INDIAN INSTITUTE OF PETROLEUM & ENERGY
VISAKHAPATNAM

Course Curriculum for B.Tech in Chemical Engineering

SEMESTER I

S. No	Subject Code	Subject Name	L-T-P	Credits
1	BS 10001	Engineering Mathematics – I	3-1-0	4
2	BS 10002	Physical Chemistry	3-1-0	4
3	BS 10003	Engineering Mechanics	3-1-0	4
4	BS 10005	Earth Energy and Environment	2-0-0	2
5	BS 10009	Fundamentals of Electrical Systems	3-1-0	4
6	BS 10006	English for Communication	1-0-2	2
7	BS 10011	Engineering Drawing & Computer Graphics	1-0-3	3
8	BS 19002	Physical Chemistry Lab	0-0-3	2
9	EA 10001	EAA – 1	0-0-2	0
		Total	**16-4-8**	**25**

DETAILED SYLLABUS

1. Engineering Mathematics-I

Differential Calculus (Functions of one Variable): Rolle's theorem, Cauchy's mean value theorem (Lagrange s mean value theorem as a special case), Taylor's and Maclaurin's theorems with remainders, indeterminate forms, concavity and convexity of a curve, points of inflexion, asymptotes and curvature.

Differential Calculus (Functions of several variables) : Limit, continuity and differentiability of functions of several variables, partial derivatives and their geometrical interpretation, differentials, derivatives of composite and implicit functions, derivatives of higher order and their commutativity, Euler s theorem on homogeneous functions, harmonic functions, Taylor s expansion of functions of several variables, maxima and minima of functions of several variables - Lagrange s method of multipliers.

Ordinary Differential Equations: First order differential equations - exact, linear and Bernoulli s form, second order differential equations with constant coefficients, method of variation of parameters, general linear differential equations with constant coefficients, Euler s equations, system of differential equations.

Sequences and Series: Sequences and their limits, convergence of series, comparison test, Ratio test, Root test, Absolute and conditional convergence, alternating series, Power series.

Complex Variables: Limit, continuity, differentiability and analyticity of functions, Cauchy-Riemann equations, line integrals in complex plane, Cauchy's integral theorem, independence of path, existence of indefinite integral, Cauchy s integral formula, derivatives of analytic functions, Taylor s series, Laurent s series, Zeros and singularities, Residue theorem, evaluation of real integrals.

Reference:

1. Advanced Engineering Mathematics by Kreyszig.

2. Physical Chemistry

Thermodynamics of Chemical Processes: Concept of entropy, Chemical potential, Equilibrium conditions for closed systems, Phase and reaction equilibria, Maxwell relations, Real gas and real solution. Electrochemical Systems: Electrochemical cells and EMF, Applications of EMF measurements: Thermodynamic data, activity coefficients, solubility product and pH, corrosion. Kinetics of Chemical Reactions: Reversible, consecutive and parallel reactions, Steady state approximation, Chain reactions, Photochemical kinetics. Bonding Models in Inorganic Chemistry: Molecular orbital theory, Valence-bond theory, Crystal field theory. Fundamentals of Microwave, IR and UV-VIS Spectroscopy: Basic concepts of spectroscopy, Selection rule, Determination of molecular structure.

Reference:

1. Physical Chemistry by G.W. Castellan (Addison Wesley Publishing Company)

3. Engineering Mechanics

Force systems: Moment of a force about a point and about an axis; Couple moment; Reduction of a force system with a force and a couple.

Equilibrium: Free body diagram; Equations of equilibrium; Problems in two and three dimensions; Plane frames and trusses.

Friction: Laws of Coulomb friction, problems involving large and small contact surfaces; Square threaded screws; Belt friction; Rolling resistance.

Kinematics and Kinetics of particles: Particle dynamics in rectangular coordinates cylindrical coordinates and in terms of path variables; Central force motion.

Properties of areas: Moments of inertia and product of inertia of areas; Polar moment of inertia; Principal axes; Principal moments of inertia.

Reference:

1. Engineering Mechanics Statics and Dynamics by Irving H Shames.

4. Earth Energy & Environment

Understanding the interconnection in earth energy and environment systems uses the principles of Geology, Biology, Engineering and Socioeconomic dynamics- Understanding of the global changes in different time scales specially emphasising on technology and socio-political approaches applied to earth, oceans, water, energy, food and population will also be addressed.

The following are the components: Anthropogenic and natural changes in the atmosphere, ocean and terrestrial and freshwater ecosystem.

Greenhouse gases and climate change, deforestation, species extinction, human population growth and resource usage.

Understanding the human-environment, interaction with a focus on culture, history, economics, policy and the role of the state.

Case studies: Environmental degradation, loss of biodiversity, and resource sustainability, complex environmental problems caused by human activities in interaction with natural changes in the earth system.

Reference:

1. Environmental Studies: From Crisis to Cure, R. Rajagopalan, OUP India, 3rd Edition.

5. Fundamentals of Electrical Systems

- Conventional sources of electrical power generation- Thermal, Hydro and Nuclear Power generation. Typical schematic diagram of generation, transmission and distribution. Concept of voltage and current sources, solution of DC resistive circuits based on Mesh current and Node voltage methods.
- Solution of DC resistive circuits using Thevenin's and Norton's Theorems. Solution of circuit problems (containing resistive elements) using different techniques having voltage and current sources.
- Basic concept of single phase (1-phase) ac voltage generation. Evaluation of average and effective (rms) values, form-factor and peak factors of sinusoidal quantities, periodic wave forms, significance of rms value of a wave form. Concept of phasor, joperator, representation of sinusoidal quantities by a phasor diagram, Phasor addition and subtraction, Complex representation of impedance (R-L, R-C, R-L-C), concepts real, reactive and apparent power in an ac circuit steady state solutions of ac R-L-C circuits. Steady state solution of 1-phase circuit problems.
- Three-phase power generation, concept of balanced load, relationships between (i) line vine voltage and phase voltage (ii) line current and phase current in a balanced load, phasor diagram, calculations of real, reactive and apparent powers, steady state solution of 3-phase circuit problems.
- Working principle of Wattmeter. Three phase power measurement of a balanced or unbalanced load using two-wattmeter method. Transformer construction, working principle of transformer, an emf equation of a transformer. Losses in a transformer, significance of transformer ratings. Open and short circuit tests of a transformer and computation of transformer parameters, approximate equivalent circuit of transformer, significance voltage regulation. Mathematical expression of voltage regulation, maximum efficiency of a transformer, solution of numerical problems on transformer.
- Working principle of Induction Motor (IM), classification of IM, concept of rotating magnetic field in an IM, slip, rotor frequency, understanding the loading of an IM, losses in an IM, significance of IM rating.
- Per-phase approximate equivalent circuit of a balanced 3-phase IM, Power flow diagram of an induction motor from input power to the shaft power. Expressions for (i) input power (ii) air-gap power and torque developed (iii) mechanical power and torque developed (iv) shaft power and shaft torque.
- Torque-speed characteristics of an IM, efficiency of IM, solution of numerical problems on IM.

Basic Electronics.

- Semiconductor Physics; Semiconductor Devices (Diode, Zener Diode, Transistors etc.); Transistor characteristics and biasing. Half-wave & Full-wave rectifiers.
- Operational Amplifiers; realization of filters (low-pass, highpass, band-pass and band stop filters).
- Different classes of power amplifiers (Class-A, Class-B, Class-AB).

6. English for Communication

This foundational course aims to help students coming from different language backgrounds acquire fluency in both spoken and written English in the workplace. The course includes three components – **Language, Speaking and Writing**. Lectures and Sessionals will be conducted to improve the skills required these three areas. Lectures will be aimed to introduce the learners to

the basic concepts in communication, while sessionals will give practical experience. The purpose of this course is to help students to communicate English more efficiently.

Section A (lecture topics)

Introduction to communication; Language and grammar skills; Speaking and writing skills

Section B (Sessional)

Building Vocabulary; Building sentences; Grammar, Pronunciation drills; Phonetics, vowels; Diphthongs, consonants; Stress; Rhythm and intonation; Conversational skills; Meta Language, the writing process; Writing with a thesis; Writing topic sentences; Writing a paragraph and linking paragraph

Reference:

1. Technical Communication: English Skills for Engineers by Meenakshi Raman and Sangeeta Sharma (OUP India)

7. Engineering Drawing and Computer Graphics

- Introduction to IS code of drawing
- Conics and Engineering Curves – ellipse, parabola, hyperbola, cycloid, trochoid, involute
- Projection of lines – traces, true length
- Projection of planes and solids
- Isometric projection
- Introduction to CAD tools
  - Basics of Auto-CAD/Solid Works
  -Creation of Points, Curves, Surfaces, Solids, Dimensioning using CAD tool
- Introduction of Development and Intersection of surfaces
  -Development of surfaces Development of prisms, pyramids and cylindrical & conical surfaces using CAD tools

8. Physical Chemistry Lab

- Measurement of surface tension, CMC of a surfactant
- Measurement of the coefficient of viscosity for water and polymer
- Conductometric titration
- pH-metric/potentiometric titration
- Solubility product
- Kinetics of ester hydrolysis
- Estimation of Fe2+
- EDTA titration

SEMESTER II

S. No	Subject code	Subject Name	L-T-P	Credits
1	BS 10007	Engineering Mathematics – II	3-1-0	4
2	BS 10008	Strength of Materials	3-1-0	4
3	CH 10001	Polymers & Surfactants	3-0-0	3
4	BS 10004	Programming and Data Structure	3-1-3	6
5	CH 10002	Intro to Chemical Engineering	2-0-0	2
6	BS 10010	Fundamentals of Biological Systems	2-0-0	2
7	BS 19012	Organic Chemistry Lab	0-0-3	2
8	BS19009	Electrical Systems Lab	0-0-3	2
9	EA 10002	EAA – 2	0-0-2	0
		Total	**16-3-9**	**25**

DETAILED SYLLABUS

1. Engineering Mathematics-II

Linear Algebra:

- Algebra of matrices.
- Vector spaces - linear dependence of vectors, basis, linear transformations, rank and inverse of a matrix, solution of algebraic equations - consistency conditions.
- Hermitian, skew Hermitian and unitary matrices, bilinear forms, eigenvalues and eigenvectors Numerical solution of system of linear equations â Gauss, Gauss-Jordan elimination and Gauss-Seidel iteration methods.

Integral Calculus:

- Fundamental theorem of integral calculus, mean value theorems, evaluation of definite integrals - reduction formulae
- Convergence of improper integrals, tests of convergence, Beta and Gamma functions – elementary properties
- Differentiation under integral sign, differentiation of integrals with variable limits - Leibnitz rule.
- Rectification, double and triple integrals, computations of area, surfaces and volumes, change of variables in double integrals - Jacobians of transformations, integrals dependent on parameters - applications.

Vector Calculus:

- Scalar and vector fields, level surfaces, directional derivative, Gradient, Curl, Divergence, Laplacian, line and surface integrals, theorems of Green, Gauss and Stokes, line integrals independent of path.

Numerical Analysis:

- Finite differences, Newtons forward and backward interpolation formulae, central difference interpolation formulae
- Trapezoidal and Simpsons 1/3rd rules for numerical integration
- Solution of polynomial and transcendental equations - bisection, Newton-Raphson and regula-falsi methods.

Reference:

1. Advanced Engineering Mathematics by Kreyszig.

2. Strength of Materials

Concept of stress and strain: Normal stress, shear stress, state of stress at a point, ultimate strength, allowable stress, factor of safety; Normal strain, shear strain, Hooke's law, Poisson's ratio, generalized Hooke's law; Analysis of axially loaded members

Torsion: Torsion of cylindrical bars, torsional stress, modulus of rigidity and deformation. **Flexural loading:** Shear and moment in beams; Load, shear and moment relationship; Shear and moment diagrams; Flexure formula; Shear stress in beams; Differential equation of the elastic curve, deflection of beams

Transformation of stress and strain: Transformation of stress and strain; principal stresses; principal strains; Mohr's circle for stress and strain.

Combined loading: Axial and torsional; axial and bending, Axial, torsional and bending

Column: Buckling of slender columns, Euler bucking load for different end conditions.

Reference:

1. Elements of Strength of Material by Timoshenko and Young (East West Press)

3. Polymers and Surfactants

To provide an overview of polymers with an emphasis of solution polymers, surfactants and its behaviour in aqueous solution, and, the properties of polymer-surfactant solutions which can be used for different industrial applications including the oil and gas industry.

Unit I

- Basics of Polymer: definition, classification, important characterizing properties
- Solution polymer, Surface active polymer
- Rheological behaviour, surface chemistry

Unit II

- Basics of Surfactants: Self-assembly and association, phase behaviour and structure Rheological behaviour, surface chemistry
- Types of surfactants, Mixed surfactant system

Unit III

- Basics of Polymer-surfactant systems: general aspects, associating polymers, phase behaviour
- Surface chemistry, rheological behaviour
- Surfactants and polymers containing oxyethylene groups
- Polymer surfactant systems for different industrial applications

Text Book

1. Surfactants and Polymers in Aqueous solution: Krister Holmberg, Bo Jönsson, Bengt Kronberg, Björn Lindman, 2nd edition, Wiley, 2002

References

1. Surface Chemistry of Surfactants and Polymers: Bengt Kronberg, Krister Holmberg, Bjorn Lindman, Wiley, 2014

2. Chemistry and Technology of Surfactants: Richard J. Farn (Editor), Wiley-Blackwell, 200
3. Handbook of Industrial Water Soluble Polymers: Peter A. Williams (Editor), Wiley-Blackwell, 2007

4. Programming and Data Structure

Introduction to digital computers; Introduction to programming variables, assignments; expressions; input/output; Conditionals and branching; Iteration; Functions; Recursion; Arrays; Introduction to pointers; Character strings; Time and space requirements; Searching and sorting; Structures; Introduction to data-procedure encapsulation; Dynamic allocation; Linked structures. Introduction to data structures â stacks and queues. (A programming language like C/C++ may be used as a basis language. The same language must be used in the laboratory).

Programming & Data Structure LAB:

The topics taught in the classes will also have a practical implementation as well. Therefore, theory is appropriately synchronized with lab experiments. A sample sequence of topics and lab classes are given below:

- Familiarization of a computer and the environment and execution of sample programmes
- Expression evaluation
- Conditionals and branching
- Iteration
- Functions
- Recursion
- Arrays
- Structures
- Linked lists
- Data structures

Reference:

1. Introduction to Algorithms by Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein (MIT Press)

5. Introduction to Chemical Engineering

What is Chemical Engineering

- Impact of chemical engineering and chemical engineering discipline
- The chemical engineering today
- Grand challenges for chemical engineering in the 21st century
- Chemical processing- Definition and its role Chemical Engineering Discipline: Chemical engineering, Energy balance, Material balances, Fluid flow, Mass Transfer/ Heat Transfer, Reaction Engineering, Process control, Thermodynamics

Chemical Engineering Discipline:

- Chemical engineering, Energy balance, Material balances
- Fluid flow
- Mass Transfer/ Heat Transfer
- Reaction Engineering
- Process control
- Thermodynamics

Case studies: Modern Chemical Engineering Process Plants Manufacture of a drug Diversity in the field of application for a chemical engineer

Reference:

1. Introduction to Chemical Engineering S Pushpavanam, Easstern Economy Edition, PHI Learning Pvt Ltd, 2012

6. Fundamentals of Biological Systems

Unit 1: Cellular Biology (10 Lectures) Ultra structure of bacteria, plants and animal cells; cell division, cell cycle and apoptosis; ATP synthesis and Glycolysis; Respiration and photosynthesis.

Unit 2: Chemical Biology (10 Lectures) Proteins: structure and sequencing; Enzymes: mechanism, kinetics and inhibition; DNA: structure and sequence, replication, recombination; RNA synthesis; Genetic code and protein biosynthesis; Recombinant DNA technology.

Unit 3: Bio-Thermo-Fluidics and Transport Processes (8 Lectures) Noncovalent interactions and free energy changes in biological processes; Fundamentals of momentum, heat and mass transport as applied to biological systems; Human body as a thermodynamic system; Blood Rheology, Fluid mechanical aspects of some diseases and organs; Bio-Micro devices.

Unit 4: Impact of Biology on Society and Mankind (2 Lectures) Crop management, Disease control, Biological Hazards and safety; Unsolved Problems in Biology.

Suggested Books:

1. Lehninger Principles of Biochemistry, Nelson and Cox, Biochemistry by Berg, Tymoczko and Stryer, Biochemistry by Voet and Voet, Molecualr Cell Biology by Lodish et al, Molecular Biology of Genes by Watson et al., Gene IX by Benjamin

7. Organic Chemistry Lab

- Identification of organic compounds from a binary mixture by qualitative analysis
- Estimation of glucose/cane sugar. Estimation of base content and acid content of commercially available antacid and vitamin C respectively
- Determination of solubility of solid sample in different solvent
- Recrystallazion of solid compound from a solution
- Esterification reaction
- Extraction
- Chromatographic separation
- Quantitative analysis of organic compound
- Determination of melting point

8. Electrical Systems Lab

- To measure the armature and field resistance of a DC machine. in R-L-C series circuit exited by single phase) AC supply.
- Verification of circuit theorems – Thevenin's and superposition theorems (with DC only).
- Measurement of current, voltage and power
- Open circuit and short circuit tests on a single phase transformer
- Connection and starting of a three phase induction motor using direct on line (DOL) or star – delta starter
- Connection and measurement of power consumption of a fluorescent lamp and voltage – current characteristics of incandescent lamps.
- Determination of open circuit characteristics (OCC) or a DC generator.
- Two wattmeter method of measuring power in three phase circuit (resistive load only).
- Familiarization with electronic components and usage of multimeter
- Familiarization with oscilloscope, signal generator and further usage of multimeters
- Frequency-response and square-wave testing of R-C, C-R and R-L networks
- Voltage Rectifiers2. To calibrate a test (moving iron) ammeter and a (dynamometer) Wattmeter with respect to standard (DC PMMC) ammeter and voltmeters
- Studies on Common-Emitter amplifiers
- Studies on analog circuits using OP-AMP
- Studies on logic gates

SEMESTER III

S. No	Subject code	Subject Name	L-T-P	Credits
1	BS 20001	Transform Calculus, Probability & Statistics	3-0-0	3
2	BS 20007	Numerical Methods	1-0-3	3
3	BS 20002	Fluid Mechanics and Multiphase Flow	3-1-0	4
4	CH 20001	Chemical Process Calculations	3-1-0	4
5	BS 20004	Information Technology	2-0-3	4
6	BS 20005	Innovations Lab	0-0-3	2
7	BS 20006	Workshop	0-0-3	2
8	EA 10003	EAA III	0-0-2	0
		Total	**12-2-14**	**22**

DETAILED SYLLABUS

1. Transform Calculus, Probability & Statistics

Laplace Transform: Definition of Laplace Transform, linearity property, conditions for existence of Laplace Transform. First and second shifting properties, Laplace Transform of derivatives and integrals, unit step functions, Dirac delta-function, error function. Differentiation and integration of transforms, convolution theorem, inversion, periodic functions. Evaluation of integrals by Laplace Transform. Solution of initial and boundary value problems.

Fourier Series: Periodic functions, Fourier series representation of a function, half range series, sine and cosine series, Fourier integral formula, Parseval's identity.

Fourier Transform: Fourier Transform, Fourier sine and cosine transforms. Linearity, scaling, frequency shifting and time shifting properties. Self-reciprocity of Fourier Transform, convolution theorem. Applications to boundary value problems.

Brief Introduction of Z-Transform, and Wavelet Transform.

Probability: Classical, relative frequency and axiomatic definitions of probability, addition rule and conditional probability, multiplication rule, total probability, Bayes' Theorem and independence. Random Variables: Discrete, continuous and mixed random variables, probability mass, probability density and cumulative distribution functions.

Special Distributions: Discrete uniform, Binomial, Geometric, Poisson, Exponential, Gamma, Normal distributions.

Sampling Distributions: The Central Limit Theorem, distributions of the sample mean and the sample variance for a normal population, Chi-Square, t and F distributions

Text and Reference Books:

1. Advanced Engineering Mathematics by Kreyszig
2. Higher Engineering Mathematics by B.S. Grewal
3. Miller & Freund's Probability and Statistics for Engineers by by Richard A. Johnson, Irwin Miller, and John Freund, Prentice Hall India; 8th edition (2010).

2. Numerical Methods

- Numerical errors, Error propagation, Taylor's series. Basic concepts of iteration, convergence, order, and stability.
- Finding roots of equations, minima and maxima of functions (single variable)
- Numerical differentiation and integration of functions, Interpolation and smoothing. Differentiation and integration of discrete data series.
- Matrices, vectors, System of Linear Equations, Gaussian elimination, Gauss-Jordan method, LU decomposition, Iterative methods, Multivariable Methods: Root finding and search for minima and maxima. Linear and nonlinear Least Squares
- Numerical Solution of ODE, system of ODEs and PDEs
- Lab session involves writing of code in C and Matlab

Text and Reference Books:

1. Numerical Methods for Engineers - S. K. Gupta, New Age International
2. Introductory Methods of Numerical Analysis - S S Sastry - Prentice Hall of India
3. Schaum's Outline of Programming With Fortran 77 - Willam Mayo, Martin Cwiakala
4. Schaum's Outline of Theory and Problems of Programming with C++ - John R. Hubbard
5. Numerical Recipes in C++: The Art of Scientific Computing: William H. Press; Cambridhe University Press

3. Fluid Mechanics & Multiphase Flow

- Definition of Fluid, Lagrangian and Eulerian methods of description; Velocity Field: Streamline and stream function, Vorticity, Stress Field; Rheology: Newtonian/non-Newtonian Fluids
- Classification of Fluid Flow: Viscous/Inviscid, Laminar/Turbulent, Compressible/ Incompressible, Internal/External, Rotational/Irrotational
- Fluid Statics: Pressure variation in static fluids, manometer, capillary hydrostatics; Macroscopic mass and momentum balance using integral control volume method, Euler & Bernoulli equations, Internal Incompressible Viscous Flow. Fully developed laminar flow in pipes, Couette and annular flows; Hagen Poiseulle Equation
- Turbulent flow: Eddy viscosity, Universal velocity profile; Skin and Form Friction, friction factor and friction factor versus Reynolds number relation, Calculation of Head Losses in pipes and fittings, Converging and diverging nozzles, Solution of single and multi-path pipe flow systems.
- External Incompressible Viscous Flow: Flow around immersed bodies, Drag and Lift, Drag coefficient
- Flow Devices and Instruments: Valves, Pumps, Compressors, Flow meters (Head/Area): Venturi, Orifice, Rotameter
- Introduction to Hydrodynamics of Gas-liquid flow: Homogeneous flow model, Separated flow model, Bubble formation and dynamics, Mass bubbling and liquid entrainment

Text and Reference Books:

1. Introduction to Fluid Mechanics by R. W. Fox & Alan T. McDonald
2. Fundamentals of Multiphase Flow by C. E. Brennen, Cambridge University Press
3. Fluid Dynamics and Heat Transfer by James G. Knudsen and Donald L. Katz, McGraw-Hill, New York.
4. Coulson & Richardson's Chemical Engineering: Fluid Flow, Heat Transfer & Mass Transfer, Vol.1.

4. Chemical Process Calculations

- Numerical techniques for solving material & energy balance equations.
- Vapor-liquid equilibrium: Bubble point, dew point calculations, phase envelop calculations.
- Material balance with and without chemical reactions, Recycle, bypass, purge calculations, psychometric calculations; computer based calculations
- Introduction to Fuels (solid, liquid and gas): Important properties and specifications,
- Energy balances with and without chemical reactions; fuel calculations, adiabatic flame temperature; computer-based calculations for energy balance

Text and Reference Books:

1. Chemical Process Principles, Part I by O. A. Hougen, K. M. Watson and R. A. Ragatz
2. Basic Principles and Calculations in Chemical Engineering by D. M. Himmelblau.

5. Information Technology

- Fundamental concepts of object oriented programming: Introduction to the principles of object-oriented programming (classes, objects, messages, encapsulation, inheritance, polymorphism, exception handling, and object-oriented containers)
- Object design implementation in a programming language, e.g., C++ or java or Python
- Object oriented database systems: Object oriented data model, query languages, storage organization and indexing techniques; object relational databases

6. Innovation Lab

7. Workshop

- Performing Processes: Casting, forging, rolling, drawing, extrusion, press tool work, plastic moulding and powder metallurgy
- Joining Processes: Welding, brazing and crimping Semi-finishing and finishing processes: Machining (Turning, shaping, drilling, Milling and grinding)
- Non-traditional Processes: Abrasive jet machining, Ultrasonic machining
- Carpentry
- Product Quality: Possible defects and their detection, assessment and remedy

SEMESTER IV

S.No	Subject Code	Subject Name	L-T-P	Credits
1	BS 20003	Advanced Statistical Techniques	3-0-0	3
2	CH 20002	Chemical Engineering Thermodynamics	3-1-0	4
3	CH 20003	Heat Transfer	3-1-0	4
4	CH 20004	Chemical Process Technology	3-0-0	3
5	CH 20005	Chemical Reaction Engineering	3-0-0	3
6	BS 20008	Fluid Flow Lab and Design	0-0-3	2
7	BS 20009	Fuel Lab	0-0-3	2
8	EA 10004	EAA IV	0-0-3	0
		Total	**15-2-9**	**21**

DETAILED SYLLABUS

1. Advanced Statistical Techniques

- Estimation: Unbiasedness, consistency, the method of moments and the method of maximum likelihood estimation, confidence intervals for parameters in one sample and two sample problems of normal populations, confidence intervals for proportions, problems.
- Testing of Hypotheses: Null and alternative hypotheses, the critical and acceptance regions, two types of error, power of the test, the most powerful test and Neyman-Pearson Fundamental Lemma, tests for one sample and two sample problems for normal populations (t, F, Z tests), tests for proportions, Chi-square goodness of fit test and its applications, problems.
- Regression Analysis: Simple linear regression (Description of the model, Least Squares estimation, Properties of the least square estimators, Confidence interval and hypothesis testing for the model parameters, Correlation); Multiple linear regression model (Description of the model, Matrix approach of Least squares, Properties of the least square estimators, Confidence interval and hypothesis testing for the model parameters).
- Design and Analysis of Experiments: Analysis of Variance (One-way classification of fixed effect model, comparing variances, Pair wise comparison), Randomized complete block design, Latin square design, Random effect models. Factorial design, Blocking and confounding. Nested and split plot design. Examples from chemical process.

References:

1. Introduction to Probability and Statistics by J.S. Milton & J.C. Arnold.
2. Introduction to Probability and Statistics for Engineers and Scientists by S.M. Ross.
3. Design and Analysis of Experiments by D C Montgomery, Wiley 2014, Eighth Edition
4. Introduction to the Theory of Statistics by Alexander Mood, Franklin Graybill, Duane Boes.

2. Chemical Engineering Thermodynamics

- Estimation of properties: Real fluids and their mixtures, Algorithms for computer aided property estimation, and their applications to chemical engineering processes.
- Heat effects of industrial reactions: Theory and applications.
- Multiphase processes and multi component equilibria; Chemical reaction equilibria; Thermodynamic analysis of real processes.

Text and Reference Books:

1. Chemical Engineering Thermodynamics by Smith and Van Ness
2. Chemical Engineering Thermodynamics by Y. V. C. Rao
3. Chemical Engineering Thermodynamics by B. G. Kyle
4. Phase Equilibrium thermodynamics by Prausnitz
5. Engineering Thermodynamics by P. K. Nag

3. Heat Transfer

- Mechanisms of heat flow - conduction, convection, and radiation.
- Conduction: Steady and unsteady state one, two and three dimensional conduction equations in different geometries.
- Convection: Dimensional analysis, forced and natural convection.
- Radiation: Stefan Boltzman law, Kirchoff s Law, and their applications, black body, grey body, exchange of radiant heat between grey bodies.
- Furnaces, flame temperature, optimum thickness of insulation.
- Heat exchangers: Classification and design, metallic and non-metallic heat exchangers. Evaporators: Types and design features. Design of natural and forced circulation reboilers-optimization of heat exchanger design; heat exchanger performance evaluation.
- Process design and performance evaluation of Double Pipe, Shell and Tube, Plate, Spiral Heat Exchangers; Process design data sheets.
- Heat pumps.

Text and Reference Book:

1. Process Heat Transfer by D. Q. Kern
2. Heat Transfer by J. P. Holman
3. Unit Operations by G. G. Brown, CBS
4. Unit Operations of Chemical Engineering by W. L. McCabe, J. C. Smith and P. Harriott
5. Process Heat Transfer Principles & Applications by R.W. Serth, Academic Press.

4. Chemical Process Technology

- Scope of CPT in process industries; Introduction of CPT with reference to Indian resources, industries, trade and export potentials, small-scale industries and rural development.
- Major process symbols, preparation of process flow diagrams, and piping and instrumentation diagrams.
- Introduction to the following industries (including the special features of design and operation) : Fuel and industrial gases including natural gas; petrochemical and downstream industries (in brief); polymer industries; fertilizer industries; caustic-chlorine industries; coal based chemical industries; petroleum refining processes (in brief) and allied industries including additives; nitrogen and nitrogen derivatives industry; sulphur and sulphur derivatives industry;

phosphorus and its derivatives industry; soap and detergent industry; pulp and paper industry; alcohols and allied chemicals industry; other important basic and specialty chemicals industry.

- Process Software

Text and Reference Books:

1. Shreve's Chemical Process Industries by G.T. Austin, Tata McGraw Hill.
2. Dryden's Outlines of Chemical Technology by M.G. Rao, East West Press.

5. Chemical Reaction Engineering

Rate laws and stoichiometry; Isothermal reactor design- Batch, plug flow and mixed flow; Chemical reactor analysis; Ideal and non-ideal flow in reactors, Residence time distribution; Non-isothermal reactors, steady state multiplicity; Reactor design.

Text and Reference Books:

1. Chemical Reaction Engineering by Octave Levenspiel
2. Chemical Engineering Kinetics by J. M. Smith
3. Elements of Chemical Reaction Engineering by H. S. Fogler

6. Fuel Lab

ASTM distillation, Reid vapour pressure (RVP), Gum content (existent), Smoke point, Aniline point, Flash point, Moisture content by Dean & Stark method, Kinematic viscosity by Dynamic viscosity; Redwood viscometer, Pour point, Conradson / Ramsbottom Carbon residue, Rotational viscometer. Gaseous fuels: Orsat analysis, Calorific Value by Junkers calorimeter. Gas chromatography

7. Fluid Flow Lab and Design

- Bernoulli s experiment; Flow through square and circular pipes; horizontal nozzles; pipe fittings; V-notch, packed bed; Venturi meter, orifice meter; rotameter; pitot tube; Pipe flow Viscometer; Characteristics of centrifugal pump.
- Two phase flow.
- Design studies on valves, pipe fittings and piping network.
- Mechanical design of pressure vessel, flange, reinforcement for opening, support.

SEMESTER V

S. No	Subject Code	Subject Name	L-T-P	Credits
1	BS 30001	Industrial psychology & Professional Ethics	2-0-0	2
2	CH 30001	Mass Transfer I	3-1-0	4
3	CH 30002	Reaction Engineering II	3-1-0	4
4	BS 30002	Instrumentation and Process Control	3-1-0	4
5	CH 30003	Particle Technology	2-0-0	2
6	CH 30006	Bio Chemical Engineering	3-1-0	3
7	CH 30009	Reaction Engineering Laboratory	0-0-3	2
8	CH 30004	Heat Transfer & Particle Technology Lab	0-0-3	2
		Total	**16-4-6**	**23**

DETAILED SYLLABUS

1. Industrial Psychology & Professional Ethics

- Understanding human experience and behavior: Definition, schools, methods, branches and application of Psychology for Engineers.
- Basic Psychological Processes:
- Intelligence, Thinking, Attention, Learning
- Motivation and Emotion: Theories, Motivating people at Workplace
- Personality: Definition, Approaches and Theories
- Psychological Disorders, Mental health and Workplace
- Psychological Problems of Everyday Life: Stress and coping
- Introduction to Psychometric and types of tests
- Attitude and work behavior, Group dynamics, Intergroup relations, conflict resolution.
- Industrial Psychology and Organizational Behaviour: Concepts, Hawthorne Studies, Application, Personnel Selection, Job satisfaction
- Leadership and Management
- Professional Ethics (includes code of conduct)

Texts Books:

1. Baron, R.A. (2001). Psychology. Prentice-Hall of India Private Limited.
2. Blum, M.L. and Naylor, J.C. (1984). Industrial Psychology. New Delhi. CBS Publishers and Distributors.

Reference Books

1. C. T. Morgan, R. A. King, J. R. Weiss and J. Schopler. (1986). Introduction to Psychology.7th ed. McGraw Hill.
2. Newstrom, J.W. & Davis, K. (2002). Organizational Behaviour- Human Behaviour at Work. New Delhi. Tata McGraw-Hill Pub. Co. Ltd.
3. Schultz, D. P., & Schultz, E. S. (2008). Psychology and Work today. Newyork. Mac Milan publishing company.

2. Mass Transfer I

Fundamentals of mass transfer: Diffusional mass transfer, mass transfer coefficients, steady state and unsteady state theories of mass transfer, interphase mass transfer, Whitman's two film theory and its variations, multiphase contacting equipments, concept of transfer unit, unified approach to staged processes.

Distillation: Vapour-liquid Equilibrium, x-y, T-x-y, P-x-y and H-x-y diagrams; Henry's, Raoult's and Dalton's Laws; Ideal and Non-ideal solutions, Azeotropes; Relative Volatility; Flash Vaporization; Differential Distillation; Steam Distillation; Continuous Rectification â Staged Calculation using Ponchon-Savarit and McCabe-Thiele Methods; Complex/Multi-draw Configuration; Packed Distillation Column; Multicomponent Distillation; Azeotropic and Extractive Distillations; Performance Evaluation of Distillation Columns including Reboilers and Condensers.

Absorption: solubility, choice of solvent, concept of rate approach and stagewise approach, stage-wise and continuous contact absorbers; rich and lean gases; absorption with chemical reaction. Counter-current and co-current multistage operations, dilute and concentrated systems, process design and performance evaluation of absorbers.

Humidification/Dehumidification: Definitions, Psychometric chart, Adiabatic saturation and wet-bulb temperatures, Adiabatic and non-adiabatic operations, Dehumidification, Mass and heat balances in bulk and at interfaces, Spray chamber, Cooling towers - counter-current, co-current and cross-current, Performance evaluation of cooling towers, Principles of air conditioning.

Text Book:

1. R. E. Treybal, Mass Transfer Operations, McGraw Hill Education 2017.
2. W. L. McCabe, J. C. Smith and P. Harriott, Unit Operations of Chemical Engineering, McGraw Hill Education 2017.
3. E. I. Cussler, Diffusion: Mass Transfer in Fluid Systems, Cambridge University Press 2009.

Reference Book:

1. J.F. Richardson, J. H. Harker, and J. R. Backhurst, Coulson &Richradson's Chemical Engineering, Volume 2 Butterworth-Heinemann 2002.
2. W. M. Kays, M. E. Crawford, Convective Heat and Mass Transfer, McGraw Hill 1993.
3. Transport Processes and Unit Operations by C. J. Geankoplis.
4. A. H. P. Skelland, Diffusional Mass Transfer, Krieger Publishing Company, 1985.

3. Reaction Engineering II

- Multiphase reactions: Introduction to heterogeneous reactions and effects of mass and heat transfer. Gas-Liquis, Liquid-Liquid, Gas-Solid, Solid-Liquid-Gas reactions.
- Catalyst preparation and characterization. Mechanism of catalytic reactions, Rate equations for solid catalyzed fluid phase reactions, External mass and heat transfer in catalyst particles, Effectiveness factor, Deactivation of catalyst.
- Models of Industrial Reactors (Packed bed, slurry, trickle bed, fluidized bed): Pressure Drop considerations, Heat management.

Text Book:

1. J. M. Smith,Chemical Engineering Kinetics, McGraw Hill 1981.

Reference Book:

1. H.S.Fogler, Elements of Chemical Reaction Engineering, Prentice Hall India 2008.
2. O. Levenspiel, Chemical Reaction Engineering, John Wiley & Sons 1998.

3. K. R. Westerterp, W. P. M. Van Swaaij and A. A. C. M. Beenackers, Chemical Reactor Design and Operation by Wiley Blackwell 1987.
4. G. F. Froment, K. B. Bischoff, and J.D. Wilde,Chemical Reactor Analysis and Design,John Wiley & Sons 2010.

4. Instrumentation and Process Control

Instrumentation:

- Static and dynamic characteristic of instruments.
- Measurement of temperature, pressure, vacuum, fluid flow rate, level and control valves.

Process Control:

- Modeling considerations for control purposes.
- State Space and Transfer function models.
- Dynamic behavior of first and higher order systems.
- Concept and dynamic behavior of feedback control. Frequency response analysis. Stability analysis of feedback systems. Design of feedback controllers.
- Feedforward, Ratio, Adaptive and inferential control, dead-time and inverse response compensator.
- Control systems with multiple loops.

Text/Reference Books:

1. G. Stephanopoulos, Chemical process control: An introduction to theory and practice, Prentice Hall India 2008.
2. D. E. Seborg, T. F. Edgar, D. A. Mellichamp, & F.J. Dyle III, Process dynamics and control, Wiley 2010.
3. D. Patranabis, Principles of industrial instrumentation, Tata McGraw Hill 2008.

5. Particle Technology

- Determinations of mean particle size, Size distribution equations. Particle size reduction and enlargement. Inter-particle forces.
- Principles and laws of crushing and grinding. Characteristics of industrial crushers and mills.
- Industrial screening, effectiveness of screens, cyclones.
- Fluid-particle mechanics, free and hindered settling. Industrial classifiers, clarifiers and thickeners, gravity separation, tabling and jigging. Floatation and its kinetics, magnetic and electrostatic separation and precipitation.
- Mixing of liquids and solids, power requirement in mixing.
- Principles of filtration, filtration equipments.
- Flow through packed and fluidized bed. Introduction to storage and conveying, elevating equipments, hydraulic and pneumatic transport.

Text Book:

1. W. L. McCabe, J. C. Smith and P. Harriott, Unit Operations of Chemical Engineering, McGraw Hill Education 2017.
2. J.F. Richardson, J. H. Harker, and J. R. Backhurst, Coulson &Richradson's Chemical Engineering, Volume 2 Butterworth-Heinemann 2002.
3. A. M. Gaudin, Principles of Mineral dressing, McGraw Hill 1939.

Reference Book:

1. D.W. Green, and R.H. Perry, Perry's Chemical Engineer's Handbook, McGraw Hill Education 2007.
2. A. F. Taggart, Handbook of Mineral Dressing: Ores and Industrial Minerals, John Wiley & Sons 1954.

6. Biochemical Engineering:

Overview of Biotechnology; Kinetics of Enzyme Catalysis; Immobilized Enzymes: effects of intra and inter-phase mass transfer on enzyme kinetics; Major Metabolic Pathways: Bioenergetics, Glucose Metabolism, Biosynthesis; Microbial Growth: Continuum and Stochastic Models; Design, Analysis and Stability of Bioreactors; Kinetics of Receptor-Ligand Binding; Molecular Genetics and Regulation of Gene Expression; Purification and Bio-product Recovery; Manufacture of Biological Products.

Text Books:

1. M.L. Shuler, and F Kargi, Bioprocess Engineering: basic concepts, Prentice Hall 2001.

Reference Books:

1. H.W. Blanch, and D.S. Clark, Biochemical Engineering,CRC Press 1997.
2. N S Mosier, and M.R Ladisch, Modern Biotechnology: Connecting Innovations in Microbiology and Biochemistry to Engineering Fundamentals, Wiley-AIChE 2009

7. Reaction Engineering Lab

- Study of liquid phase homogenous reaction in Batch /Plug flow/Three Staged Mixed reactors,
- Development of rate equations for catalytic gas solid reaction,
- Evaluation of mass transfer coefficient in an agitated contactor,
- Catalytic reaction studies in Berty Reactor,
- RTD studies for water flowing in a tubular reactor with packing/without packing.

8. Heat Transfer and Particle Technology Lab

Experiments on particles: Ball mill performance, roll crusher performance, performance of different types of classifiers, jaw crusher performance, determination of permeability, sampling, solid feeders performance, grind ability tests.

Heat Transfer experiments: Thermal conductivity of metal rod, overall heat transfer co-efficient in a vertical condenser, natural convection, critical heat flux, overall heat transfer co-efficient in horizontal condenser, heat transfer co-efficient in double pipe heat exchanger, composite wall.

SEMESTER VI

S.No	Subject Code	Subject Name	L-T-P	Credits
1	CH 30005	Mass Transfer II	3-1-0	4
2	CH40002	Transport Phenomena	3-1-0	4
3	CH 30007	Computer Aided Process Engineering	1-0-3	3
4	CH 30008	Process Equipment Design	2-0-4	4
5		Elective - I	3-0-0	3
6	BS 30003	Economics	2-0-0	2
7	BS 30004	Instrumentation and Process Control Laboratory	0-0-3	2
		Total	**14-2-10**	**22**

DETAILED SYLLABUS

1. Mass Transfer II

- Drying: Theory and mechanism of drying, Batch and continuous drying; Drying rate curves, Estimation of drying times, Cross-circulation and through-circulation drying, Transfer unit concept in drier, Design calculations with special reference to rotary and spray driers,
- Liquid-Liquid Extraction: Ternary liquid equilibria, Partial miscibility, Solvent selection, Cross-current and counter-current multistage extraction, Extraction with reflux, Extraction equipment, Performance evaluation of extractors.
- Leaching: Solid-liquid equilibria, Single and multistage, Cross-current and countercurrent leaching, Steady state and unsteady state operations, Operation and performance evaluation of leaching equipments.
- Adsorption and Ion Exchange: Adsorption equilibria - Various isotherms, Breakthrough curves, Ion exchange equilibria, Contact filtration, Design of adsorbers and ion exchangers, Chromatography.
- Membrane Separations: Reverse osmosis, Dialysis, Microfiltration, Ultrafiltration; Pervaporation, Separation of gases and liquids.
- Crystallization: Theory of solubility Crystallization, phase diagram (temp/solubility relationship), crystal geometry; crystal nucleation and growth; equilibria and yields.

Text Books:

1. R. E. Treybal, Mass Transfer Operations, McGraw Hill Education 2017.
2. W. L. McCabe, J. C. Smith and P. Harriott, Unit Operations of Chemical Engineering, McGraw Hill Education 2017.
3. E. I. Cussler, Diffusion: Mass Transfer in Fluid Systems, Cambridge University Press 2009.

Reference Books:

1. J.F. Richardson, J. H. Harker, and J. R. Backhurst, Coulson & Richradson's Chemical Engineering, Volume 2 Butterworth-Heinemann 2002.
2. W. M. Kays, M. E. Crawford, Convective Heat and Mass Transfer, McGraw Hill 1993.
3. Transport Processes and Unit Operations by C. J. Geankoplis.
4. A. H. P. Skelland, Diffusional Mass Transfer, Krieger Publishing Company, 1985.

2. Transport Phenomena

Brief revision on 'Transport by molecular motion: Newtons Law of viscosity, Fourier's law of heat conduction, Ficks law of diffusion. Transport in laminar flow or in solids in one dimension: development of continuity (conservation) equations, velocity, temperature and concentration profiles, momentum, energy and mass fluxes. Equations of change for isothermal, non-isothermal and multicomponent systems.'

Navier-Stokes equation, equation of energy, equations of motion for free and forced convection (heat/mass). Unsteady state viscous flow, heat conduction and mass diffusion. Momentum, energy and mass transport in boundary layer with relevant analogies. Transport in turbulent flow: time-smoothened equations of change. Interphase momentum, heat and mass transfer.

Text Book:

1. Transport Phenomena by Bird, Stewart and Lightfoot
2. Introduction to Heat and Mass Transfer by Incropera and Dewitt
3. Fluid Mechanics by Fox and McDonald
4. Diffusion: Mass Transfer in Fluid Systems by E. L. Cussler

3. Computer aided Process Engineering

Review of numerical methods using Chemical Engineering applications - solution of linear and non-linear algebraic equations, solution of coupled ordinary differential equations using Matlab. Importance of VLE/ LLE calculations for process simulation. Process modeling and simulation, Information Flow diagram, modeling of different process equipment - heat exchangers, boilers, evaporator, L-L extraction, furnaces, flash drum, distillation, absorption, other staged / differential contacting processes, reactors etc. Process flowsheeting and simulators - Simulator components and structures, Salient features of simulators like ASPEN etc. Industrial Automation-Real time systems.

Text Books:

1. S.K. Gupta, Numerical Methods for Engineers. New Age International Publishers (2015).
2. R.G.E. Franks, Modeling and simulation in chemical engineering, Wiley Blackwell 1972.
3. R. Smith, Chemical process: design and integration, Wiley 2005.

Reference Books:

1. N. Kaisari, Computational techniques for process simulation and analysis using Matlab. CRC Press (2017).
2. F. Ramirez, Computational methods for processes simulation, Butterworth-Heinemann 1998.
3. J.S.R. Jang, C.T. Sun, and E.Mizutani, Neurofuzzy and soft computing: A Computational Approach to Learning and Machine Intelligence, Pearson 1996.
4. A.K.Jana, Chemical process modeling and computer simulation, Prentice Hall India Learning Private Limited 2011.
5. S. Rajasekaran, and G.A.V. Pai, Neural network, fuzzy logic and genetic algorithms: synthesis and applications, Prentice Hall India Learning Private Limited 2003.

4. Process Equipment Design

- Process and mechanical design of Heat Transfer Equipments: Heat Exchangers -with and without phase change (shell and tube / double pipe / other types), Reboilers, Evaporators.
- Binary distillation: process and equipment design of bubble-cap tray column.
- Gas Liquid Absorber (absorption without chemical reaction): process and equipment design of packed column. Cooling tower design, Crystalliser design, Design of driers.

Text Book: Books suggested for **Heat Transfer** and **Mass Transfer I.**

Reference Book:

1. D.W. Green, and R.H. Perry, Perry's Chemical Engineer's Handbook, McGraw Hill Education 2007.
2. L. E. Brownell and E.H. Young Process Equipment Design, Wiley 2009.
3. B.C. Bhattacharya, Introduction to Chemical Equipment Design: Mechanical aspects, CBS Publi 2008.
4. V.V. Mahajani, S.B. Umarji, Joshi's Process Equipment Design, Laxmi Publications 2016.

6. Economics

Introduction, Demand and Supply Analysis, Production and Cost, Price Output Determination, Capital Market and Investment Decisions, Outline of Welfare Economics, Resource Accounting and Sustainability, Income Determination and Fluctuations, Trade, Aid and Development. Economic Systems & Indian Economic Policies.

Geopolitics and world petroleum market; role of OPEC, national oil companies and bilateral contracts; Fundamentals of petroleum business – strategic issues. Dynamics of petroleum pricing; Financial measures and profitability analysis; Risk, uncertainty, and decision analysis; Implications of fiscal and trade policies and regulations for petroleum industry

Text Books

1. Contemporary Engineering Economics, by, Chan S. park, Prentice Hall of India (PHI), 3rd Edition
2. Petroleum Economics and Engineering, by, Abdel Aal, Bakr, and, Al-Sahlavi, 2nd edition
3. Economics of worldwide Petroleum Production, by, Richard D. Seba, 3rd Edition

Reference Books

1. Principles of Economics, by, Samuleson and Nordhaus
2. Principles of Economics, by, N. G. Mankiw
3. Engineering Economics, by, R. Paneerselvam, PHI
4. Petroleum Economics, by, Masseron Jean, 4th edition

7. Instrumentation and Process Control Laboratory

- Calibration experiments on thermocouple, resistance thermometer, thermistor.
- Study and calibration of flapper nozzle assembly, pneumatic and electronic DP transmitter, I/P and P/I converters.
- Studies on control valve characteristics.
- Experiments on Dynamic behavior for interacting and non-interacting tank level system, and temperature control (integrated system).
- Control performance studies on pressure process, tank level system, heat exchanger.

SEMESTER VII

S.No	Subject Code	Subject Name	L-T-P	Credits
1		Elective II	3-0-0	3
2	BS 40002	Data Analytics and AI for Process Industry	3-0-0	3
3	CH 40001	Project Engineering and Management	3-0-0	3
4	BS 40001	Process Safety	1-0-0	1
5	BS 48001	Industrial Training	0-0-0	2
6	CH 40003	Mass Transfer Lab	0-0-3	2
7	BS 47001	Project I	0-0-6	4
		Total	**10-0-9**	**18**

DETAILED SYLLABUS

2. Data Analytics and AI for Process Industry

Languages of Data Science: R, Excel, SQL, Python, and Tableau; Introduction to Data Warehousing and OLAP; Data Preparation and Visualization; Descriptive Statistics: central tendency and variability; Inferential Statistics: Probability, Central Limit Theorem; Exploratory Data Analysis; Hypothesis Testing; Linear Regression; Classification: KNN, Naive Bayes and Logistic Regression; K-Means and Hierarchical clustering; Time Series; Decision Trees; Support Vector Machines; Neural networks; Association Rule Mining; Introduction to Big Data And Hadoop; Managing Big Data: Hadoop Ecosystem tools (Sqoop and Hive); Introduction to Spark; Big Data Analysis using SparkR, SparkSQL; Case Studies; Spatial Data Model; Visualization and Query of Spatial Data; Subsurface Mapping and Correlation and applications.

Text/Reference Books

1. Thomas A. Runkler, Data Analytics: Models and Algorithms for Intelligent Data Analysis. Springer 2012.
2. Wes McKinney, Python for Data Analysis. O'Reilly 2013.
3. Keith R. Holdaway, Harness Oil and Gas Big Data with Analytics: Optimize Exploration and Production with Data-Driven Models. Wiley (2014).
4. Robert Haining, Spatial Data Analysis: Theory and Practice. Cambridge University Press (2003).

3. Project Engineering and Management

Stages of Project Implementation; Project Milestone: Planning, Analysis, Selection, Implementation; Generation and Screening of project ideas. Feasibility studies. Project Analysis and introduction to various component of Project cost and their estimation; Elements of Coat of Project, Cost of Production; Financing of projects: Debt-Equity ratio etc. Depreciation concept,

Capital cost estimation, Working capital estimation, Project Evaluation, break-even analysis, ROI, IRR., Discounted cash flow analysis. Project Management and Scheduling, Network Technique for project management: CPM and PERT, Project Risk Assessment, Social Cost benefit analysis, Venture capital and Private Equity.

Text Book:

1. Projects: Planning, Analysis, Selection, Financing, Implementation, and Review by P. Chandra
2. Plant Design and Economics for Chemical Engineers by M. S. Peters and K. D. Timmerhaus
3. Project Engineering of Process Plants by H.F. Rase Cyber physical systems
4. Manufacturing and control systems technology management by Ditlonoller Springer Publications
5. Michael E. Hanyak Jr, Chemical Process Simulation and the Aspen HYSYS v8.3 Software Cretespace (2013).
6. A.K. Jana, Process Simulation and Control using Aspen. Prentice Hall India (2012).

4. Process Safety

- Safety in chemical industry; Setting & layout of chemical plant.
- Forms of hazards: chemical, toxic, explosion, electrical, mechanical, radiation, noise hazards.
- Control and prevention of hazards.
- Asphyxiation, respiratory and skin effect of petroleum hydrocarbons, sour gases. Thresh-hold limits.
- Analysis of documented accidents: emission from Leaks, free jets, Pool formation and vaporization, dispersion in atmosphere, fires and explosions, boiling liquid expanding vapour explosion (BLEVE), dust explosion.
- Characteristics of chemical with special reference to safe storage & handling.
- Layout of storage, modes of transport, associated hazards control and prevention.
- Safety audit: objective, procedure, engineering standards, Factories Act and Regulation, regulating agencies.
- Offshore safety.
- Safety and Environmental Management Systems, SEMS
- Risk Analysis: hazard and operability (HAZOP) studies. hazard analysis (HAZAN), fault tree analysis, consequence analysis, scenario and probabilistic assessment.
- Onshore and Offshore Emergency Management Plans.

Text / Reference Books:

1. David S. Gloss and Miriam Gayle ardle, Introduction to Safety Engineering. John Wiley and Sons, New York (1984).
2. Phil Hughes and Ed Ferrett, Introduction to Health and Safety at Work. Elsevier (2009).
3. Recommended Practice for Development of a Safety and Environmental Management, API (2004).
4. Program for Offshore Operations and Facilities, 3rd ed. API RP 75. API, Washington D.C.
5. Ian Sutton, Offshore Safety Management Implementing a SEMS Program. Elsevier (2014).
6. Ulrich Hauptmanns, Process and Plant Safety. Springer(2013).
7. Genserik L.L. Reniers, Multi-Plant Safety and Security Management in the Chemical and Process Industries(2010).

6. Mass Transfer Laboratory

Determination of Diffusion Coefficient of Air-Acetone By Stefans method, T-X-Y equilibrium diagram for binary mixture, Batch Distillation, Sieve Plate Distillation, Packed Bed Distillation Column, Flooding and Loading in Packed Tower, Water Cooling Tower, Liquid-Liquid Extraction, Rotating Disk Contactor, Liquid-Liquid Extraction in Sieve Plate Column, Drying Characteristics of Wet Solids in Flowing Air, Rotary Drier (Hold-Up), Rotary Drier (Drying Characteristics of Wet Solids), Gas-Solid Adsorption.

SEMESTER VIII

S. No	Subject Code	Subject Name	L-T-P	Credits
1	CH 40005	Process Integration and System Design	3-1-0	4
2		Elective III	3-0-0	3
3		Elective IV	3-0-0	3
4		Elective V	2-0-0	2
5	BS 47002	Project II	0-0-9	6
6	BS 48002	Comprehensive Viva-Voce	0-0-0	2
		Total	**11-2/1-9**	**20/21**

DETAILED SYLLABUS

1. Process Integration and System Design

- Process Flow Sheet in Aspen plus and Aspen HYSYS.
- Pinch technology and its application; Heat exchanger networks: analysis and design for maximum energy recovery, Loop Breaking & Path Relaxation, targeting of energy, area, number of units and cost, Trading off energy against capital.
- Network Integration: Super targeting, maximum energy recovery, multiple utilities and multiple pinches, Grand Composite curve.
- Mass integration: Distillation sequences. Graphical and numerical targeting methods of mass exchanger network.
- Water integration, targeting and network design. Property integration.
- Introduction to optimization; Separation scheme synthesis and residue curve theory; Non-linear programming, mixed integer and disjunctive programming, flow sheet optimization; scheduling of batch and continuous multistage plants. Case Studies: Refinery scheduling and blending, multi-site production-planning. Supply chain optimization.

Text / Reference Books

1. Linnhoff, D.W., User Guide on Process Integration for the Efficient Use of Energy, Institution of Chemical Engineers (1994).
2. Smith, R., Chemical Process Design and Integration, John Wiley & Sons (2005).

3. T. F. Edgar, D. M. Himmelblau and L. S. Lasdon, Optimization of Chemical Processes, 2nd Ed., McGraw Hill, New York, 2001
4. G. Towler and R. K. Sinnot, Chemical Engineering Design, Elsevier, Oxford, UK
5. S. Thakore and B. Bhatt, Introduction to Process Engineering Design, Tata McGraw Hill, New Delhi, India, 2008.
6. W. D. Seider, J. D. Seader, D. R. Levin and S. Widagdo, Product and Process Design Principles: Synthesis, Analysis and Design, 3rd Ed.; Wiley, New York, 2009.
7. B. V. Babu, Process Plant Simulation, Oxford University Press, New Delhi, 2004.
8. Shenoy, V. U., Heat Exchanger network synthesis, Gulf Publishing (1995).
9. Kumar, A., Chemical Process Synthesis and Engineering Design, Tata McGraw Hill (1977).
10. Kamal I.M. Al-Malah, Aspen Plus: Chemical Engineering Applications Wiley (2016).
11. Michael E. Hanyak Jr, Chemical Process Simulation and the Aspen HYSYS v8.3 Software Cretespace (2013).
12. A.K. Jana, Process Simulation and Control using Aspen. Prentice Hall India (2012).

ELECTIVES

Elective I	Unconventional Hydrocarbon Resources	Bio Energy	Waste Water Management	Management Techniques for Industrial Sector
Elective II	Enhanced Oil Recovery	Solar Energy, Photovoltaic Energy	Advanced Separation	Advanced Material Design
Elective III	Offshore and Deep sea technology	Nuclear wind and geothermal energy	Hazardous Waste treatment and safety devices	Analytical Techniques
Elective IV	Advanced Reservoir Modelling	Petroleum Refinery Engineering	Air Pollution	Tribology & Introduction to Lubricants
Elective V	Prospecting, Filed Development and Asset Management	Petrochemical Technology	Nano Materials for Hydrocarbon Industry	Process Modelling and Simulation

Note: **Electives will be offered based on the availability of resource person**

ELECTIVES – I

1. Unconventional Hydrocarbon Resources (PE 30010)

- **Coalbed Methane:** Introduction, formation and properties, exploration, isotherm studies, reserve estimation, drilling and production system, artificial lift, hydraulic fracturing of coal seam, produced water separation and disposal, surface facilities, well testing.
- **Natural Gas Hydrates:** Introduction, formation and properties, thermodynamics, kinetics and phase behavior, gas extraction methodologies.
- **Shale Gas/ Oil:** Introduction, geology, important occurrences, petrophysical properties, hydro fracturing, horizontal wells, production profiles.
- **Non-Conventional Oil:** Introduction to Heavy oil, extra heavy oil, Tar Sand and bituminous, oil shales; origin and occurrence worldwide, resources, reservoir characteristics, new production technologies.
- **Others:** Coal conversion to gas, underground coal gasification

Reference Books:

1. Carrol J., Natural Gas Hydrates: A guide for engineers, Gulf Professional Publishing 2011.
2. Warner H.R, Jr. (ed), Petroleum Engineering Handbook Vol. VI, Emerging and Peripheral Technologies, SPE 2007.
3. Thakur P., Aminian K., Schatzel S. (ed) Coal Bed Methane: From Prospects to Pipeline, Elsevier 2014.
4. Islam M.R., Unconventional Gas Reservoirs: Evaluation, Appraisal, and Development, Gulf Professional Publishing 2014

2. Bioenergy

Introduction to Bioenergy; Current status, merits & demerits. Feedstock: starch, oilseed, lignocellulogic and algae based, fuel logistics of Biomass, Biological conversion technologies, enzyme hydrolysis, ethanol fermentation, comparisons of fossil fuels and bio fuels, Fundamentals of anaerobic digestion, Microbial fuel cells, Bio-refinery, Economic, Social and Ecological Impacts of Bioenergy at Local, National and Global Levels, Life cycle assessment, current and emerging challenges to bioenergy development, Govt policies and standards.

Text Books:

1. Y. Li, and S. K. Khanal, Bio Energy: Principles & Applications: Wiley-Blackwell 2016.
2. S. Lee, and Y T Shah, Bio Fuels and Bio Energy: Processes and Technologies, CRC Press, 2012

3. Wastewater Management (CH 30010)

Introduction to water and wastewater engineering, Methods for characterisations of wastewater properties, physical, chemical and biological process for wastewater treatment, primary, secondary and tertiary treatment including suspended growth and attached growth methods. Advanced oxidations process for removal of recalcitrant components in wastewater, nutrient removal, sludge treatment and its removal, progress in zero-discharge techniques. Case studies related to treatment of Industrial and municipal effluents, standards and regulations.

Text Books:

1. W. Eckenfelder (Jr.) Industrial Water Pollution Control, McGraw Hill 1999.
2. G. Tchobanoglous, F.L. Burton, and H.D. Stensel, Wastewater Engineering Treatment and Reuse (Metcalf & Eddy),McGraw Hill 2002.
3. A. P. Sincero and G.A. Sincero

4. Management Techniques for Industrial Sector

---------- Will be offered later ----------

ELECTIVES - II

1. Enhanced Oil Recovery

- General classifications and description of EOR processes; Microscopic displacement of fluids in a reservoir; Mobilization of trapped phases—alteration of viscous/capillary force ratio, Role of phase behavior.
- Waterflood performance—frontal-advance equations; Viscous waterflood in a linear system; Chemical flooding in a linear system; displacement of slugs, dispersion during miscible displacement; Viscous Fingering - Instability in Displacement Fronts; Volumetric Displacement Efficiency
- Mobility Control Processes: Physical and Chemical Characteristics of Polymers, Flow of Polymers Through Porous Media, Polymer-Augmented Waterflood, In-Situ Permeability Modification, Field Experience; Mobility Control To Maintain Chemical Slug Integrity; Foam as an EOR Agent; WAG Process.
- Miscible Displacement Processes: Principles of Phase Behavior Related to Miscibility, FCM and MCM Process, Measurement and Prediction of the MMP or MME in a Multiple-Contact Process, Performance Modeling, CO_2 Injection, Design Procedures and Criteria, Field Experience.
- Chemical Flooding: Micellar/Polymer Process, Surfactants, microemulsions, Phase Behavior and IFT, Displacement Mechanisms, Surfactant Loss from Rock/Fluid Interactions and Phase Partitioning, Performance Modeling, Design Procedures and Criteria, Field Experience. Alkaline Flooding
- Thermal Recovery Processes: Heat Losses During Steam Injection, Cyclic Steam Stimulation, Reservoir Heating by Steam Injection, Cyclic Steam Stimulation of a Gravity-Drainage Reservoir, Estimation of Heated Radius, Estimation of Oil Recovery from Steamdrive, Production of Bitumen by Steam Injection, In-Situ Combustion

Text / Reference Book:

1. Don W. Green and G. Paul Willhite, Enhanced Oil Recovery. Society of Petroleum Engineers (2018).
2. Larry W. Lake, Russell Johns, Bill Rossen, Gary Pope, Fundamentals of Enhanced Oil Recovery. Society of Petroleum Engineers (2015).

2. Solar Energy, Photovoltaic Energy

Introduction; Nature and availability of solar energy; Principle of operation of solar cells – materials and processing, thin film, unconventional materials and systems; Concentrators; Cells and system characteristics; Power conditioning, energy storage, and grid connection; Maximum power point tracking, PV to grid – single and three phases; Economy and Life cycle costing. Solar thermal energy.

Water pumping: dc and ac pump drive; Peltier refrigeration.

Text/Reference Books:

1. Hans S. Rauschenbach, Solar Cell Array Design Handbook: The Principles and Technology of Photovoltaic Energy Conversion. Springer (2013).
2. C. Hu and R.M. White, Solar Cells: From Basic to Advanced Systems. McGraw Hill (1983)

3. Advanced Separation

- Thermodynamics: Phase equilibria, non-ideal thermodynamic property models, activity coefficient models for the liquid phase; Single equilibrium stages: Multicomponent liquid-Liquid, Solid-Liquid, Gas-Liquid, Vapor-Liquid-Liquid systems.
- Multicomponent multistage separations: Approximate methods, Equation tearing procedures.
- Enhanced distillation; Supercritical extraction.
- Vapor-liquid flow pattern and rate based models for distillation.
- Membrane separations; Adsorption, ion exchange, and chromatography.

Text/Reference Books

1. Charles Holland, Fundamentals of Multicomponent Distillation. McGraw Hill (1997)
2. J. D. Seader and E.J. Henley, Separation Process Principles. Wiley (2006).

4. Advanced Materials Design

Materials characterization using optical and neutron spectroscopies; Multiscale atomistic modeling; Use of density functional theory to predict temperature dependent thermodynamic properties of new materials e.g., complex hydrides, and kinetic processes in diffusion; Introduction to molecular simulations; Semiconductor and oxide nanostructure for optoelectronic devices, high energy solar cells; Quantum dots; Thermoelectric materials.

Text/Reference Books

1. Edward L. Wolf, Nanophysics and Nanotechnology. Wiley Verlag (2006).
2. Peter Würfel, Physics of Solar Cells: From Basic Principles to Advanced Concepts. Wiley (2009).
3. Charles Kittel, Introduction to Solid State Physics. Wiley (2012).
4. D. C. Rapaport, The Art of Molecular Dynamics Simulation. Cambridge University Press (1995).

ELECTIVES – III

1. Offshore and Deep Sea Technology

- Offshore oil and gas operations and ocean environment. Sea floor marine soils, Geotechnical aspects. Various forces acting on offshore structure; Stability of offshore structure.
- Offshore fixed platforms, mobile units, Station keeping methods like mooring & dynamic positioning system.
- Offshore drilling from fixed platform, jack-up, ships and semi submersibles. Use of conductors and risers. Well completion.
- Offshore production: Oil processing platforms, water injection platforms, storage, SPM and SBM transportation and utilities.
- Deep water applications of subsea technology: drilling rig, well construction issues, cementations, casing and mud design, mud window for vertical / horizontal drilling, gas hydrates; Deep water completion, risers, Wellheads and manifolds.
- Deep water production system: Subsea transducers / sensors, control module, phase separators.
- Emerging deep water technologies, equipment and systems, remote operation vessels, safety of divers.
- Well abandonment, environmental concerns.
- Case Studies.

Text / Reference Books

1. Yong Bai, Qiang Bai, Subsea Engineering Handbook. Gulf Professional Publishing (2012).
2. James Speight, Handbook of Offshore Oil and Gas Operations. Gulf Professional Publishing (2014).
3. Yong Bai, Qiang Bai, Subsea Pipelines and Risers. Elsevier Science (2005).
4. Andrew Clennel Palmer, Roger A. King, Subsea Pipeline Engineering. PennWell Books (2008).
5. Charles Sparks, Fundamentals of Marine Riser Mechanics: Basic Principles and Simplified Analyses. Pennwell Corp (2007).
6. Subrata Chakrabarti, Handbook of Offshore Engineering, Volume I and II. Elsevier Science (2005).

2. Nuclear, Wind and Geothermal Energy

- Basic nuclear models, radioactivity, nuclear reactions – energy systems based on fission & fusion reactions; Reactor heat generations and removal; Nuclear Fuel cycle from Uranium / Thorium supply, enrichment, fuel management and waste disposal; Interaction of ionizing radiation with matter, radiation detection, shielding, and effects on human health.
- Introduction to wind resources: wind speed and terrain properties, power density; Measurement of wind speed and turbulence; Wind turbine / rotor design: Thrust, torque, speed, and power; Turbine material design and structural analysis; Integration of variable power production into electrical systems: Control of rotor speed, maximum power in low wind speeds, constant power in high wind speeds; Offshore wind farm: Dynamic wind and wave loadings, grid integration, operational and maintenance strategies; Cost of energy from wind turbine during lifetime.
- Nature, occurrence, types and classification of geothermal fields; Basics of geothermal exploration, drilling and production, and conversion methods;
- Analysis of energy system proposals with reference to engineering, economic, socio-political, and environmental objectives.

Text/Reference Books:

1. James F. Manwell, Jon G. McGowan, Anthony L. Rogers, Wind Energy Explained: Theory, Design and Application. Wiley-Blackwell (2009).
2. Tony Burton, David Sharpe, Nick Jenkins, Ervin Bossanyi, Wind Energy Handbook. Wiley (2001).
3. Arnold Watson, Geothermal Engineering: Fundamentals and Applications. Springer (2014).
4. J.R. Lamarsh, A.J. Baratta, Introduction to Nuclear Engineering. Pearson Education India (2014).
5. Robert E. Masterson, Nuclear Engineering Fundamentals: A Practical Perspective. CRC Press (2017).

3. Hazardous Waste Management

- Fundamental knowledge of hazardous waste, their sources, generation, identification, classification and characterization.
- Health and safety related problems of hazardous waste, routes of migration.
- Minimization Technologies of hazardous waste.
- Hazardous waste treatment and its disposal.
- Regulatory aspects of hazardous wastes: regulation on storage handling and transportation of hazardous waste.
- Clean-up of hazardous waste contaminated sites.
- Risk assessment and hazardous waste management.
- Management of hazardous waste case studies: pesticides and containers.
- Management of hazardous nuclear waste

Text / Reference Books:

1. Michael D. Lagrega, Phillip L. Buckingham, Jeffrey C. Evans, Hazardous Waste Management. Waveland Pr Inc. (2010).
2. S. Bhatia, Solid and Hazardous Waste Management. Atlantic (2007).
3. Mackenzie Davis, David Cornwell, Introduction to Environmental Engineering. McGraw Hill Indian Edition (2017).

4. Analytical Techniques

Spectroscopy: Introduction, Spectroscopy methods: Infrared, UV-Visible, Fluorescence, Nuclear Magnetic Resonance, Atomic Absorption

Spectrometry: Mass, Matrix-assisted laser desorption/ionization (MALDI)

Microscopy: Introduction, Atomic Force Microscopy, Field Emission Scanning Electron Microscope with EDXS (Energy-dispersive X-ray spectroscopy), Transmission Electron Microscopy, Laser Scanning Confocal Microscopy, Confocal Raman.

Thermal analysis: Differential Scanning Calorimetry, Thermal Gravimetric Analysis

Chromatography: Introduction, Thin-Layer Chromatography, Types of Column Chromatography: Affinity and Ion Exchange, Gel Permeation and HPLC, Gas Chromatography–Mass Spectrometry

Text / Reference Books:

1. Keith Wilson and John Walker, Principles and Techniques of Biochemistry and Molecular Biology, Cambridge University Press; 8th Edition
2. D. A. Skoog and D. M. West, Fundamentals of analytical chemistry, Cengage Publishers; 9th Edition.
3. G. D. Christian, P. K. Dasgupta and K. A. Schug, Analytical Chemistry, Wiley Publishers; 7th Edition
4. R. M. Silverstein, F. X. Webster, D. J. Kiemle and D. L. Bryce, Spectrometric Identification of Organic Compounds, Wiley Publishers; 8th Edition.
5. D. B. Williams and C. B. Carter, Transmission electron microscopy-a text book for material science, Springer Publishers; 2nd Edition
6. Introduction to Polymer Science. Charles E. Carreher. Jr. CRC Press; 6th Edition

ELECTIVES – IV

1. Advanced Reservoir Modeling

Geostatistical modeling, quantification of connectivity, lithofacies, porosity, permeability using variogram, krigging techniques; Construction of heterogeneous reservoir models, constrained to well and seismic data; Upscaling and ranking; Stochastic simulation and modeling; Overview of uncertainty analysis and integrated studies; Case studies.

Text/Reference Books

1. M.J. Pyrez and C.V. Deutsch, Geostatistical Reservoir Modeling. Oxford University Press.
2. J. Caers, Modeling Uncertainty in Earth Sciences. Wiley Blackwell.
3. Matlab Reservoir Simulation Toolbox. SINTEF.
4. S. Cannon, Reservoir Modeling: A Practical Guide. Wiley

2. Petroleum Refinery Engineering

- Origin of petroleum crude oil. Evaluation of crude oil – evaluation and characterization of crude oil: TBP and other distillation tests. Petroleum products, their properties, specification and testing – different properties like flash point, fire point, smoke point, aniline point, carbon residue, kinematic viscosity, pour point, freezing point etc. Use of crude book data.
- Petroleum refinery distillation – pre-fractionation and atmospheric distillation of crude. Process design for atmospheric distillation. Stabilization of naphtha. Vacuum distillation of RCO.
- Reforming of naphtha. Isomerization and Alkalization, Other secondary processes like Vis-breaking, Furfural/Phenol/NMP extraction, Solvent dewaxing, propane deasphalting. Delayed coking process. FCC unit. Hydrotreatment processes in refining: hydro-desulfurisation, hydrofinishing, Hydrocracking. Production of lube oil base stock. Residual Hydrocracking.
- Refinery equipment: furnaces, distillation columns, reactors, pumps, compressors and piping.
- Elements of design of stream reformer naphtha cracker, catalytic reformer etc.
- Environmental impact of refineries.

Text Book:

1. Petroleum Refinery Engineering by W. L. Nelson
2. Petroleum Refining, Technology & Economics by J. H. Gray & G. E. Handwerk
3. Petroleum Refinery Distillation by R. N. Watkins
4. Modern Petroleum Refining Processes by B. K. B. Rao

Reference Book:

1. The Chemistry & Technology of Petroleum by J. G. Speight

3. Air Pollution

- Introduction to principal aspects of air pollution; History of air pollution; Sources of air pollution; Effects of major air pollutants; Current policies, standards and objectives; Air pollution legislation.
- Meteorology as applied to air pollution and dispersion of air pollutants; Atmospheric chemistry, Aerosol behavior; Transport and dispersion modeling. Commercial air quality models (ADMS and USEPA).
- Monitoring of emissions and air pollutants in ambient air; Engineering control of stationary sources; Modeling and control of emission from road transport and from industrial sources.

Selection of control equipments; Process change, fuel change; pollutant removal and disposal of pollutants; Control devices and systems, removal of dry particulate matter, liquid droplets and mist removal, gaseous pollutants and odor removal;

- Indoor air pollution; Personal exposure to air pollution.
- Economics and trends in air pollution control.

Text / Reference Books

1. Richard C. Flagan, John H. Seinfeld, Fundamentals of Air Pollution Engineering. Prentice Hall (1988).
2. M Rao, H.V.N. Rao, Air Pollution. McGraw Hill, Indian Edition (2017) A. P. Sincero and G.A. Sincero

4. Tribology & Introduction to Lubricants

The fundamentals of lubricants business

- Lubricant value chain
- Types of Lubricants- Automotive, Industrial, Marine, Railroad, Air
- Applications of lubricants – Automotive (Trucks, Cars, 2-Wheelers, Tractors, Gear Oils, Natural Gas Engine Oils etc.) and Industrial (Cutting Oils, Rust Preventives, Rolling Oils, Compressor Oils, Hydraulic, Drilling Oils etc.)
- Properties of Lubricants
- Bio-Lubricants

Fundamentals of Base Oils

- Type of Crude Oils
- Refinery process – Brief introduction
- Base Oil Groups
- Properties of Base Oils

Fundamentals of Additives

- Properties & key characteristics
- Composition of additives for various applications
- Additive Chemistry
- Types of additives
- Performance contribution of additive to Lubricants

Lubricants – Automotive

- Understanding of Key specifications like API, JASO, ACEA
- Global Specifications and Viscometrics
- India- Current scenarios of Lubricants in India & Future trends

Lubricants-Industrial, Marine, Railroad, Air sector

Indian Lubricant Market-

- Current size & key players
- Growth Potential

New trends impacting lubricants, base Oils and additive industry

- BS IV to BS VI Transition by 2020
- Transition towards high-quality lighter lubricants
- New slate of Base Oils over next 10 years

Finance and Cost optimization of Lubricants

- Tools and techniques: value engineering and collaborative optimization
- Global best practices to drive down the total costs of ownership

ELECTIVES – V

1. Prospecting, Field Development and Asset Management

Life cycle of a hydrocarbon field; Field development workflow; Probabilistic reserve estimation; Project economic evaluation: Capital expenditures (drilling costs, equipment cost, installation costs etc.) and Operating expenditures (maintenance, intervention, flow assurance measures etc.); Production profile of each field architecture; Offshore field architectures and production systems, Reservoir depletion and field performance, Production scheduling, EOR screening; Flow assurance, Flow design of well; Seabed boosting; Data processing and management; Field processing facilities and product control; Production optimization and integrated asset modeling. Reservoir management case studies.

Text / Reference Books:

1. K. Shah, O. Izgec, Real Time Reservoir Management. Society of Petroleum Engineers (2012).
2. J. Fanchi, Integrated Reservoir Asset Management: Principles and Best Practices. Gulf Publishing.
3. A. Satter, J. Baldwin, R. Jespersen, Computer Assisted Reservoir Management. Pennwell (2000).
4. Nadine Bret-Rouzaut, Jean-Pierre Favennec, Oil and Gas Exploration and Production: Reserves, Costs, Contracts. Technip 2011.
5. Ganesh Thakur, Abdus Satter, Integrated Waterflood Asset Management. Pennwell Corp.
6. Abdus Satter, Ganesh Thakur, Integrated Petroleum Reservoir Management: A Team Approach. Pennwell Publisher 1994.
7. T. Ahmed, D. Nathan Meehan, Advanced Reservoir Management and Engineering. Gulf Professional Publishing (2012)

2. Petrochemical Technology

- Survey of petrochemical industry; Availability of different feed stocks; Production, purification and separation of feed stocks;
- Chemicals from methane; Production and utilization of synthesis gas, oxo reactions, etc.; Production of and chemicals from acetylene; Naphtha cracking;
- Chemicals from C2, C3, C4 and higher carbon compounds; Polymers - properties, production and utilization;
- Catalytic reforming of naphtha and isolation of aromatics; Chemicals from aromatics; Synthetic fibres, detergents, rubbers and plastics; Petroleum coke;
- Integration of Petroleum Refining and Petrochemicals

Text Books:

1. Hydrocarbon Chemistry by G. A. Olah and A. Molnar
2. A. Text on Petrochemicals by B. K. B. Rao
3. Petroleum Refining, Technology and Economics by J. H. Gary and G. E. Handwerk

Reference Books:

1. Industrial Organic Chemicals by H. A. Wittcoff and B. G. Reuben
2. Handbook of Petrochemicals and processes by G. M. Wells

3. Nanomaterials for Hydrocarbon Industry

- Introduction to metallic nanoparticles, metal oxide nanoparticles, carbon nanotubes, magnetic nanoparticles, nanoporous materials.
- Synthesis: Chemical, electrochemical, thin films – CVD, PVD, Langmuir-Blodgett, mechanical (attrition), sol-gel, nanolithography.
- Functionalization: Ligand incorporation, biomolecule conjugation, polymer coating.
- Physical and chemical properties at nanoscale; Nanomaterial characterization: SEM, TEM, AFM, scanning probe microscopy, scanning tunneling microscopy, diffraction and scattering techniques, vibrational spectroscopy.
- Use of nanomaterials in exploration and reservoir characterization, drilling, cementing, production, stimulation, petroleum refining, fuel production, and chemical sensing.
- Use of nanomaterials in lubricants

Text/Reference Books:

1. Dieter Vollath, Nanomaterials: An Introduction to Synthesis, Properties and Applications. Wiley VCH (2013).
2. Dieter Vollath, Nanoparticles – Nanocomposites Nanomaterials: An Introduction for Beginners. Wiley VCH (2013).
3. Ratna Tantra, Nanomaterial Characterization: An Introduction. Wiley (2016).
4. Daniel L. Fedlheim and Colby A. Foss, Metal Nanoparticles: Synthesis, Characterization, and Applications. CRC Press (2001).

4. Process Modeling & Simulation

- Introduction: fundamentals of process modeling and simulations. Review of analytical and numerical techniques. Macroscopic mass, momentum and energy balances. Microscopic balances for mass, energy, and momentum, and associated constitutive relationships. Steady state and unsteady state modeling of chemical process equipments: flow systems, separators, reactors and heat exchangers. Grid generation; Introduction to SIMPLE, PISO. Finite volume approach. Introduction to simulators: Ansys Fluent, Open Foam.
- Formation of lumped parameter models, absolute and deviation variables, linearization, transfer function models, introduction to MATLAB Simulink.
- Modeling of disperse phase systems. Application of population balances in modeling particulate/disperse phase systems. Modeling of crystallizers, liquid-liquid extraction, polymerization reactors etc. Introduction to stochastic processes. Modeling of stochastic processes using Kinetic Monte Carlo simulation. Modeling of mixing. Effect of mixing on conversion and yield of reactions.

Text/Reference Books:

1. Finlayson B.A., Nonlinear Analysis in Chemical Engineering. McGraw Hill 1980.
2. Davis M.E., Numerical Methods and Modelling for ChE. Wiley 1984.
3. B. W. Bequette, Process Dynamics--Modeling, Analysis and Simulation, Prentice Hall, Englewood Cliffs, NJ, 1998.
4. W. L. Luyben, Process Modeling, Simulation and Control for Chemical Engineers, 2nd Ed., McGraw Hill, 1990.
5. B. A. Ogunnaike and W. H. Ray, Process Dynamics, Modeling and Control, Oxford University Press, UK, 1994.