

University Institute of Engineering & Technology
C.S.J.M. University Kanpur

Chemical Engineering

Semester-Wise Break up of courses

Semester-1

		L	T	P	C
HSS-S101	Professional Communication	3	0	0	4
MTH-S101	Mathematics-I	3	1	0	4
PHY-S101	Physics-I	3	1	3	5
TCA-S102	Workshop Concepts & Practice	1	1	6	5
ISC-S101	Programming & Computing	3	0	3	5

Semester-II

MTH-S102	Mathematics-II	3	1	0	4
CHM-S101	Chemistry-I	3	1	3	5
ESC-S101	Basic Electrical & Electronics Engg.	3	1	3	5
PHY-S102	Physics-II	3	1	3	5
TCA-S101	Engineering Drawing	2	1	3	5

Semester-III

MTH-S201	Mathematics-III	3	1	0	4
ESC-S201	Engineering Mechanics	3	1	0	4
ESC-S202	Basic Thermodynamics	3	1	0	4
CHE-S201	Process Calculations	3	1	0	4
CHE-S202	Fluid Mechanics	3	1	0	4
CHM-301	Chemistry-II	3	0	3	4
SST-S201	Summer Internship	0	0	0	2

Semester-IV

		L	T	P	C
CHE-S203	Chemical Engg. Thermodynamics	3	1	0	4
CHE-S204	Heat Transfer	3	1	0	4
CHE-S205	Chemical Process Industries	4	0	0	4
CHE-S206	Mechanical Operations	3	1	0	4
HSS-S401	Engineering Economics	3	0	0	4
EVS-S101	Environmental Science	2	0	0	2

Semester-V

CHE-S301	Mass Transfer-I	3	1	0	4
CHE-S303	Unit Operations Laboratory -I	0	0	4	4
CHE-S304	Chemical Reaction Engineering-I	3	1	0	4
CHE-S309	Numerical Methods for Chemical Engineers	3	1	0	4
HSS-S301	Communication Practicum	1	0	2	2
CHE-S5**	Departmental Elective	3	1	0	4
SST-S301	Summer Internship	0	0	0	2

Semester-VI

CHE-S305	Mass Transfer-II	3	1	0	4
CHE-S306	Instrumentation & Process Control	3	1	0	4
CHE-S307	Chemical Engineering Design-I	3	1	0	4
CHE-S308	Unit Operations Laboratory-II	0	0	4	4
CHE-S5**	Departmental Elective	3	1	0	4
SSM-S301	Student Seminar	0	0	2	2

Semester-VII

		L	T	P	C
CHE-S401	Chemical Engineering Design-II	4	0	0	4
CHE-S402	Chemical Reaction Engineering -II	3	1	0	4
CHE-S406	Process Simulation Lab	0	0	4	4
SST-S401	Summer Training	0	0	2	2
PRT-S401	Project-I	0	0	6	4
HSS-S201	Industrial Management	3	0	0	4

Semester-VIII

CHE-S404	Transport Phenomena	4	0	0	4
CHE-S407	Chemical Reaction Engineering and Process Control Laboratory	0	0	4	4
CHE-S5**	Departmental/Open Elective	3	1	0	4
CHE-S5**	Departmental Elective	3	1	0	4
PRT-S402	Project-II	0	0	6	4

Legends L = Lecture
 T= Tutorial
 P= Practical/Presentation/Project
 C= Credit

Highlighted Colour	Meaning
Yellow	Employability
Green	Entrepreneurship
Grey	Skill development

Course Code: HSS-S101

Breakup: 3 – 0 – 0 – 4

Course Name: Professional Communication

Course Details:

Unit -I Basics of Technical Communication

Technical Communication: features; Distinction between General and Technical communication; Language as a tool of communication; Levels of communication: Interpersonal, Organizational, Mass communication; The flow of Communication: Downward, Upward, Lateral or Horizontal (Peer group); Importance of technical communication; Barriers to Communication.

Unit - II Constituents of Technical Written Communication

Words and Phrases: Word formation. Synonyms and Antonyms; Homophones; Select vocabulary of about 500-1000 New words; Requisites of Sentence Construction: Paragraph Development: Techniques and Methods - Inductive, Deductive, Spatial, Linear, Chronological etc; The Art of Condensation- various steps.

Unit - III Forms of Technical Communication

Business Letters: Sales and Credit letters; Letter of Enquiry; Letter of Quotation, Order, Claim and Adjustment Letters; Job application and Resumes. Reports: Types; Significance; Structure, Style & Writing of Reports. Technical Proposal; Parts; Types; Writing of Proposal; Significance. Technical Paper, Project. Dissertation and Thesis Writing: Features, Methods & Writing.

Unit - IV Presentation Strategies

Defining Purpose; Audience & Locale; Organizing Contents; Preparing Outline; Audio-visual Aids; Nuances of Delivery; Body Language; Space; Setting Nuances of VoiceDynamics;Time-Dimension.

Unit - V Value- Based Text Readings

Following essays form the suggested text book with emphasis on Mechanics of writing,

The Aims of Science and the Humanities by M.E. Prior

The Language of Literature and Science by A.Huxley

Man and Nature by J.Bronowski

The Mother of the Sciences by A.J.Bahm

Science and Survival by Barry Commoner

Humanistic and Scientific Approaches to Human Activity by Moody E. Prior

The Effect of Scientific Temper on Man by Bertrand Russell.

Text and Reference Books:

1. V.N. Arora and Laxmi Chandra, Improve Your Writing ed. Oxford Univ. Press, New Delhi

2. Meenakshi Raman & Sangeeta Sharma, Technical Communication – Principles and Practices, Oxford Univ. Press 2007, New Delhi.
3. Barun K. Mitra, Effective Technical Communication, Oxford Univ. Press, 2006, New Delhi
4. R.C. Sharma & Krishna Mohan, Business Correspondence and Report Writing, Tata McGrawHill & Co. Ltd., New Delhi.
5. M. Rosen Blum, How to Build Better Vocabulary, Bloomsbury Pub. London.
6. Norman Lewis, Word Power Made Easy, W.R. Goyal Pub. & Distributors, Delhi.
7. Krishna Mohan, Developing Communication Skills Meera Banerji-Macmillan India Ltd. Delhi.
8. L.U.B. Pandey & R.P. Singh, Manual of Practical Communication, A.I.T.B.S. Publications India Ltd.; Krishan Nagar, Delhi.

Course Code: MTH-S101

Breakup: 3 –1 – 0 – 4

Course Name: Mathematics-I

Course Details:

Unit-I

Sequences & Series: Definition, Monotonic sequences, Bounded sequences, Convergent and Divergent Sequences Infinite series, Oscillating and Geometric series and their Convergence, n^{th} Term test, Integral test, Comparison Test, Limit Comparison test, Ratio test, Root test, Alternating series, Absolute and Conditional convergence, Leibnitz test.

Unit II

Differential Calculus: Limit Continuity and differentiability of functions of two variables, Euler's theorem for homogeneous equations, Tangent plane and normal. Change of variables, chain rule, Jacobians, Taylor's Theorem for two variables, Extrema of functions of two or more variables, Lagrange's method of undetermined multipliers.

Unit III

Integral Calculus: Review of curve tracing, Double and Triple integrals, Change of order of integration. Change of variables. Gamma and Beta functions, Dirichlet's integral. Applications of Multiple integrals such as surface area, volumes.

Unit –IV

Vector Calculus: Differentiation of vectors, gradient, divergence, curl and their physical meaning. Identities involving gradient, divergence and curl. Line and surface integrals. Green's, Gauss and Stoke's theorem and their applications.

Unit–V

Probability and Statistics: Concept of probability, random variable and distribution function: discrete and continuous, Binomial, Poisson and Normal Distributions.

Text and Reference Books:

1. G.B.Thomas and R.L.Finney : Calculus and Analytical Geometry, 9th edition, Pearson Education.
2. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 2005.
3. E. Kreyszig, Advanced Engineering Mathematics, 9th edition, John Wiley and Sons, Inc., U.K. 2011.
4. R.K. Jain and S.R.K. Iyenger, Advanced Engineering Mathematics, 2nd Edition, Narosa Publishing House. 2005.
5. M.D. Weir, J. Hass, F.R. Giordano, Thomas' Calculus, 11th Edition, Pearson Education. 2008

Course Code: PHY-S101**Breakup: 3 –1 – 3 – 5****Course Name: Physics-I****Course Details:(Theory)****Unit 1**

Revision of vectors, vector differentiation, ordinary derivatives of vectors, space curves continuity and differentiability, partial derivatives of vectors, gradient, divergence, curl, vector differentiation and their geometrical interpretation, various coordinate systems: polar coordinate, orthogonal curvilinear coordinate system, unit vectors and tangent vectors in curvilinear systems, special orthogonal curvilinear coordinate system, cylindrical coordinate system and spherical polar coordinate systems.

Unit 2

Inertial and non-inertial frames, fictitious force, Coriolis force, Newton's laws of motion and its applications, friction, conservative and non-conservative force, work energy theorem, conservation of linear momentum and energy, variable mass system (Rocket motion), simple harmonic motion, small oscillation, equilibrium, condition for stability of equilibrium, energy diagram, small oscillation in a bound system, working of Teetertoy.

Unit 3

Concept of centre of mass and calculation of center of mass for different objects, system of particles and collision, conditions for elastic and inelastic collision, collision in center of mass frame, rigid body kinematics, rotational motion, moment of inertia, theorems on moment of inertia, calculation of moment of inertia of bodies of different shapes.

Unit 4

Central force field, properties of central force field, inverse square law force, gravitational field and potential. Kepler's laws of planetary motion and its application. Wave mechanics, wave particle duality, De-Broglie matter wave, Schrodinger wave equations (time dependent and time independent), uncertainty principle and its applications.

Unit 5

Frame of reference, Galilean transformation, Michelson-Morley experiment, postulates of special theory of relativity, Lorentz transformations, Length contraction, time dilation, velocity addition theorem, variation of mass with velocity, Einstein's mass energy relation, relativistic relation between energy and momentum, rest mass of photon.

Text and Reference Books:

1. Vector Analysis: M. R. Spiegel Introduction to Mechanics: R. D. Kleppner and J. Kolenkow
2. A textbook of Mechanics: J. C. Upadhyay
3. Mechanics: D. S. Mathur
4. Theoretical Mechanics: M. R. Spiegel
5. Introduction to Special Theory of Relativity: Robert Resnick
6. Concept of physics (I & II): H. C. Verma

7. Principle of Quantum Mechanics: I. S. Tyagi
8. Quantum Mechanics: Eisberg and Resnick

Course Details:(Practical)

1. Graphical Analysis (Ref. UIET Laboratory Manual)
2. Trajectory of projectile (Ref. UIET Laboratory Manual) Apparatus Used (Trajectory Apparatus, Metal Balls, Channels, VernierCallipers, Carbon & Graph Paper)
3. Moment of Inertia of Bicycle wheel (Ref. Book by K. K. Dey, B. N. Dutta) Apparatus Used (Bicycle Wheel, Masses, Thread, Stopwatch, Meter Scale, VernierCallipers)
4. Spring Oscillations (Ref. UIET Laboratory Manual) Apparatus Used (Spring Oscillation Apparatus, Stop Watch, Masses)
5. Coupled Pendulum (Ref. UIET Laboratory Manual) Apparatus Used (Coupled Pendulum Setup, Stop Watch, Scale)
6. Bifilar Suspension System (Ref. UIET Laboratory Manual) Apparatus Used (Bifilar Suspension System Setup, Stop Watch, Masses)
7. Frequency of AC Mains by Melde's Method (Ref. Book by K. K. Dey, B. N. Dutta) Apparatus Used (Electrical Vibrator, String, Pulley, Small Pan, Weight Box & Physical Balance)
8. Kater's(Reversible) Pendulum (Ref. Book by K. K. Dey, B. N. Dutta) Apparatus Used (Kater's Pendulum, Stop Watch)
9. Inertia Table (Ref. Book by K. K. Dey, B. N. Dutta) Apparatus Used (Inertia Table, Stop Watch, VernierCallipers, Split Disc, Balancing Weights, and Given Body (Disc))
10. Moment of Inertia of Flywheel (Ref. Book by J. C. Upadhyay and UIET Laboratory Manual) Apparatus used (Fly wheel, weight hanger, slotted weights, stop watch, metre scale)

Course Code: TCA-S102**Breakup: 1 – 1 – 6 – 5****Course Name: Workshop Concepts****Course Details: (Theory)**

Historical perspectives; Classification of Manufacturing process.

Machining: Basic principles of lathe machine & operations performed on it. Basic description of machines & operations of shaper-planer, drilling, milling, grinding. Unconventional machining processes, Machine tools.

Casting processes: pattern & allowances. Moulding sands & its desirable properties. Mould making with the use of a core. Gating system. Casting defects & remedies. Cupola furnace. Die-casting & its uses.

Metal forming: Basic metal forming operations & uses of such as forging, rolling, wire & tube drawing/making & extrusion, & its products/applications, press work & die & punch assembly, cutting & forming, its application. Hot working vs Cold working. Powder metallurgy: powder metallurgy process & its applications, plastic-products manufacturing, galvanizing & electroplating.

Welding: Importance & basic concepts of welding, classification of welding processes. Gas welding, types of flames, Electric arc welding. Resistance welding. Soldering & brazing and its uses. Modern trends in manufacturing, Automation. Introduction to NC/CNC/DNC, FMS, CAD/CAM, CIM and factory of the future.

Text and Reference Books:

1. Chapman, W A J & Arnold, E “Workshop Technology ; vol. I, II & III” Viva Low Priced Student Edition.
2. Raghuwanshi, B S “Workshop Technology; vol. I & II” Dhanpat Rai & Sons
3. Chaudhary, Hajra “Elements of Workshop Technology; vol. I & II” Media Promoters & Publishers

Course Name: Workshop Practice**Course Details: (Practical)**

1. Foundry (1 turn)
2. Welding (3 turns)
 - (a) Gas Welding (1 turn)
 - (b) Arc Welding (2 turns)

- i. Lap Joint (1 turn)
 - ii. Butt Joint (1 turn)
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- 3. M/C Shop (4Turns)
 - 4. Fitting & Sheet Metal Work (1 turn+1turn)
 - 5. Carpentry Shop(1turn)
 - 6. Black-smithy shop(1turn)

Text and Reference Books:

- 1. Chapman, W A J & Arnold, E “Workshop Technology ; vol. I,II&III” Viva Low Priced Student Edition.
- 2. Raghuwanshi, B S “Workshop Technology; vol. I&II” Dhanpat Rai & Sons.
- 3. Chaudhary, Hajra “Elements of Workshop Technology; vol. I&II” Media Promoters & Publishers.

Course Code: ISC – S101

Breakup: 3 –0 – 3 –5

Course Name: Programming & Computing(C & UNIX)

Course Details: (Theory)

Basic concepts of Computers, Basic UNIX Concepts and Vi - Editor

Introduction to C: Basic Programming concepts, Program structure in C, Variables and Constants, Data types, Conditional statements, control statements, Functions, Arrays, Structures, Introduction to pointers, and Introduction to File Systems.

Text and ReferenceBooks:

1. Programming in C, Schaum Series
2. The 'C' Programming, Denis Ritchi (PHI)
3. Programming in C, Venugopal (TMH)
4. Let us C, YashantKanetkar (BPB)
5. Programming in C, Balaguruswami (TMH)

Course Name: Computer Programming Lab

Course Details: (Practical)

Learning OS Commands

Practice of all Internal and External DOS Commands, Writing simple batch programs, Exposure to Windows environment, Practice of UNIX commands and Vi editor, Writing simple shell script

C Programming:

Practicing programs to get exposure to basic data types, algebraic expressions, Conditional statements, Input Output Formatting, Control structures, arrays, functions, structures, pointers and basic file handling.

Course Code: MTH-S102

Breakup: 3 –1 – 0 – 4

Course Name: Mathematics-II

Course Details:

Unit-I

Matrix Algebra:Elementary operations and their use in finding Rank, Inverse of a matrix and solution of system of linear equations. Orthogonal, Symmetric, Skew-symmetric, Hermitian, Skew-Hermitian, Normal & Unitary matrices and their elementary properties.

UNIT-II

Vector Space, Linear transformation, Linear dependent and linear independent,Eigen-values and Eigenvectors of a matrix, Cayley-Hamilton theorem, Diagonalization of a matrix.

Unit-III

Ordinary Differential Equations of second order: Solution of linear differential equations with Constant coefficients. Euler-Cauchy equations, Solution of second order differential equations by changing dependent and independent variables.Method of variation of parameters, Introduction to series solution method, Frobenious Methods.

Unit- IV

Ordinary differential equations of higher orders: Matrix method

Unit-V

Laplace Transform:Laplace and inverse Laplace transform of somestandard functions, Shifting theorems, Laplace transform of derivatives andintegrals. Convolution theorem, Initial and final value theorem.Laplace transform of periodic functions, error functions, Heaviside unit step function and Dirac delta function. Applications of Laplace transform.

Text and ReferenceBooks:

1. E. Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons, 2005.
2. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 2005.
3. C. Ray Wylie & Louis C. Barrett, Advanced Engineering Mathematics, Tata McGraw-Hill PublishingCompany Ltd. 2003.
4. G.F. Simmons, Differential Equations, Tata McGraw-Hill Publishing Company Ltd. 1981.

Course Code: CHM – S101

Breakup: 3 –1 – 3 – 5

Course Name: Chemistry - I

Course Details: (Theory)

UNIT-I - Atoms and Molecules:

1. Need for wave mechanical picture of atomic structure [Photoelectric effect, deBroglie concept of matter waves], Derivation of schrodinger wave equation [asan example particle moving in unidimensional potential well]
2. Chemical Bonding- Orbital concepts in bonding, V.B. and M.O. theory, M.O.diagrams, Intermolecular interactions.

UNIT-II - Reaction Dynamics:

Order, Molecularity, Rate law, Integrated rate equations, Methods of determining of order of reaction, Complex reaction kinetics- chain reactions and reversible reactions in detail, Catalysisand enzyme catalysis

UNIT-III - Electrochemistry:

Arrhenius theory of electrolytic dissociation, Transport number, Kohlrausch's law, Solubility product, Redox reaction, Electrochemical and concentration cells.

UNIT-IV- Stereochemistry:

Introduction, Chirality, Enantiomers, Diastereomers, Projection formula of a tetrahedral carbon,Geometrical isomerism, Conformers

UNIT- V- Application of Spectroscopic Techniques:

Basic working principle on measurement technique: IR, UV visible spectroscopy and NMR

UNIT-VI - Organic Reactions:

Concepts Electron displacement effects, Organic intermediates, Types of reactions [addition,elimination and substitution reactions]

UNIT-VII - Photochemistry:

Principles of photo chemistry, Photoexcitation of organic molecules, Jablonski diagram, Laws of photochemistry and quantumyield, Some examples of photochemical reactions, Chemistry of vision and other applications ofphotochemistry.

UNIT-VIII - Transition Metal Chemistry:

Structure of coordination compounds corresponding to coordination number up to 6, Types of ligands, chelation, Isomerism [geometrical, optical, ionization, linkage and coordination], Theories ofbonding in coordination compounds- crystal field theory, Valence bond theory.

Text and ReferenceBooks:

Physical Chemistry-

- 1 Physical Chemistry, P. Atkins and j. De Paul, 8th Edition (2006), International Student Edition, Oxford University Press.
- 2 Principles of Physical Chemistry B.R Pure, L. R. Sharma, and M. S. Pathania, 37th Edition (1998), ShobanLalNagin Chand & Co., Jalandhar.

Organic Chemistry-

1. Organic Chemistry, R. T. Morrison and R. N. Boyd, 6th Edition (1992), Prentice-Hall of India (P) Ltd, New Delhi.
2. A text book of organic chemistry, ArunBahl& B. S. Bahl, S. Chand Publishers, New Delhi

Inorganic Chemistry-

1. Concise Inorganic Chemistry, J. D. Lee, 5th Edition (1996), Chapman & Hall, London.
2. Inorganic Chemistry, j. E. Huheey, E. A. Keiter and R. L. Keiter.

Engineering Chemistry-

1. Engineering Chemistry ShashiChawla.

Course Name: Chemistry Lab- I

Course Details: (Practical)

1. To estimate the strength of the given unknown solution of Mohr's salt (Ferrous ammonium sulphate ($\text{FeSO}_4 \cdot (\text{NH}_4)_2\text{SO}_4 \cdot 6\text{H}_2\text{O}$) using KMnO_4 solution as an intermediate.
2. To prepare a sample of p-nitroacetanilide.
3. To prepare a sample of Aspirin.
4. Preparation of Tris (Thiourea) Copper (I) sulphate.
5. Preparation of Hexamine Nickel (II) chloride $[\text{Ni}(\text{NH}_3)_6]\text{Cl}_2$.
6. Estimation of commercial caustic soda: Determination of the amounts of sodium carbonate and sodium hydroxide present together in the given commercial caustic soda.
7. Estimation of calcium ions present in tap water.
8. To determine the partition coefficient of acetic acid between n-butanol and water.
9. To study the photochemical reduction of a ferric salt (Blue printing).
10. To determine the viscosity of a given liquid room temperature using Ostwald's viscometer.
11. To separate Ag(I), Hg (I) and Pb(II) ions by paper chromatography and calculate their RF values.
12. Understanding reaction kinetics and calculating the rate and order of a reaction.
13. To study the kinetics of first order reaction (methyl acetate hydrolysis catalysed by 0.5 N HCl solution).

Course Code: ESC-S101**Breakup: 3 –1 – 3 – 5****Course Name: Basic Electrical & Electronics Engineering****Course Details:(Theory)****Unit – I**

Sinusoidal steady state circuit analysis, voltage, current, sinusoidal & phaser presentation single phase AC circuit – behavior of resistance, inductance & capacitance & their combination, impedance concept of power, power factor. Series & parallel resonance – band width & quality factor. Three phase circuits – phase voltage & current, line & phase quantities, phasor diagram, balanced & unbalanced loads, Measurement of R, L, and C.

Unit –II

Network Theory: Network theorems – Thevenin's, Norton, maximum power transfer theorem, star delta transformation, circuit theory concept – mesh & nodal analysis.

Unit – III

Magnetic circuit concepts: self-inductance, magnetic coupling analysis of single tuned & double tuned circuit involving mutual inductance, introduction to transformer.

Unit – IV

Basic Instruments, electrical measurement – measurement of voltage, current, power & energy, voltmeters & ammeter, wattmeter, energy meter, three phase power measurement, electronics instrument – multimeter, CRO (analog & digital), An overview of voltage regulator.

Unit – V

Introduction to basic electronics devices – junction diode, BJT, amplifier, op-amps & instrumentation amplifier with mathematical operation.

Number System: Introduction to binary, octal, decimal & hexadecimal systems, representation of negative numbers, 1's, 2's, 9's, 10's complement and their arithmetic.

Text and Reference Books:

- 1 W.H. Hayt & J.E. Kemmerly : Engg. Circuit Analysis, McGraw Hill.
- 2 N.N. Bhargava : 'Basic Electronics', Tata McGraw Hill.
- 3 Malvino, A.P. / "Electronics Principles" / Tata McGraw-Hill / 6th Ed.
- 4 Morris Mano, "Digital Computer Design" PHI
- 5 Del Toro : Principles of Electrical Engg. – PHI
- 6 Boylestad & Neshishkey, "Electronic devices & circuits", PHI
- 7 Malvino & Leech "Digital Principle and application", TMH

Course Name: Basic Electrical & Electronics Engineering Lab**Course Details: (Practical)**

1. Familiarization with the Electronic Instruments.
2. Familiarization with electronic components and Bread board.
3. To verify the Thevenin theorem.
4. To verify the Superposition theorem.

- 5.Measurement of voltage and frequency with CRO.
- 6.To study half wave rectifier.
- 7.To study full wave bridge rectifier.
- 8.To study full wave bridge rectifier with filter.
- 9.To study and verify the truth table of different logic gates using digital IC.
- 10.To study different type of transformer and there operation.
- 11.To study basic wiring and design a switchboard/extension board.
- 12.To study the polarity test of a single phase transformer.
- 13.To study the open & short circuit test of a transformer and calibration losses.
- 14.To study the load test and efficiency of a single phase transformer.

Course Details:(Theory)**Unit 1**

Vector integration, Stokes' theorem, divergence theorem, electrostatics: Coulomb's law, superposition of electric forces, electric flux, Gauss's law, electric field, potential, calculation of electric fields due to different charge distribution, gradient and curl of electric field, electric dipoles and multipoles, potential energy of a dipole placed in external electric field, Laplace's equation, Poisson's equation.

Unit 2

Magnetostatics, motion of charge in electric and magnetic field, Lorentz force, magnetic flux, torque on a current coil in uniform magnetic field, magnetic dipole, potential energy of a magnetic dipole, Biot-Savart law, Ampere's law, calculation of magnetic field due to different current distribution, divergence and curl of magnetic field.

Unit 3

Electromagnetic induction, Faraday's law, Lenz's law, self-induction, mutual induction, growth and decay of current in L-R circuit, electromagnetic waves, displacement current, Maxwell's equations in free space and matter, verification of Faraday's law of electromagnetic induction and Ampere's law in vacuum by using plane electromagnetic waves and derivation of velocity of light (c) in terms of permittivity and permeability of free space, Poynting vectors, Poynting theorem.

Unit 4

Coherent sources, Interference, Fresnel's biprism, interference in uniform and wedge shaped thin films, necessity of extended source, Newton's rings and its applications, Fresnel and Fraunhofer diffraction at single slit and double slits, absent spectra, diffraction grating, spectra with grating, dispersive power, resolving power of grating, Rayleigh's criterion of resolution

Unit 5

Dispersion of light, angular dispersion, dispersive power, irrational dispersion, angular and chromatic dispersion, deviation without dispersion, dispersion without deviation, polarization of light, Fresnel's theory of optical activity and polarimeter, fundamental idea of optical fiber, types of fibers.

Text and ReferencesBooks:

1. Electrodynamics: David J. Griffiths
2. Vector Analysis: M. R. Spiegel
3. Optics: AjoyGhatak
4. A textbook of OPTICS: Subrahmanyam, Brijlal and Avadhanulu
5. Classical electrodynamics: J. D. Jackson
6. Concept of Modern Physics: AurthurBeiser
7. Fiber optics: Jeff Hecht

Course Name: Physics Lab-II**Course Details:(Practical)**

1. Newton's Ring (Ref. Book by K. K. Dey, B. N. Dutta) Apparatus Used (Traveling Microscope, Support for Glass Plate inclined at 45° to the Vertical, Short Focus Convex Lens, Sodium Lamp, Plano Convex Lens, An Optically Plane Glass Plate)
2. Prism Spectrometer (Ref. Book by K. K. Dey, B. N. Dutta) Apparatus Used (Spectrometer, Glass Prism, Reading Lens, Mercury Lamp)
3. Plane Transmission Grating (Ref. Book by K. K. Dey, B. N. Dutta) Apparatus Used (Spectrometer, Diffraction Grating, Mercury Lamp)
4. Ballistic Galvanometer (Ref. Book by K. K. Dey, B. N. Dutta) Apparatus Used (Ballistic Galvanometer, Morse key, Damping key, Condenser, Rheostat, Volt Meter, Storage Battery, Connection Wires)
5. Carey Foster's Bridge (Ref. Book by K. K. Dey, B. N. Dutta) Apparatus Used (Carey Foster's Bridge, Laclanche cell, Resistance Box, Galvanometer, Plug Key, Copper Strip)
6. Fresnel's Biprism (Ref. Book by K. K. Dey, B. N. Dutta) Apparatus Used (Sodium Lamp, Biprism, Convex Lens, Optical Bench with Four Uprights)
7. Variation of Magnetic Field (Ref. Book by K. K. Dey, B. N. Dutta) Apparatus Used (Stewart and Gee type Tangent Galvanometer, Storage Battery, Commutator, Ammeter, Rheostat, One way Plug Key, Connection Wires)
8. Polarimeter (Ref. Book by K. K. Dey, B. N. Dutta) Apparatus Used (Sodium Lamp, Polarimeter, Physical Balance)
9. Planck's Constant (Ref. Book by S.K. Gupta and UIET Laboratory Manual) Apparatus Used (Power supply, photocell, connecting wires)
10. Energy Band Gap by Four Probe Method (Ref. Book by S.K. Gupta and UIET Laboratory Manual) Apparatus Used (An experimental kit)

Course Name: Engineering Drawing

Course Details:

Introduction- Drawing instruments and their uses, BIS conventions, lettering dimensioning and free hand practicing.

Orthographic projections: Lines, planes and surfaces of objects, Sectional views, Auxiliary views, Space geometry: lines and planes, True lengths and shapes, Properties of parallelism, Perpendicularity and intersections of lines and planes, Simple intersections of solids and development of lateral simple solids.

Isometric Projections: Introduction isometric scale, isometric projection of simple plane figures, isometric projection of tetrahedron, hexahedron (cube), right regular prisms, pyramids, cylinders, cones, spheres, cut spheres and combinations of solids.

Introduction to computer graphics: Some problems on above topics on computer graphics.

Text and References Books:

1. Narayana, K.L. & Kannaiah, P. "Engg. Graphics". Tata McGraw Hill, New Delhi.
2. Bhatt, N.D. "Elementary Engg. Drawing" Charotar Book stall. Anand.
3. Lakshminarayanan, V and Vaish Wannar, R. S. "Engg. Graphics". Jain Brothers, New Delhi.
4. Chandra, A.M. & Chandra Satish, "Engg. Graphics". Narosa.
5. French & Vireck, "The Fundamental Of Engg. Drawing & Graphic Tech.". McGraw Hill.
6. Gill, P.S. "A Text Book Of Machine Drawing" Katson Publishing House, Ludhiana.

Course Name: Mathematics - III

Course Details:

Unit – I

Function of a Complex variable: Complex numbers- power and roots, limits, continuity and derivative of functions of complex variable, Analytic functions, Cauchy-Reimann equations, Harmonic function, Harmonic conjugate of analytic function and methods of finding it, Complex Exponential, Trigonometric, Hyperbolic and Logarithm function.

Unit – II

Complex Integration: Line integral in complex plane(definite and indefinite), Cauchy's Integral theorem, Cauchy's Integral formula, Derivatives of analytic functions, Cauchy's Inequality, Liouville's theorem, Morera's theorem, Power series representation of analytic function and radius of convergence, Taylor's and Laurent's series, singularities, Residue theorem, Evaluation of real integrals, Improper Integrals of rational functions.

Unit-III

Fourier series: Trigonometric Fourier series and its convergence. Fourier series of even and odd functions. Fourier half-range series. Parseval's identity. Complex form of Fourier series.

Unit-IV

Fourier Transforms: Fourier integrals, Fourier sine and cosine integrals, Fourier transform, Fourier sine and cosine transforms and their elementary properties. Convolution theorem. Application of Fourier transforms to BVP. Laplace

Unit-V

Partial Differential Equations: Formation of first and second order partial differential equations. Solution of first order partial differential equations: Lagrange's equation, Four standard forms of non-linear first order equations.

Text and Reference Books:

1. E. Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons, 2005.
2. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 2005.

Course Name: Engineering Mechanics**Course Details:**

General Coplanar force systems: Basis concepts, Law of motions, principle of transmissibility of forces, Transfer of a force to parallel position, Resultant of a force system, simplest resultant of two dimensional concurrent & non concurrent force systems, free body diagrams, equilibrium & its equations, applications.

Trusses & Cables: Introductions, simple truss & solutions of simple truss, method of joints & method of sections.

Friction: Introduction, Laws of Coulomb friction, equilibrium of bodies involving dry friction, belt friction, applications.

Centre of gravity, centroid, Moment of Inertia: Centroid of plane, curve, area, volume & composite bodies, moment of inertia of plane area, parallel axis theorem, perpendicular axis theorem, principal moment of inertia, mass moment of inertia of circular ring, disc, cylinder, sphere and cone about their axis of symmetry.

Beams: Introductions, shear force and bending moment, differential equations for equilibrium, shear force & bending moment diagrams for statically determinate beams.

Kinematics of rigid body: Introduction, plane motion of rigid bodies, velocity & acceleration under translation & rotational motion, Relative velocity, projectile motion.

Kinetics of rigid bodies: Introduction, force, mass & acceleration, work & energy, impulse & momentum, D'Alembert principles & dynamic equilibrium, Virtual work.

Text and Reference Books:

1. Beer F.P. & Johnston, F.R. "Mechanics For Engineers", McGraw Hill.
2. Shames, I.H. "Engg. Mechanics", PHI.
3. Meriam, J. L. "Statics", J. Wiley.
4. Meriam, J. L. "Dynamics", J. Wiley.

Course Code: ESC-S202

Breakup: 3 – 1 – 0 – 4

Course Name: Basic Thermodynamics (CHE)

Course Details:

Introduction: Definition and scope of thermodynamics, macroscopic and microscopic viewpoint, system, properties, processes and cycles, homogeneous and heterogeneous systems, thermodynamic equilibrium, quasi-static process, phases of a substance, unit systems, specific volume, pressure.

Temperature: Zeroth law of thermodynamics, measurement of temperature, different temperature scales.

Properties of pure substances: Pure substance, p-v diagram, p-T diagram, T-s diagram, h-s diagram or Mollier diagram, quality or dryness fraction, steam table.

Energy and its transfer: Energy, different forms of energy, energy transfer by heat, energy transfer by work, different forms of work transfer - pdV work or displacement work, shaft work, flow work, etc., pdV work in various quasi-static processes, specific heat and latent heat.

First Law of Thermodynamics: Energy balance, energy conversion efficiency, energy analysis of open and closed systems, PMM1.

Second Law of Thermodynamics: Cyclic heat engine, thermal reservoirs, Kelvin-Planck statement, Clausius' statement, refrigerator and heat pump, equivalence of Kelvin-Planck and Clausius' statement, PMM2, conditions for reversibility, Carnot cycle, Carnot's theorem, corollary of Carnot's theorem, absolute thermodynamic temperature scale, efficiency of the reversible heat engine.

Entropy: Clausius' theorem, temperature-entropy plot, Clausius inequality, entropy change in an irreversible process, entropy principle, entropy generation in a closed and open system, entropy and direction, entropy and disorder.

Availability: Available energy, available energy in a cycle, quality of energy, law of degradation of energy, maximum work in a reversible process, second law efficiency.

Thermodynamic relations: Maxwell's equations, TdS equations, Joule-Kelvin effect, Clausius-Clapeyron equation, Gibbs phase rule for non-reactive system.

Power and refrigeration cycles: Simple steam power cycle, Rankine cycle, comparison of Rankine and Carnot cycles, characteristics of an ideal working fluid in vapour power cycles. Carnot gas power cycle, Refrigeration cycle – reversed heat engine cycle, vapour compression refrigeration cycle, components in a vapour compression plant, refrigerants.

Text Books and Reference:

1. P K Nag, Engineering Thermodynamics, Sixth edition, McGraw Hill Education, Delhi (2017).
2. Y A Cengel, M A Boles, M Kanoglu, Thermodynamics An Engineering Approach, Ninth edition, McGraw Hill Education, Delhi (2019).
3. Y V C Rao, An Introduction to Thermodynamics, Universities Press, Hyderabad (2003).

Course Code: CHE-S201**Breakup: 3 – 1 – 0 – 4****Course Name: Process Calculations****Course Details:**

Introduction: Units, their dimensions and conversions, Dimensional consistency of equations, Dimensional and dimensionless constants,

Fundamental concept of stoichiometric: Mass and volume relations, Stoichiometric and composition relations, Excess reactants, Degree of completion, Conversion, Selectivity and Yield.

Ideal gases and gas mixture: Gas laws-Ideal gas law, Dalton's Law, Amagat's Law, and Average molecular weight of gaseous mixtures.

Vapour pressure: Effect of temperature on vapour pressure, Vapour pressure plot (Cox chart), Vapour pressures of miscible and immiscible liquids and solutions, Raoult's Law and Henry's Law.

Humidity and Humidity charts: Relative Humidity and percent saturation; Dew point, Dry and Wet bulb temperatures; Use of humidity charts for engineering calculations

Material balances for systems with and without chemical reactions: species and elemental balance. Analysis of systems with by-pass, recycle and purge.

Thermophysics: Heat capacity of gases, liquids and solutions, Heat of fusion and vaporisation;

Thermochemistry: Calculations and application of heat of reaction, combustion, formation, neutralisation and solution; Enthalpy-concentration charts;

Steady state energy balance for systems with and without chemical reactions:

Combustion of solids, liquids and gaseous fuels, calculation of theoretical and actual flame temperatures, Degrees of freedom in steady state processes, solution of simultaneous material and energy balance problems using flow sheeting codes;

Unsteady state material and energy balance

Text and References Books:

1. D.M.Himmelblau, Basic Principles and calculations in Chemical Engineering, Printice-Hall.
2. O.A. Hougen, K.M. Watson & R.A. Ragatz, Chemical process principles, John Willey & sons.

Course Code: CHE-S202

Breakup: 3 – 1 – 0 – 4

Course Name: Fluid Mechanics

Course Details:

Fundamentals of fluid mechanics: Concept of a fluid; Properties of fluid – mass density, specific weight, specific volume, specific gravity, relative density, pressure; Viscosity; Newton's law of viscosity; Newtonian and non-Newtonian fluids; Vapour pressure, boiling point; Bulk modulus and compressibility; Capillarity; Surface tension and its effect.

Fluid pressure and its measurements: Introduction; Pressure at a point – forces on a fluid element, stress, stress at a point, Pascal's law; Pressure variation in a static fluid; Pressure measurement - Barometer, Piezometer, Manometer, Bourdon gauge, Diaphragm pressure gauge.

Buoyancy and floatation: Buoyancy, Buoyant force, Centre of buoyancy; Archimedes' principle; Maximum height of a body floating vertically in water.

Kinematics: Kinematics of fluid flow, scalar, vector, and tensor quantities; Classification of fluid flow – one, two, and three dimensional flow, steady and unsteady flow, uniform and non-uniform flow, laminar and turbulent flow, compressible and incompressible flow, rotational and irrotational flow, ideal and real fluid flow; Lagrangian and Eulerian flow descriptions; Fundamentals of flow visualization – Pathlines, Streaklines, Streamlines, Timelines; Continuity equation.

Fluid dynamics: Euler's equation of motion; Bernoulli's equation; Applications of Bernoulli's theorem - Venturi meter, Orifice meter, Pitot tube; Variable area meter - Rotameter.

Viscous flow: Laminar flow; Turbulent flow; Navier-Stokes equation; Flow through a circular pipe (Hagen-Poiseuille theory); Turbulent flow – Prandtl mixing length theory.

Boundary layer theory: Description of boundary layer; Laminar and turbulent boundary layer in pipes; Boundary layer thickness; Boundary layer separation; Methods of controlling the boundary layer.

Dimensional analysis: Rayleigh's method; Buckingham pi theorem.

Flow through orifices and mouthpieces: Discharge through a sharp edged orifice; Hydraulic coefficients; Discharge through a large rectangular orifice; Discharge through a large circular orifice; Time of emptying a tank through an orifice at its bottom; Time of emptying a conical tank through an orifice at its bottom; Time of emptying a circular horizontal tank through an orifice at its bottom.

Classification of mouthpieces; Loss of head of a flowing liquid due to sudden enlargement, sudden contraction, at the entrance and exit of a pipe, due to an obstruction in a pipe; Discharge through an external and internal mouthpiece.

Flow over notches and weirs: Definition; Types of notches; Discharge over a rectangular notch; Time of emptying a tank over a rectangular notch; Discharge over a triangular notch; Advantages of a V-notch over a rectangular notch; Time of emptying a tank over a triangular

notch; Discharge over a trapezoidal notch; Discharge over a stepped notch; Classification of weirs; Discharge over a rectangular weir; Discharge over a triangular weir; Discharge over a trapezoidal weir.

Flow through pipes: Introduction; Reynolds experiment; Loss of energy in pipes; Darcy-Weisbach formula for loss of head in pipes, Moody's chart, Colebrook equation, Haaland equation, Swamee-Jain equation, Chezy's formula; Minor losses; Combination of pipes – pipes in series, equivalent size of a compound pipe, Dupuit's equation, parallel pipes; Flow through nozzles; Water hammer.

Pumps: Introduction; Classification of pumps; Centrifugal pumps – Components of a centrifugal pump, Working of a centrifugal pump, Priming of a centrifugal pump, Definitions of heads and efficiencies of a centrifugal pump, Effect of variation in speed, Specific speed and pump similarity, Characteristic curves of centrifugal pumps, Net positive suction head, Cavitation in pumps. Reciprocating pumps – Types of reciprocating pumps, Working of a reciprocating pump, Discharge of reciprocating pump, Coefficient of discharge, Slip of the reciprocating pump, Power required to drive a reciprocating pump; Comparison between centrifugal pump and reciprocating pump.

Text and ReferencesBooks:

1. C S P Ojha, R Berndtsson, P N Chandramouli, Fluid Mechanics and Machinery, Oxford University Press, New Delhi (2010).
2. P N Modi, S M Seth, Hydraulics and Fluid Mechanics including Hydraulics Machines, Standard Book House, New Delhi (2017).
3. N de Nevers, Fluid Mechanics for Chemical Engineers, Third edition, McGraw Hill, Chennai (2017).
4. Y ACengel, J M Cimbala, Fluid Mechanics Fundamentals and Applications, Fourth edition, McGraw Hill, Chennai (2019).
5. W L McCabe, J Smith and P Harriot, Unit Operations of Chemical Engineering, Seventh edition, Tata McGraw Hill, New Delhi (2014).
6. C J Geankoplis, Transport Processes and Unit Operations, Third edition, PHI, New Delhi (1993).

Course Code: CHM-S301

Breakup: 3 –0 – 3 –4

Course Name: Chemistry II

Course Details:(Theory)

UNIT-1

Solid state:Crystal lattices, space lattices and unit cells, crystal systems, Miller indices, Imperfection in crystals: Point defects- schottky and Frankel defects, Liquid crystals, conducting properties of solids.

Phase Rule- Gibbs's phase rule, phase diagrams of one-component system (water), two component system (lead-silver)

Electronic materials- Composites, Materials related to nanotechnology.

UNIT-II

Polymers:Introduction, Classification of Polymers, Intermolecular forces in Polymers, Structure of Organic and Inorganic polymers of industrial importance, Specialty Polymers: Liquid crystalline polymer, Conducting & electroluminescent polymers.

UNIT-III

Chemistry of cells:Proteins, Nucleic acids, Enzymes, Lipids, Genome.

UNIT-IV

Corrosion:Causes and types of corrosion, Measurement of corrosion, Corrosion prevention methods(electrochemical, inhibitor and coating methods)

UNIT-V

Water Treatment:Hardness of water, softening of water, Reverse osmosis, Treatment of boiler feed water by Calgon process, Ion- exchange resins and Zeolites.

UNIT-VI

Fuels:Coal, Biomass, Biogas, Determination of net calorific values of Bomb calorimeter.

UNIT-VII

Environmental Pollution:Types of pollution and pollutants, Air pollution, Formation and depletion of ozone, Smog and acid rain.

UNIT-VIII

Clusters:Introduction, Types of clusters- Vander Waals clusters, Molecular clusters, Nanoclusters, Macroscopic clusters.

Text and ReferencesBooks:

Engineering Chemistry-

1. Kuricose&Rajaram (Vol I &II)
2. S.S. Dara

Course Details: (Practical)

1. To determine the chloride content in supplied water sample using Mohr's method or To determine the percentage of available chlorine in sample of bleaching powder.
2. To determine the Chemical oxygen demand (COD) of polluted water sample using potassium dichromate.
3. To determine the Biological oxygen demand (BOD) /dissolved oxygen (DO) of polluted water sample.
4. To determine the critical micelles concentration (CMC) of surfactant (Sodium dodecyl Sulphate (SDS)) using conductivity meter.
5. To determine the upper Critical Solution Temperature of partially immiscible phenol-water system.
6. To determine the viscosity of addition polymer like polystyrene/PEG.
7. To separate chlorophyll and carotenoids using Column Chromatography.
8. To determine equivalence point of strong acid- strong base, Strong acid-weak base and weak acid-strong base, mixture by conductometric titration.
9. To determine coal sample contents by proximate analysis using muffle furnace.
10. To determine neutralization value of a lubricant oil sample.

Course Code: CHE-S203

Breakup: 3 – 1 – 0 – 4

Course Name: Chemical Engineering Thermodynamics

Course Details:

Introduction: macroscopic and microscopic approaches; units; basic concepts of system, property, force, temperature, pressure, work, energy, heat and equilibrium

Review of First and Second law of thermodynamics for closed and open system,

P-v-T behaviour of pure substance: graphical, tabular and mathematical representation Ideal gas, Cubic equations of state; Virial equation of state, laws of corresponding states, compressibility factor, accentric factor, generalized correlation for gases and liquids;

Thermodynamic Potentials and Thermodynamic Property relations: Postulates; Intensive properties; Criteria of equilibrium; Euler relation, Gibbs Duhem relation; Potentials- A, G, H, U; Property relations for homogeneous phases; Maxwell's relation,

Thermodynamic properties of real gases: departure functions; evaluation of departure functions; partial molar properties, fugacity and fugacity coefficient, estimation of fugacity coefficient, thermodynamic properties of real gas mixtures – mixing rules, prediction of P-v-T behaviour, departure functions, fugacity coefficients for real gases; Fugacity of a component in a mixture, Fugacity of liquid and solid,

Thermodynamics of solution: Ideal solution, Raoult's law, phase equilibrium problems; excess properties, activity and activity coefficient, excess Gibbs free energy models; Henry's law, basic equation for vapour liquid equilibrium; VLE at low to moderate pressures and high pressures, excess Gibbs free energy models, azeotropic data, bubble, dew point and flash calculations; dilute solution laws

Chemical reaction equilibrium: standard Gibbs free energy change and equilibrium constant, effect of temperature on equilibrium constant; homogeneous gas and liquid phase reactions

Text and References Books:

1. Y.V.C. Rao, Chemical Engineering Thermodynamics, University Press.
2. Smith & van Ness, Introduction to Chemical Engineering Thermodynamics, McGraw Hill
3. K. V. Narayanan, Chemical Engineering Thermodynamics, CBS Publication.

Course Code: CHE-S204**Breakup: 3 – 1 – 0 – 4****Course Name: Heat Transfer****Course Details:**

General Principles of heat transfer by conduction, convection, radiation.

Conduction: Fourier's law of heat conduction; steady state conduction in one dimension with and without heat source through plain wall, cylindrical & spherical surfaces; variable thermal conductivity, combined mechanism of heat transfer (conduction and convection), conduction through composite slab, cylinder and sphere; thermal contact resistance; thermal insulations, properties of insulating materials; critical radius of insulation; extended surfaces: heat transfer from a fin, effectiveness and efficiency

Convection: Natural and forced convection; convective heat transfer coefficient; concept of thermal boundary layer; laminar & turbulent flow heat transfer inside and outside tubes; dimensional analysis, Buckingham pi theorem, dimensionless numbers in heat transfer and their significance; determination of individual & overall heat transfer coefficients and their temperature dependency

Forced convection: correlation for heat transfer in laminar and turbulent flow in a circular tube and duct, Reynolds and Colburn analogies between momentum and heat transfer
Natural convection – natural convection from vertical and horizontal surfaces, Grashof and Rayleigh numbers

Heat exchangers: Types of heat exchangers like double pipe, shell & tube, plate type, extended surface, multi-pass exchangers; their detailed construction and operation; calculations on design of heat exchangers; effectiveness of a heat exchanger

Heat transfer with phase change: condensation of pure and mixed vapours; film wise and drop wise condensation, calculations on condensers, heat transfer in boiling liquids, boiling curve, nucleate and film boiling; correlations for pool boiling

Evaporation: elementary principles, boiling point elevation and Duhring's plot; types of evaporators – single, multiple (forward, backward, mixed feed), capacity and economy of evaporators simple calculation on single and multiple effect evaporators

Radiation: Basic concepts of radiation from surface, black body and grey body concepts, Planks Law, Wein's displacement law, Stefan Boltzmann's law, Kirchoff's law, View factor, combined heat transfer coefficients by convection and radiation.

Introduction to unsteady state heat transfer: lumped parameter model, unsteady state heat conduction in various geometries, Heisler charts

Text and References Books:

1. B. K. Dutta, Heat Transfer Principles and Applications, PHI
2. D.Q. Kern, Process Heat Transfer, McGraw Hill.
3. J. P. Holman, Heat Transfer, McGraw Hill.
4. F.P. Incropera and D. P. Dewitt, Fundamentals of Heat and Mass Transfer, John Wiley
5. Y. A. Cengel, A. J. Ghajar, Heat and Mass Transfer: Fundamentals & Applications, McGraw Hill

Course Code: CHE-S205

Breakup: 4 – 0 – 0 – 4

Course Name: Chemical Process Industries

Course Details:

Overview: Typical chemical processes: unit operations and unit processes; classification of Indian chemical process industry; study aspects of a CPI- raw materials, process, chemical reactions, process and block flow diagram, major engineering issues and uses; Common utilities such as electricity, cooling water, steam, hot oil, refrigeration and chilled water.

Chlor-alkali industry: manufacture of soda ash, caustic soda, chlorine and hydrochloric acid
Sulphur industry: Sulphur, sulphuric acid and oleum

Phosphorus industry: Phosphorus, phosphoric acid and superphosphates

Nitrogen industry: Ammonia, urea, nitric acid and ammonium nitrate.

Cement industry: manufacture by cement rock (limestone) beneficiation and Portland process

Natural product industry: pulp and paper, sugar and alcohol, edible oils and fats

Soap and detergent industry: classification of soap, detergent and surfactants and their manufacture

Polymer industry: general polymerization systems: bulk, solution, suspension and emulsion polymerisation; synthesis of polyethylene, polypropylene, polystyrene and PVC, polyester synthetic fibres

Natural and synthetic fibre industry: manufacture of viscose rayon, nylon 6,6 and nylon 6 fibres and polyester fibres.

Petroleum and petrochemical industry: Petroleum refining: Basic distillation, thermal cracking, alkylation and catalytic cracking, other refining unit processes: reforming, hydrodealkylation, isomerisation, hydrogenation, desulphurisation, polymerisation etc.

Important petrochemicals: C1, C2, C3, C4 etc, benzene, toluene, xylene and other petrochemicals from these basic building blocks

Text and References Books:

1. Dryden, Principles in Chemical Technology.
2. G.T. Austin, Shreve's Chemical Process Industries, McGraw Hill.

Course Code: CHE-S206**Breakup: 3 – 1 – 0 – 4****Course Name: Mechanical Operations****Course Details:**

Introduction: Unit operations; Unit processes; Requirement of separation processes in chemical engineering practice; Classification of separation processes; General introduction of mechanical-physical separation processes.

Properties and storage of solids: Characterization of solid particles - Particle shape and size, mixed particle sizes, average particle sizes; Solids in bulk - angle of repose, angle of internal friction, storage of bulk solids, flow of bulk solids, problems with the flow of bulk solids.

Size reduction of solids: Size reduction methods - compression, impact, attrition, shear, cutting; Principles of size reduction - properties of solids, factors affecting size reduction process, energy and power consumption in size reduction, crushing efficiency, determination of power consumption, laws of comminution; Size reduction equipments, selection criteria of size-reduction equipments; Coarse crushers; Intermediate crushers; Grinders; Ultra-fine grinders.

Solid-solid separation: Screening, Screening equipments; Electrical separation – Magnetic and electrostatic separation; Classification with water – Principles of separation (Free settling and hindered settling), Classifying equipments – nonmechanical and mechanical classifiers; Gravity concentration, equipments; Flotation, equipments.

Solid-liquid separation: Sedimentation, Batch sedimentation, Sedimentation theory, equipments (Thickeners and classifiers); Filtration – Principles of cake filtration, types of cake filtration, filter media, filter aids, filtration theory, batch and continuous filtration; Filtration equipments – Filter press, Leaf filter, Rotary drum filter.

Gas-solid separation: Introduction; Gas cleaning equipments – Gravity settling chamber, Inertial separator, Fabric filter, Wet scrubber, Electrostatic precipitator, Cyclone separator, Air classifier.

Transportation of solids: Introduction; Transportation equipment – Belt conveyors, Screw conveyors, Pipe conveyors, Bucket elevators, conveying of powders.

Mixing of solids: Introduction; Liquid mixing – Use of baffles, power consumption; Solid mixing – Mixing index concept, Rate of mixing, Energy consumption; Mixing equipment – Liquid mixers, Solid mixers, Viscous mixers.

Auxiliary operations: Introduction; Size enlargement; Crystallization; Feeding; Weighing; Coagulation and flocculation.

Text and References Books:

1. A K Swain, H Patra, G K Roy, Mechanical Operations, McGraw Hill, Chennai (2018).
2. B A Wills, J Finch, Wills' Mineral Processing Technology, Eighth edition, Butterworth-Heinemann (2015).
3. A S Foust, Principles of Unit Operations, Second edition, Wiley, New York (1980).
4. W L McCabe, J Smith and P Harriot, Unit Operations of Chemical Engineering, Seventh edition, Tata McGraw Hill, New Delhi (2014).
5. C J Geankoplis, Transport Processes and Unit Operations, Third edition, PHI, New Delhi (1993).

Course Code: HSS-S401

Breakup: 3 – 0 – 0 – 4

Course Name: Engineering Economics

Course Details:

UNIT-1

Meaning, definition and scope of economics, Basic concepts of demand and supply, Market equilibrium, Ceiling price and floor price.

UNIT-2

Price elasticity of demand: Factors affecting price elasticity of demand, Calculation, Relation between marginal revenue, demand and price elasticity, Income elasticity of demand and Cross elasticity of demand, Indifference curves, Budget Line

UNIT-3

Production and Cost analysis: Basic concepts, Production in the short- run and long-run, cost analysis

Finding the optimal combination of inputs, Returns to scale.

UNIT-4

Market: Characteristics of perfect completion, Profit maximisation in short-run and long-run
Firms with market power: Measurement and determinants of market power, Profit maximisation under monopoly: output and pricing decisions, Price discrimination, capturing consumer surplus, Strategic decision making in oligopoly markets

UNIT-5

National income: Concepts, Sources, Measurement, Difficulties, circular flow of income

Inflation: Cost-push and Demand-pull inflation, Effects and control of inflation, Business cycle, Functions of RBI, GST

Text and References Books:

1. Economics by Paul. A. Samuelson
2. Managerial Economics by Christopher R. Thomas, S. Charles Maurice, SumitSarkar
3. Financial Management by J. V. Vaishampayan
4. Micro Economics by A. Koutsoyannis

Course Code: EVS-S101

Breakup: 2 – 0 – 0 – 2

Course Name: Environmental Science

Course Details:

UNIT-I

Scope and Importance of environmental studies, Need for public awareness, Segments of environment, biodiversities: Genetic diversity, Species diversity, Ecosystem diversity, Landscape diversity, Causes of pollution and detrimental effects.

UNIT-II

Eco systems- Types of systems, energy flow in an ecosystem, Balanced ecosystem, Human activities- Food, shelter, economic and social security, Effects of human activities on environment- Agriculture, housing, Industry, mining and transportation activities, Basics of Environmental Impact Assessment, Sustainable Development.

UNIT-III

Types of natural resources: Water resources-Availability and quality aspects, Water borne diseases, Fluoride problems in portable water, Mineral resources, Food resources, Land resources, Forest Wealth, Material cycles- Carbon, Nitrogen and Sulphur cycle.

UNIT-IV

Energy- Different types of energy (Renewable and Non-renewable), Convectional and non-conventional energy-sources. Electromagnetic radiation, Hydro Electric, Fossil fuel based, Nuclear, Solar, Biomass and Bio-gas, Hydrogen as an alternative future source of energy.

UNIT-V

Environmental pollution and their effects, Water pollution, Land pollution, Noise pollution, public Health aspects, Air pollution. Current environmental issues of importance and their impact on environment: Population Growth, Climate change and global warming effect, Urbanization, Automobile pollution, Acid rain, Ozone layer depletion.

UNIT-VI

Preventive measures and control of pollution, Air and Water pollution control, Solid waste management, Case studies.

UNIT-VII

Role of Government in environment protection, Legal Aspects, Initiatives and protection Acts, public awareness, Initiatives by Non-governmental Organizations (NGOs), Role of IT services, Disaster management.

UNIT-VIII

Field work/ Activities/ Visit.

Text and References Books:

1. Environmental Studies- Benny Joseph, TATA McGraw Hill publication.
2. Environmental Studies- Dr. D.L. Manjunath, Pearson Education.
3. Environmental Studies- R. Rajgopalan, Oxford publication.
4. Environmental Science and Technology- M. Anji Reddy, BS publication.

5. Principles of Environmental Science and Engineering- P. VenugopalanRao, Prentice Hall of India.
6. Environmental Science and Engineering- Meenakshi, Prentice Hall of India.

Course Code: CHE-S301**Breakup: 3 – 1 – 0 – 4****Course Name: Mass Transfer I****Course Details:**

Distillation: Vapour-liquid equilibria, Relative volatility, Raoult's law, minimum and maximum boiling mixtures, enthalpy-concentration diagrams for binary systems, multicomponent systems – bubble point and dew point calculation, Flash vaporization, Differential distillation, Steam Distillation, Continuous rectification, Azeotropic and Extractive Distillation, Multistage tray towers - Graphical methods of Ponchon-Savarit and McCabe-Thiele, feed-tray location, total reflux, minimum reflux ratio, optimum reflux ratio, open steam, multiple feed and side stream, multi component calculations using short-cut methods.

Liquid Extraction: Introduction, liquid equilibria, equilateral-triangular coordinates systems of three liquids, choice of solvent, single stage and multistage crosscurrent extraction, insoluble liquids, continuous counter current multistage extraction, insoluble liquids.

Leaching: Introduction, lixiviation, decoction, elutriation or elution, preparation of the solid, effect of temperature, types of equilibrium curves, single stage and multistage crosscurrent leaching, multistage counter current leaching.

Adsorption: Introduction, types of adsorption, nature of adsorbents, adsorption equilibria – single gases and vapours, adsorption hysteresis, effect of temperature, heat of adsorption, adsorption of solute from dilute solution, single stage and multistage crosscurrent operation using Freundlich equation, multistage counter current operation using Freundlich equation.

Text and References Books:

1. R E Treybal, Mass-Transfer Operations, Third edition, McGraw Hill, New Delhi (2012).
2. K V Narayanan, B Lakshmikutty, Mass Transfer Theory and Applications, CBS Publishers and Distributors, New Delhi (2014).
3. B K Dutta, Principles of Mass Transfer and Separation Processes, Second edition, PHI, New Delhi (2007).
4. A S Foust, Principles of Unit Operations, Second edition, Wiley, New York (1980).
5. W L McCabe, J Smith and P Harriot, Unit Operations of Chemical Engineering, Seventh edition, Tata McGraw Hill, New Delhi (2014).
6. C J Geankoplis, Transport Processes and Unit Operations, Third edition, PHI, New Delhi (1993).

Course Code: CHE-S303

Breakup: 3 – 1 – 0 – 4

Course Name: Unit Operation Laboratory -1

Course Details:

Screen Analysis; Crushing efficiency for jaw crusher; Crusher rolls; Disintegrater; etc.; Sedimentation and Thickeners; Viscosity measurement; Flow through pipes (Reynold'S experiment); Flow-Through Open Channels; Flow Through fitting and Joints; Orifice meter; Venturi meter; Rotameter; Verification of Bernoulli's Theorem; Characteristics of Centrifugal pumps; Fluidized bed; Spouted bed; Plate and Frame filter press; Rotary drum; Vacuum filter; Agitator and mixing.

Course Code: CHE-S304**Breakup: 3 – 1 – 0 – 4****Course Name: Chemical Reaction Engineering-1****Course Details:**

Introduction and overview of chemical reaction engineering

Kinetics of homogeneous reactions, concentration dependent term and temperature dependent term of the rate equation, searching for rate expressions from mechanisms; non elementary homogeneous reactions;

Interpretation of batch reactor data: Constant volume batch reactor; varying volume batch reactor; collection and analysis of batch data – integral and differential method; half-life method, reversible reaction data, temperature and reaction rate;

Introduction to Reactor Design

Single Ideal Reactor: Ideal batch reactor; steady state continuously stirred tank reactor; steady state plug flow reactor; size comparison of single reactions; multiple reactor systems; recycle reactor; autocatalytic reactions;

Design for multiple reactions: parallel reactions-product distribution, fractional yield, reversible and irreversible reaction; series reactions - reversible and irreversible reaction; series-parallel reactions, Denbigh reactions

Non isothermal reactors: temperature and pressure effects on single and multiple reactions, equilibrium conversions, optimum temperature progression, adiabatic and non-adiabatic operations

Non ideal Reactors: Residence time distribution, E, C, F curves, segregation model, dispersion model, chemical reaction and dispersion, tank-in-series model; multiparameter models

Text and References Books:

1. O. Levenspiel, Chemical Reaction Engineering, John Willey & Sons.
2. H.S. Fogler, Elements of Chemical Reaction Engineering, Prentice Hall

Course Code: CHE-S309

Breakup: 3 – 1 – 0 – 4

Course Name: Numerical Methods for Chemical Engineers

Course Details:

Introduction to Numerical Method: Approximations and errors in computation, commonly used Taylor series, Binomial theorem

Solution of Algebraic and Transcendental equations: bisection methods, Regula-Falsi method, Newton-Raphson methods, Secant method

Solution of simultaneous Algebraic equations:

Gauss elimination method, Gauss Jordan method, Jacobi Iteration method, Gauss-Seidel iteration method

Interpolation and curve- fitting

Graphical method, Least Square method and curve fitting of data, Method of Moments, cubic spline problems, Methods of group averages, approximation of functions interpolation and extrapolation of techniques, Finite differences, forward, backward and central difference,

Numerical differentiation and integration: derivatives from difference tables; Numerical integration – Newton Cotes Integration technique, trapezoidal rule, Simpson's 1/3 rd and 3/8th rule,, Gaussian quadrature; double integration.

Ordinary differential equation: Picard's method, Taylor series method, Euler's method, Euler's modified iteration technique, Runge method, Runge-Kutta 4th order technique, Solutions of ordinary differential equation (initial and boundary value problem)

Linear programming: simplex method, dual simplex, charne penalty method.

Text and References Books:

1. S. K. Gupta, Numerical Methods for Chemical Engineers, New Age International
2. S. Chapra and R. Canale, Numerical Methods for Engineers, McGraw Hill Education.
3. B. S. Grewal, Numerical Methods in Engineering and science. Khanna Publishers
4. S. S. Sastry, Introductory Methods of Numerical analysis, PHI learning.

Course Code: HSS-S301

Breakup: 1 –0 – 1 – 2

Course Name: Communication Practicum

Course Details:

Unit 1- Presentation techniques

Meaning and importance of presentation technique

Presentation skills required for business organization: Negotiation, Persuasion & Time management

Types of business presentations- meetings, seminars, conferences

Unit 2- Oral presentations

Effective oral delivery- Phonetics

Interviews, Group discussions, debates, speeches

Listening skills, Reading skills

Unit 3- Written communication

Style and tone of writing business messages and documents.

Persuasive, sales and goodwill messages, delivering bad news

Writing e-mails and short messages, Resume writing

Unit 4 – Non Verbal communication

Nonverbal communication techniques

Business manners, ethics and personality development

Power point presentations

Text and References Books:

1. "Business Communication Today", Bove`e, Thill and Schatzman: Pearson Education (Singapore), 2003.
2. "Business Communication-a framework of success", H. Dan O'Hair, James S. O'Rourke and Mary John O'Hair: South Western College Publishing, 2001.
3. "Basic Business Communication", Raymond V. Lesikar, Marie E. Flatley: Tata McGraw Hill Publishing Company Ltd., 2002.

Course Code: CHE-S305

Breakup: 3 – 1 – 0 – 4

Course Name: Mass Transfer II

Course Details:

Molecular diffusion in fluids: Introduction; Molecular diffusion; Flux J and N ; Steady state molecular diffusion in fluids at rest and in laminar flow; Molecular diffusion in gases through non-diffusing B, equimolar counter diffusion and multicomponent mixtures; Factors affecting gas phase diffusion; Experimental determination of the gas phase diffusion coefficient – Twin bulb method, Stefan tube; Pseudo steady state diffusion through a stagnant gas film; Predictive equations for the gas phase diffusivity; Molecular diffusion in liquids; Predictive equations for liquid phase diffusivity; Diffusion through varying cross-sectional area – Spherical geometry, Tapered tube; Types of diffusion – Knudsen, molecular, and transition, surface diffusion.

Mass transfer coefficients: Mass transfer coefficient in different units; Mass transfer from a gas into a falling liquid film; Eddy diffusion; Prandtl mixing length; Theories of mass transfer - Film theory, Penetration theory, Surface renewal theory; Momentum, heat and mass transfer analogies; dimensionless numbers in mass transfer and their analogues in heat transfer; Mass transfer in wetted wall column; Mass transfer for simple situations; j_H and j_D factor.

Diffusion in solids: Fick's law diffusion; Unsteady state diffusion; Diffusion through polymers; Diffusion through crystalline solids; Diffusion in porous solids.

Interphase mass transfer: Equilibrium; Equilibrium relations; Diffusion between phases; Two-resistance theory; Individual and overall mass transfer coefficients; Material balance in continuous contact equipments - steady state cocurrent and countercurrent processes; Stages - continuous cocurrent processes, batch processes, cascades; Kremser equations.

Humidification and Dehumidification: Psychometric chart; Adiabatic saturation curves; Wet bulb temperature; Adiabatic operations - Water cooling with air, Dehumidification of air-water vapour.

Gas absorption: Equilibrium solubility of gases in liquids; Ideal and non-ideal liquid solutions; Choice of solvent for absorption; Material balance for cocurrent and countercurrent gas absorption and stripping; Absorption factor A ; Design of packed towers; Concept of HETP, H_{tG} , N_{tG} , H_{tL} , N_{tL} , H_{tOG} , N_{tOG} , H_{tOL} , N_{tOL} .

Drying: Equilibrium; Definitions; Drying operation; Batch drying - rate of batch drying; Mechanisms of batch drying - cross circulation drying, through-circulation drying.

Adsorption: Continuous countercurrent adsorption of one and two components; Rate of adsorption in fixed beds.

Text and References Books:

1. R E Treybal, Mass-Transfer Operations, Third edition, McGraw Hill, New Delhi (2012).
2. K V Narayanan, B Lakshmikutty, Mass Transfer Theory and Applications, CBS Publishers and Distributors, New Delhi (2014).

3. B K Dutta, Principles of Mass Transfer and Separation Processes, Second edition, PHI, New Delhi (2007).
4. A. S. Foust, Principles of Unit Operations, Second edition, Wiley, New York (1980).
5. W L McCabe, J Smith and P Harriot, Unit Operations of Chemical Engineering, Seventh edition, Tata McGraw Hill, New Delhi (2014).
6. C J Geankoplis, Transport Processes and Unit Operations, Third edition, PHI, New Delhi (1993).

Course Code: CHE-S306

Breakup: 3 – 1 – 0 – 4

Course Name: Instrumentation and Process Control

Course Details:

Introduction to process control: Needs & control aspects of a chemical plant: stirred tank heater, flow in tank, control of heat exchanger, distillation column and reactor, SISO and MIMO control., Types of controller , on-off, P, PI and PID control modes, introduction to measuring sensors for level, flow, temperature and pressure measurements. Transmission lines, final control elements, Control valves and their characteristics.

Introduction to mathematical modelling: state variables and state equations, dead time, modelling with dead time, degree of freedom, linearization of nonlinear system, deviation variables, multivariable system linearization.

Laplace transform: Laplace transform of step, impulse , pulse ,ramp, trigonometric functions, derivative and integral functions, initial value theorem, Final value theorem, Dirac delta functions, Inverse Laplace transform, solution of linear differential equation using Laplace transform, transfer function and input–output model, Poles & zeros of system.

Dynamic behavior of first order system: Time constant, steady state gain, response of the system

Dynamic behaviors of second order system: study of interacting & noninteracting response, Inverse response, multicapacity process, overdamped, critically damped, underdamped response their characteristics, overshoot ,decay ratio, period of oscillation, rise time, ultimate period, delay time.

Feedback control system: concept of feedback control system, types of controller, on-off, P, PI, PID controller, introduction to measuring sensors, transmission lines, final control elements, block diagram reduction and signal flow graph theory to solve feedback loop,

Stability of Closed-Loop Control Systems: Criteria for stability, characteristic equation, Routh –Hurwitz criteria of stability, Root-Locus analysis, Frequency response analysis of linear processes, Bode stability criteria, Nyquist stability criteria , gain margin, phase margin,

Design of controllers: Simple performance criteria, Time Integral performance criteria, Ziegler Nichols tuning technique, Cohen –oon tuning technique.

Introduction to advance control strategies: ratio, cascade, feedforward, override and valve positioning (optimizing) control. Microprocessor–based controllers and economic plantwide computer control.

Text and References Books:

1. D.R. Coughnour, Process system Analysis & Control, McGraw Hill.
2. George Stenphanopolous, An Introduction of Process Dynamics & Control.
3. Curtis D. Johnson, Process Control Instrumentation Technology, international eighth edition, Pearson Education Limited.

Course Code: CHE-S307**Breakup: 3 – 1 – 0 – 4****Course Name: Chemical Engineering Design-I****Course Details:**

Introduction to Chemical Engineering Plant design: General overall design considerations, design steps for chemical processes; types of projects; optimum design – optimum economic design, optimum operation design, practical considerations in design; engineering ethics in design

Process design development: development of design database; process creation; types of process design; feasibility survey; flow sheet presentation – PFD, PID, utility and safety diagrams; vessel and piping layout isometrics; flowsheet symbols; utility streams; equipment design and specifications, equipment specification sheet, scale-up of equipment in design, safety factors;

Flowsheet synthesis and development: fundamentals of material balance and energy balance for manual flowsheet calculations, general procedure for flowsheet development – hierarchical and algorithmic methods; conceptual design of a chemical process - hierarchy of decisions; computer-aided flow sheeting

General design considerations: Health and safety hazards; Loss prevention; Environmental consideration; Plant location; Plant layout, Plant operation and control

Cost estimation: cash flow for industrial operations, factors affecting investment and production costs, capital investment – fixed capital and working capital investment, cost indices, cost components and methods for estimating capital investment, estimation of revenue, estimation of total product cost, gross and net profit

Interest and investments costs: simple, compound and continuous interest rates, nominal and effective interest rates, time value of money, annuity, cash flow patterns, capitalized cost; Taxes and Insurance: cost of capital, corporate tax, insurance

Depreciation: depreciable investments, depreciation and taxes, current value, salvage value, methods for calculating depreciation

Profitability, Alternative investments and Replacements: methods of calculating profitability, alternate investment, replacements, practical factors in alternative investment and replacement analysis

Optimum design and Design strategy: optimum solution methodologies – one variable and two variable, optimum production rates in plant operation, optimum conditions in cyclic operations, optimum operating time, optimum cooling water flowrates in exchangers, optimum reflux ratio

Project management – network construction, critical path method (CPM), project evaluation and review technique (PERT)

Material selection for equipment: factors contributing to corrosion, combating corrosion, properties of materials, selection of materials,

Text and ReferencesBooks:

1. M.S. Peters, K. D. Timmerhaus, R. E. West, Plant Design and Economics for Chemical Engineers, McGraw Hill.
2. R. K. Sinnott, Coulson and Richardson's Chemical Engineering Series, Chemical Engineering Design Vol 6, Elsevier
3. J. M. Douglas, Conceptual Design of Chemical Processes, McGraw Hill
4. R. Turton, R. C. Bailie, W. B. Whiting, J. A. Shaeiwitz, Analysis, Synthesis, and Design of Chemical Processes, Prentice Hall
5. K. H. Humphreys, Jelen's Cost and Optimization Engineering, McGraw Hill
6. V. V. Mahajani and S. M. Mokashi, Chemical Project Economics, Laxmi Publications
7. W. D. Seider, J. D. Seader, D. R. Lewin, Product and Process Design Principles, Willy & Sons

Course Code: CHE-S308

Breakup: 0 – 0 – 4 – 4

Course Name: Transport Process & Unit Operations Laboratory -2

Course Details:

Heat conduction through rods of different materials; Thermal conductivity of insulating materials; Boiling and Condensation; Double pipe Heat Exchanger; Shell & Tube Heat Exchanger; Long tube evaporator; Distillation; Batch & Continuous column; Absorption with and without chemical reaction; Liquid-liquid extraction/leaching; Adiabatic humidifier, Water cooler; Driers; Tray, Rotary, Spray; Ion exchange, Reverse osmosis.

Course Code: SSM-S301

Breakup: 0 – 0 – 2 – 2

Course Name: Student Seminar

Course Details:

Each student is required to present a seminar of 20-30 minutes on a topic related to current research in Chemical Engineering

Course Code: CHE-S401

Breakup: 4 – 0 – 0 – 4

Course Name: Chemical Engineering Design-II

Course Details:

Introduction, nature of design, anatomy of a chemical manufacturing process, organisation of a chemical engineering project, project documentation, codes and standard, factor of safety, degree of freedom and design variables, optimisation

Design information and data – prediction of physical properties, phase equilibrium data

Pumps: Theory and characteristics; types of pumps, criterion for selection of pumps; theory of compression, equipment for gas compression; Ejectors and Vacuum systems

Equipment selection, specification and design: Separation processes, solid- solid separations; liquid solid separators - thickeners and classifiers, filtration, centrifuges, hydro-cyclones; separation of dissolved solids - Evaporation and crystallisation; liquid- liquid separation- decanters, centrifugal separators; gas – solid separation – gravity settlers, impingement separator, filters, wet scrubbers, cyclones, electrostatic precipitators

Separation columns: Continuous distillation - process description, reflux considerations, feed-point location, selection of column pressure, stage equations, dew point – bubble points, equilibrium flash calculations, design variable in distillation; design method for binary system: basic equations, McCabe –Thiele method, low product concentrations, Smoker equations

Multicomponent distillation; Key components, number of columns, short –cut method for stage and reflux requirements, pseudo- binary systems, Smith–Brinkley method, empirical correlations, rigorous solution procedures, batch distillation, plate efficiency, column sizing, plate hydraulic design, Packed columns

Heat transfer equipment: Types of exchangers – double pipe, shell and tube, plate, spiral, finned tube, air cooled, fired heater; Overall heat transfer coefficient, fouling factors, double pipe heat exchangers, shell and tube heat exchangers - tube count, shell type, baffles, support plate and tie rods, tube sheet, shell and header nozzles; mean temperature difference, general design consideration - fluid allocation, shell and tube fluid velocity stream temperature pressure drop, tube side heat transfer coefficient and pressure drop, shell side heat transfer coefficient and pressure drop; design methods - Kern's Method, Bell's method,

Condensers – single and mixed vapours, Reboilers and Vaporisers

Evaporators – boiling point elevation, design of multiple effect evaporators

Pressure vessels: design pressure, design temperature, design stress, welded joint efficiency, minimum practical wall thickness, design of thin walled vessels under internal pressure – head and closures; vessel supports – saddle, skirt, bracket support

Text and Reference Books:

1. R. K. Sinnott, Coulson and Richardson's Chemical Engineering Series, Chemical Engineering Design Vol 6, Elsevier

2. E. E. Ludwig, Applied Process Design for Chemical and Petrochemical Plants, Elsevier
3. S. M. Walas, Chemical Process Equipment - Selection and Design, Butterworth Series of Chemical Engineering
4. R. Smith, Chemical Process Design and Integration, Wiley
5. V. V. Mahajan and S. B. Umarji, Joshi's Process Equipment Design, Laxmi Publications
6. S. B. Thakore and B. I. Bhatt, Introduction to Process Engineering and Design, McGraw Hill Education

Course Code: CHE-S402

Breakup: 4 – 0 – 0 – 4

Course Name: Chemical Reaction Engineering -II

Course Details:

Introduction to heterogeneous reaction; global reaction;

Catalysis: definition, physical properties of catalyst, preparation, testing and characterization of solid catalysts, catalyst selection,

Adsorption: physical and chemical adsorption, isotherms – Langmuir, Freundlich, BET
Rate equation for fluid-solid reaction, surface reaction – dual and single site mechanism, kinetic models (Langmuir-Hinshelwood, Eley-Rideal), heterogeneous data analysis – parameter estimation using regression analysis/Polymath

Internal transport processes: reaction and diffusion with porous catalyst, bulk and Knudsen diffusion, Effectiveness factor, Thiele modulus, Weisz -Prater criterion, falsified kinetics, heat effects during reaction, effect of internal transport on selectivity

External transport processes: overall effectiveness factor, mass transfer coefficient, external temperature gradient, Mear's criterion, effect of external transport on selectivity, non-isothermal condition

Design of solid catalytic reactors: packed bed, mixed flow reactor, bubbling fluidized bed reactor

Deactivation of catalyst: Mechanism of deactivation, rate and performance study of deactivation, effect of pore diffusion on catalysts deactivation, rates for poisoned porous catalyst – uniform poisoning and shell poisoning

Fluid-particle reaction kinetics: selection of a model, progressive conversion model, shrinking core model for spherical particle of changing and unchanging size, comparison of various model selected, determining controlling resistances and rate equation, fluid particle reactor design

Fluid-fluid reaction kinetics: rate equations for gas -liquid and liquid-liquid systems, Different reaction rates – instantaneous, fast, intermediate, slow; Enhancement factor, Hatta number; fluid-fluid reactor design

Text and Reference Books:

1. H. Scott. Fogler, Elements of Chemical Reaction Engineering, Prentice Hall
2. J.M. Smith, Chemical Engineering Kinetics, McGraw Hill.
3. O. Levenspiel, Chemical Reaction Engineering, John Willey & Sons.

Course Code: CHE-S406

Breakup: 0-0 – 3 – 3

Course Name: Process Simulation Lab

Course Details:

CHEMCAD Process simulation software used for

1. Comparing different models for computing thermodynamic and transport properties such as K-values, Enthalpy, VLE data etc. for pure substances and mixtures; Flash calculations and VLE of azeotropic mixtures
2. Design of flow network consisting of fittings, pumps and piping (horizontal, vertical & inclined); single and multiple branches
3. Calculations for performances of pumps, compressors, expanders, valves etc.
4. Preparing steady state process flow sheets (equipment selection, numbering, stream designation) and carrying out mass and energy balances with and without recycle for chemical processes
5. Design and rating of heat exchangers (with and without phase changes); double pipe, shell and tube, plate and frame heat exchangers
6. Design and rating of separation processes – simple distillation column with different reflux ratios (short cut design), rigorous column design; multi-component distillation column design, sequencing of distillation columns, absorption and stripping, liquid-liquid extraction
7. Simulating performance of different reactor models for reversible and irreversible reactions
8. Batch reactor rate regression from process of lab data
9. Control of simple unit operations

Course Code: SST-S401

Breakup: 0 – 0 – 0 – 2

Course Name: Summer Training

Course Details:

A written report and an oral presentation/ interview during the (following) semester after successful completion of an 8-week industrial in-plant training with a chemical industry taken during the summer break.

Course Code: PRT-S401

Breakup: 0 – 0 – 6 – 4

Course Name: Project-I

Course Details:

Equipment/Plant design to be done by groups of students

Course Code: HSS-S201

Breakup: 3 – 0 – 0 – 3

Course Name: Industrial Management

Course Details:

UNIT-1

Introduction, Nature and Scope, Evolution of Management, Approaches to Management: Scientific, System and Contingency.

UNIT-2

Taylor's Scientific Management, Fayol's Administrative Management, Contribution of Mayo, Drucker etc. Levels and skills of management.

UNIT-3

Organisation: Types and structure, Formal-Informal, Line and Staff relationship, Centralisation- Decentralisation.

UNIT-4

Functions of Management Planning: Organisation, Staffing, Directing, Controlling, Decision-Making, Management by objectives, Leadership.

UNIT-5

Psychological foundation of Management: Motivation, Personality, Group dynamics, Models of Herzberg, Maslow etc.

UNIT-6

Plant layout, Plant location, Planning and Control, Materials, Management, Inventory control.

Text and Reference Books:

1. O.P.Khanna, Industrial Engineering
2. T. R. Banga Industrial Engineering and Management
3. Mahajan : Industrial and Process Management

Course Code: CHE-S404

Breakup: 4 – 0 – 0 – 4

Course Name: Transport Phenomena

Course Details:

Introduction, classification of fluids, Fluid kinematics, rate of rotation, vorticity, Nature of transport Phenomena, The phenomenological law, Analogies between momentum, heat and mass transfer and defining of dimensionless number, Reynolds transport theorem, Eulerian and Lagrangian approach, Navier stokes equation; Introduction of molecular and convective flux.

Momentum Transport Phenomena: Newton's law of Viscosity, science of rheology, Prediction of viscosity and its dependence on temperature, pressure, Non– Newtonian models at steady state for Newton's law of Viscosity, Momentum transport in laminar flow, Boundary conditions and shell momentum balance approach for stress distribution; profiles for flow of a falling film, flow through circular tube, flow through an Annulus, Adjacent flow of two Immiscible fluids, time derivatives. Equation of continuity, motion and mechanical energy their applications in fluid flow problems for isothermal system.

Energy Transport Phenomena: Energy transport in laminar flow, Fourier's law of heat conduction, thermal conductivities and its dependence on temperature, pressure, Boundary conditions, Shell balance approach for different types of heat sources such as Electrical, Nuclear, Viscous and Chemical. Heat conduction through composite walls, Principle of extended surfaces as cooling fin, free and forced convection.

Equation of change for Non-isothermal systems, The Equations of energy, Equation of motion for free and forced convection in Non-isothermal flow, use of the equation of change to set up steady state heat transfer problems such as tangential flow in an Annulus with viscous heat generation steady flow of a non-isothermal film, Transpiration cooling , free convection from a vertical plate.

Mass Transport Phenomena: Fick's law of diffusion, Prediction of diffusivity and its dependence on temperature and pressure for gas, liquids and solids, Boundary conditions, Shell balance approach for mass transfer problems, Diffusion through stagnant gas film, Diffusion with homogeneous and heterogeneous chemical reaction, Diffusion in to a falling liquid film, Diffusion and chemical reaction in porous catalyst and the effectiveness factor, equation of continuity for binary mixtures, equation of change to set up diffusion problems for simultaneous heat and mass transfer, thermal diffusion, pressure diffusion, forced diffusion.

Text and Reference Books:

1. Transport Phenomena, Bird Stewart & Lightfoot,. John Wiley & sons.
2. Introduction to transport Phenomena, William J.Thomson, Pearson education Asia.
3. Momentum heat and mass transfer, Bannet and Myers, , Tata Mcgraw Hill.
4. Transport Phenomena: Aunifiedappraoach, R S Broadkey, Tata Mcgraw Hill

Course Code: CHE-S407

Breakup: 0 –0 –3 – 4

Course Name: Chemical Reaction Engineering and Process Control Lab

Course Details:

1. Estimation of activation energy of saponification reaction in a batch reactor
2. Estimation of reaction rate constant in a semi-batch reactor
3. Estimation of reaction rate constant in a plug flow reactor
4. Estimation of reaction rate constant in a continuously stirred tank reactor
5. Residence Time Distribution in a plug flow reactor
6. Residence Time Distribution in a continuously stirred tank reactor
7. Process Control Simulator using electrical analogue
8. Study of Flow Control Trainer
9. Study of Level Control Trainer
10. Study of Temperature Control Trainer
11. Study of Pressure Control Trainer
12. To study the dynamics of two tank interacting and non-interacting system
13. Study of open loop dynamics of first and second order system using MATLAB-SIMULINK

Course Code: PRT-402

Breakup: 0 – 0 – 6 – 4

Course Name: Project-II

Course Details:

Simulation/Experimental/Research/Design Projects to be done by groups of students.

List of possible departmental electives:

1. Polymer Engineering (CHE-S501)
2. Safety in Chemical process Industries. (CHE-S502)
3. Petroleum Engineering. (CHE-S503)
4. Environmental Pollution & Control (CHE-S504)
5. Non-conventional energy sources (CHE-S505)
6. Advanced Separation Processes (CHE-S507)
7. Optimization Techniques (CHE-S508)
8. Biochemical Engineering (CHE-S509)
9. Process Modelling and Simulation (CHE-S510)
10. Fluidization Engineering (CHE-S511)
11. Electrochemical Engineering (CHE-S512)
12. Piping Engineering (CHE-S513)

Course Code: CHE-S501

Breakup: 3-1-0-4

Course Name: Polymer Engineering

Course Details:

Introduction – defining polymers, classification, molecular weight distributions, conformations

Addition polymerization or chain growth polymerization, radical, ionic and Ziegler-Natta polymer, kinetics

Step growth polymerization, kinetics Techniques of polymerizations; Characterisation-measurement of molecular weight, thermal behaviour, morphology, viscoelastic behaviour, mechanical properties

Polymer processing; rubbers, plastics and fibres

Text and Reference Books:

1. George Odian, Principles of Polymerization, John Wiley
2. Billmeyer, Polymer Science and Engineering, John Wiley

Course Code: CHE-S502**Breakup: 3-1-0-4****Course Name: Safety in Chemical Process Industries****Course Details:**

Introduction: Definition of safety, Hazards in common chemical industries, Need and significance of safety in chemical industries, Important case histories.

Hazards associated with chemical substances: Safety related properties of hazardous substances, Classification of dangerous substances, Hazards of flammable and explosive materials, Hazards of common unit operations, Hazards of common chemical reactions, Safety in bulk storage of hazardous chemicals, Safety in shelf storage of hazardous chemicals, Corrosion in chemical industries.

Hazards associated with chemical plants: Safety in use of pipelines and their fixtures in industries, Safety in use of cross country pipelines, Safety in process control systems and use of instruments, Safety in pressure system design and operation, Safety in process plant maintenance, Safety considerations in plant site selection and layout planning.

Hazard identification and assessment: Hazard identification techniques, Hazard and operability studies (HAZOP), Fire and explosion index and toxicity index, Fault tree and event tree analysis, Emission of toxic and flammable gases and vapours, Dispersion of toxic and flammable gases and vapours, Heat radiation from vapour cloud explosions, jet fires, fire balls and pool fires, Probability of accidents and risk calculation.

Safety management: On site emergency planning, Off site emergency planning, Personnel protection and other safety devices, Safety in chemical laboratories, Reliability engineering.

Text and Reference Books:

1. D ACrowl, J F Louvar, Chemical Process Safety Fundamentals With Applications, Third edition, Prentice Hall, Boston (2011).
2. E Sanders, Chemical Process Safety Learning From Case Histories, Third edition, Elsevier, Oxford (2005).
3. R RTatiya, Elements of Industrial Hazards, CRC Press, London (2011).
4. B O Alli, Fundamental Principles of Occupational Health and Safety, Second edition, International Labour Office, Geneva (2008).
5. V Marshall, S Ruhemann, Fundamentals of Process Safety, Institution of Chemical Engineers, Warwickshire (2001).
6. S Mannan (Editor), Lees' Process Safety Essentials: Hazard Identification, Assessment and Control, First edition, Butterworth-Heinemann, Oxford (2014).

Course Code: CHE-S503

Breakup: 3-1-0-4

Course Name: Petroleum Engineering

Course Details:

Introduction to mineral oils, their origin and mode of occurrence; Oil resources and refineries in India Composition of petroleum, refinery products and their test methods Evaluation of oil stacks introduction to processing of petroleum; general processing & crude distillation, refinery products and their application, natural gas, gasoline, naphtha kerosene, fuel oil and gas oil, petroleum waxes, lubricating oils, tar and asphalts.

Petroleum refining processes and operation: thermal cracking, catalytic cracking, hydro-forming, catalytic reforming, alkylation, polymerization, isomerization and other auxiliary process e.g.vis-breaking, de-waxing and de-asphalting operations.

Manufacture of paraffins wax and microcrystalline waxes.

Introduction to lubricants: liquid, solid and gas lubricants and their application.

Lubricating oils: liquids mineral lubricants, synthetic liquids lubricants; Physical properties, additives, manufacture of lubrication oils; Analysis of lubricating oils;

Lubricating Greases: properties, types, ingredients, additives, analysis of lubricating greaser as per BIS test methods; Manufacture of lubricating greases-processes and equipments.

Introduction to petrochemicals; manufacture of alkyl aryl compounds, ethylene oxide; condensation products benzene, toluene, xylene, butadienes, vinyl chloride and styrene etc

Text and Reference Books:

1. Petroleum Refinery Engineering, Nelson, McGraw Hill
2. Petroleum Refining Technology, Dr. Ram Prasad, Khanna Publishers

Course Code: CHE- S504

Breakup: 3-1-0-4

Course Name: Environmental Pollution and Control

Course Details:

Introduction and importance of Environmental Pollution, case studies;

Air Pollution – sources, causes, effects; meteorological and natural purification processes; control of air pollutants – particulates and gases –design aspects ; automobile pollution;

Water Pollution – classification and characterization of water pollutants, sources, causes, effects of water pollution; control processes : physical- design of equalization tanks, sedimentation tanks clarifiers etc., chemical- coagulation, disinfection, adsorption etc.,

biological – introduction to bacterial growth and kinetics, BOD estimation, aerobic and anaerobic treatment methods, activated sludge process, trickling filters- design aspects, sludge disposal, clarified water disposal,

Solid-waste management, Noise Pollution, Radioactive Pollution

Text and Reference Books:

1. Metcalf & Eddy, Waste Water Engineering- Treatment Disposal and Reuse, Tata McGraw Hill
2. De Nevers, Air Pollution Control Engineering, McGraw Hill
3. Wark& Werner, Air Pollution
4. C. S. Rao, Environmental Pollution Control, CBS Publishers
5. Peavy& Rowe, Environmental Engineering, McGraw Hill

Course Code: CHE- S60

Breakup: 3-1-0-4

Course Name: Non-conventional Energy Sources

Course Details:

Introduction: Energy and development; Types of energy resources – Conventional and nonconventional; Indian energy scenario.

Solar energy: Introduction; Fundamentals of solar radiation - Structure of Sun, Solar constant, Extraterrestrial solar radiation, Spectral nature of solar radiation, Terrestrial solar radiation, Solar radiation geometry, Solar radiation measurement.

Solar collectors: Flat plate collectors, Liquid-heating and air-heating flat plate collectors; Solar concentrators - Operating principle, Difference between flat plate collector and concentrating collector, Concentrator parameters, Types of concentrators, Concentrating solar power plants.

Solar thermal energy storage: Introduction, Sensible heat storage, Latent heat storage, Thermochemical energy storage, Storage material containers, Solar thermal energy storage for buildings, Solar pond - Nonconvecting solar pond, Physics of solar ponds, Design considerations of a solar pond.

Solar photovoltaic power generation: Introduction, Basic structure of a photovoltaic cell, Semiconductor materials, Semiconductor junctions, Photovoltaic cell operation, Types of solar cells.

Wind energy: Introduction, Wind resources, Local winds, Global wind patterns, Jet streams, Theoretical power of the wind, Types of wind turbines - Horizontal axis wind turbines, Vertical axis wind turbines, Offshore wind turbines, Near-shore wind turbines, Selection of wind site, Design of a wind turbine rotor blade, Major components of wind electric system - Wind turbine blades or rotor, Transmission System (Hub, Main shaft, Main bearings, Clamping unit, Gear box, Coupling), Generator, Controller, Towers, Advantages and disadvantages of wind energy, Environmental concerns of wind energy.

Bioenergy: Introduction, Feedstock properties, Chemistry of biomass, Biomass conversion processes - Direct combustion, Thermal conversion, Biochemical conversion; Gasification process - Types of Gasifiers, Properties of Producer gas, Advantages of gasification, Difference between gasification and combustion; Anaerobic digestion process - Types of microorganisms, Anaerobic digestion process, Anaerobic digestion operation modes, Feedstock properties; Biogas plants, Design of biogas plants, Benefits of biogas technology to rural economy; Fuels from biomass – Biogas, Alcohols, Biodiesel, Charcoal.

Geothermal energy: Introduction, Geothermal resources – Hydrothermal, Geopressured, Hot Dry Rock, Magma; Technology and resource type - High temperature resources, Medium temperature resources, Low temperature resources, Advantages and disadvantages of geothermal energy.

Ocean Thermal Energy Conversion: Introduction, Solar energy absorption by water, Cycle types - Closed cycle OTEC, Open cycle OTEC, Hybrid; Selection of working fluids,

Potential sites and plant design - Land-based and near-shore facilities, Shelf-mounted facilities, Floating facilities; Advantages and disadvantages of OTEC systems.

Tidal energy: Introduction, Fundamental principles of tides, Creation of tides, Effect of gravity and inertia on tidal bulges, variations in tides due to position and distance of Sun, Moon and Earth, Other factors affecting tidal characteristics, Coriolis forces, Energy of tides, Tidal current velocity, Extraction of tidal energy, Advantages and disadvantages of tidal energy.

Wave energy: Introduction; Formation of waves; Power in waves; Ocean wave energy technologies - Terminator, Attenuator, Point absorber, Overtopping Device; Advantages and disadvantages of wave energy.

Fuel cells: Introduction, Thermodynamics of a fuel cell, Types of fuel cells - Polymer electrolyte membrane fuel cell, Direct methanol fuel cell, Alkaline fuel cell, Phosphoric acid fuel cell, Molten carbonate fuel cell, Solid oxide fuel cell.

Batteries: Introduction; Generation of electricity by a battery; Basic parameters - Free energy, Theoretical voltage, Theoretical capacity (Coulombic), Theoretical energy; Types of batteries - Primary (non-rechargeable) batteries, Secondary (rechargeable) batteries, Reserve batteries; Discussion on some examples of different battery types; Major considerations in selecting a battery; Advantages and limitations of batteries.

Hydrogen energy: Introduction; Production of hydrogen from fossil fuels, water splitting, biomass, and chemical hydrides; Storage of hydrogen in gaseous, liquid, and solid form; Technical issues in hydrogen storage; Pipeline transport of compressed hydrogen gas; Road delivery of hydrogen; Liquid hydrogen transport; Hydrogen fueled vehicular transport.

Energy from waste: Introduction, Definitions of waste, Characteristics of municipal solid wastes, Energy from waste, Incineration of municipal solid waste, Advantages and disadvantages of incineration, Pyrolysis, Other methods.

Text and Reference Books:

1. U C Sharma, Non-conventional Sources of Energy, Studium Press, Texas (2014).
2. T K Ghosh, M A Prelas, Energy Resources and Systems, Vol. 1: Fundamentals and Non-Renewable Resources, Springer (2009).
3. T K Ghosh, M A Prelas, Energy Resources and Systems, Vol. 2: Renewable Resources, Springer (2011).
4. E EMichaelides, Alternative Energy Sources, Springer (2012).
5. J Twidell, T Weir, Renewable Energy Sources, Second edition, Taylor & Francis (2006).
6. V V N Kishore, Renewable Energy Engineering and Technology: Principles and Practice, Fundamentals of Renewable Energy Processes, Earthscan (2009).
7. A V da Rosa, Fundamentals of Renewable Energy Processes, Elsevier (2009).

Course Code: CHE- S62

Breakup: 3-1-0-4

Course Name: Advanced Separation Processes

Course Details:

Introduction to membrane separations, advantages and limitations; equilibrium and rate governed processes, separation factor for rate governed separation processes, Film theory, Sherwood number, Classification of membrane separation processes, Membrane type and materials; Membrane Modules; Principles, transport mechanisms, governing equations and applications of the following Membrane Separation Processes - Microfiltration, Ultrafiltration, Nanofiltration, Reverse Osmosis, Dialysis, Gas Separation and Pervaporation; Similarity parameter (concentration boundary layer); unstirred batch cell; one, two dimensional model of Gel layer; module design (rectangular, spiral and tubular)

Surfactant based separation processes- Liquid Membranes, cloud point extraction, micellar enhanced ultrafiltration; External field induced membrane separations for colloidal particles: electro-osmosis, streaming potential, sedimentation potential, zeta potential, Electrophoretic separations; Electrodialysis;

Introduction to membrane contactor and membrane reactor; membrane fouling and concentration polarization; Membrane plant configurations and plant design; Ion-exchange and chromatographic separations, molecular sieve separations; supercritical fluid extraction

Text and Reference Books:

1. J. D. Seader, E. J. Henley, Separation Process and Principles, Wiley
2. M. Mulder, Basic Principles of Membrane Technology, Kluwer Academic Publishers
3. K. Scott and R. Hughes, Industrial Membrane Separation Technology, Blackie Academic and Professional

Course Code: CHE-S508

Breakup: 3-1-0-4

Course Name: Optimization Techniques

Course Details:

Introduction of optimization, classification of models, model building, degree of freedom, Analytical method necessary and sufficient conditions for optimum in single and multi-variable unconstrained and constrained problems

Unconstrained one dimensional search, Newton, Quasi-Newton and Secant method for uni-dimensional search, region elimination methods (Golden Section, Fibonacci, Dichotomusetc)

Linear Programming, Graphical simplex method, revised simplex method, duality and transportation problems

Unconstrained multi-variable search, Direct methods, Indirect method, Finite difference approximation

Dynamic Programming, Principle of optimality, Discrete and continuous dynamic programming

Text and Reference Books:

1. T.E. Edger, D.M. Himmelblau, Optimization of Chemical Processes, McGraw Hill
2. Hameed S. Taha, Operational Research
3. G. C. Onwubolu, B.V. Babu, New Optimization Techniques in Engineering
4. S.S. Rao, Engineering Optimization

Course Name: Biochemical Engineering

Course Details:

Cell Structure and Cell Types, Chemicals of Life (RNA, DNA, enzymes etc.),

Kinetics of Enzyme Reactions, Applied Enzyme Catalysis, Metabolic Stoichiometric and Energetics, Molecular Genetics and Control, Biomass Production,

Transport Phenomena in Biosystems, Design and Analysis of Biological Reactors, Fermentors, Downstream Product Recovery and Purification, Interaction of Mixed Microbial Populations, Biological Wastewater Treatment

Text and Reference Books:

1. M.L. Shular, F. Kargi, Bioprocess Engineering: Basic Concepts, Prentice Hall
2. J.E. Bailey and D.F. Ollis, Biochemical Engineering Fundamentals, McGraw Hill
3. P.M. Doran, Bioprocess Engineering Principles, Academic Press Limited

Course Code: CHE- S65

Breakup: 3-1-0-4

Course Name: Process Modelling and Simulation

Course Details:

Introduction to mathematical modeling; Advantages and limitations of models and applications of process models of stand-alone unit operations and unit processes;

Classification of models – Simple vs. rigorous, Lumped parameter vs. distributed parameter; Steady state vs. dynamic, Transport phenomena based vs. Statistical; Concept of degree of freedom analysis.

Simple examples of process models; Models giving rise to nonlinear algebraic equation (NAE) systems, - steady state models of flash vessels, equilibrium staged processes distillation columns, absorbers, strippers, CSTR, heat exchangers, etc.; Review of solution procedures and available numerical software libraries.

Steady state models giving rise to differential algebraic equation (DAE) systems; Rate based approaches for staged processes; Modeling of differential contactors – distributed parameter models of packed beds; Packed bed reactors; Modeling of reactive separation processes; Review of solution strategies for Differential Algebraic Equations (DAEs), Partial Differential Equations (PDEs), and available numerical software libraries.

Unsteady state (time dependent) models and their applications; Simple dynamic models of Batch reactors, Adsorption columns, Multistage separation systems; Model reduction through orthogonal collocation; Review of solution techniques and available numerical software libraries.

Introduction to flow sheet simulation; Sequential modular approach; Equation oriented approach; Partitioning and tearing; Recycle convergence methods; Review of thermodynamic procedures and physical property data banks.

Text and Reference Books:

1. W.L. Luyben, Process Modeling, Simulation, and Control for Chemical Engineering, Wiley
2. A. Hussain, Chemical Process Simulation”, Wiley Eastern Ltd., New Delhi,
3. C.D. Holland, Fundamentals of Modelling Separation Processes”, Prentice Hall,

Course Name: Fluidization Engineering**Course Details:**

Introduction: Phenomenon of fluidization, Liquidlike behaviour of a fluidized bed, Comparison with other contacting methods, Advantages and disadvantages of fluidized beds for industrial operations, Selection of a contacting mode for a given application.

Industrial applications: History, Physical operations, Synthesis reactions, Hydrocarbon cracking, Combustion and incineration, Carbonization and gasification, Calcination, Reactions involving solids, Biofluidization.

Fluidization and mapping of regimes: Fixed bed of particles, Fluidization without carryover of particles, Types of gas fluidization without carryover, Fluidization with carryover of particles, Mapping of fluidization regimes.

Dense bed: Distributor types, Gas entry region of a bed, Gas jets in fluidized beds, Pressure drop requirements across distributors, Design of gas distributors, Power consumption.

Bubbles in dense beds: Single rising bubbles, Coalescence and splitting of bubbles, Bubble formation above a distributor, Slug flow.

Bubbling fluidized beds: Experimental findings, Estimation of bed properties, Physical models, scale-up and scale-down, Flow models for bubbling beds.

Entrainment and elutriation from fluidized beds: Freeboard behaviour, Location of the gas outlet of a vessel, Entrainment from tall vessels ($H_f > TDH$), Entrainment from short vessels ($H_f < TDH$).

High velocity fluidization: Turbulent fluidized beds, Fast fluidization, Freeboard-entrainment model applied to fast fluidization, Pressure drop in turbulent and fast fluidization.

Solid movement: Vertical movement of solids, Horizontal movement of solids, Segregation of particles, Large solids in beds of smaller particles, Staging of fluidized beds, Leakage of solids through distributor plates.

Gas dispersion and gas interchange in bubbling beds: Dispersion of gas in beds, Gas interchange between bubble and emulsion, Estimation of gas interchange coefficients.

Text and Reference Books:

1. D Kunni, O Levenspiel, Fluidization Engineering, Second edition, Butterworth Heinemann, USA (1991).
2. J R Grace, J M Matsen, Fluidization, Plenum Press, New York (1980). L G Gibilaro, Fluidization Dynamics, Butterworth Heinemann, Oxford (2001).
3. M L Passos, M A S Barrozo, A S Mujumdar, Fluidization Engineering Practice, Second expanded edition, Laval, Canada (2014).
4. W C Yang, Handbook of fluidization and fluid-particle systems, First edition, Marcel Dekker, New York (2003).
5. M Pell, Gas Fluidization, Elsevier, Amsterdam (1990).

Course Code: CHE- S512**Breakup: 3-1-0-4****Course Name: Electrochemical Engineering****Course Details:**

Review of fundamental principles of electrochemistry: Faraday's laws and ion-conduction electrode processes, transport number and transference number, Nernst equation and equilibrium constant, Pourbaix diagram.

Phase equilibrium: electrochemical potential, Debye-Huckel theory, liquid junction potential

Electrode kinetics: electric double layer, simplified electrode kinetics models

Ionic mass transport: Nernst-Planck equation, mass transport boundary layer, concentration over potential, limiting current density

Experimental methods: potentiometry and galvanometry, impedance methods, scanning probe techniques, electrochemical instrumentation

Applications: energy storage and conversion, fuel cells, electrochemical reactions, electric vehicles, electro-dialysis, ion exchange membrane separations

Text and Reference Books:

1. Geoffrey Prentice, Electrochemical Engineering Principles, Prentice Hall, 1991
2. Bard, A. J. And Faulkner, L. R., Electrochemical Methods- Fundamentals and Applications , Wiley India, 2nded, 2004
3. Newman, John and Alea, K. E. Thomas, Electrochemical Systems, John Wiley, 3rd ed. 2004
4. Strathmann, H., Ion-Exchange Membrane Separation Processes, Elsevier, 1st ed. 2004

Course Code: CHE- S68

Breakup: 3-1-0-4

Course Name: Piping Engineering

Course Details:

Introduction to piping: Pipe, Pipe size, Pipe wall thickness, Piping classification, Basic definitions, Forces, moments, and equilibrium, Work, power, and energy, Heat and temperature, Lengths, areas, surfaces, and volumes.

Piping components: Pipe and tube products; Traps; Strainers; Expansion joints; Threaded joints; Welded and brazed joints; Joining cast-iron pipe; Concrete, cement, and cement-lined pipe.

Piping materials: Material properties of piping materials, Metallic materials, Physical metallurgy of steel, Alloying of steel, Classification of steels, Steel heat treating practices, Degradation of materials in service, Material specifications.

Piping codes and standards: American standards – API, AISI, ANSI, ASME, ASTM, AWS, AWWA, MSS-SP, Unified numbering system (UNS); British standards; German standards; Indian standards.

Bolted joints: Cost of a leak, Flange joint components, Function of gaskets, Function of bolts, Gasket selection, Bolt selection, Flange stress analysis.

Selection and application of valves: Valve terminology, Reference codes and standards, Classification of valves, Valve components, Materials, Valve categories, Valve types, Pressure relief devices, Actuators, Selection and application guidelines.

Piping layout: Piping layout considerations, Specific system considerations, Application of CAD to piping layout.

Stress analysis of piping systems: Theories of failure, Stress categories, Stress limits, Fatigue; Load Classification, Service limits, and code requirements; Local stresses; Types of pipe loading conditions; Methods of analysis.

Piping supports: Introduction, Determination of support locations; Determination of loads and movements; Selection of pipe-supporting devices; Support requirements for specific piping materials; Design detail considerations; Other support considerations.

Thermal insulation of piping: Fundamentals of heat transfer, Design parameters, Design conditions, Service considerations, Insulation materials, Accessory materials.

Flow of fluids: Basic fluid properties, Dimensions and units, Viscosity, Pressure variation in a static fluid, Continuity equation, Conservation of energy; Steady single-phase incompressible flow in piping; Steady single-phase compressible flow in piping; Single-phase flow in nozzles, venturi, and orifices; Steady two-phase flow; Transient flow analysis.

Pressure and leak testing of piping systems: Piping codes, Leak testing methods, Selection of a test method and fluid test medium, Pressure testing procedures.

Process systems piping:

Introduction, Reference codes and standards, Design conditions, Design loading considerations, Pressure design of piping components, Selection and limitations of piping components, General process piping system considerations, Special design piping systems, System layout considerations, Case histories.

Nonmetallic piping: Thermoplastics piping - Introduction, Piping materials, Joining methods, Dimensioning systems, Physical and mechanical properties, Chemical resistance, Common design considerations. Fiberglass piping - Typical applications, Resins, Joining systems, Resistant properties, Physical properties, Advantages and limitations of fiberglass piping systems, Pressure ratings, Connection to other equipment and piping material.

Text and Reference Books:

1. M L Nayyar (Editor), Piping Handbook, Seventh edition, McGraw-Hill (2000).
2. M W Kellogg, Design of Piping Systems, Revised Second edition, John-Wiley (1956).
3. P Smith, Process Piping Design Handbook Vol. 1: The Fundamentals of Piping Design, Gulf Publishing Company, Texas (2007).
4. G AAntaki, Piping and Pipeline Engineering, Marcel Dekker, New York (2003).
5. J P Ellenberger, Piping and Pipeline Calculations Manual, Second edition, Butterworth-Heinemann (2014).
6. ITT Grinnel Industrial Piping, Inc., Piping Design and Engineering, Sixth edition (1981).
7. Tube Turns, Inc., Piping Engineering, Sixth edition (1986).