement Concrete – R.C.C – Decay of Concrete and Protective Measures – Special Cements

Refractories: Classification – Properties – Engineering Applications

Ceramics: Classification – Properties – Engineering Applications

Chapter 6: Fuels and Lubricants   [10 Hrs.]

Solid Fuels: Wood and Coal, Ranking of Coal – Analysis (Proximate and Ultimate) Coke Manufacture – Otto Hoffmann's Process – Applications

Liquid Fuels: Petroleum Refining – Motor fuels – Petrol and Diesel oil – Knocking – Octane number – Cetane number

Gaseous Fuels: Biogas, LPG and CNG – Characteristics – Applications

Rocket Fuels – Propellants – Classification – Characteristics

Lubricants – Classification – Mechanism – Properties of Lubricating Oils – Selection of lubricants for Engineering Applications

Reference Books:

Engineering Chemistry – PC Jain and M Jain – DhanpathRai and Sons, New Delhi

A Text Book of Engineering Chemistry – S. S. Dara – S. Chand and Co. New Delhi

Engineering Chemistry – B. K. Sharma – Krishna Prakashan – Meerut

ENG-1106   COMPUTER PROGRAMMING AND NUMERICAL METHODS
Objectives :
To make the student familiar with programming in C and enable the student to implement the numerical methods described in this course using C as Programming language.

Section A

Computer Programming in C :
Basics : Variables, constants, expressions, operators and their precedence and associativity, basic input and output statements, control structures, simple programs in C using all the operators and control structure.
Functions : Concept of a function, parameters and how they are passed, automatic variables, recursion, scope and extent of variables, writing programs using recursive and non-recursive functions.
Arrays and Strings : Single and multidimensional arrays, character array as a string, functions on strings, writing C programs using arrays and for string manipulation.
Structures : Declaring and using structures, operations on structures, arrays of structures, user defined data types, pointers to using files.
Files : Introduction, file structure, file handing functions, file types, files, error handing, C programming examples for using files.

Section B

Computer oriented numerical methods :
Basic concepts : Preliminary concepts of algorithms, flow charts and their execution traces, a simplified model of a computer,
Representation for characters and numbers : Representation for integer and real numbers, effect of finite representation on arithmetic operations for ex. overflow, underflow, associativity and normalization, some elementary methods for overcoming these limitations,
Numerical methods : Notation of round-off and truncation errors, numerical methods of finding roots of an algebraic equation of one variable, successive bisection method, false position method, Newton Raphson method and Secant method.
Solutions of simultaneous algebraic equations ; Gauss elimination method and Gauss Seidal methods,
Interpolation : Lagrange's interpolation and difference table methods,
Numerical integration : Simpson's rule, Gaussian quadrature furmula,
Numerical solution of differential equation : Euler's method, Taylor's series method and Runge-Kutta method.

SYLLABUS:
1. **Introduction to C :** Basic structure of C program, Constants, Variables and data types, Operators and Expressions, Arithmetic Precedence and associativity, Type Conversions. Managing Input and Output Operations, Formatted Input, Formatted Output.

2. **Descision Making, Branching, Looping, Arrays & Strings :** Decision making with if statement, Simple if statement, The if… else statement, Nesting of if ….esle statement, the else…. If ladder, switch statement, the (?:) operator, the GOTO statement., The while statement, the do statement, The for statement, Jumps in Loops, One, Two-dimensional Arrays, Character Arrays. Declaration and initialization of Strings, reading and writing of strings, String handling functions, Table of strings.

3. **Functions :** Definition of Functions, Return Values and their Types, Function Calls, Function Declaration, Category of Functions : No Arguments and no Return Values, Arguments but no Return Values, Arguments with Return Values, No Argument but Return a Value, Functions that Return Multiple Values. Nesting of functions, recursion, passing arrays to functions, passing strings to functions, The scope, visibility and lifetime of variables.

4. **Pointers :** Accessing the address of a variable, declaring pointer variables, initializing of pointer variables, accessing variables using pointers, chain of pointers, pointer expressions, pointers and arrays, pointers and character strings, array of pointes, pointers as function arguments, functions returning pointers, pointers to functions, pointers to structures-Program Applications.

5. **Structure and Unions :** Defining a structure, declaring structure variables, accessing structure members, structure initialization, copying and comparing structure variables, arrays of structures, arrays within structures, structures within structures, structures and functions and unions, size of structures and bit-fields-Program applications.

6. **File handing :** Defining and opening a file, closing a file, Input/Output operations on files, Error handling during I/O operations, random access to files and Command Line Arguments – Program Applications.

7. **Numerical Methods : Solutions of Algebraic and Transcendental Equations :** Bisection Method, Newton Raphson Method. **Interpolation :** Newton's forward and backward Interpolation, Lagrange's Interpolation in unequal intervals. **Numerical Integration :** Trapezoidalrule, Simpson's 1/3 rule. **Solutions of Ordinary First Order Differential Equations** : Euler's Method, Modified Euler's Method and Runge-Kutta Method.

Text Books :
1. Programming in ANSI C, E Balagurusamy, 6th Edition, McGraw Hill Education (India) Private Limited.
2. Introduction to Numerical Methods, SS Sastry, Prentice Hall.

Reference Books :
1. Let Us C, Yashwant Kanetkar, BPB Publications, 5th Edition.
2. Computer Science, A structured programming approach using C", B.A. Forouzan and R.F. Gilberg, "3rd Edition, Thomson, 2007.
3. The C-Programming Language' B.W. Kernighan, Dennis M. Ritchie, PHI.
4. Scientific Programming : C-Language, Algorithms and Models in Science, Luciano M. Barone (Author), Enzo Marinari (Author), Giovanni Organtini, World Scientific.

ENG-1108   **HISTORY OF SCIENCE AND TECHNOLOGY**

Objectives:
- ❖ To know the contributions of scientists for the development of society over a period of time.
- ❖ To understand the Science and Technological developments that lead to human welfare.
- ❖ To appreciate the Science and Technological contributions for the development of various sectors of the economy.
- ❖ To identify the technological transfer versus economic progress of the countries.

Outcome: By the end of this course the students should be able to understand the contribution of Scientific and Technological developments for the benefit of society at large.

Syllabus:

UNIT-I

Historical Perspective of Science and Technology:

Nature and Definitions; Roots of Science – In Ancient Period and Modern Period (During the British Period); Science and Society; Role of Scientist in the Society.   **(6 periods)**

UNIT-II

Policies and Plans after Independence:

Science and Technology Policy Resolutions; New Technology Fund; Technology Development (TIFAC); Programs aimed at Technological Self Reliance; Activities of Council of Scientific and Industrial Research.   **(6 periods)**

UNIT-III

Science and Technological Developments in Critical Areas:

Space – The Indian Space Program: India's Geostationary Satellite Services – INSAT System And INSAT Services; **Defense Research and Technology** – Research Coordination, Research efforts and Development of technologies and Spin-off technologies for civilian use; **Nuclear Energy** –Effects of a nuclear explosion and India's safety measures**.**   **(6 Periods)**

UNIT-IV

Impact of Science and Technology in Major Areas:

Ocean Development: Objectives of Ocean Development, Biological and Mineral resources, Marine Research and Capacity Building; **Biotechnology:** Meaning, Biotechnology techniques-Bioreactors, Cell fusion, Cell or Tissue Culture, DNA Fingerprinting, Cloning, Artificial Insemination and Embryo Transfer Technology and Stem Cell Technology; Application of Biotechnology – Medicine, Biocatalysts, Food Biotechnology, Fuel and Fodder and Development of Biosensors.   **(6 periods)**

UNIT-V

Technology Transfer and Development:

Transfer of Technology – Types, Methods, Mechanisms, Process, Channels and Techniques; **Appropriate Technology** - Criteria and Selection of an Appropriate Technology; Barriers of Technological Change. .   **(6 periods)**

Text Books:

1. Kalpana Rajaram, **Science and Technology in India,** Published and Distributed by Spectrum Books (P) Ltd., New Delhi-58.
2. Srinivasan, M., **Management of Science and Technology (Problems & Prospects),** East – West Press (P) Ltd., New Delhi.

1/4 B.Tech(Chemical Engineering) - Second Semester
&
1/6 B.Tech + M.Tech(Chemical Engineering) - Second Semester

ENG-1201   **MATHEMATICS-III**

OBJECTIVE: The main objective of Engineering Mathematics is to make the students familiar with mathematical thinking and realization of the background of their problems. Multiple Integral is a natural extension of a definite integral to a function of more than one real variable. A major reason to study solid geometry is the application to computer graphics, sphere and cylinder are one of the most basic curvilinear geometric shapes. Fourier Series is a way to represent a periodic signal into the sum of a set of simple oscillating functions namely sines and cosines. Fourier Series has many applications in Electrical Engineering, vibration analysis, acoustics, signal and image processing, etc.

OUTCOME: On successful completion of the course , the student will be able to evaluate double and triple integrals which are useful in evaluating area, volume, mass, centroid and moments of inertia of plane and solid regions. He knows how to convert a double integral in Cartesian co-ordinates into an integral in polar co-ordinates. He also knows to find the volume in between the intersection of solids. He can evaluate the surface area of solid figures. The student can expand a given function as Fourier series and half range series. The student will be familiar with the properties and relations of lines, surfaces and solids in space.

SYLLABUS:

Unit-I
Solid Geometry
Equations of Straight Line - Conditions for a line to lie in a Plane - Coplanar lines - Shortest distance between two lines - Intersection of three Planes - Equations of Sphere - Tangent Plane to a Sphere –Cone - Cylinder.

Unit-II
Multiple Integrals-1
Double Integrals - Change of Order of Integration - Double Integrals in Polar Coordinates - Triple Integrals - Change of Variables.

Unit-III
Multiple Integrals-2
Beta Function - Gamma Function - Relation between Beta and Gamma Functions - Error Function or Probability Integral - Area enclosed by plane curves - Volumes of solids - Area of a curved surface - Calculation of mass - Center of gravity - Moment of inertia - product of inertia – principal axes.

Unit-IV
Fourier series
Introduction - Euler's Formulae - Conditions for a Fourier Expansion - Functions having points of discontinuity - Change of Interval - Odd and Even Functions - Expansions of Odd or Even Periodic Functions, Half-Range Series - Parseval's Formula.

TEXT BOOK:

Scope and Treatment as in "Higher Engineering Mathematics", by Dr. B.S. Grewal, 43rd edition, Khanna publishers.

REFERENCE BOOKS:

1. Advanced Engineering Mathematics by Erwin Kreyszig.
2. A text book of Engineering Mathematics, by N.P. Bali and Dr. Manish Goyal; Lakshmi Publications.
3. Advanced Engineering Mathematics by H.K. Dass. S. Chand Company.
4. Higher Engineering Mathematics by B.V. Ramana, Tata Mc Graw Hill Company.
5. Engineering Mathematics series by Chandrica Prasad.

ENG-1202   **PHYSICS**

Outcome:

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

- ❖ Solve engineering problems using the concepts of wave and particle nature of radiant energy
- ❖ Understand the use of lasers as light sources for low and high energy applications
- ❖ Apply the concepts of light in optical fibers, light wave communication systems.
- ❖ Construct a quantum mechanical model to explain the behaviour of a system at microscopic level Mapping of course outcomes
- ❖ student will be able to understand many modern devices and technologies based on lasers and optical fibers.
- ❖ Student can also appreciate various material properties which are used in engineering applications and devices.
- ❖ The student will be able to understand fundamentals of electrodynamics and semiconductor physics which is base of many modern devices and technologies.
- ❖ Student will also get an exposure to modern physics topics like nanotechnology and advanced materials.

Syllabus:

<div align="center">

Unit-I
</div>

THERMODYNAMICS

       Introduction, Heat and Work, First law of thermodynamics and applications, Reversible and Irreversible process, Carnot cycle and Efficiency, Second law of thermodynamics, Carnot's Theorem, Entropy, Second law in terms of entropy, Entropy and disorder, Third law of thermodynamics (statement only).

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(8 Hours)
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Unit –II
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ELECTROMAGNETISM

       Concept of electric flux, Gauss's law - some applications, Electric potential and field strength, potential due to a point charge and dipole, Magnetic field - Magnetic force on current, torque on current loop, The Biot-Savart's Law, B near a long wire, B for a circular Current loop Ampere's law, B for a solenoid, Hall effect, Faraday's law of induction, Lenz's law, Inductance, L-R Circuit, Induced magnetic fields, Displacement current, Maxwell's equations (Both differential and Integral forms), Magnetic materials: Classification of magnetic materials and properties.   (16 Hours)

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Unit III
</div>

OPTICS

Interference: Principles of superposition – Young's Experiment – Coherence - Interference in thin films, Wedge shaped film, Newton's Rings, Michelson Interferometer and its applications.

Diffraction: Single slit (Qualitative and quantitative treatment)

Polarisation : Polarisation by reflection, refraction and double refraction in uniaxial crystals, Nicol prism, Quarter and Half wave plate, circular and elliptical polarization and detection.

(12 Hours)

Unit - IV

LASERS

Introduction, spontaneous and stimulated emissions, population inversions, pumping, Ruby laser, Gas laser (He-Ne Laser), Semiconductor laser, Applications of lasers.

FIBRE OPTICS

Optical Fibre and Total Internal Reflection, Acceptance Angle and cone of a fibre, Numerical aperture, Fibre optics in communications, Optical parts in Fibre, Application of optical fibers.

ULTRASONICS

Introduction, Production of Ultrasonics by Magnetostriction and Piezoelectric effects, Ultrasonics and diffraction pattern, Applications of Ultrasonics.

(14 Hours)

Unit - V

MODERN PHYSICS

De Broglie concept of matter waves, Heisenberg uncertainty principle, Schrodinger time independent wave equation, application to a particle in a box. Free electron theory of metals, Kronig - Penney model (qualitative treatment), Origin of energy band formation in solids, Classification of materials into conductors, semi conductors and insulators .

SUPERCONDUCTIVITY

Super conductivity, Meisner Effect, Types of Superconductors and Applications of Superconductors.

NANOPHASE MATERIALS – Introduction and properties, Synthesis - Chemical vapour deposition method – sol-gel methods, Applications of nano materials.

(10 Hours)

Books Recommended
1) Engineering Physics by R.K. Gaur and S.L. Gupta
2) Physics by David Halliday and Robert Resnick – Part I and Part II

Reference Books:
1) Engineering Physics by M.N. Avadhanulu & P.G. Kshirasagar; S. Chand & Company Ltd.
2) Modern Engineering Physics by A.S. Vadudeva
3) University Physics by Young and Freedman
4) Nonconventional Energy by Ashok V. Desai

ENG-1204   **ENGINEERING GRAPHICS**

Objectives:
- To develop an ability for visualise an object with physical and dimensional configurations
- Build to improve the analytical capabilities of student for solving a great variety of engineering problems.
- Solve the numerous real-time problems in various applications of all engineering branches

Outcomes:
The main purpose of this course is to make the students be aware of :
- Knowledge the various rules and regulations for the construction of different geometric drawings for effective communication among engineers
- From the fundamental knowledge of graphics can able to understand the advanced computer aided designs in industrial applications
- This course widely used in Mechanical, Production, Automobile, Aeronautical, Chemical, Civil, Marine and Electrical engineering to describe an engineering components which has the correct shape and size
- Applications of this course are development of product designs, plan and elevation of the buildings, electrical wiring drawings, printed circuit boards, installation drawings, process drawings and pictorial drawings etc.

Syllabus:

Introduction: Lines, Lettering and Dimensioning. Geometrical Constructions. Introduction to Scales.

Curves: Conic sections: General construction of ellipse, parabola and hyperbola. Construction of involutes. Normal and tangent.

Projections of Points: Principal or Reference Planes, Projections of a point situated in any one of the four quadrants

Projections of Straight Lines: Projections of straight lines parallel to both reference planes, perpendicular to one reference plane and parallel to other reference plane, inclined to one reference plane and parallel to the other reference plane. Projections of straight line inclined to both the reference planes:

Projections of Planes: Projection of Perpendicular planes: Perpendicular to both reference planes, perpendicular to one reference plane and parallel to other reference plane and perpendicular to one reference plane and inclined to other reference plane. Projection of Oblique planes. Introduction to Auxiliary Planes.

Projections of Solids: Types of solids: Polyhedra and Solids of revolution. Projection of solids in simple positions: Axis perpendicular to horizontal plane, Axis perpendicular to vertical plane and Axis parallel to both the reference planes, Projection of Solids with axis inclined to one reference plane and parallel to other and axes inclined to both the reference planes.

Projections of Section of Solids: Section Planes: Parallel and inclined section planes, Sections and True shape of section, Sections of Solids: Prism, Pyramid, Cylinder and Cone .
Development of Surfaces: Methods of Development: Parallel line development and radial line development. Development of a cube, prism, cylinder, pyramid and cone.

Isometric Views: Introduction to Isometric projection, Isometric scale and Isometric view. Isometric views of simple planes. Isometric view of Prisms, Pyramids, cylinder and cone. Isometric view of an object when projections are given.

Text Book:

Elementary Engineering Drawing by N.D.Bhatt, Charotar Publishing House.

Reference:

Engineering Graphics by K.L. Narayana and P. Kannaiah, Tata Mc-Graw Hill.

ENG-1206   ETHICS AND MORAL VALUES

Objectives:
- ❖ To inculcate Ethics and Human Values into the young minds.
- ❖ To develop moral responsibility and mould them as best professionals.
- ❖ To create ethical vision and achieve harmony in life.

Outcome: By the end of the course student should be able to understand the importance of ethics and values in life and society.

Syllabus:
UNIT – I
Ethics and Human Values: Ethics and Values, Ethical Vision, Ethical Decisions, **Human Values** – Classification of Values, Universality of Values.   **(6 Periods)**

UNIT - II

Engineering Ethics: Nature of Engineering Ethics, Profession and Professionalism, Professional Ethics, Code of Ethics, Sample Codes – IEEE, ASCE, ASME and CSI.   **(6 Periods)**

UNIT – III

Engineering as Social Experimentation: Engineering as social experimentation, Engineering Professionals – life skills, Engineers as Managers, Consultants and Leaders, Role of engineers in promoting ethical climate, balanced outlook on law.   **(6 Periods)**

UNIT - IV

Safety Social Responsibility and Rights: Safety and Risk, moral responsibility of engineers for safety, case studies – Bhopal gas tragedy, Chernobyl disaster, Fukushima Nuclear disaster, Professional rights, Gender discrimination, Sexual harassment at work place.   **(6 Periods)**

UNIT – V

Global Issues: Globalization and MNCs, Environmental Ethics, Computer Ethics, Cyber Crimes, Ethical living, concept of Harmony in life.   **(6 Periods)**

Text Books:
1. Govindharajan, M., Natarajan, S. and Senthil Kumar, V.S., Engineering Ethics, Prentice Hall of India, (PHI) Delhi, 2004.
2. Subramainam, R., Professional Ethics, Oxford University Press, New Delhi, 2013.

References:
1. Charles D, Fleddermann, "Engineering Ethics", Pearson / PHI, New Jersey 2004 (Indian Reprint).

DS-1208   **INORGANIC CHEMISTRY**

Objectives: The student will be able to:

1. appreciate the nature and scope of inorganic chemistry.
2. apply key concepts from atomic structure and periodic table
3. apply valence shell, electron pair repulsion method, molecular orbital theory for homonuclear diatomic molecules
4. apply chemical bonding and molecular structure
5. understand titrimetric analysis, classification of reactions in titrimetric analysis, standard solutions and classification of errors

Outcome:

The course introduces studentsto the atomic structure and periodic table, chemical bonding and molecular structure, chemistry of transition elements and coordination compounds and fundamentals of analytical chemistry

Syllabus:

Chapter 1: Atomic structure and periodic table: Early models of atom - Rutherford's model, Bohr's model, Bohr-Sommerfeld model, quantum numbers and their significance, dual nature of matter, failure of classical mechanics, Louis de Broglie wavelength, the uncertainty principle-Schrodinger wave equation (derivation not required), the meaning of wave function, quantum mechanical model of the hydrogen atom-some general conclusions, radial dependence, radial probability distribution curves and angular dependence curves, electronic configuration of elements, the modern periodic table (a brief discussion on the arrangement of elements), classification of elements, periodic properties - ionization energy, electron affinity, electronic structure and color, electronic structure and magnetism,

Chapter 2: Chemical bonding and molecular structure: The covalent bond, the simplest molecule H^+ ion its exact description, dative bond and its influence on covalence, the concept of resonance and hybridization, multiple bonding characters of second period and higher period elements and the difference between the two, Pauling's electro-neutrality principle, valence shell, electron pair repulsion method, molecular orbital theory for homonuclear diatomic molecules only, electro-negativity (Milliken approach), Fajan's rules for the prediction of non-polar character,

Chapter 3: Chemistry of Transition Elements and Co-ordination Compounds: First transition series and their general physical and chemical properties- oxides, halides, sulphides, chemistry in aqueous solution of first transition metals, co-ordination compounds, nomenclature, Werner's theory, isomerism in coordination compounds, valence bond theory, crystal field theory, colors of transition metal complexes, stability of complexes,

Chapter 4: Analytical Chemistry: Titrimetric analysis, classification of reactions in titrimetric analysis, standard solutions, equivalents, normalities and oxidation numbers, preparation of standard solutions, primary and secondary standards, classification of errors-accuracy, precision-minimization of errors, significant figures and computation-mean and standard deviation, reliability results, confidence interval.

Text books:

1. 'University General Chemistry' by C.N.R. Rao, MacMillan India Ltd., Hyderabad
2. C'oncepts and Models of Inorganic Chemistry' by B.E Douglas, D.H McDaniel and J. Alexander. 3rd edition; John Wiley & Sons Inc., New York
    3. 'Concise Inorganic Chemistry' by J.D.Lee, Fourth Edition, Chapman & Hall

2/4 B.Tech(Chemical Engineering) - First Semester
&
2/6 B.Tech + M.Tech (Chemical Engineering) First Semester

CHE-2.1.1   **MATHEMATICS-IV**

OBJECTIVES:

In general , the students are introduced with a knowledge on - Vector Calculus, Partial differential equations, their applications and Integral Transforms(Fourier transforms, FST, FCT) to facilitate them to use these concepts in their core subjects.

- The basic knowledge and applications of Vector Calculus used in Engineering problems.
- about the gradient, divergence and curl under the differentiation of scalar and vector point functions, also on Line-, Surface- and Volume integrals under the integration of point functions; their applications in Engineering problems.
- the transformation theorems such as **Green's** theorem in the plane, **Stoke's** theorem, **Gauss Divergence** theorem and their applications
- how to formulate the Partial Differential Equations from the relations between the dependent and independent variables, and understand the methods of solving first order first degree linear, non-linear **Partial Differential Equations**, Homogeneous and Non homogeneous linear partial differential equations with constant coefficients .
- the procedure to find out the solutions of Partial Differential Equations by using the method of separation of variables (product method)
- about the formulation of one dimensional wave (string equation), one-and two-dimensional **Heat flow equations**, **Laplace's equation** in Cartesian and polar coordinates; also to solve these equations by the method of separation of variables.
- on the concept of integral transforms, namely, **Fourier transforms**, **Fourier Sine, Cosine and related inverse transforms;** their applications in solving several Physical and Engineering problems.

OUTCOMES: After going through this course , the students would be able to:

- operate the differential operator 'del' to the scalar and vector point functions, Calculate the Gradient, Divergence and Curl, Vector normal to a surface, maximum rate of change of a scalar field, test whether two surfaces are to cut orthogonally or not .
- find the rate per unit volume at which the physical quantity is issuing from a point, the rate of inflow minus out flow using the Divergence and the angular velocity of rotation at any point of the vector field using the Curl.
- **test** whether the given motion is irrotational or rotational, whether a vector force acting on a particle is conservative or not
- find out the potential function from a given vector field.
- obtain the well known Laplace and poisson equations from an irrotational field

- understand to determine the work done by a force field and circulation using a Line integral
- find out the Line, Surface and Volume integrals - find the flux using surface integral and volumes using the volume integral
- apply the vector integral theorems (Green's theorem in the plane, Stoke's and Divergence theorems) for evaluating the double and triple integrals as these are used to find areas and volumes.
- know the methods of solving Linear and Non linear first order and first degree partial differential equations.
- solve the Linear Partial Differential Equations with constant coefficients (homogeneous and non homogeneous) and know the procedure for finding the complementary function and particular integrals
- apply the method of separation of variables to obtain solutions of most of the boundary value problems involving Linear partial differential equations occurred in engineering studies
- solve , in particular the wave equations, heat equations and Laplace's equations in Cartesian and polar coordinates using the method of separation of variables.
- apply and extend the knowledge of Fourier transform techniques in solving several Initial and Boundary value problems of Engineering, such as in Conduction of heat / Thermodynamics, Hydraulics transverse vibrations of a string, oscillations of an elastic beam, bending of beams, electrical circuits, free and forced vibrations of a membrane and transmission lines , etc.

SYLLABUS:
Unit-I : VECTOR CALCULUS-1
Differentiation of vectors, curves in space, velocity and acceleration, relative velocity and relative acceleration, scalar and vector point functions, vector operator ∇ applied to scalar point functions- gradient, ∇ applied to vector point functions- divergence and curl. Physical interpretation of ∇f, $\nabla . \overline{F}$, $\nabla \times \overline{F}$, ∇ applied twice to point functions, ∇ applied to products of two functions; Irrotational and Solenoidal fields.

Unit-II : VECTOR CALCULUS-2
Integration of vectors, line integral, circulation, work done, surface integral-flux, Green's theorem in the plane, Stoke's theorem, volume integral, Gauss Divergence theorem.
Introduction of orthogonal curvilinear coordinates, cylindrical and spherical polar coordinates

Unit-III : INTRODUCTION OF PARTIAL DIFFERENTIAL EQUATIONS

Formation of partial differential equations, solutions of partial differential equations- equations solvable by direct integration, linear equations of first order: Lagrange's Linear equation, non-linear equations of first order, Charpit's method.

Homogeneous linear equations with constant coefficients- rules for finding the complementary function, rules for finding the particular integral (working procedure), non- homogeneous linear equations.

Unit-IV : APPLICATIONS OF PARTIAL DIFFERENTIAL EQUATIONS

Method of separation of variables, One dimensional wave equation-vibrations of a stretched string, one dimensional Heat equation, Two dimensional heat flow in steady state - solution of Laplace's equation in Cartesian and polar coordinates (two dimensional).

Unit-V : INTEGRAL TRANSFORMS

Introduction, definition, Fourier integral, Sine and Cosine integrals, Complex form of Fourier integral, Fourier transform, Fourier Sine and Cosine transforms, Finite Fourier Sine and Cosine transforms, properties of Fourier transforms, Convolution theorem for Fourier transforms, Parseval's identity for Fourier transforms, Fourier transforms of the derivatives of a function, simple applications to Boundary value problems.

TEXT BOOKS:

      Scope and treatment as in "Higher Engineering Mathematics", by Dr. B.S.Grewal, **43rd Edition**, Khanna Publishers.

REFERENCE BOOKS:
1. A text book of Engineering Mathematics by N.P. Bali and Dr. Manish Goyal, Lakshmi Publications.
2. Mathematical Methods of Science & Engineering aided with MATLAB by Kanti B.Dutta, Cengage Learning India Pvt. Ltd.
3. Advanced Engineering Mathematics by Erwin Kreyszig.
4. Higher Engineering Mathematics by B. V. Ramana, Tata McGraw Hill Company.
5. Advanced Engineering Mathematics by H.K.Dass. S.Chand Company.
6. Higher Engineering Mathematics by Dr. M.K.Venkataraman.

CHE-2.1.2   **PHYSICAL CHEMISTRY**

Objectives: The student will be able to:

1. appreciate the nature and scope of Physical chemistry.
2. apply key concepts from Liquid state and properties of liquids
3. apply thermodynamics, thermochemistry and chemical equilibrium, electrochemistry, Phase rule for various systems in chemical engineering
4. apply chemical kinetics and catalysis for effective reaction processes

Outcome:

The course introduces studentsto the liquid state and various properties of liquids, thermodynamics and thermo chemistry. It brings in an understanding of chemical equilibrium, electrochemistry, phase rule and catalysis to the students of chemical engineering

Syllabus:

Chapter 1: Liquid State: Liquefaction of gases, critical constants, Classius-Clayperon equation, vapor pressure of liquids, salt hydrates, variation of vapor-pressure with temperature, elementary treatment of vapor pressure, composition diagrams of binary liquid mixtures, azeotropic and zeotropic mixtures, fractional distillation and steam distillation.

Physical properties of liquids: Surface tension, explanation, measurement, effect of temperature on surface tension, applications, viscosity - definition, measurement, applications, intermolecular forces in liquids, hydrogen bond,

Chapter 2: Thermodynamics and thermochemistry: First law, internal energy, work and heat changes, enthalpy, reversible changes, maximum work, heat capacities at constant pressure and volume, adiabatic changes, heat of reaction, heat of formation, heat of combustion, thermo-chemical laws, effect of temperature on heat of reaction, second law of thermodynamics, spontaneous processes, entropy and entropy change for an ideal gas, entropy change accompanying phase change, physical significance of entropy, Gibb's free energy and applications,

Chapter 3: Chemical equilibrium: Reversible reactions, law of mass action, homogeneous equilibria in gaseous and liquid systems, simple example of heterogeneous equilibria, effect of temperature on equilibrium, Van'tHoff equation,

Chapter 4: Electrochemistry: Laws of electrolysis and their applications, difference between galvanic and electrolytic cells, electrode reactions, polarized electrode, decomposition potential, over voltage and its applications, EMF galvanic cells, free energy changes in cells, reversible electrode potentials, single electrode potential and its determination, Nernst equation and its derivation, reference (hydrogen and calomel) electrode, EMF series and its applications, primary and secondary galvanic cells (acid and alkaline)- lead acid battery, fuel cells and applications,

Chapter 5: Phase rule: Definition and explanation of terms involved in phase rule, derivation of the phase rule, one component systems (Ag-Pb and KI-H_2O), eutectic point and its significance

Chapter 6: Chemical kinetics and catalysis: Order and molecularity of a reaction, specific reaction rate and its determination, first order and second order reactions, half life period, pseudo first order and second reactions, effect of temperature on reaction rate, energy of activation, elementary treatment of collision theory and activated complex theory,

Catalysis: Types, characteristics of a catalyst, enzyme catalysts, industrial applications of catalysts.

Text books:

1. 'Elements of Physical Chemistry' by Samuel Glasstone and David Lewis
   Macmillan & Company Ltd., London

2. 'Physical Chemistry' 3rd edition, by P.W.Atkins, Oxford University Press
3. 'Text Book of Physical Chemistry' by Bahl and Tuli

CHE-2.1.3   **ORGANIC CHEMISTRY**

Objectives:

The student will be able to:

1. appreciate the nature and scope of organic chemistry.
2. apply key concepts from general chemistry including electronegativity, bonding (ionic and covalent), hybridization of atomic orbitals, and molecular orbital theory to organic systems.
3. draw skeletal structures for organic compounds.
4. apply acid-base concepts to organic systems; predict ordering of acid or base strength.
5. name alkanes, alkenes, polyenes, alkynes, alkyl halides, aromatic compounds, carbonyl compounds, amines and their various derivatives using systematic (IUPAC) nomenclature.
6. draw reaction mechanisms for some key reactions.
7. recognize stereochemistry and be able to apply the Cahn-Ingold-Prelog system to designation of stereochemistry (E/Z or R/S).
8. learn many of the reactions of alkanes, alkenes, polyenes, alkynes, aromatic, carbonyl, and amine compounds, and close related species. Be able to predict reactions involving these functional groups.
9. be able to solve problems employing spectroscopic methods including mass spectrometry, infrared and NMR spectroscopy
10. understand the basic chemical and structural features of biomolecules, including lipids, carbohydrates, amino acids and proteins, and nucleic acids

Outcome:

This course enables the students to acquire knowledge, comprehension and application in numerical problems related to organic chemistry, nomenclature and reactions of alkanes, alkenes, alkynes, dienes, electrophilic aromatic substitution, alcohols, acids, aldehydes and ketones, amines, soaps and detergents.

Syllabus:

Chapter 1:Numerical problems: Determination of percentage composition of carbon, hydrogen and nitrogen, molecular weight determination by depression in freezing point and elevation of boiling point methods, molecular weight of acids by silver salt method; molecular weight of bases by chloroplatinate method, determination of molecular formula of a compound, problems relating to reactions of carboxylic acids, functional derivatives of acids, carbonyl compounds, alcohols, amines, phenols, diazonium salts applications, alkenes and their laboratory tests,

Chapter 2:Nomenclature of alkanes, alkenes, alkynes, dienes, cyclic aliphatic hydrocarbons, structure of benzene, nomenclature of benzene derivatives, arenas, industrial preparation of ethylene, acetylene; sp, sp^2 and sp^3 hybridization; preparation and chemical reactions; conformational analysis of ethane, propane and butane, Wurtz reaction, Diels-Alder reaction, aromaticityMorkovinkov rule, Clemmensen and Wulf-Kishner reduction,

Chapter 3:Electro-philic and nucleo-philic aromatic substitution: Orientation in desubstituted benzenes, mechanism of nitration, halogenation, sulphonation, Friedel-Craft's alkylation and acylation reactions, nomenclature of alkyl halides, preparation and chemical reactions, mechanisms of SN_1, SN_2, E_1, E_2 reactions, nomenclature of aryl halides, preparation and chemical reactions: low reactivity of vinyl and aryl halides, Sandmeyer reaction,

Chapter 4: Nomenclature of alcohols; industrial preparation of ethyl alcohol, preparation and chemical reactions, Lucas test, nomenclature of mono, dicarboxylic acids, industrial preparation of formic, acetic, benzoic, phthalic, salicylic acids, preparation and chemical reactions, mechanism of HVZ reaction and Claisen condensation, nomenclature of functional derivatives of acids, preparation and chemical reactions, mechanism of Hoffmann bromamide reaction, acid and base catalyzed hydrolysis of ester, nomenclature of ethers and epoxides, industrial preparation of ether and ethylene oxide, preparation and chemical reactions; Williamson's synthesis,

Chapter 5:Nomenclature of aldehydes and ketenes: Industrial preparation of formaldehyde, acetaldehyde, benzaldehyde, salicyaldehyde, acetone; preparation and chemical reactions; mechanisms of Cannizaro, Aldol, Reformatsky and Wittig reactions, reactions without mechanisms -Perkin, Cope, Knoevenagel and Pinacol-Pinacolone reactions, difference between aldehyde and ketone, nomenclature of phenols, industrial preparation of phenol, preparation and chemical reactions, mechanisms of Fries rearrangement, Kobe reaction, Reimer-Tiemann reaction, classification of carbohydrates, structure of glucose and fructose, reactions of glucose and fructose, Ruff degradation, Wohls degradation, filiani-Fisher synthesis, glucose into fructose, fructose into glucose, glucose to vitamin-C, mechanism of Osazone formation,

Chapter 6:Nomenclature of amines, industrial preparation of aAniline, preparation and chemical reactions - exhaustive methylation, mechanism of Hoffmann elimination, benzedene rearrangement without mechanism, Hinsberg test, differentiation test using nitrous acid, preparation of diazonium salts and synthetic applications, preparation of sulphanilamide, sulphaguanidine, sulphamerazine, sulphapyridene (sulpha drugs), mode of action of sulpha drugs,

Chapter 7:Preparation of soaps and detergents: Mode of action of soaps, differences between soaps and detergents; preparation of malonic, acetoacetic ester and their synthetic applications, preparation of Grignard reagents and their synthetic applications, preparation of polyethylene, polystyrene, teflon, PVC, polyvinyl cyanide, rubber-vulcanisation, styrene-butadiene rubber, polychloroprene, bakelite, nylon-6 and nylon 6-6, plexiglas, terylene, Ziegler-Natta polymerization, definition of thermoplastics and thermosetting plastics,

Chapter 8:Isomerism: Structural and optical isomerism, geometrical isomerism, E Z configuration, sequence rules, R & S configuration, racemic mixture and their separation, asymmetric synthesis - Fischer projection formula, definitions of axial and equatorial bonds, 1-3-diaxial interaction, enatiomers, diastereomers, mesomers, isomerism in cyclic compounds, chair, boat and twisted boat structures (1-methylcyclohexane, 1, 2-cyclohexane diol), sSynthetic applications of - Zn/Hg, Na-NH$_3$LiAH$_4$, NaBH$_4$, diborane and zinc dust, soda lime, OsO$_4$, hydroxylamine, acetic anhydride, benzoylchloride and PCl$_5$.

Reference books:

1. 'Text Book of Organic Chemistry' by Morrison & Boyd
2. 'Text Book of Organic Chemistry' by Bahl&Tuli
3. 'Text Book of Organic Chemistry' by M.K.Jain
4. 'Text Book of Organic Chemistry' by I.L.Finar (Vols.1&2 as **reference books**)

CHE-2.1.4   **MECHANICAL ENGINEERING**

Objectives:
- To understand the basics in Thermodynamics
- To get knowledge on applications of steam tables.
- To understand the principles and applications of turbines and compressors.

Syllabus:

Thermodynamics: Definitions, systems, classification of thermodynamic systems, cycle, and zeroth law of thermodynamics, first law of thermodynamics, closed system, flow processes, open systems with steady flow process, applications of steady flow energy equation to engineering systems,

Second law of thermodynamics: Carnot cycle, inequality of Classius-reversible Carnot cycle, entropy, relation between heat and entropy, general expression for entropy change, entropy change of a perfect gas during various thermodynamic processes, air standard cycles, Otto, diesel, dual combustion cycles,

Properties of steam and use of steam tables: Boilers, classification steam boilers, simple vertical, Cocheran locomotive boiler, Babcock and Wilcox boiler, steam generation, Rankine cycle,

Impulse and reaction turbine: Classification of steam turbines, velocity diagram and power produced in impulse turbine, performance of steam turbines, reduction of rotor speed,

I C engines: Classification-main composition of IC engines, carburetter, fuel pump injector, cooling systems for IC engines, working of 2-stroke and v4-stroke petrol and diesel engines, power and efficiency of IC engines,

Reciprocating air-compressors: Single stage, work done during cycle, effect of clearance, two stage compressors, condition for minimum work, effect of inter-cooling, efficiency,

Drives: Belts, expression for the ratios of tension on the slack and tight side, power transmitted – V-belts, chain drives, gears – spur, helical, bevel gear, trains simple and compound.

Text books:

1. 'A Text Book of Thermal Engineering' by R.S.Khurmi and J.K.Gupta
2. 'Theory of Machines' by R.S.Khurmi

Reference books:

1. 'Engineering Thermodynamics' by P.K.Nag
2. 'Engineering Thermodynamics' by J.B.Jones and R.E.Dugar
3. 'Engineering Thermodynamics' by R.K.Rajput
4. 'Theory of Machines' by Balani

CHE-2.1.5   **BASIC ELECTRICAL ENGINEERING**

Objectives:

- An understanding of basic EE abstractions depends on analysis and design of electric and magnetic circuits and its elements.
- To provide the students with knowledge of fundamental laws in electrical engineering
- To develop the ability of the students to analyze electrical and magnetic circuits using the basic laws of electrical engineering
- To expose the students to the concepts of various types of electrical machines and application of electrical machines.
- To inculcate the understanding about the AC fundamentals
- To prepare the students to have a basic knowledge of transformers
- To acknowledge about three phase induction motor and its operating principle
- To know about the fundamentals of synchronous motors and its working principle

Outcomes:

After the completion of the course, the student should be able

- To predict the behavior of any electrical and magnetic circuits.
- student will be able to state and explain the basic laws of electromagnetic induction.
- To impart knowledge on Constructional details, principle of operation, types of Electrical Machines   performance Characteristics ,speed control methods and its applications
- Ability to conduct experiments on Ac Machines to find its characteristics.
- Abel to calculate performance characteristics of transformer like regulation and efficiency
- The ability to formulate and then analyze the working of synchronous motors
- Able to solve simple problems on synchronous motors

Syllabus:
Magnetic circuits: Definitions of magnetic circuit, reluctance, magneto motive force (mmf), magnetic flux, simple problems on magnetic circuits, hysterisis loss (chapter 8, page nos. 155-175),

Electromagnetic induction: Faraday's laws of electromagnetic induction, induced E.M.F., dynamically induced E.M.F, statistically induced EMF, self inductance, mutual inductance (Chapter 9, page nos. 176-190),

D.C. generators: D.C generator principle, construction of D.C generator, E.M.F equation of D.C generator, types of D.C generators, armature reaction, losses in D.C generator, efficiency, characteristics of D.C generators, applications of D.C generators (chapter 10, 11, pages 208-238),

D.C. motors: D.C motor principle, working of D.C motors, significance of back, E.M.F, torque equation of D.C motors, types of D.C motors, characteristics of D.C motors, speed control methods of D.C motors, applications of D.C motor, testing of D.C machines, losses and efficiency, direct load test and Swinburne's test (Chapter 12, 13, page Nos. 239-269),

A.C. circuits: Introduction to steady state analysis of A.C circuits, single and balanced 3 phase circuits (chapter 16, page nos. 323-348),

Transformers: Transformer principle, EMF-equation of transformer, transformer on load, equivalent circuit of transformer, voltage regulation of transformer, losses in a transformer, calculation of efficiency and regulation by open circuit and short circuit tests (Chapter 20, page Nos. 423-455),

Three phase inductance motor: Induction motor working principle, construction of 3-phase induction motor, principle of operation, types of 3-phase induction motor, torque equation of induction motor, slip-torque characteristics, starting torque, torque under running condition, maximum torque equation, power stages of induction motor, efficiency calculation of induction motor by direct loading (Chapter 21, page nos. 463-489),

Altemator: Altenator working principle, EMF equation of altenator, voltage regulation by Synchronised impedance method (Chapter 23, page nos. 505-515),

Synchonous motor: Synchronous motor principle of operation, construction, methods of starting of synchronous motor, (Chapter- 24, page nos. 516-526),

Text book:
    1. 'Elements of Electrical Engineering & Electronics' by V.K. Mehta, S.Chand & Co.
Reference book:
        1. 'A first course in Electrical Engineering' by Kothari.

CHE-2.1.6   **STRENGTH OF MATERIALS**

Objectives:

1. To impart knowledge about the behaviour of elastic bodies subjected to different types of external forces.
2. To impart skills of analysing the statically determinate beams subjected to different types of loads for shear force, bending moment and their corresponding stress distribution.
3. To develop skills to analyse shafts, springs and shells for determining the critical stress distribution..

Outcomes:

1. The students are expected to analyse different bodies subjected to different types of loads like axial forces, transverse loads and torsional moment.
2. The students are expected to analyse the statically determinate beams subjected to loads.
3. The students are expected to analyse shafts, springs and shells.

Syllabus:

Axial loads: Simple stress and strain, Hook's law, load extension diagram for mild steel, stress in compound assemblies, thermal stresses,

Transverse loads: Shear force and bending moment diagrams for a) cantilevers, b) simply supported beams and c) over-hanging beams due to concentrated loads and U D L s only,

Theory of simple bending: Relation between i) f and y, ii) M and I, iii) E and R, distribution of shear stress in common shapes of cross-section,

Principal stresses and principal planes, maximum shear stress and its plane, Mohar's circle of stress,

Torsion of solid and hollow circular shafts, transmission of horse power, design of flange coupling, closed coil helical spring i) under axial load and ii) under axial twist, riveted joints, design of lap joints,

Stress in thin cylindrical shells and spherical shells, stress in thick cylinders, compound cylinders, pressure due to shrink-fitting,

Text book:

1. 'Strength of Materials' by Ramamrutaham

Reference book:
1. 'Elements of Strength of Materials' by S.P.Timoshenko and D.H.Young, East West Press, New Delhi

CHE-2.2.1   **FLUID MECHANICS**

The main objectives are to provide:

1. Knowledge on pressure distribution in static fluids.
2. Knowledge on rheological behavior of fluids, types of fluid flow, boundary layers and basic equations of fluid flow.
3. Knowledge of incompressible & compressible fluid flow in pipes
4. Knowledge on fluid flowing past solid surfaces
5. Knowledge on pipes, fittings, transportation and metering devices.

Outcome:

1. Able to estimate the pressure drop.
2. Enhance the flow by reduction by reducing boundary layer separation.
3. Estimating the pumping capacity and friction losses of flowing fluids.
4. Designing fluidized and packed beds.
5. Able to select pumps based on their performance.
6. Able to select proper measuring device and estimate the quantity of flow.

Syllabus:

Dimensional Analysis: Units and Dimensions, Dimensional Homogeneity, Dimensional Analysis, Buckingham π theorem, Geometric similarity, kinematic similarity, and dynamic similarity.

Fluid statics and applications: Nature of fluids, Hydrostatic Equilibrium, Applications of fluid statics – Manometers, continuous gravity decanter and centrifugal decanter.

Fluid Flow phenomena: Laminar flow, shear rate, shear stress. Rheological properties of fluids – Newtonian fluids, Non Newtonian fluids, time dependent flow, viscoelastic fluids. Viscosity, Reynolds number, Turbulence - nature of turbulence, deviating velocities, intensity and scale of turbulence, Reynolds stresses and eddy viscosity. Boundary layers - boundary layer formation over flat plate, flow in boundary layers, laminar and turbulent flow in boundary layers, boundary layer formation in straight tubes, boundary layer separation and wake formation.

Basic Equations of Fluid Flow: Continuity equation (Mass Balance in a flowing fluid), equation of motion (Differential Momentum Balance), Navier - stokes equations, Euler's equation, Couette flow, Macroscopic Momentum Balance, layer flow with free surface, Bernoulli equation (Energy equation), corrections for effect of solid boundaries and pump work.

Incompressible flow in pipes and channels : Shear Stress and skin friction in pipes, Relation with skin friction and wall shear, Friction factor, relations between skin friction parameters, equivalent diameter, laminar flow in pipes and channels, velocity distribution, average velocity, Kinetic energy correction factor and momentum correction factor for laminar flow, Hagen-Poiseuille equation, laminar flow of non-Newtonian liquids, laminar flow in annulus. Turbulent flow in pipes and channels, Velocity distribution for turbulent flow, universal velocity

distribution equations, its limitations, flow quantities for turbulent flow in smooth round pipes, Reynolds number- friction factor law for smooth tubes, effect of roughness, friction factor chart, drag reduction, friction from changes in velocity or direction – sudden expansion, sudden contraction, pipe fittings, friction losses in Bernoulli equation, velocity heads, separation of boundary layer in diverging channel, minimizing losses.

Flow in compressible fluids: Definitions and basic equations, processes of compressible flow, isentropic flow through nozzles, Adiabatic friction flow, Isothermal friction flow

Flow past immersed objects: Drag and drag coefficients, flow through bed of solids, Motion of particles through fluids - mechanics of particle motion, equation for one-dimensional motion of particles through fluid, terminal velocity, criterion for settling, free and hindered settling. Fluidization – conditions, minimum fluidization velocity, types of fluidizations and its applications.

Transportation and Metering of Fluids: Pipes, fittings, valves. Positive displacement Pumps – reciprocating, rotary and peristaltic pumps. Centrifugal pumps - theory, construction, performance, single and multistage pumps. Fans, Blowers and Compressors. Vacuum pumps – jet ejectors.

Metering of fluids: Full bore meters – Venturi meter, Orifice meter, Rotameters, Vortex-Shedding meters, Magnetic meters and Coriolis meters. Insertion meters – Pitot Tube, Thermal meters, notches and weirs.

Text Books:

1. "Unit Operations of Chemical Engineering" Seventh Edition, by W.L. McCabe, J C Smith and P Harriot, Mc Graw Hill

Reference Books:

1. "Chemical Engineering" Volume I by Coulson J.M. and Richardson J.F, Elsevier
2. "Fluid Mechanics" 2nd edition by Noel de Nevers, Mc Graw Hill

CHE-2.2.2   **MECHANICAL OPERATIONS**

Objectives:

Mechanical Operations is one of the core subjects for chemical engineers, where student can learn some of the unit operations necessary for process industry. Main objects of the inclusion of this subject are:

1. To make the students exposed to different geometrical sizes of raw materials used in the industries, area of calculation of the particles w.r.t their sizes
2. To get familiarity with the different laws of grinding
3. To do the power consumption calculations
4. To learn different separation process on their physical properties
5. To differentiate between the process such as mixing and agitation
6. To know the movement of particles in different liquids (viscous)

Outcome:

By the end of the course, student will be able to know the following things:

1. Separation of materials (useful and gangue) from their physical properties.
2. Selection of Machinery for size reduction of the raw materials
3. Power consumption calculation for crushing and grinding
4. Application of different techniques for separation
5. Minimization of impurities in the raw materials
6. General outlook for transportation of materials in the industry by choosing different conveyers.

Syllabus:

Characteristics of solid particles – shape, size, differential and cumulative screen analysis, specific surface area, particle population, different mean diameters for a mixture of particles,

Principles of comminution - Laws of crushing, description and working of size reduction equipment - jaw, gyratory and roll crushers, hammer mills, revolving mills, attrition mills, fluid energy mill, cutting machines, open and closed circuit grinding, wet and dry grinding, grindability index,

Size separation, screening, industrial screens - grizzly, gyratory and vibratory screens, revolving screens, trammels, capacity and effectiveness of screens, magnetic separation, electrostatic separation, froth flotation,

Filtration - description and working of filtration equipment, plate and frame filter press, shell and leaf filters, rotary drum filter, filter aid, centrifugal filtration, top suspended batch centrifuge, theory of filtration, washing of cakes,

Motion of particles through fluids- drag, free and hindered settling, settling velocities, classification, sink and float methods, differential setting methods - jigging and tabling, cyclone separators,

Batch sedimentation, thickeners, flocculation, centrifugal sedimentation, gravity and centrifugal decanters,

Agitation of liquids, power consumption in agitated vessels, scale up of agitation equipment, mixing equipment for mixing of solids and pastes, mixers for dry powders, mixing index,

Conveying, tpes of conveyors – mechanical, belt, chain and screw conveyors, elevators, pneumatic conveyors, size enlargement - need and applications.

Text books:

1. 'Unit Operations of Chemical Engineering' by W.L. McCabe, J.C. Smith and P.Harriot, McGraw- Hill Book Company

Reference books:
1. 'Chemical Engineering -Vol.2' by J.H.Coulson and J.F.Richardson, Pergaman press and ELBS
2. 'Chemical Engineer's Hand Book' by R.H.Perry {ed}, McGraw-Hill Book Co.
3. 'Unit Operations' by Brown et al., Asian Publishing House
4. 'Introduction to Chemical Engineering' by Badger and Banchero, McGraw-Hill Book Company

CHE- 2.2.3   **CHEMICAL PROCESS CALCULATIONS**

Objective: To give intensive quantitative training in the practical applications of the principles of physical chemistry to the solution of complicated industrial problems and in methods of predicting missing physicochemical data from generalized principles.

Outcome: 1. Able to solve the problems based on stoichiometry, ideal gas and vapor pressure.
             2. Able to write and solve material and energy balances for a process.
Syllabus:

Stoichiometry and composition relationships- the gram-mole and pound-mole, limiting reactant, excess reactant, degree of completion, basis of calculation, weight percent, volume percent and mole percent, density and specific gravity- Baume and API gravity scales,
Behavior of ideal gases- application of the ideal-gas law, Dalton and Amagat laws to gaseous mixtures, composition of gases on dry basis and on wet basis,
Vapor pressures- Effect of temperature on vapor pressure, Antoine equation, reference substance vapor pressure plots, vapor pressure of immiscible liquids, ideal solutions and Raoult's law, non-volatile solutes,
Humidity - Percentage saturation, relative saturation or relative humidity, dew point, vaporization, condensation, wet and dry bulb temperatures, adiabatic vaporization and adiabatic saturation temperature,
Material balances- Tie substance, yield, conversion, processes involving chemical reactions, material balance- calculations involving drying, dissolution, and crystallization, processes involving recycle, bypass and purge,
Heat capacities of gases and gaseous mixtures- effect of temperature on heat capacity of gas, mean heat capacity of gas, Kopp's rule, latent heats, heat of fusion, heat of vaporization, Trouton's rule, Kistyakowsky equation for non-polar liquids, estimation of latent heat of vaporization using Classius-Clayperon equation, enthalpy of humid air and humid heat capacity,

Standard heat of reaction - Standard heat of formation, laws of thermochemistry, standard heat of combustion, calculation of heat of formation from heats of combustion, calculation standard heat of reaction from heats of formation and from heats of combustion, standard integral heat of solution, effect of temperature on heat of reaction, Kirchoff's equation, adiabatic and non-adiabatic reactions, theoretical and actual flame temperatures.
Text book:
  1. 'Chemical Process Principles, Part-I - Material and Energy balances' by Olaf A Hougen, K.M. Watson and R.A.Ragatz, CBS Publishers and Distributors (1995)
Reference books:
  1. 'Basic principles and Calculations in Chemical Engineering' by David M. Himmelblau, Prentice Hall of India Pvt Ltd, 1995
  2. 'Stoichiometry' by B.I. Bhatt and S.M. Vora, 3rd Edition, Tata McGraw Hill Publishing Company Limited, New Delhi (1996)
  3. 'Stoichiometry for Chemical Engineers' by Williams and Johnson, McGraw Hill Publishers.

CHE 2.2.4   **CHEMICAL ENGINEERING THERMODYNAMICS – I**

Objectives:

Chemical Engineering Thermodynamics is one of the core subjects of Chemical Engineering Curriculum. Knowledge of thermodynamics helps student compute heat and work requirements of a process. The student would also learn how to estimate data in case of absence of experimental data.

Outcome:

1. Identification of system so that application of thermodynamics to real problems would be done
2. Arriving at the limitations of the first law thus enabling a need for second law
3. Application of thermodynamic laws to pipe flow, nozzle flow, expansion, compression, refrigeration and liquefaction.
4. Development of generalized correlations
5. Evolving Gibbs energy as a generating function of all thermodynamic properties

Syllabus:

The first law and other basic concepts: Joule's experiments, internal energy, the first law of thermodynamics, thermodynamic state and state functions, enthalpy, the steady-state, steady-flow process, equilibrium, the phase rule, the reversible process, constant-V and constant-P processes, heat capacity.

Volumetric properties of pure fluids: PVT behavior of pure substances, virial equations, the ideal gas, application of the virial equations, cubic equations of state, generalized correlations for gases, generalized correlations for liquids, molecular theory of fluids, second virial coefficients from potential functions.

Heat effects: Sensible heat effects, internal energy of ideal gases, microscopic view, latent heats of pure substances, standard heat of reaction, standard of heat of formation, standard heat of combustion, temperature dependence of heat effects of industrial reactions.

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

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

Thermodynamics of flow processes: Equations of balance, duct flow of compressible fluids, turbines (expanders), compression processes.

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

Textbook:
1. `Introduction to Chemical Engineering Thermodynamics' by J.M.Smith, H.C.Van Ness and M.M.Abbott, 6th Edition, McGraw-Hill International Editions, 2000.

Reference Books:
1. `Chemical Engineering Thermodynamics' by B.F.Dodge, McGraw-Hill Book Co.,
2. `Schaum Outline of Theory and Problems of Thermodynamics' by Michael M. Abbott and Hendrick C.VanNess, McGraw-Hill International Book Co., Singapore, 1981.

CHE-2.2.5   **INORGANIC CHEMICAL TECHNOLOGY**
Objectives:

- To provide the student understanding of importance of chemical process industries over the other manufacturing industries.
- To provide the brief introduction of chemical process equipments, the application of thermodynamics, the chemical process principles, the equipment design and also the corrosion and the safety aspects to consider in the chemical manufacturing processes.
- To provide basic inorganic chemistry background required for the undergraduate students of engineering.
- To provide an overview of chemical properties of inorganic chemicals and the manufacturing processes.
- To provide an overview of applications of materials which the engineers are likely to use during their professional career.

Outcome:

- The student learnt the importance of chemical process industries over the other manufacturing industries.
- The student had a brief introduction of chemical process equipments, the application of thermodynamics, the chemical process principles, the equipment design and so on.
- Provided the basic inorganic chemistry background required for the undergraduate students of engineering.
- Provided an overview on chemical process industries.
- Learn the topics "The Fuel and Industrial Gases".
- Enabled the students to get knowledge on metallurgy.

Syllabus:

Water: Sources of water, hardness, treatment for different end uses, municipal water conditioning, industrial waste water treatment.

Sulphur and sulphuric acid: Sources of sulphur-sulphuric acid, different processes of manufacturing-contact process, DCDA process for sulphuric acid manufacture.

Nitrogen industries: Manufacture of ammonia, nitric acid, urea and ammonium nitrate.

Phosphorous and phosphoric acid industries: Methods for production of phosphorous and phosphoric acid, manufacture of super phosphate and triple super phosphate.

Chloro-alkali industries: - Manufacture of soda ash, caustic soda and chlorine.

Cement: Types of cement, manufacture of ordinary portland cement [opc], slag cement.

Fuel and industrial gases: Production of water gas, producer gas and coke oven gas, production of acetylene, oxygen and nitrogen.

Metallurgy: Manufacture of pig iron, cast iron, methods of making steel, open hearth process, production of aluminium by electrolytic process.

Textbooks:
1. "Dryden's Outlines of Chemical Technology" by M.Gopala Rao & Marshall Sitting (Editors). Affiliated East West Press Pvt. Ltd.
2. "Shreve's Chemical Process Industries" by G.T.Austin, McGraw Hill Books

Reference Books:
1. " Encyclopedia of Chemical Technology" by R.E.Kirk & D.F.Othmer (Editors) Interscience.

CHE-2.2.6   **ENVIRONMENTAL STUDIES**

OBJECTIVE : The aim of this course is to make the students better understand the changes in the environment and be given a greater voice and planning conservation through an interdisciplinary environmental science curriculum that is design to enhance scientific enquiry and to strengthen competence.

OUTCOME :

1. Understanding various types of pollution regulations and their scientific bases.
2. Apply knowledge for the protection and improvement of the environment.
3. Finally the students can recognize all the major concepts in environmental science and demonstrating in-depth of the environment

Syllabus:

Introduction: Definition, scope and importance, measuring and defining environmental development – indicators,

Ecosystems: Introduction, types, characteristic features, structure and functions of ecosystems – forest, grassland, desert, aquatic (lakes, rivers and estuaries),

Environmental and natural resources management: Land resources- land as a resource, common property resources, land degradation, soil erosion and desertification, effects of modern agriculture, fertilizer-pesticide problems,

Forest resources- use and over-exploitation, mining and dams –their effects on forest and tribal people,

Water resources – use and over utilization of surface and ground water, floods, droughts, water logging and salinity, dams-benefits and costs, conflicts over water,

Energy resources- Energy needs, renewable and non-renewable energy sources, use of alternate energy sources, impact of energy use on environment,

Bio-diversity and its conservation: Value of bio-diversity- consumptive and productive use, social, ethical, aesthetic and option values, bio-geographical classification of India - India as a mega diversity nation, threats to biodiversity, hot spots, habitat loss, poaching of wild life, loss of species, seeds etc., conservation of biodiversity - in-situ and ex-situ conservation,

Environmental pollution- local and global issues: Causes, effects and control measures of air pollution, indoor air pollution, water pollution, soil pollution, marine pollution, noise pollution, solid waste management, composting, vermiculture, urban and industrial wastes, recycling and

re-use, nature of thermal pollution and nuclear hazards, global warming, acid rain , ozone depletion,

Environmental problems in India: Drinking water, sanitation and public health, effects of activities on the quality of environment, urbanization, transportation, industrialization, green revolution, water scarcity and ground water depletion, controversies on major dams – resettlement and rehabilitation of people: problems and concerns, rain water harvesting, cloud seeding and watershed management,

Economy and environment: The economy and environment interaction, economics of development, preservation and conservation, sustainability: theory and practice, limits to growth, equitable use of resources for sustainable lifestyles, environmental impact assessment,

Social issues and the environment: Population growth and environment, environmental education, environment movements, environment versus development,

Institutions and governance: Regulation by Government, monitoring and enforcement of environmental regulation, environmental Acts, water (prevention and control of pollution) act, air (prevention and control of pollution) act, environment .protection act, wild life protection act, forest conservation act, coastal zone regulations, institutions and policies relating to India, environmental governance,

 International conventions: Stockholm conference-1972, Earth summit-1992, World commission for environmental development (WCED),

Case studies: Chipko movement, Narmada bachao andolan, Silent valley project, Madhura refinery and Taj mahal, Industrialization of Pattancheru, Nuclear reactor at Nagarjuna sagar, Tehri dam, Ralegaon siddhi (Anna Hazare), Kolleru lake-aquaculture, Fluorosis in Andhra Pradesh,

Field work: Visit to a local area to document and mapping environmental assets – river/forest/grass land / hill/ mountain, study of local environment-common plants, insects, birds, study of simple ecosystems – pond, river hill, slopes etc, visits to industries- water treatment plants, effluent treatment plants.

CHE- 3.1.1   **MASS TRANSFER –I**

Objectives:

- To explain the students with the basic principles of mass transfer operations and other separation processes with examples.
- To impart knowledge on how certain substances undergo the physical change with diffusion/mass transfer of components from one phase to other phases.
- To describe the students with equipment used in operations involving mass transfer and other separation processes and their advantages and disadvantages.
- To focus on absorption and distillation operations and the process design aspects of the same operations.
- To provide the knowledge on humidification and dehumidification operations and their applications in real situations

Outcome:

- An ability to define the basic principles of mass transfer operations and other separation processes
- An ability to identify the basic techniques for measurement of diffusivity, mass transfer coefficient, evaporation rate,
- An ability to understand the importance of mass transfer phenomena in the design of process equipment in distillation operation
- An ability to understand the VLE concepts and application to different distillations
- An ability to identify the major parts of various mass transfer equipment
- An ability to understand the design of sizing of packed columns in absorption and plate columns in distillation
- An ability to understand the importance of humidification and dehumidification processes and their industrial applications

Syllabus:

Introduction: Mass transfer Operations.

Molecular diffusion in fluids: Binary solutions, Fick's law, equation of continuity, Steady state equimolal counter current diffusion, Stefan's diffusion, estimation of diffusivity of gases and liquids, application of molecular diffusion.

Mass transfer coefficients: Mass transfer coefficients in turbulent flow, theories of mass transfer, analogy between momentum, heat and mass transfer in laminar and turbulent flow, correlations for mass transfer coefficients in simple situations, diffusion in solids.

Interphase mass transfer: Concept of equilibrium, diffusion between phases, two resistance theory, material balances in steady state co-current and counter-current stage processes, Murphy stage efficiency.

Equipment for gas-liquid operations: Sparged vessels, mechanically agitated vessels for single phase liquids and gas-liquid mixtures, tray towers, sieve tray for absorption and distillation, venturi scrubbers, spray towers and spray chambers, packed towers for absorption and distillation, tray towers versus packed towers.

Humidification operations: Definition of fundamental terms, Psychrometric charts, theory of adiabatic saturation and wet bulb temperature, Lewis relation, gas-liquid contact operations, water cooling with air, dehumidification of air-water-vapor mixture, cooling towers, evaporative cooling.

Absorption: Solubility's of gases in liquids, two component systems, multi-component systems, ideal and non-ideal solutions, choice of solvent for absorption, single component absorption material balances, counter current multistage operations, dilute gas mixtures, on-isothermal operation, tray efficiency, continuous contact equipment, HETP, HTU, NTU concepts for single operation absorption with chemical reaction.

Distillation: Principles of VLE for binary systems, phase diagrams, relative volatility, ideal solutions, azeotropes, enthalpy concentration diagrams, flash vaporization, partial condensation, differential distillation, steam distillation, continuous distillation, McCabe-Thiele method, Ponchon-Savarit method, tray efficiencies, introduction to multi-component distillation, azeotropic and extractive distillations.

Text book:

1. Mass transfer Operations, Robert E. Treybal, 3rd edition, McGraw-Hill Book Co.,
Reference books:

1."Unit Operations in Chemical Engineering" by McCabe,W.L.,Smith,J.C.and Harriot,P., 5th Edition, McGraw-Hill Book Co.,

2. "Chemical Engineering Hand Book" by J.H. Perry.

CHE-3.1.2   **HEAT TRANSFER**

Objectives:
- This course is designed to introduce a basic study of the phenomena of heat to develop methodologies for solving a wide variety of practical engineering problems, and to provide useful information concerning the performance and design of particular systems and processes.
- Conduction: Fourier's law, Thermal Conductivity – its variation with temperature & Pressure and its relationship with electrical conductivity. Heat transfer through composite walls and cylinders.
- To enable the students to learn heat transfer by conduction, convection and radiation and heat transfer equipments like evaporator and heat exchanger
- Radiation: Radiation laws like Stefan Boltzmann's law, Kirchhoff's law, Wien's law, Plank's law etc. Black body, Grey body.
- Transmissivity, Absorptivity, Reflectivity, Emissivity of black bodies and gray bodies. Application of thermal radiation: Radiation Transfer between surfaces. Radiation through semi transparent materials.
- Heat transfer with phase change: Boiling of liquids, Pool boiling curve, different types of pool boiling, condensation of vapor, film wise & drop wise condensation, weighted LMTD & Overall Heat transfer Coefficient for desuperheating & sub cooling.
- Evaporation: Performance of tubular evaporator. Individual & overall Coefficients, Capacity & economy of evaporators. Boiling point elevation, Durhing's rule, Effect of liquid head & friction on pressure drop, Types of evaporators, Multiple effect evaporators. Vapor recompression, Thermal recompression & mechanical recompression.

Outcome:
- Understand the basic laws of heat transfer.
- Account for the consequence of heat transfer in thermal analyses of engineering systems.
- Analyze problems involving steady state heat conduction in simple geometries
- Develop solutions for transient heat conduction in simple geometries.
- Apply the concepts of heat transfer and associated thermal boundary conditions to transform the physical system into a mathematical model, selecting an appropriate solution technique and evaluating the significance of results.
- Understand various types of heat Transfer equipments
- Understanding of various types of heat transfer process and devices
- Evaluate heat transfer coefficients for natural convection.
- Evaluate heat transfer coefficients for forced convection inside ducts.
- Evaluate heat transfer coefficients for forced convection over exterior surfaces.
- Analyze heat exchanger performance by using the method of log mean temperature difference.
- Analyze heat exchanger performance by using the method of heat exchanger effectiveness.
- Calculate radiation heat transfer between black body surfaces.
- Calculate radiation heat exchange between gray body surfaces.

- Understanding of the basic concepts of conduction, convection and radiation heat transfer,
- Apply the concepts of heat transfer and associated thermal boundary conditions to transform the physical system into a mathematical model, selecting an appropriate solution technique and evaluating the significance of results.

Syllabus:

Nature of heat flow: Conduction, convection, natural and forced convection, radiation.

Heat transfer by conduction : Basic laws of conduction, thermal conductivity; Steady-state conduction – compound resistances in series, heat flow through a cylinder; Unsteady-state conduction – one dimensional heat flow with constant surface temperature, het flow with variable surface temperature, semi-infinite solid;

Heat transfer by convection: Principles of heat flow in fluids – Typical heat exchange equipment, countercurrent and parallel flows, energy balances, heat flux and heat transfer coefficients, overall heat transfer coefficients, integration over total surface, LMTD, individual heat transfer coefficients.

Heat transfer to fluids without phase change : boundary layers, laminar flow heat transfer, correction for heating and cooling, heat transfer in turbulent flow, estimation of wall temperature, cross-sections other than circular, analogy between transfer of momentum and heat, heat transfer to liquid metals, heating and cooling of fluids outside tubes, natural convection.

Heat transfer to fluids with phase change: heat transfer from condensing vapors, heat transfer to boiling liquids.

Radiation heat transfer: Fundamental facts concerning radiation, emission of radiation, absorption of radiation by opaque solids, radiation between surfaces, radiation to semitransparent materials, combined heat transfer by conduction-convection-radiation.

Heat-exchange equipment: General design of heat exchange equipment, shell and tube heat exchangers, plate-type exchangers, extended surface equipment, heat pipes, scraped-surface exchangers, condensers and vaporizers, heat transfer in agitated vessels, heat transfer in packed beds.

Evaporation: Evaporation, types of evaporators, performance of tubular evaporators, multiple-effect evaporators, methods of feeding, vapor compression.

Text Book: Unit Operations of Chemical Engineering, 7th Ed. by W. L. McCabe, J. C. Smith and P. Harriot, McGraw Hill International Edition, Singapore (2005).

Reference book: Process Heat Transfer, by D. Q. Kern, Tata McGraw Hill, New Delhi.

CHE-3.1.3   **CHEMICAL ENGINEERING THERMODYNAMICS-II**

Objectives: The course will help to learn about :
1. Solution thermodynamics and Applications
2. Thermodynamic properties and VLE from equations of state
3. Concept of phase equilibrium
4. Concept of reaction equilibrium

Outcome:
1. This course helps the students to be proficient in applying thermodynamic principles to various chemical engineering processes involving energy flow.
2. Understand the phase equilibrium.
3. Understand the Chemical reaction equilibrium

Syllabus :

Solution thermodynamics: Theory: Fundamental property relation, chemical potential as a criterion for phase equilibria, partial properties, ideal gas mixtures, fugacity and fugacity coefficient for a pure species, fugacity and fugacity coefficient for species in solution, generalized correlations for the fugacity coefficients, the ideal solution, excess properties, behaviour of excess properties of liquid mixtures.

Solution thermodynamics: Applications: Liquid-phase properties from VLE data, models for the excess Gibbs Energy, property changes of mixing, heat effects of mixing processes.

VLE at low to moderate pressures: The nature of equilibrium, the phase rule, Duhem's theorem, VLE- qualitative behavior, the gamma/phi formulation of VLE, dew point and bubble point calculations, flash calculations, solute (1)/solvent (2) systems.

Thermodynamic properties and VLE from equations of state: Properties of fluids from the virial equations of state, properties of fluids from cubic equations of state, fluid properties from correlations of the Pitzer type, VLE from cubic equations of state.

Topics in phase equilibria: Equilibrium and stability, liquid/liquid equilibrium(LLE), vapor/liquid/liquid equilibrium(VLLE), solid/liquid equilibrium (SLE), solid/vapor equilibrium (SVE).

Chemical reaction equillibria: The reaction coordinate,–application of equilibrium criteria to chemical reactions, the standard Gibbs energy change and the equilibrium constant, effect of temperature on the equilibrium constant, evaluation of equilibrium constants, relation of equilibrium constants to composition, equilibrium conversions for single reactions, phase rule and Duhem's theorem for reacting systems, multi reaction equilibria.

Thermodynamic analysis of processes: Calculation of ideal work, lost work, thermodynamic analysis of steady-state flow processes.

Text book:
1. `Introduction to Chemical Engineering Thermodynamics' by J.M.Smith, H.C.Van Ness and M.M.Abbott., 6th Edition, Tata McGraw-Hill Edition 2003

Reference books:
   1. `Chemical Engineering Thermodynamics' by Y.V.C.Rao, University Press (India) Ltd., Hyderabad 1997

CHE-3.1.4   **ORGANIC CHEMICAL TECHNOLOGY**

Objectives:

The course consists of all essential features of chemical process industries. An outline series of discussion was thought for the course which analyzes processes from industries classified as organic products. In this course a student is to comprehend, a necessary criterion for the short, concise study of a broad spectrum of industries. And also, the student observes how chemical and engineering principles are used in each process and industry. The course mainly consists of extensive use of flowcharts to allow a great deal of information to be collected and explains in a small space.

Outcomes:

➢ Able to know what the main types of coal and uses are. And also knows about the Fractionating distilling column used for distillation of coal.

➢ Able to know the Origin, classification, composition of crude petroleum, production and distillation of crude petroleum, refining-methods, and uses of products from petroleum.

➢ Enables a student to know the Extraction of vegetable oils, Manufacture of fatty acids and Soaps and Detergents- classification and manufacture.

➢ Able to know about the organic chemical products like Paints and varnishes and Pigments and also about the Manufacture of pulp and production of paper, manufacture of cane sugar and penicillin.

Syllabus:

Unit 1: Coal and Coal chemicals: Types of coal, different uses, distillation of coal, treatment of products, low and high temperature carbonization of coal, coal tar distillation,

Unit 2: Petroleum: Origin, classification, composition of crude oil, production of crude oil, distillation of crude petroleum, refining-methods, uses of products,

Unit 3: Extraction of vegetable oils: Purification, acid value, hydrogenation of oils,

Iodine value: Manufacture of fatty acids and soaps, saponification value, detergents-classification and manufacture.

Unit 4: Paints and varnishes: Constituents of paints, functions of paint, manufacturing procedures, Pigments-manufacture of lithophone, varnishes,

Unit 5: Manufacture of pulp: Kraft process and sulphite process, production of paper,

Unit6: Manufacture of cane sugar: Refining, manufacture of starch, dextrin and dextrose, production of ethanol by fermentation, manufacture of penicillin,

Unit 7: Polymerization: Different methods, manufacture of polyethylene, phenol formaldehyde, SBR, synthetic fibers, rayon, 6-nylon, 6,6-nylon, polyesters.

Text books:
1. `Dryden's out lines of chemical Technology' by Gopala Rao, M. & Marshall Sitting, .Affilated East West Press Pvt.Ltd.
2. `Shreve's Chemical Process Industries' Austin,G.T,,. Mcgraw Hill Publishers

Reference book:
1.`Encyclopedia of Chemical Technology' by Kirk.R.E & othmer,D.F., Inter Science.

CHE-3.1.5   **MATERIAL SCIENCE AND ENGINEERING**

Objectives:

      Materials science and engineering is an important subject to every engineer to understand about the materials' behavior in different environments. Main objectives of the study are as follows:

1. To understand the structure of atoms
2. To learn something about the crystalline nature of the materials
3. To know about the influence of atoms controlling the properties of materials
4. To know the equivalency of the materials for replacement
5. To learn to prepare alloys, composites for conventional materials
6. To find the relation between arrangement an thermodynamic properties of materials

Outcome:

1. To know about the appropriate utility of materials based on their nature.
2. To know the behavior of the materials w.r.t their directions.
3. To know the behaviour of materials exposed to different conditions in different phases.
4. To calculate the stability materials and knew the importance of crystalllinity.
5. Selectivity of the materials for suitable design to manufacture the machines
6. To improve the properties choosing alternative materials suchas alloys, composites instead of conventional materials (to minimize fractures, wear and tear).
7. Leads to prepare some knew semiconductors for important purposes.

Syllabus: A brief review on bonding, bond Energy, $H_{crystal, ?}H_{lattice,}$

Crystal structure: Symmetry, elements of symmetry in cubic crystals-space lattices two and three dimensiona, unit cell, crystal, Bravais lattices, crystal systems with examples, lattice coordinates, Miller and Miller –Bravais indices for directions and planes, linear density of atoms, planar density of atoms-close packed directions and planes, atomic and ionic packing fractions, densities of metals and ionic structures, covalent structures, close packed structures, crystal structure determination,

X-ray diffraction: Powder method, ionic covalent and metallic structures, structure determination of cubic crystals, Ligancy and limiting radii ratio,

Basic thermodynamic functions: Impure phases, solid solutions, alloys, single phase and multi phase alloys, crystal defects, point imperfections, classification, application of configurational entropy to estimate vacancy concentration and other defect concentrations, defect structures, line imperfections, edge and screw dislocations –their nature, Burgers circuit and Burgers vector, dislocation reaction, dislocation motion, multiplication of dislocations during deformation, role of dislocations in determining crystal properties, twining – surface defects, grains and grain boundary, dislocation energy, stress required to move a dislocation, dislocation density,

Elasticity, plasticity, stress, strain: True stress, true strain, Poissons ratio, elastic compliances, strain energy, stress-strain diagrams for ductile and brittle materials, proof stress, yield stress, plastic stress, modulus of elasticity, rigidity, bulk modulus–relationship between the three, plastic deformation, uniform elongation and necking strain hardening, work hardening as strengthening mechanism, plastic deformation by slip-slip systems and planes, critical resolved shear stress (CRSS), cold working, dynamic recovery, re-crystallization, grain growth, grain size and yield stress, Hall-petch equation, single crystal, polycrystalline material, comparison of stress – strain diagrams, anelasticity, elastic after effect, damping, internal friction, energy loss, viscoelasticity, viscoelastic models,

Composite materials: Fibrous, particulate, their properties and Young's modulus of composites when axially and transversely loaded, fraction of the load taken by fiber and matrix,

Fracture, ductile and brittle: Griffth's criterion for brittle failure, ductile brittle transition temperature, creep, mechanisms of creep, creep resistance materials, creep rate and related equations to find creep rates, fatigue-mechanism-factors to increase fatigue resistance,

Transition between states of matter: Energetics of transitioin, structure of solids, nucleation, mechanisms, nucleation rates, homogeneous and heterogeneous nucleation,

phase rule, unary, binary phase diagrams, thermal equilibrium diagrams, eutectic, eutectic phase diagrams, Cd-Bi, Pb-Sn, Cu-Ni, Ag-Cu, Fe-C or Fe-Fe$_3$C-phase transformations, time temperature, transformation curves for eutectoid steels, plain carbon steels, effect of addition of alloying elements on the properties of steels, types of steels used in Chemical industries.

Text books:

1. `Materials Science & Engineering' by V.Raghavan, Prentice Hall of India Ltd, New Delhi
2. `Elements of Materials Science & Engineering', 5th Edition, Lawrence H.VanVlack, Addision-Weley Publishing Company

Reference books:

1. `Science of Engineering Materials', Vols.1-3, by Manas Chanda, McMillan Company of India, Delhi
2. `Principles of Materials Science & Engineering', William F.Smith, McGraw-Hill Publishing Co.
3. `Essentials of Materials Science' by A.G. Guy.

CHE-3.1.6(A)   **PAPER TECHNOLOGY (Elective – I)**

Objectives:

        To understand the growth prospects of Indian paper mills, history of paper industry, different types, composition and uses of paper, raw materials for paper making, preparation of raw materials, classification of fibers, recovery of cooking chemicals from spent cooking liquors, Pulping processes, manufacture of paper and Testing of different properties of pulp and paper and the types of pollutants from paper industry and their treatment.

Outcome:
- Able to know about the history of development of paper industry in India and Importance of paper industry, historical background of paper making.
- Able to learn growth prospects of Indian Paper mills.
- Able to design the equipment used for the manufacture of paper.
- Able to reduce the paper wastes, by proper choice of the equipment, modifications in the design and process parameters to improve the production rate and recovery of use full chemicals.

Syllabus:

History: Importance of paper industry, historical background of paper making, development of paper industry in India, **Different types and uses of paper**: Different types and uses of papers and paper boards, composition, method of making different types of papers and boards, **Raw materials for paper making:** Classification of fibres, characteristics and composition of some important vegetable fibers (hard woods, softwoods, bagasse, straws, rags and paper stock)**Preparation of raw materials**: Wood preparation – pulp wood measurement, barking, chipping, screening and conveying of chips)**Pulping processes:** Mechanical pulping, alkaline pulping (Soda and Kraft), sulfite pulping, semi-chemical pulping, recovery of cooking chemicals from spent cooking liquors, **Pulp bleaching:** Bleaching agents, bleaching methods – single stage and multi stage bleaching, **Stock preparation**: Beating and refining, sizing and loading (filling),**Manufacture of paper**: Paper machines (Fourdrinier and Cylinder), making of paper – forming section, press section, dryer section, calendaring section, **Testing of different properties of pulp and paper**: Testing and evaluation of pulp, various properties of pulp and paper and their testing.

Text books:

1. 'Handbook of Pulp and Paper Technology' by Kenneth W.Britt, Vols.I&II

2. 'Modern Pulp and Paper Making' edited by John B.Calkin

3**.** `Pulp and Paper: Science and Technology - Vols.I&II' by E.Libby, McGraw Hill
    Books Co.

4. 'Pulp and Paper Manufacture- Vols. I & II' by R.C.McDonald & Others, McGraw Hill
    Books Company.

CHE-3.1.6(B)   **FERTILIZER TECHNOLOGY (Elective-I)**

Objectives:

➢ To introduce various nutrients and their role in growth of a plant
➢ To introduce different types of the nitrogenous, phosphatic, potassic and compound fertilizers
➢ To introduce different fertilizer production methods

Outcome:

1. Able to know different raw material availability
2. Able to know the beneficiation of rock phosphate
3. Able to know the production of all types of fertilizers
4. Able to formulate different fertilizer mixtures

Syllabus:
Details about indigenous fertilizer production – raw materials, details of various nutrients with their importance, sources of nitrogen and hydrogen, steam reforming of hydrocarbons, partial oxidation of fuel cells with gas purification including high and low temperature shift conversion, carbondioxide removal processes and methanation.

Coal gasification, ammonia synthesis, thermodynamic principles associated with ammonia synthesis, ammonia reactors, nitric acid and sulfuric acid.

Urea – total recycle and stripping processes, process details of ammonium sulfate, ammonium chloride, ammonium nitrate, calcium ammonium nitrate.

Phosphate rock – availability and beneficiation methods for upgrading, bone meal, basic slag, single super phosphate, triple super phosphate, phosphoric acid by wet process and furnace process, AMI process with hydrochloric acid, complex fertilizers like mono and di-ammonium phosphates, urea ammonium phosphate.

Text book :

1. 'Hand Book of Fertilizers' published by fertilizer Association of India, New Delhi

Reference Books :

1. 'Chemistry and Technology of Fertilizers' by V. Sauchelli, Reinhold Publications
2. 'Fertilizers Manual, a UNIDO Publication from International Fertilizer Development Centre, Alabama, USA.
3. 'Chemical Technology-II' published by IIT, Madras.

CHE-3.1.6(C)   **PETROCHEMICALS (ELECTIVE-I)**

Objectives:
        To make a thorough understanding of the availability of petroleum resources, technical and financial constrains of all the elementary problems. To know the development of petrochemical industries and methodolically furnishes the conversion of petroleum feedstock's to chemical and intermediates.

Outcome:
   - Able to know Petrochemical industry-Feedstock, various important Chemicals produced from ethylene and C_3, C_4 and higher carbon atoms.
   - Able to know the structure of Polymer, methods of polymerization, high pressure polyethylene (LDPE), low pressure polyethylene (HDPE),
   - Able to know Petroleum aromatics, synthetic fibers, Synthetic rubber, Plastics and Synthetic detergents.
   - Able to understand all the production processes and will get an awareness on accidents that are occurring in industries during handling, storage, and manufacturing of chemicals, remedial measures to arrest the accidents immediately.

Syllabus:

Petrochemical industry-Feedstocks: Petrochemical industry in India, feed stocks for petrochemicals.

Chemicals from ethylene: Vinyl chloride monomer, vinylacetate monomer, ethylene oxide, ethylene glycol, acetaldehyde.

Chemicals from C_3,C_4 and higher carbon atoms: Isopropylalcohol, acrylonitrile, acrylic acid, phenol, bisphenol-A, iso and n-butanol, methyltertbutylether, methacrylic acid, malic anhydride.

Polymers of olefins: Polymer structure, methods of polymerization, high pressure polyethylene (LDPE), low pressure polyethylene (HDPE), polypropylene, polyvinylchloride, polystyrene.

Petroleum aromatics: Benzoic acid, caprolactum, terephthalic acid, phthalic anhydride,

Synthetic fibres: Production techniques of synthetic fibres, production of polyester, nylon-6,6, nylon-6, acrylic fibers.

Synthetic rubber: Styrene butadiene rubber (SBR), butyl rubber, synthesis of polyurethane.

Plastics: Phenol formaldehyde resins, urea formaldehyde resins, polycarbonates.

Synthetic detergents: Classification of detergents, general manufacture of sulphonates, keryl benzene sulphonate (Surf).

Textbook:
   1. `A Text on Petrochemicals' by B.K.Bhaskara Rao, 3rd Edition, Khanna Publishers, NewDelhi.

Reference text books:
   1. `Petrochemical processes', Vol.2, 2nd edition, by A.Chanvel and G. Lefebvre, Gulf publishing company.
   2. `Shreve's chemical process industries', 5th edition, by George T. Austin, Mc Graw Hill Publishers

CHE-3.1.6 (D)   **CERAMIC RAW MATERIALS (ELECTIVE - I)**

Ceramic Raw Materials is a vital subject to the Ceramic technology students. It is life and back-bone of the ceramic engineers to become a skilled technician. This will provide knowledge regarding the raw materials which are used in the ceramic industry. Important objectives beyond the incorporation of the paper 'Ceramic Raw Materials' are:

Objectives:

1. To procure knowledge about the earth
2. To gain knowledge regarding the rocks which are host useful ores.
3. To know about the physical and optical properties of the minerals and ores
4. To gain acquaintance with formation of different raw materials.
5. To collect information about the different types of clays
6. To put on the knowledge regarding other raw materials used in the ceramics
7. To get information regarding the distribution of the deposits

Outcome:
1. Will be gained knowledge about the availability of raw materials for ceramics
2. Able to identify the suitable raw materials for the production of good ceramics
3. Be expertise in the selection of raw materials with quality.
4. Will be gained knowledge regarding the different beneficiation techniques through materials can be purified for further process.
5. Acquaintance with chemistry of the different raw materials suchas quartz, feldspar and rheological properties of the different clays

Syllabus: General geology and minerology: Formation of rocks, their characteristics, classification into igneous, sedimentary and metamorphic groups, formation of mineral deposits, physical and mineral characteristics of minerals – composition, color, streak, luster, fracture, cleavage, hardness, density and tenacity, elements of optical mineralogy.

Clays: Clay minerals, clay structure – kaolinite and montmorillonite groups, geology of clay deposits, their classification - china clay, ball clay, fire clay, building clay etc., beneficiation of clays, mica chlorite, illite group, talc, pyrophyllite, wollastonite group, chemical properties, physical properties.

Fluxes: Soda and potash feldspar, other feldspars, nephline syenite, geology of formation, physical and chemical properties, beneficiation.

Silica and silicate materials: Silica, polymorphic modification, silica structure, physical and chemical properties of silica, silicate chemistry, minerals, sillimanite, kyanite, and alusite, availability in India and their uses in ceramic industry.

Other raw materials: Geology of bauxite, magnesite, dolomite, chrome, limestone, rutile, zircon, beryllia minerals, alumina, carbides, nitrides, properties and uses.

Textbooks:

1. 'Fine Ceramics Technology and Applications' by F.H.Norton, McGraw Hill
   Publishers, New York,
2. 'Ceramic Raw Materials' by W.E.Worrall, Pergamon press, New York.

Reference books:
1. 'Forming Minerals' by W.A.Deer, R.A. Howie & J.Rock, Longman Publishers,
   London
2. 'Properties of Ceramic Raw Materials' by W.Ryan, Pergamon press, 2nd Edition
3. 'Clay Mineralogy' by M.J.Wilson, Chapman & Hall.

3/4 B.Tech. (Chemical Engineering) - Second Semester
&
3/6 B.Tech + M.Tech. (Chemical Engineering) Second Semester

CHE-3.2.1 **MASS TRANSFER-II**

Objective : To explore about different mass transfer operations and its applications in industrial scale.

Outcome: At the end of the course student would have learnt about the liquid-liquid extraction processes ,leaching, adsorption phenomena, drying, crystallization and different membrane separation process/techniques and their applications.

SYLLABUS:

Liquid-liquid operations: Extraction: Introduction, liquid-liquid equilibria, analytical and graphical solutions for single and multistage operations, continuous counter current operation without and with reflux, fractional extraction, equipment for liquid-liquid contacting operations, single stage, multistage and continuous contacting equipment,

Leaching: Preparation of solid, steady and unsteady state operation, equipment, analytical methods both theoretical and problematic approaches for single and multistage operations,

Adsorption: Theory of adsorption, Industrial adsorbents, adsorption equilibria, Freundlich equation, single and multistage operations, unsteady state adsorption, equipment for single stage and continuous contact, ion-exchange,

Drying: Equilibria, drying rate curve, batch and continuous drying, time of drying and calculations, mechanism of batch drying, equipment's for batch and continuous drying operations,

Crystallization: Equipment and analytical methods, factors governing nucleation and crystal growth rates, controlled rate of crystals, incorporation of principles into the design of the equipment,

Less conventional operations: Dialysis, thermal diffusion, mass diffusion,

Membrane separation processes: Separation of gases, separation of liquids, dialysis, membranes for liquid extraction, pervaporation, reverse osmosis.

Text book:
1. 'Mass Transfer Operations', by Robert E.Treybal, III Edition, McGraw-Hill Book Co.
Reference books:
1. 'Unit Operations in Chemical Engineering' by McCabe,W.L., Smith, J.C. and Harriot, P., 5th Edition, McGraw-Hill Book Co.
2. 'Chemical Engineering Hand Book' by J.H.Perry

CHE – 3.2.2   **CHEMICAL REACTION ENGINEERING – I**

Objectives:
To learn principles of rate law and stoichometry. Isothermal reactors- Batch, plug flow reactor and mixed flow reactor. Design of single and multiple reactors.

Outcome: The student learns the design of homogeneous reactors single and multiple reactions.

Syllabus:
Introduction and overview of chemical reaction engineering – Variables affecting a chemical reaction – Kinetics of homogeneous reactions – Concentration dependent term of rate equation – Elementary and nonelementary reactions – Temperature dependent term – Arrhenius law, activation energy, collision theory, transition state theory Searching for a mechanism.

Interpretation of batch reactor data – Methods of analysis, integral, differential and half life methods – Analysis of different types of reactions, irreversible and reversible – Variable volume reactor.

Ideal reactors for a single reaction – Performance equations for batch, mixed flow and plug flow reactors – Space time, space velocity and mean residence time.

Design for single reactions – Size comparison of reactors – Multiple reactor systems – Recycle reactor.

Design for parallel reactions – Qualitative and quantitative discussion about product distribution.

Design for series reactions – Qualitative and quantitative discussion about product distribution.

Textbook:

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

Reference Books:

1. "Chemical Engineering Kinetics"., Smith, J.M, 3rd Edition. McGraw Hill Inc.
2. "Elements of Chemical Reaction Engineering"., Fogler, H.S, 3rd Edition, Prentice Hall India Ltd.

CHE-3.2.3   **PROCESS INSTRUMENTATION**

Objectives:

To understand how physical quantities are measured and how they are converted to electrical or other forms.

To have an adequate knowledge on various types of instruments.

To study the characteristics of Instruments.

Outcome:

Understand the measurement techniques for Pressure, Temperature, Flow and Level.

Understand recording, indicating and signaling instruments.

Analyze repeatability, precision and accuracy of instruments.

Syllabus:

Qualities of measurement: The elements of instruments, static and dynamic characteristics, dynamic response of first order and second order instruments.

Expansion thermometers: Temperature scales, constant-volume gas thermometer, bimetallic thermometer, pressure spring thermometer, theory of volumetric and pressure thermometers, static accuracy of thermometer, comparison of pressure-spring thermometers.

Thermoelectric temperature measurement: Thermoelectricity, industrial thermocouples, thermocouple lead wires, thermal wells, response of thermocouples, the mill voltmeter.

Resistance thermometers: Thermal coefficient of resistance, industrial resistance thermometer bulbs, resistance thermometer circuits, null-bridge resistance thermometers, deflectional resistance thermometers.

Radiation temperature measurement: Introduction, blackbody devices and radiation receiving elements, radiation pyrometers, photoelectric pyrometers and optical pyrometers.

Methods of Composition analysis: Spectroscopic analysis, absorption, Emission and Mass spectroscopy- IR, UV absorption and mass spectrometers , Gas analysis by thermal conductivity, analysis of moisture in gases (humidity), psychrometer method, hygrometer method, dew-point method for moisture analysis in gases, measurement of moisture in paper, textile and lumber.

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

Measurement of Head and Level: Density and specific gravity, direct measurement of liquid level, pressure(level) measurement in open vessels, level measurement in pressure vessels, density measurement, level measurement by weighing.

Text Book:

   1. Eckman Donald P., Industrial Instrumentation, Wiley Eastern Ltd., 2004.

References:

1. Patranabis D, Principles of Industrial Instrumentation, 2nd Edition, Tata McGraw Hill Publishing Company, New Delhi, 1999..

2. William C. Dunn, Fundamentals of Industrial Instrumentation and Process Control, 1st Edition, Tata McGraw-Hill Education Private Limited, 2009.

3. Instrumentation Manual by walt boyes

4. Hand Book of Instrumentation and control, Considine.

CHE-3.2.4   **CHEMICAL ENGINEERING MATHEMATICS**

Objectives:
- To learn various computational techniques for analyzing and solving chemical engineering problems.
- To develop engineering models by integrating the fundamentals of mathematics and computer programming.

Outcome:
- Understanding of fundamental Mathematics and to solve problems of algebraic and differential equations, simultaneous equations and partial differential equations.
- Ability to convert problem solving strategies to procedural algorithms and to write program structures.
- Ability to solve engineering problems using computational techniques.

Syllabus:

Mathematical formulation of the physical problems: i). Application of the law of conservation of mass, salt accumulation in stirred tank, starting an equilibrium still, solvent extraction in N stages, diffusion with chemical reaction and ii). application of the law of conservation of energy, radial heat transfer through a cylindrical conductor, heating a closed kettle, flow of heat from fin,

Analytical (explicit) solution of ordinary differential equations encountered in Chemical engineering problems: i). First order differential equations, method of separation of variables, equations solved by integration factors, certain examples involving mass and energy balances and reaction kinetics and ii). second order differential equations, non-linear equations, linear equations, simultaneous diffusion and chemical reaction in a tubular reactor, continuous hydrolysis of tallow in a spray column,

Partial differential equations: i). Formulation of partial differential equations, unsteady-state heat conduction in one dimension, mass transfer with axial symmetry, continuity equation, ii). boundary conditions- function specified, derivative specified and mixed conditions and iii). particular solutions of partial differential equation- compounding the independent variable into one variable, superposition of solutions, the method of images and particular solution suggested by the boundary conditions,

Finite differences: i). The difference operator, properties of the difference operator, difference tables, other difference operators, ii). linear finite difference equation, complementary solution, particular solution, simultaneous linear difference equations and iii). non-linear finite difference equations, analytical solutions,

Solutions for the following type of problems by finite difference method: a). Calculation of the number of plates required for an absorption column, b). calculation of the number of theoretical plates required for distillation column and c). calculation of number of stages required for a counter current extraction and leaching operation,

Application of statistical methods: i). Propagation of errors of experimental data, ii). parameter estimation of algebraic equations encountered in heat and mass transfer, kinetics and thermodynamics by method of averages, linear least squares and weighted linear least squares methods and iii). design of experiments - factorial and fractional factorial methods.

Text book:

1. 'Mathematical Methods in Chemical Engineering' by V.G.Jenson and G.V.Jeffreys, Academic Press, London

Reference books:

1. 'Applied Mathematics in Chemical Engineering' by Harold S. Mickley, Thomas S. Sherwood and Charles E. Reed, Tata McGraw Hill Publications
2. 'Applied Statistics' 2nd edition by Volk, W., McGraw Hill Chemical Engg. series
3. 'Applied Numerical Methods with Personal Computers, by Alkis Constantinides,S., McGraw Hills, Chemical Engineering series, 1987

CHE-3.2.5   **PROCESS DYNAMICS AND CONTROL**

OBJECTIVE:
In chemical industries controlling various parameters like temperature, pressure ,flow rate, etc are very important in smooth functioning of the plant. Process dynamics and control deals with all control equipment and various controllers and their functions and applications. So, in studying this course Chemical Engg students can know the operation of control systems very usefully.

OUTCOME:
      1.Able to understand the simple control system and its elements
      2. Study various Controllers like P, P-I ,P-I-D Controllers and its mechanism
      3.Develop transfer functions for Controllers Control systems
      4.Understand the tuning of Controllers

SYLLABUS:

UNIT-I
Introduction to process dynamics and control, Response of First Order Systems - Physical examples of first order systems

UNIT-II
Response of first order systems in series, higher order systems: Second order and transportation lag

UNIT-III
Control systems Controllers and final control elements, Block diagram of a chemical rector control system

UNIT-IV
Closed loop transfer functions, Transient response of simple control systems

UNIT-V
Stability Criterion, Routh Test, Root locus

UNIT-VI
Transient response from root locus, Application of root locus to control systems Introduction to frequency response, Control systems design by frequency response.

UNIT-VII
Advanced control strategies, Cascade control, Feed forward control, ratio control, Smith predictor, dead time compensation, internal model control.

UNIT -VIII
Controller tuning and process identification. Control valves.

TEXT BOOKS:
1. Process Systems Analysis and Control by D.R. Coughanowr, 2nd ed. Mc Graw Hill, 1991.

REFERENCE BOOKS:
1. Chemical Process Control, G. Stephanopolous, Prentice Hall, 1984.
2. Coulson and Richardson's Chemical Engineering, Volume 3, 3rd Edition: Chemical and Biochemical Reactors and Process Control, Richardson J. F. et.al, Elsevier India, 2006.
3. Process control, Peter Harriott, Tata McGraw-Hill 1964. (10th reprint 2008).
4. Essentials of process control, William L. Luyben, Michacl L. Luyben, McGraw-Hill, 1997.

CHE-3.2.6(A)   COMPUTER APPLICATIONS IN CHEMICAL ENGINEERING
(ELECTIVE - II)

Objectives:

The objective of this course is to provide student with
- a sufficient background regarding the applications of computers in Chemical Engineering problems.
- The Knowledge of numerical integration, numerical differentiation, function approximations, solution of linear equations using matrix methods, solution of ordinary differential equations, initial value problems, boundary value problems and solution of partial differential equations by solving number of problems.

Outcome:

- Enables students to learn the applications of computers in solving chemical Engineering problems
- Students will be able to solve/write programs for Chemical Engineering problems

Syllabus:

Roots of algebraic and transcendental equations: Iteration methods, Regula-Falsi method, Newton Rapson method, roots of simultaneous sets of transcendental and algebraic equations,

System of linear equations and their solution by different techniques, numerical differential and integration, regression analysis, least squares and orthogonal polynomial approximation,

Numerical solution of ordinary differential equations,

Numerical solution of partial differential equations (simple case studies),

Application of the above techniques to problems of interest in Chemical Engineering.

Text book:

1. 'Digital computation for chemical engineers' by Leaon Lapidus, McGraw Hill Book Company

Reference books:

1. 'Applied Numerical Methods' by Camehanet, McGraw Hill Book Co.
2. 'Applied Numerical Methods with Personal Computers, by Constantinides, McGraw Hill Book Co, New York

CHE-3.2.6(C)   **PETROLEUM REFINING (ELECTIVE -II)**

Objective:

To introduce the basics of refinery engineering subject for petroleum specialization students to gain knowledge of the overall refinery operations, refinery products and its test methods. To learn various primary and secondary cracking process available to produce normal and value added products. Further, to learn the treatment process available to remove the impurities in the crude and finished products and its test methods for quality check.

Outcome:

Student gains very basic knowledge which every petroleum specialization student should know to work in the refinery field. Student will learn the importance of quality check and different methods available for quality check. Student learns about various treatment processes available to increase the quality of the product. Student is able to gain complete knowledge on the process available including operating conditions, reaction kinetics, catalyst, products, etc. This knowledge is very helpful for the student to have primary and basic knowledge of the process in advance before delivering the duty as process engineer.

Syllabus:

Origin and formation of petroleum,Reserves and deposits of the world,Indian petroleum industry,Composition of crudes,Refinery products and test methods,Evaluation of crudes,Crude pretreatment,Dehydration and desalting pipe still heater,Atmospheric and vacuum distillation of crude oil,Treatment of products, additives, blending of gasoline, treatment of gasoline, kerosene, lubes, lubricating oils and wax,Thermal and catalytic racking,Hydrocracking and Hydrotreating,Coking,Visbreaking,Alkylation,Isomerisation,Polymerisation,Asphalt   and   air blown asphalt.

CHE-3.2.6(D)   WHITEWARE AND HEAVY CLAYWARE (ELECTIVE - II)

OBJECTIVE:

The main objective of this subject is: Applications for advanced ceramics have received major media attention in recent years, particularly for use as parts in a future ceramic heat engine. However, corrosion resistance, chemical inertness, thermal shock resistance and other properties that materials scientists and engineers can design into ceramic materials make both traditional and advanced ceramics highly attractive in a large number of applications.

OUTCOME:

At the end of the course student will be able to understand

1. Lowering the social cost and risks of waste.
2. Reducing the damage to the environment from waste generation and disposal.
3. Use resources more efficiently.
4. Enhance product design.
5. Include the costs of waste management into the price of products.

Syllabus:

Claassification of whiteware products: Body formulation and properties, tableware, earthenware talc bodies, vitreous bodies, high alumina bodies, porcelain, bone china, sanitary ware, stoneware, majolica, terracotta, art ware, physical properties of mixtures, role of water.

Whiteware: Classification, body composition, white wares at home, construction, electrical appliances, industrial uses, manufacturing and properties.

Heavy clayware: Raw materials, methods of winning and handling, classification of building materials, manufacture of building bricks, hollow bricks and other bricks, roof tiles, paving tiles, sewer pipes.

Fine ceramics: Packing of two component system, porosity, effect of grain size, unfired porosity, experimental verifications, wet to dry contraction, unfired strength, permeability and casting rate, dry to fired contraction.

Tests and quality control: IS inspection, LOI, plasticity, strength, MOR, thermal shock resistance, abrasion resistance, porosity, acid and alkali resistance, chipping resistance, chemical analysis, electrical and thermal conductivity.

Text books:
1. 'Pottery Science: Materials, Processes and Products' by Allen Dinsdale, Ellis Horwood Ltd., New York,
2. 'Ceramic White Ware' by Sudhir Sen, Oxford & IBH Publishing Co., New Delhi

Reference book:

1. 'Industrial Ceramics' by F. Singer and S. Singer, Oxford & IBH Publishing Company,

4/4 B.Tech. (Chemical Engineering) - First Semester
&
4/6 B.Tech + M.Tech. (Chemical Engineering) First Semester

CHE-4.1.1   **TRANSPORT PHENOMENA**

Objectives:

The objective of this course is to provide to the student a sufficient background to be able to understand the fundamental phenomena, governing equations and assumptions used in the analysis of transport processes. Three fundamental transport processes, momentum, heat and mass, including conservation and constitutive equations, and solution methods to solve a variety of problems.

Outcome:

- (Part-A): Students will acquire knowledge of basic physical principles related to Momentum transport, Velocity distributions in laminar flow, The equations of change for isothermal systems, Velocity distributions, Velocity distributions in turbulent flow
- Students will be able to apply the knowledge in Interphase transport in isothermal systems.
- (Part-B): Enables students to learn the characteristics and applications Energy transport, Temperature distributions in solids and in laminar flow, The equations of change for non-isothermal systems, Temperature distribution with more than one independent variable, Temperature distribution in turbulent flow, Interphase transport in non-isothermal systems.
- (Part-C): Enables the students gain knowledge in Mass transport, Concentration distributions, the equations of change for multicomponent systems, Concentration distributions in turbulent flow and Interphase transport in multicomponent systems.

Syllabus:

PART-A

Momentum transport: Viscosity and the mechanism of momentum transport- i). Newton's law of viscosity, ii). Non-Newtonian fluids and iii). pressure and temperature dependence of viscosity,

Velocity distributions in laminar flow: i). Shell momentum balances boundary conditions, ii). flow of a falling film, iii). flow through a circular tube and iv). flow through an annulus,

The equations of change for isothermal systems: i). The equations of continuity, motion and mechanical energy in rectangular and curvilinear coordinates, ii). use of the equations of change to set up steady flow problems and iii). dimensional analysis of the equations of change,

Velocity distributions with more than one independent variable and unsteady viscous flow,

Velocity distributions in turbulent flow: i). Fluctuations and time-smoothed quantities, ii). time-smoothing of the equations of change for an incompressible fluid and iii). semiempirical expressions for the Reynolds stresses,

Interphase transport in isothermal systems: i) Definition of friction factors, ii). friction factors for flow in tubes and iii). friction factors for flow around spheres,

PART-B

Energy transport: Thermal conductivity and the mechanism of energy transport- i). Fourier's law of heat conduction and ii). temperature and pressure dependence of thermal conductivity in gases and liquids,

Temperature distributions in solids and in laminar flow: i) Shell energy balances-boundary conditions, ii). heat conduction with an electrical heat source, iii). heat conduction with a viscous heat source, iv). heat conduction through composite walls, v). forced convection and vi). free convection,

The equations of change for non-isothermal systems: i). The equation of energy in rectangular and curvilinear coordinates, ii). the equations of motion for forced and free convection in non-isothermal flow, iii). use of the equations of change to set up steady state heat transfer problems and iv). dimensional analysis of the equations of change,

Temperature distribution with more than one independent variable: Unsteady state heat conduction in solids,

Temperature distribution in turbulent flow: i). Temperature fluctuations and the time-smoothed temperature, ii). time smoothing the energy equation and iii). semi empirical expressions for the turbulent energy flux,

Interphase transport in non-isothermal systems: i). Definition of the heat transfer coefficient, ii). heat transfer coefficients for forced convection in tubes and around submerged objects and iii). heat transfer coefficients for free convection,

PART-C

Mass transport: Diffusivity and mechanism of mass transport- i). Definitions of concentrations, velocities and mass fluxes, ii). Fick's law of diffusion and iii). temperature and pressure dependence of mass diffusivity,

Concentration distribution in solids and in laminar flow: i). Shell mass balances – boundary conditions, ii). diffusion through a stagnant gas film, iii). diffusion with heterogeneous chemical reaction, iv). diffusion with homogeneous chemical reaction and v). diffusion into a falling liquid film,

The equations of change for multicomponent systems: i). The equations of continuity for a binary mixture, ii). the equations of continuity of A in curvilinear coordinates and iii). dimensional analysis of the equations of change for a binary isothermal fluid mixture,

Concentration distributions in turbulent flow: i).Concentration fluctuations and the time smoothed concentration and ii). time-smoothing of the equation of continuity of A,

Interphase transport in multicomponent systems: i). Definition of binary mass transfer coefficients in one phase, ii). correlations of binary masstransfer coefficients in one phase at low mass-transfer rates, iii). definition of binary mass-transfer coefficients in two phases at low mass-transfer rates and iv). definition of the transfer coefficients for high mass transfer rates.

Text book:

1. 'Transport Phenomena' by R. Byron Bird, W.E. Steward and Edwin N. Lightfoot, John Wiley & Sons Inc., New York

Reference books:

1. 'Transport phenomena' by Robert S. Brodkey & Haryr C. Hershey, McGraw Hills Company, New Yark
2. 'Transport Phenomena-for engineers' byLouis Theodore, International Book Compnay, London
3. 'Transport Phenomena' by W.J.Book and K.M.K.Multzall, JW&Sons Ltd.
4. 'Fundamentals of Momentum, Heat and Mass Transfer' by Mames R Welty, Charlese Wicks and Robert E Wilson, J W & Sons Inc., New York
5. 'Fluid Dynamics and Heat Transfer' by James G. Knudsen and Donald L.Katz., McGraw Hills Company Inc., New York.

CHE-4.1.2   **INDUSTRIAL MANAGEMENT**

Objectives:

1. To familiarize the students with the concepts of Management.
2. To relate the concepts of management with industrial organizations.
3. To explain the factors affecting productivity and how productivity can be increased in an Industrial undertaking.

Outcome:

An engineer with knowledge of Industrial Management will help him to take right decisions in the Corporate environment.

Syllabus:

Management: Functions of management – Planning, Organizing, Staffing, Directing Controlling and Coordinating, Levels of management, Role of Manager, Skills of manager, Pioneers in management – F.W. Taylor's scientific management and Henry Fayol's principles of management.

Organization: Meaning of Organization, Principles of organization, Organization structure, Types of organization structures, Line and Staff organization structure, Functional organization structure, Committee organization structure and Matrix organization structure.

Forms of business organizations: Salient features of Sole proprietorship, Partnership, Joint Stock Company, Private limited company and Public limited company, Government enterprises and Co-operative societies.

Production operations management: Production planning and control, Plant location and factors affecting plant location, Plant layout and types of layout, Line or product layout, Process or functional layout, Fixed position layout and Combination layout; Work study and Method study.

Human Resources Management: Basic functions of human resource management. Manpower planning, Recruitment, Selection, Training and Development, Placement, Compensation and Performance appraisal.

Text Books:

1. 'Industrial Organization & Engineering Economics' by S.C. Sharma & T.R. Banga, Khanna Publishers, Delhi.

2. 'Management Science' by A.R. Aryasri, Tata Mc Graw Hill, Publishers, New Delhi.

Reference Book:

1. 'Industrial Engineering and Management' by O.P. Khanna, Dhanpat Raj and Sons.

CHE-4.1.3.   CHEMICAL PLANT EQUIPMENT DESIGN

Objectives:

   The student is trained to develop new process from concept evaluation to profitable reality. The student would also learn to introduce changes in the existing processes that could alter the environmental or economic aspects of the process.

Outcome:

1. Preliminary design and cost estimation of new processes and modification of existing process could be made.
2. The choice of choosing appropriate material of construction would be understood.
3. Process design of various equipments used in the chemical industry would be known.
4. Sizing of the vessels can be estimated
5. Complete cost analysis can be done

Syllabus:

Introduction of plant design and costs,

Process design development: Design project procedure, design information from the literature and other sources of information, flow diagrams, preliminary design, comparison of different processes, firm process design, equipment design and specialization, scale up in design, safety factors specifications, materials of construction,

General design considerations: Health and safety hazards, fire and explosion hazards, personnel safety, loss prevention, thermal pollution control, noise pollution and control, plant location, plant layout, plant operation and control, utilities, structural design, storage, materials handling, materials and fabrication selection.

Material transfer, handling and treatment equipment design and costs: Incompressible fluid flow systems design, flow through parallel, series and piping network systems, compressible fluid flow systems design, design and cost estimation of filters.

Mechanical design of process equipment: Design and selection of storage vessels and low pressure vessels, design of roofs, bottom plates, formed heads, flat plate and conical closures, tall vertical columns, supports to process vessels, distillation columns, heat exchanges, evaporators.

Heat transfer equipment design and costs: Heat exchangers for sensible heat exchange - double pipe, shell and tube, plate heat exchangers, heat exchangers with extended surface, optimum heat exchanger design, heat exchangers with phase change – single effect evaporators, multiple effect evaporators, vapor recompression evaporators, condensers – condensation of single vapors, condensation with boiling range, reboilers.

Mass transfer equipment design: Continuous distillation- design for binary systems and pseudo binary systems for multi component distillation, plate efficiencies, entrainment, approximate column sizing, selection of plate type, plate construction, plate hydraulic design, plate design procedure, plate areas, diameters, liquid flow arrangements, entrainment, weep point weir dimensions, perforated area, hole size, hole pitch, hydraulic gradient, liquid flow, plate pressure drop, down comer design, packed columns - choice of plate or packing, types of packing, packed bed height, prediction of height of transfer unit (HTU) liquid distribution, stimulation of pressure drop in packed towers, allowable velocities, column diameter, column internals, wetting rates, reactor design, equations for reactor design application - batch reactor, tubular flow reactor, back mix reactors expression of reaction rates mechanical features of reactor design.

Text books:
1. 'Plant design & Economics for Chemical Engineers', 4th edition, M.S.Peters & K.D.Timmerhaus, Mc Graw Hills Publishing Company
2. 'Process Equipment Design', 3rd Edition, M.V.Joshi, MacMillan India Ltd 1981

Reference books:
1. 'Process-Plant-Design' by J.R.Backhurst & J.H.Harker, Heieman Education London
2. 'Chemical Engineering' Volume-VI (An introduction to Chemical Engineering Design' by J.M.Coulson & J.F.Richardon

CHE-4.1.4   **PROCESS ENGINEERING ECONOMICS**

Objectives:
1. To introduce types of interests, annuity, perpetuity, bond, debenture
2. To introduce depreciation and cost accounting methods
3. To introduce cash flow tree diagram, methods of cost estimation.
4. To introduce profitability, profitability evaluation
5. To introduce optimization in industries
6. To introduce economic balance of various operations.

Outcome:
1. Able to determine the different types of interests
2. Able to determine time value of annuity, perpetuity, bond and debenture
3. Able to determine depreciation costs and various ratios to tell about financial status of the company
4. Able to determine total cost of the project
5. Able to select an alternate investment using different profitability methods
6. Able to determine different optimum parameters in different operations.

Syllabus:

Value of money - equivalence: Value of money, equations for economic studies, equivalence, types of interest- discrete and continuous, annuities - relation between ordinary annuity and the periodic payments, continuous cash flow and interest compounding, present worth of an annuity, perpetuities and capitalized costs, bonds and debentures, value of a bond and yield rate,

Depreciation: Types and various methods of calculating depreciations, depreciation accounting,

Cost accounting: Basic relationship in accounting, balance sheet and income statement, various ratios to study the balance sheet and income statements,

Cost estimation: Cash flow for industrial operations, factors affecting investments and production costs, estimation of capital investment, cost indices, cost factors in capital investment, methods of estimating capital investment, estimation of total product cost- manufacturing costs and general expenses,

Profitability: Alternate investments and replacements. mathematical methods for profitability evaluation, economic production charts for plants operating below 100%, above 100% and under dumping conditions, general procedure for determining optimum conditions, break even chart for production schedule and its significance for optimum analysis,

Economic balance in fluid flow, heat transfer and mass transfer operations; optimum economic pipe diameter in fluid dynamics, optimum flow rate of cooling water in condenser in heat transfer and optimum reflux ratio in distillation operation,

Economic balance in cyclic operations and semi continuous cyclic operations, economic balance in yield and recovery, economic balance in chemical reactors, batch and flow reactors.

Text books:
1. `Plant Design and Economics for Engineers' by Max S. Peters and K.D.Timmerhans, McGraw Hill Book Company,
2. `Process Engineering Economics' by Herbest E. Schweyer, McGraw Hill Book Company.

CHE-4.1.5   **CHEMICAL REACTION ENGINEERING-II**

Objectives:
- To endow with the knowledge on thermal characteristics of various reactions
- To accomplish knowledge on non-ideal reactors
- To impart the knowledge on heterogeneous reacting systems
- To study the design aspects of heterogeneous catalytic systems
- To impart the knowledge on mass transfer with reaction situations

Outcome:
- Able to explain the thermal characteristics and design of adiabatic reactors for single and multiple reactions
- Able to apply the non-ideality concepts in the reacting system for better understanding the deviations from ideality
- Able to use the tanks-in-series model, and the dispersion (single parameter) models for a first-order reaction, to account for the non ideality
- Able to develop the progressive conversion model and shrinking core model for explaining the fluid particle reaction
- Enables the students to understand the principles and mechanism involved in heterogeneous catalysis and analyze the data of heterogeneous catalytic reactions.
- Enables the students to understand the rate controlling mechanisms in heterogeneous catalysis and their rate determinations

Syllabus:

Temperature and pressure effects – Heats of reaction and temperature – Equilibrium constants from thermodynamics – Equilibrium conversion – General graphical design procedure – Optimum temperature progression – Adiabatic operations.

Non ideal flow – Basics – C,E and F curves – Conversion in non ideal flow reactors – Dispersion model – Tanks-in-series model.

Heterogeneous catalysis – Physical adsorption – Chemisorption – Catalytic properties – Estimation of surface area, pore volume and porosity – Catalyst preparation – Catalyst poisons – Catalytic deactivation.

Solid catalysed reactions – Rate equations – Pore diffusion combined with surface kinetics – Thiele modulus – Effectiveness factor – Performance equations for reactions containing porous catalyst particles – Experimental methods for finding rates – Determining controlling resistances.

Noncatalytic systems – Design of fluid-fluid reactors – Factors to consider in selecting a contractor – Various contractors and contacting patterns for G/L reactions.

Design of fluid particle reactions – Progressive Conversion Model (PCM), Shrinking Core Model (SCM) – Comparison – Controlling mechanisms – Determination of rate controlling step.

Text book:
1. 'Chemical Reaction Engineering' Levenspiel O, 3rd Edition, John Wiley & Sons.

Reference books:
1. "Chemical Engineering Kinetics' by Smith, J.M. 3rd Edition, McGraw Hill Inc.
2. "Elements of Chemical Reaction Engineering" by Fogler, H.S, 3rd Edition, Printice Hall India Ltd.

CHE-416(A)   **COMPUTER AIDED DESIGN (ELECTIVE III)**

Objective:
To revise the basic concepts in Fluid Mechanics, Heat Transfer, Mass Transfer and Chemical Reaction Engineering and apply the numerical methods with the aid of computer in designing such systems.

Outcome:

Able to understand the concept behind the designing of various systems which includes Fluid Mechanics, Heat Transfer, Mass Transfer and Chemical Reaction Engineering. From this course, student gains the knowledge of how to apply the theoretical knowledge gained into practical design of any process; equipment. From this course, student also gains knowledge in terms of application of various numerical methods, correlations and computer applications in designing the equipment. In addition, student is able to know the importance of optimization of the process conditions with the given conditions.

Using the knowledge gained during this course, one can easily start the job as process engineer or design engineer. Student knows the importance of practical aspect of any process. This outcome is very helpful for the student in delivering the job as basic design engineer.

Syllabus:
CAD of fluid flow system:
Flow of Newtonian fluids in pipes
Pressure drop in compressible flow
Flow of Non-Newtonian fluids in pipes
Pipe network calculations
Two phase flow system,**CAD of Heat transfer equipment:** Shell and tube exchangers without phase change,Condensers, Reboilers,Furnaces,**CAD of Mass transfer equipment:** Distillation,Gas absorption ,Liquid extraction,**CAD of chemical Reactors:** Chemical reaction equilibrium ,Analysis of rate data, Ideal reactor models,Non-ideality in chemical reaction,Performance analysis using residence time distribution,Temperature effects in homogeneous reactors,Heterogeneous systems, Fluidized bed reactors.

Text Book: Chemical Process Computations by Raghu Raman.
Elsevier Scientific Publishers, London, 1987

Ref. Books:

1. Fundamentals and Modelling of Separation process by C D Holland, rentice Hall Inc. New Jercey, 1975
2. Catalytic Reactor Design by Orhan, Tarhan, Mc Graw Hill, 1983
3. Chemical Engineering, Vol 6 by Sinnot, Pergamon Press, 1993

**CHE-4.1.6(B)   INDUSTRIAL POLLUTION AND CONTROL ENGINEERING
(ELECTIVE III)**

Objectives:

To understand the types of emissions from chemical industries and their effects on environment, methods of analysis of air pollutants, general methods of control like primary, secondary, tertiary treatment methods, solid waste management and Industrial safety.

Outcome:

> ➢ Able to know the types of pollution and pollutants, sources of these pollutants from domestic and industrial wastes, permissive and excessive limits of the pollutants and standards of these pollutants especially in drinking water.
>
> ➢ Able to know the sophisticated instruments used for the analysis of water and air pollutants. The student will be having knowledge to design the equipment used for the abatement of these pollutants.
>
> ➢ Able to modernize the solid waste management and acquiring awareness on accidents that are occurring in industries during handling, storage, and manufacturing of chemicals, remedial measures to arrest the accidents immediately.

Syllabus:

Types of emission from chemical industries and their effects on environment, Environmental legislation, noise pollution, occupational health hazards, meteriological   factors in pollution dispersion (ALP and ELP), plume   behaviour   and   characteristics, chimney design considerations: Plume raise, effective stack height,

Methods of analysis of air pollutants, particulate matter, SO_x, NO_x, CO_x analysis, removal of particulate matters: principles and design of setting chambers, solid traps, cyclone separators, fabric and design of fibre filters, scrubbers and electrostatic precipitators,

General methods of control and removal of sulphur dioxide, oxides of nitrogen, organic vapors from gaseous effluents with design aspects, sources of waste waters, effluent guidelines and standards, characterization of effluent streams, oxygen demanding wastes, oxygen sag curve, BOD curve, analysis of water pollutants,

Methods of primary treatment: Screening, sedimentation, floatation and neutralization, biological treatment, bacteria and bacterial growth curve, aerobic processes suspended growth processes, activated sludge process, extended aeration, contact stabilization, aerated lagoons and stabilization ponds, attached growth process with design aspects, trickling filters, rotary drum filters, fluidized bed contactors, anaerobic processes,

Methods of tertiary treatment: Carbon adsorption, ion exchange, reverse osmosis, ultra filtration, chlorination, ozonation & sonozone process, sludge treatment and disposal,

Solid waste management: solid waste collection, transportation, solid waste processing and recovery, hazards in waste management, risk assessment and safety measures, types of hazardous wastes, health effects, safety measures, risk assessment response measures, case studies or pollutants removal and safety measures in fertilizer, petrochemical, paper, pharmaceutical industries and petroleum refinery,

Industrial safety: Why safety, accidents, causes and remedial measures, safety aspects of site selection, plant layout and unit plot planning, hazards of commercial chemical operations and reactions, safety aspects of process design, instrumentation for safe operations, safety aspects in design and inspection of pressure vessels, effect of toxic agents, toxicity vs hazards, respiratory hazards, safe experimentation and testing of reactions, materials for safety,

Flamable materials: Fire extinguishing agents and their applications, eye safety in chemical processing, personnel protective equipment, permit systems, hazard evaluation techniques, modern safety management systems, safety effectiveness.

Text books:

1. 'Environmental Pollution Control', by C.S. Rao, Wiley Eastern Limited
2. 'Safety and Accident Prevention in Chemical Operations' by Fawcett and Wood

Reference books:

1. 'Environmental Engineering' by Arcdio P.Sincero and Geogoria Sincero

2. 'Loss Prevention in Chemical Industries' by Frank P.Lees

CHE-4.1.6 (C)   PROCESS OPTIMIZATION (ELECTIVE III)

Objective:
Optimization of Chemical Process is an important of subject for Chemical Engineers. It deals with various optimization techniques in reducing cost of production ,energy consumption, maximum throughput and minimum labour cost etc. Onstudying the course one can understand how to write a model of the process optimize the process using the model

Outcome:
    1.Understand the definition of Optimization and how to write an Objective function
    2. Understand various types of Objective functions like Concave and Convex functions and its properties
      3. Study the Optimization of uni and multi dimensional search problems
    4. Solve the Optimization problems by Linear and Non-Linear Programming methods

Syllabus:

UNIT I: Definition of optimization Applications of optimization optimal insulation thickness Requirements for an optimization technique, Writing an objective function Production schedule ,material balance requirements , six steps of solving an optimization problem

UNITI I: Basic concepts of optimization continuous and discontinuous , unimodal and multi modal functions concave and convex functions, Finding the optimal point, definition of maximum, minimum and saddle points with examples

UNITIII: Unconstrained unidimensional search , Newton method Quasi Newton method and Secant method, Speed of iterations linear ,order p and super linear, Quadratic interpolation, cubic interpolation, Region elimination method, Fabonacci and Golden section method

UNITIV: Multivariable unconstrained optimization ,direct methods Powell method,Conjugate searchdirection,   Gradient and conjugate Gradient, Fletcher Reeves method , Positive definite of Hessian matrix Marquadt method

UNITV: Linear programming ,definition , solving the refinery schedule problem by linear programming method using graph, Simplex method and definition

UNITVI: Non linear programming , Lagrange multiplier method, Iterative linearization and Quadratic programming method, Necessary and sufficient condition for a minimum value ,Kuhn-tucker conditions

Text books:

1. Optimization of Chemical Process by Edgar and Himmelblau, 2nd edition, Mc GrawHill Publications.
2. Optimization Theory and Applications by S.S. Rao, 2nd Edition, Wiley Eastern Limited.
3. Formulation and optimization of Mathematical Models by C.L.Smith, R.W. Pike and P.W.Mur.

CHE-4.1.6 D   **BIOCHEMICAL ENGINEERING (ELECTIVE – III)**

Syllabus:

Introduction to Biochemical engineering and Biotechnology: Overall view of biotechnology since its practice–to date, enzyme kinetics, derivation of M.M. equation of single as well as multiple substrates, enzyme inhibition, determination of M.M. parameters, industrial applications of enzymes,

Cell cultivation & kinetics: Microbial, animal and plant cell cultivation, cell immobilization, batch growth of cells, yield coefficient, monod growth kinetics,

Analysis and design of fermenters: Batch fermenter, mixed flow fermenter (chemostat), plug flow fermenter, mixed flow fermenters in series, and cell recycling,

Genetic engineering: DNA and RNA, cloning of genes, stability of recombinant microorganisms, gene manipulation,

Sterilization: Sterilization of media and air, thermal death kinetics, design criterion, continuous sterilization methods,

Aeration and agitation in fermenters: Correlations of mass transfer coefficient, measurement of interfacial area and gas holdup, power consumption, scale up concepts,

Bioanalytical techniques: Gas chromatography, thin layer and paper chromatography, HPLC, affinity, gel, adsorption and ion exchange chromatography.

Text book:

1. 'Biochemical Engineering Fundamentals' 2nd edition by J.E.Bailey and D.F.Ollis,

 McGraw-Hill Publishers, Newyork, 1986

Reference books:

1. 'Chemical Engineering' volume-3, 3rd Edition by J.F Richardson and D.G. peacock, (Chapter-5: Biochemical Reaction Engineering), Pergomon Press, U.K, 1994
2. 'Bioprocess Engineering: Basic Concepts' 2nd edition by M.L.Shuler and F.Kargi, Prentice Hall India, New Delhi, 2003
3. 'Biochemical engineering' by D.G. Rao, Tata McGraw-Hill Publishers, New Delhi,

4. 'Biochemical Engineering' by J.M. Lee, Prentice Hall, Englewood Clifts, 1992.

CHE-4.1.6(E)   **RESERVOIR ENGINEERING (ELECTIVE - III)**

Objective: To know the fundamental concepts of reservoir engineering, basic properties of reservoir rocks, various types of reservoirs and driving mechanisms for the production of Oil and gas from an oil reservoir.

Outcome:
1. Able to identify the type of oil reservoirs by knowing the characteristics and mechanisms.
2. Able to predict the reservoir performance by knowing the past performance history of the oil reservoir.

Syllabus:

Fundamental concepts of Reservoir Engineering: Porosity, fluid saturation, permeability, flow through layered beds, flow through series beds, Klinkenberg effect, effective permeability data, phase behavior.

Oil reservoirs: Reservoir driving mechanisms, basic equation and tools, volatile oil reservoirs, identification of volatile oil reservoirs, ultimate recovery, predicting reservoirs behavior, performance, mechanics of reservoir performance, prediction procedure, limitations of predictions, relating reservoir performance to time, factors affecting ultimate recovery, analysis of gas oil ratio history.

Depletion drive reservoirs: Producing characteristics and methods of identification, detailed procedure for predicting reservoir performance, limitations of predictions, factors affecting ultimate recovery.

Water drive reservoirs: Effect of free gas saturation on recovery, predicting reservoirs performance, calculating water influx, use of the unsteady state equation in predicting reservoir performance, validity of performance prediction, limitations in predicting reservoir performance, the material balance equation as a straight line.

Gravity drainage reservoirs: Permeability in the direction dip, dip of the reservoir, reservoir producing rates, oil viscosity, relative permeability characteristics, fundamental recovery process, predicting reservoir performance, apparent relative permeability, oil saturation method.

Combination of drive reservoirs: Index of drives, equations used, material balance equations, instantaneous gas- oil ratio equation.

Pressure maintenance: Pressure maintenance by gas injection, condensing gas drive, predicting performance by gas injected gas drive index, pressure maintenance by water injection, predicting performance by water injection, index of injected water drive, control of the gas cap, typical water injection pressure maintenance operations.

Improving oil recovery: Improving oil recovery by fluid immiscible gas–water, miscible fluid injection thermal oil recovery, predicting recovery from fluid injection products, Stiles's method of water flood prediction, derivation of water cut and recovery equations, frontal advance techniques for prediction result of either water or gas injection, well arrangements, peripheral water flooding, predicting behavior of peripheral water floods, special consideration involved in water flooding, water flood case history, predicting the results of water flooding.

Text book:
1. 'Reservoir Engineering Manual' – 2nd Edition by Frank W. Cole, Gulf Publishing
 Company, Houstan, Texas, 1969.

CHE-4.1.6 (F)   FUELS, REFRACTORIES AND FURNACES (ELECTIVE - III)

Objective: The main objective of this course is to study the different minerals used for the manufacturing of different types of refractories and its large scale applications in industries**.**

Outcome: At the end of the course the students would have learnt about the importance, types of refractories, properties, design and installation and different types of coatings on refractories.

SYLLABUS:

INTRODUCTION OF REFRACTORIES

Production, demand and growth of refractories in India – layout of modern refractory plant – fundamental properties of refractories – Indian and international standards – factors for selection and use of refractories – test and quality control procedures.

 SILICA REFRACTORIES

Raw materials and composition – manufacturing process steps – quality of raw materials and process parameter on quartz inversion – glassy phase and other micro structural features – porosity, strength, RUL dependence on micro structure – specifications of silica refractories.

ALUMINA – SILICA REFRACTORIES

Al_2O_3 – SiO_2 phase diagram – clay, pyrophyllite, sillimanite, grog, bauxite and diaspore as raw materials – manufacturing processes – micro structure and properties

BASIC PROPERTIES

Magnesite, forsterite, dolomite and chrome based refractories – raw materials and composition – manufacturing processes – micro structure and properties.

SPECIAL REFRACTORIES

Oxide based, carbide based and nitride based refractories – cordierite – zirconia – carbon – fusion cast refractories, slide gate, purging refractories, and continuous casting refractories – ceramic fibres.

 REFRACTORIES FOR IRON AND STEEL INDUSTRY

Coke oven, blast furnace, twin hearth, LD converter – continuous casting – electric arc furnace, induction furnaces – reheating furnaces – slide plate system – nozzle, shroud/ SDN – ladle and tundish lining practices – monolithic - gunning techniques – refractor, slag and metal interactions.

REFRACTORIES FOR CEMENT AND NON FERROUS INDUSTRY

Wet/ dry process for cement making – preheater and pre calcinatory and zone lining – alkali and wear resistance – refractory requirement and use in copper, aluminum and hydro carbon industry – use of monolithic.

REFRACTORIES FOR GLASS INDUSTRY

Design of glass tank for container, sheet, lamp, float glasses, refractory practices in side wall, throat, forehearth, and roof of glass tanks – regenerator systems – alumina and AZS fused cast refractories – glass corrosion resistance, oxidation, seed potential tests – glass defects and analysis – feeder expendables

REFRACTORIES FOR CERAMIC INDUSTRY

Kiln furniture – types – properties of requirement - silicon carbide, mullite, corderite, alumina, zirconia – mullite, zirconia types – kiln design – LTM concept – fast firing technology

REFRACTORIES FOR ENERGY CONSERVATION

Insulation refractories – types- ceramic fiber product – design and installation – ceramic coatings – case studies in ceramic fiber usage.

Textbook:

1. B. M. Coop and E. M Piekson, Raw Materials for the refractory industries and industry materials and consumer survey, 1981.

References

1. J. H. Eheslers Refracrtories: production and Properties. Iron and Steel Institute, London, 1972.

2. Akira Nistrikawa, Technology of monolithic refractories, Plibrico japan co. Tokyo 1984

3. D.N. Nandi, Hand Book Refractory's, Tata Mc Graw hill publishing Co. New Delhi 1991

4. K.Shaw, Refractories and thick uses ADP sciences publisher U K 1972

5. Keishi GOTON, Powder Technology Hand Book, Marcel Dekker Inc. 1997

6.Chester J.H., Steel Plant Refractories, 2nd Edition, 1973, United Steel Companies Limited, Sheffield UK8.Advances in Refractory Technology, Ed. Robert E Fisher, Ceramic Transaction Vol 4., American Ceramic society, 1990, Westerville, Ohio, USA.

4/4 B.Tech. (Chemical Engineering) - Second Semester

&

4/6 B.Tech + M.Tech. (Chemical Engineering) Second Semester

CHE 4.2.1   -   INDUSTRIAL TRAINING REPORT

Note: 50% of the 4/4 & 4/6, 1st semester students will do course work in the first semester and the remaining 50% of the students will go for industrial training. The students who have gone for industrial training during first semester will do 1st semester course work in second semester and the students who have done course work in 1st semester will go for industrial training during second semester.

SYLLABUS

M.TECH. I SEMESTER

CHEM-1.1.1 : PROCESS MODELING AND SIMULATION

Objective:
Deals with writing various process models based on basic physical process. It also deals with solving the various models by means of numerical methods by computer simulation. By studying this course, one can simulate various chemical processes by computer simulation.

Outcome:
1. Understand the writing of a model of a process based on basic physical processes like mass ,momentum and energy balances
2. Able to develop a model equation for Tanks, Isothermal and Non-Isothermal Systems
3. Able to understand the models for binary distillation column, batch reactors, etc
4. Able to solve the model equations by numerical methods.

Syllabus:

Principles of formulation - Continuity equations – Energy equation – Equation of motion – Equations of state – Transport equations – Chemical Kinetics – Algebraic and Integral / differential equations, Explicit and Implicit equations –Numerical Integration,Feed forward and feed backward control.

Basic modeling for tank system, mixing vessel – Simultaneous mass and energy balances – Models for boiling, batch distillation, and partial condenser.

Models for Reactor – Model for heterogeneous catalysis – Models for pumping system – Model for heat exchanger.

Operational blocks in simulation- Simulation Programming – Simulation examples of three CSTR's in series, gravity flow tank, binary distillation column, non–isothermal CSTR.3

Implicit function convergence ,Internal–halving convergence, Newton–Raphson method, False position convergence, Explicit convergence methods, Numerical Integration, Euler Integration, Runge - Kutta (fourth order) method.

Textbooks:
1. Process Modeling, Simulation and Control for Chemical Engineers by Luyben, W.L., McGraw Hill Books Co.
2. Mathematical Modeling in Chemical Engineering by Roger, G.E. Franks – John Wiley Sons Inc.

Reference Book:
Mathematical Methods in Chemical Engineering by V.G. Jenson and G.V. Jefferys, Academic Press – 2nd Edition.

CHEM-1.1.2 : PROCESS DYNAMICS & CONTROL

Objectives :

The main purpose of teaching Process Dynamics & Control for first year postgraduate students is to take the student from basic mathematics to a variety of design applications in a clear, concise manner. This course is focused on the use of the digital computer in complex problem solving and in process control instrumentation. For chemical engineering problem solving students need more advanced mathematical preparation like partial differential equations, linear algebra and Fourier series all are introduced in this course.

Outcome:

➢ Able to know the sampled data control systems consists of sampling and advanced mathematical model Z- transforms.
➢ Able to describe the process in which the flow of the signals is interrupted periodically like in chromatograph.
➢ Able to calculate the open loop response of a sampled data system and can develop a pulse transfer function that is the counterpart of the transfer function for continuous systems.
➢ Able to know the sophisticated instruments used for the analysis of water and air pollutants, The student should have knowledge to design the equipment used for the abatement of these pollutants.
➢ In a position to modernize the solid waste management and the student must be in a position to get awareness on accidents that are occurring in industries during handling, storage, and manufacturing of chemicals, remedial measures to arrest the accidents immediately.

Syllabus:

Review of time domain, Laplace domain and frequency domain dynamics of process and control system.

Sampled data control system – sampling and Z–Transforms , open loop and closed loop response, Stability.

State space methods – representation of physical systems – transfer function matrix – Multivariable systems – Analysis and control.

Non linear control –examples of non linear systems – Methods of phase plane analysis. Control of heat exchangers, distillation columns and Chemical Reactors.

Textbooks:
1. Process system Analysis and control, 2nd edition, Donald R Coughanower and Koppel.
2. Automatic process Control by Peter Harriot.
3. Process Modeling, Simulation and control for Chemical Engineers by   W.L. Luyben.

CHEM-1.1.3 : CHEMICAL REACTION ENGINEERING

Objectives:
- To focus on the thermal characteristics of various reactions and the design aspects of non isothermal and adiabatic reactors
- To focus on Heterogeneous data analysis and design
- To focus on CVD reactors
- To study the design aspects of heterogeneous catalytic systems
- To impart the knowledge on mass transfer with reaction in process catalysts

Outcome:
- Enables the students to understand the design aspects of non isothermal and adiabatic reactors
- Enables the students to on heterogeneous data analysis and design aspects of heterogeneous catalytic systems
- Able to derive the rate laws for CVD
- Able to develop the rate laws for heterogeneous fluid solid catalyzed reactions under rate limiting situations.

Syllabus:

Review of Fundamentals Rate laws and stiochiometry, reactions with phase change (Scope: Chapter 3 of Fogler) Least squares Analysis of rate data: differential reactors: Laboratory reactors (Scope: sections 5.4 to 5.6 of Fogler) Multiple reactions (Scope: Chapter 9 of Fogler).

Isothermal reactor design (Scope: Chapter 4 of Fogler) Batch reactor, PFR, CSTR design. Pressure drop in reactors, Reversible reactions, unsteady state operation of reactors, Simultaneous reaction and separation

Catalysis and catalytic reactors (Scope: Chapter 6 of Fogler) Steps in catalytic reaction: derivation of rate laws, design for gas-solid reactions, heterogeneous data analysis and design; Chemical vapour deposition, catalyst reactivation, moving bed reactions.

Diffusion and reaction in process catalysts (Scope: Chapter 11 of Fogler).

Diffusion and reaction in spherical catalyst.

Internal effectiveness factor, falsified kinetics; estimation of diffusion and reaction limited regimes. Mass transfer and reaction in packed bed. Determination of limiting situations from reaction data, CVD reactors.

Non-isothermal reactor design (Scope: Chapter 8 of Fogler), Energy Balance, equilibrium conversion under adiabatic conditions unsteady state operation, multiple steady states.

Textbook:
Fogler. H.S: Elements for Chemical Reaction Engineering 2nd Edition, Prentice Hall, New Delhi, 1992.

Reference:
Smith J.M: 'Chemical Engineering Kinetics' 3rd Edition, McGraw Hill, 1981.

CHEM-1.1.4: TRANSPORT PHENOMENA

Objectives:
- To be able to analyze various transport processes with understanding of solution approximation methods and their limitations.

Outcomes:
- Ability to understand the chemical and physical transport processes and their mechanism.
- Ability to do heat, mass and momentum transfer analysis.
- Ability to analyze industrial problems along with relevant approximations and boundary conditions.
- Ability to develop steady and time dependent solutions along with their limitations.

Syllabus:

Unit 1: Momentum Transport

1.1 The Equations of change for isothermal systems.
1.2 Velocity distributions with more than one independent variable.
1.3 Velocity distributions in turbulent flow.
1.4 Inter phase transport in isothermal systems.

Unit 2: Energy Transport

1.1 The Equations of change for non – isothermal systems.
1.2 Temperature distributions with more than one independent variable.
1.3 Temperature distributions with more than one independent variable.
1.4 Interphase transport in nonisothermal systems.

Unit 3: Mass Transport

1.1 The Equations of Change for multicomponent systems.
1.2 Concentration distribution with more than one independent variable.
1.3 Concentration distribution in turbulent flow.

Textbook:

"Transport phenomena" R. Byron Bird, Warren E. Stewart and E.N. Light foot, Wiley & Sons, Inc., New York.

Reference Books:

1."Fundamentals of Momentum, Heat and Mass Transfer" James R. Welty, Charles E. Wicks and Robert E. Wilson, John Wiley & Sons, Inc., New York.

2. "Boundary – Layer Theory", Dr.H.Sehlichting, McGraw – Hill Book Company, New York.

CHEM-1.1.5: ELECTIVE – I

CHEM- 1.1.5 A - ELECTIVE-I (PETROLEUM REFINERY ENGINEERING-I)

Objective:

To introduce the basics of refinery engineering subject for petroleum specialization students to gain knowledge of the overall refinery operations, refinery products and its test methods. To learn various primary and secondary cracking process available to produce normal and value added products. Further, to learn the treatment process available to remove the impurities in the crude and finished products and its test methods for quality check.

Out come:

Student gains very basic knowledge which every petroleum specialization student should know to work in the refinery field. Student will learn the importance of quality check and different methods available for quality check. Student learns about various treatment processes available to increase the quality of the product. Student is able to gain complete knowledge on the process available including operating conditions, reaction kinetics, catalyst, products, etc. This knowledge is very helpful for the student to have primary and basic knowledge of the process in advance before delivering the duty as process engineer.

Syllabus:

Origin and formation of petroleum: Reserves and deposits of the world - Indialn petroleum industry - Composition of crudes.

Refinery products specifications and test methods: Evaluation of crudes. Crudes Pretreatment dehydration and desalting. Physical properties of petroleum oils and products.

Introduction to processing- Refinery distillation - processes - catalytic cracking, Reforming Hydro cracking , and hydro treating, hydrosulfurization.
Chemical treatments & Extraction Processes *:* Alkylation, polymerization Lube oil processing.

De-waxing :

Asphalt and air blown asphalt.
Treatment of products, additines, blending of gasoline, treatment of gasoline, Kerosene etc.,

Heat transfer equipment in Refinery - Heat exchangers and pipe still heaters.
Design of atmospheric distillation tower and Vacuum distillation tower, catalytic cracking units.

Text Books :

1. Petroleum Refinery Engineering - Nelson.
2. Refinery distillation - Watkins.

CHEM- 1.1.5 B - ELECTIVE-I (PROCESS DYNAMICS AND CONTROL-I)

Objectives:

The student is equipped with the analytical tools that are required in the actual design and analysis of distillation control systems. Further this subject provides a unified treatment of steady-state and control aspects of distillation operations.

Outcome:

1. The student know different techniques to formulate and solve binary and multicomponent distillation problems along with case studies
2. Knowing of those variables that affect the composition of the products
3. Dynamic mathematical tools used in controller tuning and process-identification techniques would be known.
4. Design and application of advanced control concepts to distillation would be thoroughly understood.

Syllabus:

Unit 1 : Overview of steady state distillation concepts.

Unit 2 : Distillation control concept - Controlled variables in distillation - Basis for distillation control strategies - Dynamic Modelling & Simulation.

Unit 3 : Process identification - Frequency response and Controller tuning - Pairing and interaction in distillation.

Unit 4 : Feed forward control - Cascade and parallel cascade control - Dead time compensation.

Unit 5 : Inferential control and model algorithmic control.

Textbook :

Distillation Dynamic and Control - Pradeep B., Deshpande, ISA, Tata McGraw Hill Co. Ltd.

Reference:

Design of Distillation Column Control Systems -Luyben and Shunta ISA. Tata McGraw Hill Co.

CHEM- 1.1.5 C - ELECTIVE-I (ELECTROCHEMICAL ENGINEERING-I)

OBJECTIVES:

- To enable the basic principles of electrochemistry, electrochemical devices, electro active materials used in such devices, and case studies of batteries.

- To enable the clean energy needs and demands especially in the electrochemical power generation sector; and to become educators, practicing engineers, and national leaders in electrochemical energy conversion and storage.

- To enable the integrated skills in fundamentals of electrochemistry (e.g.; chemistry, physics, mathematics, thermodynamics, and chemical kinetics) and electrochemical engineering applications (batteries, solar, flow and fuel cells, electrochemical synthesis and corrosion) to ensure successful career opportunities and growth within electrochemical power generation industries and academia.

- To enable the students in energy related programs such as clean power generation and future green technologies.

OUTCOMES:

- The student would know how to solve the problems relating to the production, storage, distribution and utilization of electrochemical energy and the associated environmental issues. And he would know integration of electrochemical principles and materials science for application in modern electrochemical devices.

- The student would know design and conduct experiments, acquire data, analyze, interpret data, solve practical and complex problems on a variety of electrochemical devices such as batteries, solar cells, flow and fuel cells and integrate the professional, ethical, social and environmental factors in electrochemical engineering and understand the impact of these factors on global energy issues.

Syllabus:

Introduction:

Unit I : Basic Concept: Mechanism of Electrolysis, Laws of Electrolysis, Curent and Voltage Efficiency - Electrolytic dissociation, Coulometers, Ionic conduction. Electrolytic conductivity, Absolute ionic velocities, ionic mobilities, Transference Nos. Modern Ionic Theory, Ionic activity Degree of dissociation. Ionic Atmosphere Time of relaxation and relaxation effect, Electrophoretic effect - Debye - Huckel Onsager equation of conductance (Derivation is not required) and its validity.

Unit II: Thermodynamics I: Chemical Potential and Free Energy changes. Cell and Electrode potentials. Thermodynamics of Electrode potentials - Nernst Equation. Equilibrium Constant, Arbitrary Zero of potential, EMF series and their limitations Activity Coefficient of and their evaluation, Liquid Junction potentials, Concentration Cells - Reference Electrodes.

Unit III : Thermodynamics II : Electrode Kinetics, Role of Interface, Electric Double Layer and its capacitance - Irreversible Electrode processes - Irreversibility, Tates of Electrode Processes. Electrode Kinetics Model, Cathodic Hydrogen evolution, Depolarisation - Overpotential, Tafel Equation, Ohmic or resistance Over potential, Concentration overpotential, Oxygen Evolution reaction and Decompostion potential, Ionic Transport by Migration, Diffusion and Convection - Mass transfer.

Unit IV : Kenetics of Corrosion Processes and Evans Diagrams : Electrokinetic phenomenon - Straming potential, zeta potential and Electro - Osmosis, Electrophoresis, Dorn Effect.

Measurements and Systems Analysis : Conductivity measurements - Conductometric analysis - Titrations, Measurements of pH, potential - potentiometric titrations, Polarography Electrogravimetry, Coulometry. Current Distribution in a cell. Rotating Disc Electrode, Rotating Cylinder electrode, Rough Surface Electrode Limiting Current Technique.

Unit-V: Potential relations in corrosion cells potentials, pH diagrams in corrosion.

Corrosion theory : Manifestation of corrosion, bases of electrochemical corrosion, amount and intensity of corrosion, Eight forms of corrosion : Uniform attack, Galavanic corrosion, crevice corrosion,Pitting, inter granular corrosion. Selective leaching, stress corrosion cracking. Conditions leading to pitting attack., environmental factors, hydrogen damage. Corrosion inhibition and prevention : Domestic water supplies, recirculating water systems, corrosion inhibitors, Inhibitors for acid pickling, vapor phase inhibitors. Coatings and paits: Phosphating, Protective metal coatings; cathodic protection and corrosion of buried structures.

Textbooks:
1. An Introduction to Electrochemistry by Samuel Glasstone, D. Van Nostrand Company Inc princeton, Affiliated East-West press Pvt. Ltd.
2. Electrochemistry - Principles and Applications by Edmund C. Fotter Oliver Hume Press Ltd., London.

Reference Books:
1. Electrochemical Engineering, Principles, by Geofferey Prentice, The Johns Hopkins University, Prentice Hall, Englewood Cliffs, New Jersy, 07632.
2. Electrochemistry - Bookris and A.K.Reddy.
3. Electrochemical Engineering by C.L.Mantell.
4. Principles of Electrochemical Engineering by L.W.Shemilt.
5. Chemical Engineering Development Centre, Indian Institute of Technology, Madras 600 036.
6. Fontanna and Grene 'Corrosion Engineering'.

CHEM-1.1.6: ELECTIVE –II

CHEM-1.1.6 A   - ELECTIVE-II (CORROSION ENGINEERING-I)

The main objectives are to provide:
1. Basic aspects of electrochemistry relevant to corrosion phenomena,
2. Importance and forms of corrosion.
3. Knowledge on corrosion rate expressions and measurement techniques.
4. Knowledge on factors influencing corrosion of iron and steel exposed to atmospheric, soil and aqueous medium.
5. Basic knowledge on remedial measures for corrosion.

Outcome:

1. Acquires knowledge on basic principles of electrochemistry, importance of corrosion, corrosion tendency and electrode potentials.
2. Able to identify the nature of corrosion and form in which it attacks(Uniform attack, Galvanic Corrosion, Crevice Corrosion, Pitting, Intergranular Corrosion, Selective Leaching, Erosion Corrosion and Stress Corrosion. Hydrogen damage .
3. By acquiring knowledge on polarization and its influence on corrosion rates will be able to measure corrosion rates and analyze.
4. Acquires knowledge on mechanism and propose viable remedial measures.

Syllabus:

Basic Concepts and Outlines of Electrochemistry :   Fundamentals of Electrochemical reactions, Faradaye's Laws Electrolytic and ionic conductance, ionic mobility's, Transport Nos. Galvanic Cell and Electrolytic cells.

Definition and importance of corrosion, Dry cell, analogy, Corrosion Cells, Types of Corrosion Cells- a) Dissimilar electrode cells b) Concentration cells such as a salt concentration cells, differential aeration cells c) differential Temperature cells. Forms of Corrosion – Uniform attract Galvanic Corrosion, Crevice Corrosion, Pitting, Intergranular Corrosion, Selective Leaching, Erosion Corrosion and Stress Corrosion. Hydrogen damage.

Corrosion Tendency and Electrode Potentials : Free Energy changes, Development of Nernst Equation for calculation of Half-cell potentials, Hydrogen electrode, Spontaniety of a reaction, Reversible cells and potentials – convention of Sign and calculations of EMF from standard Equilibrium potentials. Pourbaix Diagram for Iron, EMF Series and Galvanic series, Reference Half Cells – Calomel, Silver-Silver Chloride and Saturated Copper-Copper Sulphate Half Cells. Corrosion Rate Expresions-mdd, ipy, cpy, mpy, etc.

Polarization and Corrosion Rates : polarization and a Polarized Cell, Causes of Polarization – Concentration Polarization, Activation Polarization and IR drop. Hydrogen Over potentials, Tafel Slopes and Tafel Equation. Graphical method of expressing Corrosion Reactions (Polarization diagrams/Evans diagrams), Influence of Polarization on Corrosion rates. Calculation of Corrosion rates from Polarization data, Stern-Geary Equation. Theories of Cathodic Protection.

Passivity : Characteristics of Passivation, Flade potential, behavior of passivators, Anodic Protection and transpasivity, Theories on Passivity.

Corrosion of Iron and Steel in Aqueous Environments : Effect of Dissolved Oxygen (Air saturated Water, High Partial Pressure of Oxygen and Anaerobic bacteria), Temperature, pH, Galvanic coupling, velocity, dissolved salts.

Metallurgical factor : Varieties of Iron and Steel, Effect of Composition, Heat Treatment. Effect of Stress – Mechanisms and some Remedial measures.

Atmospheric Corrosion of Iron : Types of Atmospheres, Corrosion Product Films, Factors influencing Corrosivity of the Atmosphere – Dust Content, Gases in the Atmosphere and Moisture. Remedial measures.

Corrosion of Iron in Soils : Factors effecting the corrosivity of soils. Pitting and Stress Corrosion Cracking of Iron in Soils, Remedial measures.

Oxidation and Tarnish : Dry Corrosion – Pilling-Bed Worth Ratio, Protective and Non-Protective Scales. Equations of Oxidation, Oxide properties and Oxidation of Copper, Iron and Steel, Some Oxidation Resistant Alloys.

Textbooks :

1. Corrosion and Corrosion Control by Herbert, H. Uhlig John Wiley and Sons Inc., New York.

2. An Introduction to Electrochemistry by Samuel Glass stone, Affiliated East West

    Press Pvt. Ltd.,

Reference Books :

1. Corrosion Engineering by Mars F Fontana, McGraw Hill.
2. Corrrosion Volumes 1 & 2 by L.L. Shrier, Newnes - Butter-worths, London.

CHEM- 1.1.6 B - ELECTIVE-II (ENERGY ENGINEERING - I)

Objectives: To lean overview of solar radiation and it's potential for collection to meet the energy needs of mankind and potential for solar energy option. To learn measuring techniques of solar radiation and its compilation.
To learn various design and operational aspects of solar energy collection and storage.
To learn the design and operation of solar energy appliances like liquid flat plate collectors, Solar Air Heaters, Thermal energy storage, Thermal energy storage, Solar Pond, Solar thermal power generation.
To learn theory and application of Photovoltaic cells

Outcome: The student learns collection and design of various kinds of equipment operated on solar energy. The student learns principles and practice of Photo voltaic cells.

Syllabus:
The Solar Energy option

Thermal conversion – collection and storage Thermal applications – photovoltaic conversion – wind energy – Energy from Bio – mass – ocean thermal energy conversion.

Solar Radiation

Solar Radiation outside the earths – atmosphere Solar radiation at the Earth's surface – Instruments for measuring Solar Radiation – Solar Radiation data – Solar Radiation Geometry Empirical equations for predicting the availability of Solar Radiation – Solar radiation on tilted surface.

Liquid flat – Plate Collectors

Components of liquid flat plate – various types of collectors – Performance Analysis – Transmissivity – Absorptivity product – Overall loss coefficients and heat Transfer correlations – Collector efficiency heat removal factors – effect of various parameters on performance. Transient Analysis – Testing procedures.

Solar Air Heaters

Various types of solar Heaters – Performance Analysis of a conventional Air Heater – Testing procedures – Concentrating collectors – various types of concentrating collectors cylindrical and parabolic collectors – General receiver collectors.

Thermal energy storage

Sensible heat storage – Latent heat storage – Thermochemical storage

Solar Pond

Description – Performance analysis – Experimental studies – Operational Problems.

Solar Air Conditioning and Refrigeration

Heat pump cycle – Coefficient of performance of the heat pumps – solar air-conditioning with absorption – Refrigeration system (Ammonia water and lithium bromide – water systems).

Solar thermal power generation

Thermal and direct electricity generation – Major sub-stations of a solar thermal power plant, Examples of installed systems – Concentration ratio. Temperature and efficiency concepts – Solar farm and tower – Economics.

Photovoltaic Energy Conversion

Photovoltaic Energy Conversion Fundamentals – band theory of solids – Physical processes in a solar cell – Solar cell with light incidence – Solar cell module – Silicon Solar Cells – Copper Sulphate / Cadmium sulphide Solar Cells.(Banasal et at.,chapters 9;Taylor, chapters 6, pages 256-298.

Text Books:

1. Solar Energy: Principles of thermal collection and storage by S.P. Sukhatme, Tata McGraw Hill, New Delhi 1984 (Chapters 2 to 8)
2. Renewable energy sources and conversion technology by N. K. Bansal, M. Kleemann, Michael Mcliss, 1990 (Chapters 2 – 9).

CHEM- 1.1.6 C - ELECTIVE-II (REACTION ENGINEERING-I)

Unit I : (Scope : J.M. Smith : Chapter 7): Heterogeneous Processes, catalysis, and absorption: Global Rates of Reaction - Types of Heterogeneous Reactions - The nature of catalytic Reactions - The Mechanism of catalytic Reactions - Surface Chemistry and Absorption - Absorption Isotherms - Rates of Absorption.

Unit II (Scope : J. M. Smith: Chapter 8 : Solid Catalysts: Determination of surface area - Void Volume and solid density - Fore volume distribution - Theories of Heterogeneous Catalysis - Classification of catalysts - Catalyst Preparation - Promoters and Inhibitors   Catalyst Deactivation (Poisoning).

Unit III: (Scope: J.M. Smith : Chapter 9): Rate equations for fluid - Solid Catalytic Reactions: Rates of adsorption, Desorption, Surface Reaction - Rate equations in terms of Fluid phase concentrations at the catalyst surface - Qualitative analysis of rate equation - Quantitative inter pretation of Kinetic data - Redox Rate equations.

Unit IV: (Scope : Octave Levenspiel : Chapter 15) : Deactivating Catalysts : Mechanism of Catalyst Deactivation - The ratre of equation - The rate of equation from experiment - Batch - solids: Determining the rate for Independent Deactivation Batch - solids : Determining the rate of parellel, series or side - by - side Deactivation - Flowing solids experimental Reactors - Finding the Mechanism of Decay from experiment Design.

UnitV: (Scope : J. M. Smith : Chapter 10) : External transport Processes in Heterogeneous Reactions: Fixed bed reactors - The effect of physical processes on observed rate of reaction - Mass and Heat transfer coefficients (fluid particle) in packed beds - Quantitative treatment of external transport effects - Stable operating conditions - Effect of external transport Processes on selectivity.

Fluidised bed reactors - Particle - fluid Mass and Heat transfer Slurry Reactors - Mass transfer coefficients: Gas bubble to liquid (K_1) - Mass transfer coefficients: Liquid to particle (K_c) - The effect of mass - transfer on observed rates Trickle - Bed reactors - mass transfer coefficients: Gas to liquid ($K_1 a_g$) - Liquid to particle ($k_c a_c$) - Calculation of global rate.

Text Books:
1. Smith. J.M., " Chemical Engineering Kinetics", McGraw Hill book Company, New Delhi (Third Edition) 1981.
2. Octave Levenspiel, " Chemical Reaction Engineering" , Wiley Eastern Limited - Second Edition - 1972.

Reference Books :
1. Thomas, J.M. And Thomas, W.J. " Introduction to the Principles of Heterogeneous Catalysis". Academic Press Inc., New York 1967.
2. Carbnerry, James, J., " Chemical and Catalytjic Reaction - Engineering", McGraw - Hill, Engineering Series.

II SEMESTER

CHEM –1.2.1: COMPUTER AIDED DESIGN

The objectives of this course are to provide the student with:

- a basic understanding of the fundamentals of executive program, executive program aided simulation, unit computations, information flow diagram, encoding of information flow diagram, simulation of a simple plant, applications of simulation
- knowledge to write algorithm and programs for various fluid flow problems, pressure drop in two phase flow, pipeline network calculations
- knowledge to write algorithm and programs for rating and design calculations heat exchanger, condenser, reboiler, flash calculations, distillation column, gas absorption column, crosscurrent and counter current extraction, analysis of data in a reactor, extent of reaction, ideal reactors, semibatch reactor, packed bed reactor and fluidized bed reactor

Outcome:
- Enables students to learn the basics of computer aided design, executive program aided simulation and its applications
- Students will be able to write/develop unit computations (programs) for fluid flow, mass transfer, heat transfer and reaction engineering problems

Syllabus:
1. Process creation
   Introduction, preliminary data base creation: thermo-physical data, environment & safety data, chemical process data, experiments, preliminary process synthesis, development of base case design: flow diagram, process integration, detailed database pilot plant testing, and process simulation
2. Simulation to assist process creation
   Introduction, principles of steady state flow chart simulation, Process and simulation flow charts, unit subroutines, calculation order, recycle, recycle convergence methods, flash with recycle problem, flash vessel control, equation oriented architecture; synthesis of toluene hydroalkylation process, steady state process simulation of monochlorobenzene separation process, use of simulators, principles of batch flow sheet simulation, process and simulation flow charts, Equipment models.
3. Reactor design and reactor network synthesis
   Reaction models: reactor stiochiometry, extent of reaction, equilibrium, kinetics, ideal kinetic reaction models- CSTR's and PFR's; reactor design for complex configurations, reactor network design using attainable region, construction of attainable region, principles of reaction invariants

4. Heat and power integration

Introduction, minimum utility targets, temperature interval method, composite curve method, linear programming method; networks for maximum energy recovery, steam matching at the pinch, mixed integer linear programming; minimum number of heat exchangers, reducing no. of heat exchangers ,breaking heat loops, reducing no. of heat exchangers stream splitting; threshold approach temperature, optimum approach temperature
Heat exchanger design:

Introduction: Heat duty, heat transfer media, temperature driving force for heat transfer, pressure   drop

Equipment for heat exchange: double pipe heat exchanger, shell and tube heat exchanger, air cooled heat exchanger, compact heat exchanger, furnaces, temperature driving force in shell and tube heat exchanger

Heat transfer coefficients and pressure drop: estimation of overall heat transfer coefficients, estimation of individual heat transfer coefficients, turbulent flow in smooth ducts, pipes and tubes of circular cross section, turbulent flow in annular region between straight, smooth, concentric pipes of circular cross section, turbulent flow on shell side of shell and tube heat exchanger, heat transfer coefficients for laminar flow, condensation, boiling, compact heat exchanger, design of shell and tube heat exchanger
Mass integration

Introduction, minimum mass separating agent, approach to phase equilibrium, concentration interval method, composite curve method; mass exchange net works for minimum external MSA, stream matching at the pinch, stream splitting at the pinch, minimum number of mass exchangers: reducing the number of mass exchangers, breaking mass loops.
Separation tower design

Objectives, operating conditions, Fenske-Underwood-Gilliland shortcut method for ordinary   distillation, Kemser shortcut method for absorption and stripping, rigorous multicomponent and multiequilibrium stage method with a simulator, plate efficiency and HETP, tower diameter; tray   tower, packed tower, pressure drop and weeping
5. Optimal design and scheduling of batch process

Introduction, design of batch process units: batch processing, fed batch processing, batch product removal, design of reactor- separator processes, design of single product processing sequences, batch cycle times, intermediate storage, batch size
6. Optimization of process flow sheets

Introduction, General formulation of the optimization problem, Objective function and decision variables, Equality constraints, Inequality constraints, lower and upper bounds; classification of   optimization problems; linear programming, nonlinear programming with a single variable: golden section   search, optimization algorithm: repeated simulation, infeasible path approach, compromise approach, practical aspects of flow optimization

(Students are trained in this course to use steady state and dynamic process simulators like ASPEN PLUS, HYSYS, and MATLAB&SIMULINK by way of assignments for designing process equipment and questions on the use of these languages are not open for external assessment.)
Tex book:

W.D. Seider, J.D. Seader, and D.R.Lewin, **Product and process design principles: Synthesis, analysis and evaluation**, 2nd edition, John Wiley Asia, 2003.

Reference books :

1. L. Puigjaner and G.Hayer, Computer Aided Process and Product Engineering, Wiley-VCH, 2006.
2. B.V.Babu, Process Plant Simulation, Oxford University Press (India), 2004
3. Douglas, J.M., Conceptual Design of Chemical Processes, McGraw Hill, New York, 1988
4. B.C. Bhattacharyya and C.M. Narayanan, "Computer Aided Design of Chemical Process Equipment", New Central Book Agency (P) Ltd., New Delhi, 1992.

CHEM-1.2.2 – ADVANCED ENGINEERING MATHEMATICS & STATISTICS

Syllabus:

1. Finite Difference Methods of Solving Boundary value problems Associated with partial Differential Equations: Introduction, Finite difference scheme for Laplac's equation, Finite difference methods for the parabolic type of partial differential equations, Forward difference method, Crank-Nicholson implicit method, Stability analysis, backward difference equation for parabolic equations, finite difference explicit scheme for the wave equation, An implicit scheme for the linear wave equation, method of characteristics for solving hyperbolic partial differential equations.
2. Boundary value problems in ordinary differential equations: Reduction to an initial value problems, Finite difference method, The shooting method, Multiple integration, Numerical solution of integral equations.
3. Statistics and probability: Concept of random variable – distributions and density functions conditional distribution and density functions, Functions of one and two random variables, Many random variables, Concept of Stochastic Process, Stationery and ergodic process, Transformation of Stochastic Processes.

Textbooks:

1.   Computer Programming and Numerical Analysis by N.Datta Published by Universities Press (India) Private Limited, 3-5-819, Hyderabad – 500 029 for Chapters I & II.
2.   Probability by Seymour Lipschutz: Schaum's outline series for Section III.

Objectives:
- To develop skills in the process design of mass transfer operations
- To understand problems involving mass transfer using the principles of material and energy balances.

Outcomes:
- Ability to design process equipment for various mass transfer operations.
- Ability to use equations of change for multi-component systems.
- Ability to solve problems of mass transfer in laminar and turbulent regimes.
- Ability to solve problems of interphase transport in non-isothermal systems.

Syllabus:

Chapter 1: Flux Definition

- Mass and molar transport by convection
- Summary of mass and molar fluxes
- Fick's law

Chapter 2: Differential Equations of Mass transfer

- Differential equation for mass transfer
- Boundary conditions

Chapter 3: Molecular diffusivities

- Diffusivities in gases
- Diffusivities in liquids

Chapter 4: Molecular diffusion

- Steady state molecular diffusion
- Steady-State Equimolal counter diffusion in gases
- Steady state Equimolal unidirectional diffusion in gases
- Molar diffusion in liquids
- Diffusion through a stagnant gas film
- Diffusion with a moving interface
- Diffusion through a Nonisothermal Spherical film
- Diffusion with a Heterogeneous Chemical reaction
- Diffusion with a slow Heterogeneous Chemical reaction
- Diffusion with a homogeneous Chemical reaction
- Unsteady state diffusion in a sphere
- Unsteady state diffusion in a slab
- Unsteady state diffusion in a Cylinder

Chapter 5: Mass Transfer coefficients

- Individual Mass transfer coefficients
- Overall Mass Transfer coefficients
- Mechanism of Mass transfer
- The two-film theory
- The penetration theory
- The theory of penetration with Random surface renewal

Chapter 6: Mass transfer in Laminar Flow

- Mass transfer in the laminar boundary layer on a flat plate (Integral Solution)
- Mass transfer in laminar Natural convection on a vertical plate
- Mass transfer in a falling liquid film in a laminar flow
    - Mass transfer between a gas phase and a falling liquid film (gas absorption)
    - Mass transfer between an inclined plate and a falling liquid film (Solid dissolution)
    - Gas absorption with rapid reaction

Chapter 7: Mass Transfer in turbulent flow

- Mass transfer in the turbulent boundary layer on a flat plate
- Mass transfer in turbulent Natural convectionon a vertical plate
- Mass transfer between inclined plate and a falling liquid film in turbulent flow
- Anologies between momentum, heat and mass transfer
    - Reynolds analogy
    - Prandtl analogy
    - Von Karman analogy
    - Analogies in terms of j factor

Text Books:

1. A H P Skelland, Diffusional Mass transfer, John Wiley and Sons (1974)

Reference Books:

1. R B Bird, W E Steward and E N Lightfoot, Transport Phenomena, 2nd Ed., John Wiley and Sons (2002)
2. J R Welty, C E Wicks, R E Wilson and G. Rorrer, Fundamentals of Momentum, Heat and Mass transfer, 4th Ed., John Wiley and Sons (2001)

CHEM-1.2.4: POLLUTION CONTROL

Objectives:

- Focus on classification of air pollutants, water pollutants and solid waste –causes, effects and control methods, need of environmental Legislation.

Outcome:

- Enables the students to adopt the preventive measures for the control of air pollutants, waste water treatment methods, and solid waste management methods in domestic, municipal waste.
- Enables the students to understand the control measures of pollutants emitted from different industries like Paper and pulp, fertilizer, sugar and alcohol, petrochemical and petroleum refinery, pharmaceutical and metal finishing industries.

Syllabus:

Kinds of ecology, environment and ecofactors, types of ecosystems, sulphur cycles, phosphorous cycle, Nitrogen cycle and hydrological cycle

Sources for water, Air and solid pollution, Analysis and effects of the pollutants in air, in water, Solids(particulate matter, SOx, NOx, Cox, CHx).

Limits of pollutants, Environmental Legislation.

Control aspects of various pollutants Air (Particulate matter, SOx, NOx, COx, CHx, Noise) water (primary, secondary and territory treatment techniques) Solids (recycling, incineration,bio-conversion).

Case studies of Industries: Paper and pulp, petrochemical, Fertilizer, Pharmaceuticals, tannery, sugar and alcohol industries, metal finishing industries.

Text books:-

1. S.P.Mahajan., Pollution control in process Industries, Tata McGraw hill publishing company.
2. Arcadio P. Sincero and Georgia Sincero., Environmental Engineering
3. Environmental Pollution Control., by C.S.Rao, wiely eastern ltd.

CHEM-1.2.5 - Elective-I

CHEM-1.2.5 A – ELECTIVE-I (PETROLEUM REFINERY ENGINEERING-II)

Objective: To know about various production processes for the manufacture of C1 to Aromatic Compounds.
To know the design aspects to be taken into consideration for the designing of various equipments used in the process.

Outcome: 1.Able to understand the processes and mechanisms of various production processes of C1 to Aromatic compounds.
2.Able to understand the design aspects of various equipment used in the production processes.

Syllabus:
Raw materials for petrochemicals - Refinery process and petrochemical feed stocks - pyrolysis for petrochemical feed stocks - separation of individual hydrocarbons by fractionation.

Petrochemicals from C_1, C_2, C_3 & C_4 fractions. Petrochemicals from aromatic feed stocks.

Design of petrochemical equipment: Pyrolysis furnace, Pyrolysis reactor (Ethane Cracking or propene cracking).

Super fractionator (Ethyane - Ethylene, Propene - Propylene, Ethyle Benzene - styrene)

Fixed bed reactor (Ethyle Benzene - Styrene)

Multiphase reactor (Oxo synthesis).

Text Books :

1. Ethylene & its derivations - S.A. Miller
2. Propylene and its derivations - E.G. Hancock.
3. Benzene, Toluene, Xylene and their Derivations. E.G. Hancock.

CHEM-1.2.5 B – ELECTIVE-I (PROCESS DYNAMICS AND CONTROL-II)

Objectives :

The main purpose of teaching Process Dynamics and Control as elective-II for M. tech second year postgraduate students is to make them to understand the unity in outlook that has been lacking in the field of chemical reactor design. The stability viewpoint does in a sense in diverse areas like stirred tank reactor, plug flow reactor. The course in common emerge as qualitative description of the behavior of the respective models, for the stability viewpoint deals with certain structural aspects present in both problems.

Outcome:

- ➢ The student should be able to know a brief introduction about the most common chemical reactor models. The subject of steady state multiplicity in stirred tank reactors and develops uniqueness criteria for various cases that may be of interest for design.
- ➢ The student should be able to know the interpretation of terms such as steady and stable. The student should have knowledge to explore the implications of the stability concept in dealing with finite disturbances of practical magnitude.
- ➢ The student should be in a position to analyze from ordinary differential equation models to partial differential equation models.
- ➢ The student should be in a position to understand the steady state multiplicity, local stability, and regional stability are treated for distributed systems.

Syllabus:

Unit I : Mathematical modeling of reactors - Mass and energy balance equations for CSTR,PFTR, TRAM, TRRM, catalyst particle - multiphase models.

Lumped parameter model - steady state multiplicity of a CSTR- Van Herden diagram - criteria for uniqueness of steady state for isothermal and temperature dependent reactors and multiphase systems - design consideration.

Unit II : Geometry of dynamics for a lumped parameter model - stable and unstable steady states - phase plane for the CSTR and eigen values - linear second order system and eigen vector - Liapunov stability criterion and Liapunov functions - fundamental linearization theorem - local stability and steady state operating curves for a temperature - dependent reactor.

Unit III : Region of asymptotic stability and v-function in x-space - Krasovskil's theorem and V-function in f-space.

Unit IV : Steady states in distributed parameter systems - uncoupling the energy and mass balances for TRAM model - Steady state models of a PFTR and parametric sensitivity - Steady state multiplicity of a TRAM and catalyst particle model - uniqueness criteria for fixed bed reactors.

Unit V : Local stability of distributed parameter systems - the techniques of linearization of nonlinear differential equations and uncoupling of certain transient conservation equations - applications of these techniques to the cases of catalyst particle and TRAM.

Methods of solution of transient mass and energy balance quations applied to catalyst particle model and TRAM - Galerkin method - Collocation method.

Text Book:

Stability of Chemical Reactors by Daniel D. Perlmutter, John Weily and Sons Inc. (New York, (1976).

CHEM-1.2.5 C- ELECTIVE-I (ELECTRO CHEMICAL ENGINEERING-II)

The main objectives are to provide:

1. Knowledge on Electroplating, Electroforming, electro refining, electro wining.
2. Knowledge on Electrolysis and Manufacturing process.
3. Knowledge on primary & secondary batteries and fuel

Outcome:

1. Acquires knowledge on electrochemical ore beneficiation techniques, electroplating, electro refining and electro winning.
2. Able to work in commercial and industrial manufacturing units using electrolysis.
3. Familiarize with batteries and components like separators, binder, electrolyte, and additives used in batteries.
4. Familiarize with the characterization methods of batteries, e.g. charge/discharge cycles, overpotential, battery capacity, state of charge, state of health, impedance.
5. Familiarize with the Fuel cells.

Syllabus:

Part –A

Electroplating, Electroforming and Electrophoresis

Electrorefining of metals - Copper, Silver, Gold, Nickel, Lead and Cobalt.

Electrowinning of metals - Copper, Zinc, Cadmium, Chromium and Manganese.

Electrolysis of Alkali Halides and Sulfates - Chlorine and Caustic, Potassium halides, Hydrochloric acid, Fluorine and sodium sulfate.

Manufacture of Hydrogen and Oxygen. Electrolytic Reduction and Oxidation - Persalts, Cuprous oxide, Mercuric oxide, Manganese dioxide and Perchlorates.

Electrolysis of fused Salts - Aluminum, Magnesium, Sodium, Beryllium and Zirconium.

Part –B

Batteries: Classification of cells and batteries, theoretical cell voltage, capacity, energy, electrochemical principles and reactions

Primary batteries: Zinc carbon batteries(Leclanche and Zinc chloride cell system), Magnesium and Aluminum batteries, Alkaline manganese dioxide batteries, Lithium batteries.

Secondary batteries: Lead acid batteries, nickel cadmium batteries, nickel metal hydride batteries, lithium ion batteries, rechargeable zinc, alkaline, manganese dioxide batteries

Fuel cells: Molten carbonate fuel cell(MCFC), phosphoric acid fuel cell(PAFC), Solid oxide fuel cell (SOFC), proton exchange membrane fuel cell(PEMFC).

Textbooks:

1. Electrochemical Engineering by Mantell, C.L. McGraw–Hill
2. Electrochemistry Principles and Applications Edmund Potter, Cleaver–Hume Press Ltd.
3. Handbook of batteries by David linden and Thomas B Reddy, McGraw –Hill

CHEM-1.2.6- ELECTIVE-II

CHEM-1.2.6 A-ELECTIVE-II (CORROSION ENGINEERING-II)

Objectives:

- To enable the principles of corrosion, common corrosion forms, uniform, galvanic, pitting, inter granular, crevice, dezincification, stress corrosion, corrosion fatigue, hydrogen embrittlement corrosion control methods, and material selection to reduce corrosion cost.
- To enable the ability to understand electrochemical fundamentals
- To enable the ability to understand corrosion preventing methods

Outcome:

- The student would know application of weight loss method
- The student would know application of cathodic protection, anodic ptotection
- At the end of this course, the student would know effective surface preparation of specimen can be done
- After completion of this course, the student would understand the causes and the mechanisms of various types of corrosion, including uniform corrosion, galvanic corrosion, crevice corrosion, pitting corrosion, intergranular corrosion.
- The student would know application of Corrosion Processes and Evans Diagrams and application of electroplating, coatings and importance of inhibitors.

Syllabus:

Unit I : Theories of corrosion, classification of corrosion, forms of Corrosion - Calvanic, Crevice, Pitting, Inter-granular, selective leaching, erosion, corrosion, stress corrosion, hydrogen damage.

Unit II: Corrosion in selective environments : Marine, Acids (Sulfuric acid, Hydrochloric acid, Nitirc acid, Phosphoric acid) Biological and industrial gases (SO_2H_2S)Solids.

Unit III: Corrosion Testing - Purposes, Materials and specimen. Surface preparation, Measuring and weighing , Exposure Techniques - duration, Planned - Interval Tests, Ariation, cleaning specimens after exposure, Temperature, Standard expression for corrosion rates - Gavlanic Corrosion, Erosion Corrosion, crevice Corrosion, Intergranular corrosion, test for stainless steels, warren test pitting, stress corrosion, Paint tests, Sea Water tests, Presenting and summarising data - Nomograph for corrosion rates and interpretation of results.

Unit IV : Cathodic and anodic protection, surface preparation for coatings and chemical conversions : Degreasing, Descaling , Polishing - Anodized coating : anodizing oxidizing, chromate coating, phosphate coatings - Metallic coatings : Hot dipping, cementation, vapor deposition olf metallic coating; Sprayed coatings: flame spraying plasma spraying, Galvanizing - Electroplating : Nickel & chromium coatings, chromizing.- Organic coatings : paints, enamels, lacquers, resin mixtures.

Unit V : Linings, laminates, reinforced plastic, fibre glass - Corrosion inhibitors : mechanism of inhibition, recirculating of water of water systems; Measurement and testing of preventive coatings ; Paint tests, tests for electro - plating and anodizing.

Reference books :

1. Fontana and Crcens' - 'Corrosion Engineering'
2. Potter, E.

3. Burns, R.M., Bradley, W.W., 'protective coatings for Metals.' Chapters 2 to 18.

CHEM- 1.2.6 B - ELECTIVE-II (ENERGY ENGINEERING-II)

Objectives:

The student is provided with the fundamentals of some renewable energy processes. Basic information to comprehend the various non-conventional energy systems would be gained by the student.

Outcome:

1. Methods to be adopted to utilize biomass as an important energy source.
2. Application of thermodynamics to convert ocean energy.
3. Possible mechanism to drawn energy from wind and other natural sources
4. Fuel cells as sources of energy.
5. New technologies to produce energy such as thermionics, thermoelectricity etc.

Syllabus:

Non – Conventional & New Energy Systems and Energy Conservation Technology

Systems based on bio mass

Physical and Bio mass – Definition – potential thermo – chemical methods of Bio - Conversion – Gasification – Liquefaction – Pyrolysis.

Bio-gas technology – Historical review and development in India Different designs of bio-gas jplants – Selection of a model and size – Installation – Gas collection and distribution – operation and maintenance – Properties and uses of bio-gas – Utilization of manure – National Projects for Bio – gas development – safety.(Bansal et at,chapters 10 and 11; Khandelwal and Mahdi, Chapters 3,4,5,6,7,8,9,10: Chawla,chapters 2,3,4,5,6,7 & 8).

Fuel Cells

Hydrogen – Oxygen Fuel Cells – carbonaceous Fuel Cells – Molten Alkali Carbonate

Cells – Electrode Reactions and kinetics. (Fuel Cells by Young).

Energy Wind, Tidal and OTEC

Potential in India – Origin of wind and general circulation systems of Earth – Wind direction – Wind measurement – Wind energy converters – Historical development – Power coefficient – Aerodynamic construction of a rotor blade Rotors – Wind electric generators in India – Economics of wind farm – Fundamentals and concepts of Wave energy – Ocean thermal – energy conversion (OTEC). (Bansal et at., Chapters 12,13 & 14).

Hydrogen Energy, Methanol & Ethanol

Hydrogen from fossil fuels from Electrolysis – Developments of various electrolytic cells – High pressure cells – Solid electrolytic systems – Hydrogen powered IC engines – Storage system – Handling and Transmission.(Journals on Hydrogen energy).

Methanol and Ethanol as Automobile fuels – Comparison with Gasoline and Diesel oil. (Journals on Hydrocarbon on processing).

Energy Conservation Technologies:

Principles of Energy Conservation – Optimum Energy Conservation – Industrial Energy Conservation modeling – waste heat recovery and utilization.

Prescribed Books:

1. Renewable Energy Sources and Conversion Technology, N.K.Bansal, Manfred Klieemann,Michael Meliss, tataMcGraw Hill, 1990.
2. Bio Gas Technology, A practical hand book Vol 1, K.C.Khandelwal and S.S.Maholi, TataMcGraw Hill, 1986.
3. Advances in Bio Gas Technology: O.P.Chawla,publications and Information Division, Indian council of Agricultural Research,New Delhi, 1986.
4. Alternative Energy Sources: R.H .Taylor, Adam Hilger Ltd.,Brister.
5. Fuel cells, Vols.I & II: Reinhold publishing Crop.,New York.
6. International journal of hydrogen Energy, Vol.5, No. I, 1980 pages 1- 84: No.2, pages 119-129; pages 151-203; No.5. Pages 527 – 534 & 539 – 553; No.6, Pages 611 – 625.
7. Hydro Carbon Processing Vol. 58, May 1979 pages 127 – 138:Vol. 59, Feb. 1980, pages 72–75.
8. Handbook of Industrial Energy Conservation, David Hu, S., Van Nostrand Reinhold Company pages 73 – 133, 149-199, 297-327.

CHEM- 1.2.6 C - ELECTIVE-II (REACTION ENGINEERING-II)

Syllabus:

UNIT - I
Laboratory Reactors - Interpretation of Experimental Data - Interpretation of Laboratory Kinetics Data - Homogeneous and Heterogeneous Laboratory Reactors. Calculation of Global Rate - The structure of Reactor Design.

(Scope: Chapter 12 of J.M Smith 3rd Edition)

UNIT - II
Design of Heterogeneous Catalytic Reactors Isothermal and Adiabatic Fixed Bed Reactors Non-isothermal, Non-adiabatic Fixed Bed Reactors.
(Scope: Chapters 13.1 - 13.9 of J.M Smith 3rd Edition)

UNIT - III
Design of fluidized bed Reactors - Two -Phase Fluidized Bed model - Operating characteristics - Slurry Reactors - Trickle - Bed Reactors - Optimization.

(Scope: Chapter 13.10 - 13.13 of J.M Smith 3rd Edition.)

UNIT - IV
Fluid - Solid Noncatalytic Reactions - Design concepts - Single Particle Behavior - Reactor Models.

(Scope: Chapter 14 of J.M Smith 3rd Edition)

UNIT - V
Short notes from the portions of all the above four units. Four bits are to be answered out of 7 bits (Not more than 2 bits to be given from any one Unit).

Text Book: Chemical Engineering Kinetics by J.M Smith, McGraw - Hill Book

Company , 1980, 3rd Edition.