National Institute of Technology, Hamirpur (H.P.)
Department of Chemical Engineering

New Curriculum - 2018

FIRST YEAR													
I Semester							*II Semester*						
S. No.	**Code**	**Subject**	**L**	**T**	**P**	**Credits**	**S. No.**	**Code**	**Subject**	**L**	**T**	**P**	**Credits**
1	CHS-111	Engineering Mathematics-I	3	1	0	3	1	CHS-121	Engineering Mathematics – II	3	1	0	3
2	CHS-112	Chemistry for CHE	3	1	0	3	2	CHS-122	Physics for CHE	3	1	0	3
3	CHH-113	Communication Skills	3	1	0	3	3	CHD-123	Basic Electrical & Electronics	3	1	0	3
4	CHD-114	Introduction to Chemical Engineering	3	1	0	3	4	CHD-124	Environmental Science and Engineering	3	1	0	3
5	CHD-115	Strength of Materials	3	1	0	3	5	CHD-125	Engineering Graphics	1	0	3	3
6	CHS-116	Chemistry Lab	0	0	3	1	6	CHS-126	Physics Lab.	0	0	3	1
7	CHH-117	Communication Skills Lab.	0	0	3	1	7	CHD-127	Basic Electrical & Electronics Engineering Lab.	0	0	3	1
~~8~~							8	CHD-128	Workshop Practice	1	0	3	2
			26			17				30			19

SECOND YEAR

III Semester							*IV Semester*						
S. No.	**Code**	**Subject**	**L**	**T**	**P**	**Credits**	**S. No.**	**Code**	**Subject**	**L**	**T**	**P**	**Credits**
1	CHD-211	Industrial Instrumentation	3	1	0	3	1	CHD-221	Heat Transfer	3	1	0	3
2	CHD-212	Fluid Mechanics	3	1	0	3	2	CHD-222	Chemical Engineering Thermodynamics-II	3	1	0	3
3	CHD-213	Chemical Process Calculation	3	1	0	3	3	CHD-223	Energy Management	3	1	0	3
4	CHD-214	Mechanical Unit Operation	3	1	0	3	4	CHS-224	Engineering Mathematics – III	3	1	0	3
5	CHD-215	Material Science and Engineering	3	1	0	3	5	CHD-225	Chemical Technology	3	1	0	3
6	CHD-216	Chemical Engineering Thermodynamics-I	3	1	0	3	6	CHD-226	Computational Methods in Chemical Engineering	3	1	0	3
7	CHD-217	Fluid Mechanics Lab.	0	0	3	1	7	CHD-227	Chemical Technology Lab.	0	0	3	1
8	CHD-218	Mechanical Unit Operation Lab.	0	0	3	1	8	CHD-228	Heat Transfer Lab.	0	0	3	1
9	CHD-219	MATLAB	0	0	3	1	9	CHD-229	Computational Methods In Chemical Engineering Lab	0	0	3	1
			33			21				33			21

THIRD YEAR

V Semester							*VI Semester*						
S. No.	**Code**	**Subject**	**L**	**T**	**P**	**Credits**	**S. No.**	**Code**	**Subject**	**L**	**T**	**P**	**Credits**
1	CHD-311	Mass Transfer-I	3	1	0	3	1	CHH-321	Engineering Economics and Management	3	1	0	3
2	CHD-312	Chemical Reaction Engineering-I	3	1	0	3	2	CHD-322	Mass Transfer-II	3	1	0	3
3	CHD-313	Process Dynamic Control	3	1	0	3	3	CHD-323	Chemical Reaction Engineering-II	3	1	0	3
4	CHD-314	Process Equipment Design-I*	3	1	0	3	4	CHD-324	Petroleum Refinery & Petrochemical Engineering	3	1	0	3
5	CHD-315	Industrial Safety and Hazard Management	3	1	0	3	5	CHD-325	Transport Phenomena	3	1	0	3
6	CHO-316	#Open Elective-I	3	1	0	3	6	CHO-326	##Open Elective-II	3	1	0	3
7	CHD-317	Energy Technology Lab.	0	0	3	2	7	CHD-327	Mass Transfer Lab.	0	0	3	2
8	CHD-318	Process Dynamic Control Lab.	0	0	3	2	8	CHD-328	Chemical Reaction Engineering Lab.	0	0	3	2
9	CHD-319	Process Equipment Design and Drawing Lab.	0	0	3	2	9	CHD-329	Seminar	0	0	3	2
			33			24				33			24

 # Open Electives:-I

i) Computational Fluid Dynamics [CHO 316(a)]
ii) Electrochemical Energy Engineering [CHO 316(b)]
iii) Separation Processes [CHO 316(c)]

Open Electives-II

i) Industrial Safety and Risk Management [CHO 326(a)]
ii) Engineering Optimization [CHO 326(b)]
iii) Food Technology [CHO 326(c)]

FOURTH YEAR

VII Semester							*VIII Semester*						
S. No.	**Code**	**Subject**	**L**	**T**	**P**	**Credits**	**S. No.**	**Code**	**Subject**	**L**	**T**	**P**	**Credits**
1	CHD-411	Process Modeling and Simulation	3	1	0	3	1	CHD-421	Separation Processes	3	1	0	3
2	CHD-412	Process Economics and Plant Design	3	1	0	3	2	CHD-422	Industrial Pollution Abatement	3	1	0	3
3	CHD-413	Process Equipment Design-II*	3	1	0	3	3	CHD-423	Computational Fluid Dynamics	3	1	0	3
4	CHE-414	Elective-I	3	1	0	3	4	CHE-424	Elective-III	3	1	0	3
5	CHE-415	Elective-II	3	1	0	3	5	CHE-425	Elective-IV	3	1	0	3
6	CHD-416	CAD and Simulation Lab.	0	0	3	2	6	CHD-426	CFD Lab.	0	0	3	2
7	CHD-417	Process Equipment Design Lab.	0	0	3	2	7	CHD-427	Industrial Pollution Abatement Lab.	0	0	3	2
8	CHD-418	Project-I	0	3	6	4	8	CHD-428	Project-II	0	3	9	6
9	CHD-419	Industrial Training Viva	0	0	0	2	9	CHD-429	General Proficiency	0	0	0	3
10	CHD-410	Term Paper	0	0	0	1							
			35			26				38			28

Elective-I

i) Polymer Science and Engineering [CHE 414(a)]
ii) Optimization of Chemical Processes [CHE 414(b)]
iii) Food Technology [CHE 414(c)]

Elective-II

i) Fertilizer Technology [CHE 415(a)]
ii) Introduction to Colloid and Interface Science [CHE 415(b)]
iii) Process Intensification [CHE 415(c)]

Elective III

i) Biochemical Engineering [CHE 424(a)]
ii) Piping Engineering [CHE 424(b)]
iii) Corrosion Science and Engineering [CHE 424(c)]

Elective IV

i) Heterogeneous Catalysis and Catalytic Process [CHE 425(a)]
ii) Instrumental Analytical Technique [CHE 425(b)]

Total Credit = 17+19+21+21+24+24+26+28=180

Total Hours = 26+30+33+33+33+33+35+38 = 261

Semester I

ENGINEERING MATHEMATICS-I [CHS-111]

L	T	P
3	1	0

1.MATRICES

Matrices, Related matrices, Complex matrices (Hermitian and skew-Hermitian matrices, Unitary matrix), Solution of linear system of equations, Rank of a matrix, Gauss-Jordan method, Normal form of a matrix, Vectors, Linear dependence, Consistency of a linear system of equations, Rouche's theorem, System of linear homogeneous equations, Linear and orthogonal transformations, Characteristic equation, Eigen values, Eigen vectors, Properties of eigen values, Cayley-Hamilton theorem, Reduction to diagonal form, Quadratic form and their reduction to canonical form.

2. INFINITE SERIES

Convergence and divergence of infinite series, Geometric series test, Positive term series, p-series test, [Comparison test, D'Alembert's ratio test, Cauchy's root test (Radical test), Integral test, Raabe's test, Logarithmic test, Gauss's test] (without proofs), Alternating series and Leibnitz's rule, Power series, Radius and interval of convergence.

3. DIFFERENTIAL CALCULUS

Indeterminate forms, Partial Differentiation and its geometrical interpretation, Homogeneous functions, Euler's theorem and its extension, Total differentials, Composite function, Jacobian, Taylor's and Maclaurin's infinite series, Errors and increments, Introduction to limits and Indeterminate forms, Maxima and minima of functions of two variables, Method of undetermined multipliers. Curve tracing.

4. INTEGRAL CALCULUS

Quadrature, Rectification, Surface and Volume of revolution for simple curves, Double integrals and their applications, Change of order of integration, Change of variables, Triple integrals and their applications, Change of variables.

5. VECTOR CALCULUS

Differentiation of vectors, Curves in space, Velocity and acceleration, Relative velocity and acceleration, Scalar and vector point functions, Vector operator del, gradient, divergence and curl with their physical interpretations, Formulae involving gradient, divergence and curl. Line, surface and volume integrals, Theorems of Green, Stokes and Gauss (without proofs) and their verifications and applications, Irrotational and Solenoidal fields.

TEXT BOOKS

1. Advanced Engineering Mathematics: by Erwin Kreyszig, John Wiley and Sons, NC, New York.
2. Advanced Engineering Mathematics: by R. K. Jain & S. R. K Iyengar, Narosa Pub. House.

REFERENCE BOOKS

1. Advanced Engineering Mathematics: by C. R. Wylie & L. C. Barrett, McGraw Hill
2. Differential & Integral Calculus: by N. Piskunov, MIR Publications.

CHEMISTRY FOR CHE [CHS-112]

L	T	P
3	1	0

WATER: Sources, hard & soft water, estimation of hardness by EDTA method, softening of water, zeolite process & demineralization by ion exchangers, boiler feed water, internal treatment methods, specifications for drinking water, BIS & WHO standards, treatment of water for domestic use, desalination - reverse osmosis & electrodialysis.

POLYMERS: Introduction, classification, tacticity, types of polymerization, coordination polymerization, mechanisms of polymerization, synthesis and applications of some important polymers Effect of polymer structure on properties, Moulding of plastics into articles, Conducting polymers: preparation, types, properties and applications.

ELECTROCHEMISTRY: Reference electrodes, Ion selective electrodes, Chemically modified electrodes as sensors, Electrochemical energy systems, lithium batteries, Fuel cells corrosion and its prevention.

SCIENCE OF COMPOSITE MATERIALS: Introduction, Classification, constituents of composites, Fiber reinforced composites, unidirectional fibre reinforced composites, short fibre reinforced composites, particle reinforced composites, important types and failures of fiber reinforced composites, Advantages and applications of composites.

NANOCHEMISTRY: Introduction to nano chemsitry, synthesis, characteristics and applications of carbon nanostructures fullerenes, carbon nanotubes and graphene.

CORROSION AND ITS CONTROL: Introduction, Types of corrosion – chemical and electrochemical, Mechanisms of corrosion, factors affecting corrosion and different protection techniques for corrosion control.

CHARACTERIZATION TECHNIQUES: Introduction to spectroscopy; UV-Visible spectroscopy- Absorption laws, Instrumentation, formation of absorption bands, Theory of electronic spectroscopy, Chromophore and auxochrome concept, fluorescence & phosphorescence, application of UV-Visible spectroscopy ; IR spectroscopy- Principle, theory of molecular vibrations, selection rules, spectral features of some classes of compounds, important features of IR spectroscopy and applications; NMR- Principle, relaxation processes, Instrumentation, shielding-desheilding effects, spinspin coupling, coupling constant, applications of NMR; MS spectroscopy- Basic principle, Instrumentation, determination of molecular formulae, important features of mass spectroscopy; Chromatography- Introduction, types, gas chromatography ; thermal method- instrumentation, fundamental principles and applications of TGA, DTA and DSC.

Text Books:

1. P.C. Jain, M. Jain, Engineering Chemistry Dhanpat Rai Publishing Company, New Delhi, 2005.

2. P. W. Atkins and Julio de Paula, Atkins Physical Chemistry l Chemistry,7th Edition, Oxford University Press, New York, 2002.
3. H.D. Gesser. Applied Chemistry- A textbook for engineers and technologist.
4. Shashi Chawla, A Text Book of Engineering Chemistry.

COMMUNICATION SKILLS [CHH-113]

L	T	P
3	1	0

Unit 1: The Process of Communication

Introduction, What is communication? Barriers to communication, Different types of communication, Written vs. Oral communication, Different types of face to face interactions, Characteristics and Conventions of Conversation, Conversational Problems of Second Language Users, Difference between Conversation and Other Speech Events.

Unit 2: Telephone Techniques

Speaking and Listening. Commonly used phrases in telephone Conversations. Reading: Conference Calls, Vocabulary. Writing and Listening. Leaving a message. Grammar and Usage": The perfect tenses, pronunciation: Contracted Forms

Unit 3: Job Applications and Interviews

Reading, Vocabulary, Apply for job, Curriculum Vitae. Language Focus: Some Useful Words, Study Skills. Preparing for an interview, Listening, Speaking, Writing.

Unit 4: Group Discussions

Reading, Writing Skills, Listening, How to be successful in a Group Discussion, Study skills, Language Focus, Vocabulary. Speking. Grammar: Connectives, Pronunciation

Unit 5: Managing Organisational Structure

Warm up, Reading, The role of a Manager, Vocabulary, Leadership, Speaking and Listening, Language Focus: Degree of Probability, Grammar: Modals, Writing, Reports, Pronunciation

Unit 6: Meetings

Reading, A Successful Meeting, Speaking: One to One Meetings, Vocabulary, Grammar: Reporting Verbs, Writing Memos, Pronunciation, Stress according to Part of Speech

Unit 7: Taking Notes and Preparing Minutes

Taking Notes, The note taking skill, The Essential Components, The note taking Skill: An Example, Preparing Minutes, Format of Minutes, Language and Style of Minutes, Grammar: Using the Passive Voice

Unit 8: Presentation Skills I

Reading, Presentation skills, Grammar, Verbs often required in Presentations, Language Focus, Listening, Importance of body language in Presentations, Speaking, Preparing an outline of a presentation, Pronunciation.

Unit 9: Presentation Skills II

Reading, Structure of Presentation, Study Skills: Visual Aids, Ending the Presentation, Language Focus: Talking about Increase and Decrease. Grammar: Prepositions, Listening: Podium Panic, Speaking, Pronunciation: Emphasizing the important Words in Context

Unit 10: Negotiation Skills

Language Focus: Syntax, Expressions, Study Skills: Process of Negotiations, Grammar: Phrasal Verbs, Listening: Effective Negotiation, Speaking, Writing.

Reference Books:

1. Effective Technical Communication by M. Ashraf Rizvi. Pub: Tata McGraw Hill (2009)
2. Preparing Communication Skills by Krishna Mohan Pub: Mac Millan India Limited (2009)
3. An Approach to Communication Skills by Indrajit Bhattacharya. Pub: Dhanpat Rai Co Pvt Ltd. New Delhi (2007)

4. Effective Practical Communication Skills by Wright, Chrissie Pub: Jaico Publishing House. Mumbai (2007)
5. Skills of Communicating by Bill Scott, Jaico Publishing House, Mumbai (2009).

INTRODUCTION TO CHEMICAL ENGINEERING [CHD-114]

L	T	P
3	1	0

Unit I

Historical overview of Chemical Engineering: Origin, growth and role in chemical process industries, concepts of unit operations and unit processes, and recent developments.

Unit II

Fuels –Solid, liquid & Gaseous fuels.

Unit III

Chemical kinetics constant rate constant order and molecularity of a reaction, zero, 1^{st}, 2^{nd}, and 3^{rd} order reactions. Kinetics of opposing reactions, methods of determination of order of reactions. Reaction rate theories, Arrhenius parameters, catalysis (including enzyme catalysis), effect of catalysis on reaction rate.

Unit IV

Introduction to heat transfer, conduction, convection, radiation, flow arrangement in heat exchangers, variation of fluid temperature in heat exchangers.

Unit V

Introduction to mass transfer, crystallization, distillation.

Unit VI

Concerns of chemical engineering traditional areas: environment, energy, new materials, bioengineering and biotechnology, food, health and safety. Concepts of scale-up.

Texts/References

Salil. K Ghosal, Shyamal K Sanyal, Siddhratha Datta "Introduction to Chemical Engineering, Tata McGraw Hill, New Delhi.

R. M. Felder and R.W. Rousseau, Elementary Principles of Chemical Processes, 3rd ed., John Wiley, New York,

Enderson and Belzil, Introduction to Chemical Engineering, McGraw-Hill Book Company, Inc., New York

STRENGTH OF MATERIALS [CHD-115]

L	T	P
3	1	0

Simple Stresses and Strains: Stress & Strain, types of stresses and strains in elastic body, Hooks law, Stress-Strain diagram for ductile and brittle material, Elastic constants and their relationships, Thermal stress & strain, Stresses induced due to uniaxial stress, Stresses induced by state of simple shear, stresses induced due to biaxial stress, Transformation of plane stress and strains, Principal stresses and strains, Maximum shearing stress and strain, Analytical and graphical methods; Mohr's circle.

Centre of Gravity and Moment of Inertia: Centroid and centre of mass; Centroids of composite plane figures and curves, Centre of gravity and moment of inertia; First and second moment of area; Radius of gyration; Parallel and perpendicular axistheorm; Product of inertia, Rotation of axes and principal moment of inertia; Moment of inertia of simple and composite bodies. Mass moment of inertia.

Beam Under Transverse Loading: Shear force and bending moment, Relationship between load, Shear force and bending moment, Shear force and bending moment diagrams for types of load- Concentrated, uniformly distributed, uniformly varying load and combination of loads and types of beams – Cantilever beam, Simply supported beam, overhanging beam, point of contra flexure, using singularity functions to determine shear and bending moment in a beam, equation of the elastic curve, direct determination of the elastic curve from the load distribution and method of superposition.

Stresses in Beam: Pure bending of beams, moment of resistance, section modulus & neutral axis, stress distribution in symmetric and unsymmetrical sections, concept of direct & transverse shear stress, response under of axial and eccentric load, direct stresses, bending stresses, general case of eccentric axial loading, determination of the shearing stresses in a beam, shear center, shearing stresses in common types of beams, distribution of stresses in a narrow rectangular beam, longitudinal shear on a beam element of arbitrary.

Torsion: Theory of pure torsion, Derivation of torsion equation for a circular shaft subject to torsion, maximum torque transmitted by a solid and hollow shaft, power transmitted by a shaft, close coiled helical spring subjected to axial load and axial torque, polar modulus, torsion rigidity, shear stress produced in the members.

Thin and Thick Cylinders and Spheres: Thin and Thick Cylinders subjected to internal pressures, concept of stresses & strains, hoop stress, longitudinal stress, in a cylinder, principal stresses and change in diameter and internal volume.

Columns & Stuts: Stability of structures, Euler's formula for Pin-Ended columns, Extension of Euler's formula to Columns with other end conditions, Eccentric loading; the Secant formula, Columns under a centric load and Eccentric load, Rankin's Theory.

Books Recommended:

1. Ferdinand Beer, E. Russell Johnston, Jhon DeWolf, David Mazurek, Mechanics of materials, 7^{th} edition, Mc Graw-Hill Engineering.

2. Gere and Timoshenko, mechanis of materials, 4^{th} edition, PWS publishing company.
3. R.C.Hibbeler, mechanics of materials, Pearson.
4. E.P.Popov, Engineering Mechanics of solids, Pearson.
5. I.H.Shames&J.M.Pitarresi, introduction to solid mechanics.
6. S.H.Crandall,N.C.Dahl & T.J.Lardner, Mechanics of solids, Tata Mc Graw Hill Education
7. M.A.Jayaram, Mechanics of materials with programs in C, PHI.
8. B.C.Punmia . Ashok Kumar jain & Arun Kumar Jain, Strength of materials, Laxmi.
9. S.Ramamrutham, R.Narayan, Strength of Materials, DhanpatRai Publishing company.

Chemistry Lab [CHS-116]

L	T	P
0	0	3

List of Experiments:

1. To determine the amount of residual chlorine in a given sample of water
2. To determine the percentage of chlorine in the given sample of bleaching powder
3. To determine the concentration of hydroxyl ions, carbonate ions and bicarbonates ions in the given sample of water before and after passing through an ion exchanger.
4. To determine the temporary, permanent and total hardness of a given water sample.
5. To determine viscosity by Ostwald viscometer.
6. To determine surface tension of unknown liquid
7. To determine total, suspended and dissolved solids in wastewater.
8. To determine the percentage of moisture, volatile matter, ash content and fixed carbon in a sample of coal.
9. To determine the aniline points of a given sample of lubricating oil.
10. To determine the cloud and pour point of a given sample of a lubricating oil.

Semester II

ENGINEERING MATHEMATICS – II [CHS-121]

L	T	P
3	1	0

Fourier Series: Euler's formula, Conditions for a Fourier expansion, Functions having points of discontinuity, Change of interval, Odd and even periodic functions, Expansion of odd and even periodic functions, Half-range series, Typical wave-forms, Parseval's formula, Practical harmonic analysis.

Ordinary Differential Equations: Brief review of first order ordinary differential equations, Exact equations, Equations reducible to exact equations, Equations of the first order and higher degree, Clairaut's equation, Applications of differential equations of first order (Orthogonal trajectories). Linear differential equations with constant co-efficients, Complimentary functions and particular integral, Method of variation of parameters, Equations reducible to linear equations with constant co-efficients (Cauchy's and Legendre's linear equations), Simultaneous linear equations with constant co-efficients, Applications of linear differential equations in engineering.

Complex Numbers: Applications of De Moivre's theorem, Exponential, Circular, Hyperbolic and Logarithmic functions of a complex variable, Inverse Hyperbolic functions, Real and imaginary parts of Circular and Hyperbolic functions, Summation of the series-'C+iS' method.

Functions of Complex Variable: Limit and derivative of complex functions, Cauchy-Riemann equations, Analytic functions and its applications, Geometrical representation of complex function, Conformal mapping and standard transformations, Complex integration, Cauchy's theorem, Cauchy's integral formula, Series of complex terms, Taylor's and Laurent's series, Cauchy's residue theorem and its application for the evaluation of real definite integrals.

Integral Transforms: Laplace Transforms of standard functions and their properties, Inverse Laplace Transforms, General Properties of inverse Laplace transforms and Convolution Theorem, Laplace Transforms of periodic functions, Bessel functions, Error function, Dirac-delta Function, Heaviside's Unit Function, Applications to linear simultaneous differential equations.

Books Recommended:

1. Advanced Engineering Mathematics: by Erwin Kreyszig, John Wiley and Sons, NC, N.Y.
2. Advanced Engineering Mathematics: by R. K. Jain & S. R. K Iyengar, Narosa Pub. House.

Reference Books

1. Advanced Engineering Mathematics: by C. R. Wylie & L. C. Barrett, McGraw Hill.
2. Vector Calculus: by C. E. Weatherburn. John Wiley and Sons, NC, New York.
3. Complex variables and Applications: by R. V. Churchill, T. J. Brown & R. F. Verhey, McGraw Hill.
4. Differential Equations: by Shepley L. Ross, John Wiley & Sons, New York.

PHYSICS FOR CHE [CHS-122]

L	T	P
3	1	0

Lasers: Concepts of maser and laser, spontaneous and stimulated emission, elementary idea about lasers, basic principles involves in laser, three and four level laser system, coherence, characteristics of laser light; ruby, He-Ne, CO_2 and semiconductor lasers, application of lasers.

Fibers Optics: Optical Fiber, physical structure and basic theory, modes in optical fibers, step index and graded index fibers, losses in optical fibers, sources and sensors for optical fibers, applications of optical fibers in communication.

Electrostatics and Electrodynamics: Gauss's Law in dielectric medium, Equation of continuity, displacement current, Maxwell's equations, wave equation for electromagnetic radiation, electromagnetic wave propagation in free space and isotropic dielectric medium, Poynting theorem & Poynting vector.

Mechanics and Theory of Reactivity: Displacement, Velocity and acceleration in polar and spherical coordinate systems, inertial and non-inertial frames, Michelson and Morley experiment, postulates of special theory of relativity, Lorentz's space- time transformations and their consequences, mass variation with velocity, mass energy equivalence, momentum and energy transformation.

Quantum Mechanics: Need of quantum mechanics, Compton effect, Born's concept of wave function, eigen function and eigen values, operators in quantum mechanics, expectation values, time independent and time dependant Schrodinger's wave eqations and its applications viz., particle in one dimensional potential well.

Super Conductivity: Introduction and discovery of superconductivity, superconducting materials, Meissner effect, critical magnetic field and critical current, type-1 and type-2 superconductors, isotope effect, theory of superconductivity, flux quantization, SQUIDS, applications of superconductivity.

Books Recommended:

1. A text book of engineering Physics; M.N. Avadhanulu and P.G. Kashirsagar, S. Chand & Co. Ltd.
2. Engineering Physics; Satya Prakash and Vibhav Saluja, Pragati Prakashan, Meerut.
3. Modern Engineering Physics; A.S. Vasudeva, S. Chand & Co. Ltd.
4. Optical Electronics; AK Ghatak and Thyagarajan, Foundation books, New Delhi.

BASIC ELECTRICAL AND ELECTRONICS ENGINEERING [CHD-123]

L	T	P
3	1	0

Electric Circuits: Introduction to linear and non linear circuits, circuit elements, various sources and source transformation, star delta transformation, solution of D.C circuits using Kirchoff's law, Signal wave forms and passive elements specifications, basic theorms, generation of A.C. sinusoidal voltage and currents, average and r.m.s. values, form factor and peak factor, phasor representation, phasor in polar, rectangular and exponential forms, terminal relationship for pure passive elements and their combination in series and parallel. Analysis of single phase series, parallel and series parallel circuits. Active and reactive power, p.f. and volt-ampares, introductory concept, voltage, current and power in three phase balanced circuits. Introduction to Domestic Electric Wiring.

Electromagnetic Circuits: Magnetic circuit concept, B-H curve characteristics of magnetic materials, practical magnetic circuits, magnetic circuits with D.C and A.C. excitation, hysteresis and eddy current losses. Magnetic force, self and mutual inductances, Faraday's laws, Lenz's law, Statically and dynamically induced emfs, energy stored in magnetic fields.

Measuring Instruments: Introduction to galvanometer (moving coil and moving iron), ammeter, voltmeter, wattmeter, energy meter, use of shunt and multiplier.

Electrical Machines: Fundamentals of transformer, D.C and A.C machines.

Semiconductor Devices: Characteristics of PN Junction Diode, Zener effect, Zener Diode and its characteristics, Half wave and full wave rectifiers, voltage regulation, bipolar junction transistor, CB, CE, CC configurations and characteristics.

Books Recommended:

1. Fundamentals of electric circuits by Charles K Alexander and Matthew N.O Sadiku, TMH publication. 2nd edition, 2009.
2. Electrical Engineering fundamentals by Vincent Del Toro, PHI Publication, Second edition.
3. Basic electrical technology by AE Fitzgerald, McGraw Hill Publication.
4. Mehta VK "Principles of electronics" S.Chand & Company Ltd.

ENVIRONMENTAL SCIENCE AND ENGINEERING [CHD-124]

L	T	P
3	1	0

Environmental Management, Resources and Legislation: Environmental disturbances, quantification of environmental issues, soil resources and their classification ,equitable use of resources , natural resources management food chain and trophic levels, environmental impacts of energy development.

Global Atmospheric Changes: The atmosphere of earth, global temperature, greenhouse effect, radiative forcing climate change, global warming potential, carbon cycle, carbon emissions from fossil fuels, regional impacts of temperature changes, global initiatives.

Physical, Chemical and Biological Processes: Particle dispersion, methods of expressing particle concentrations, stoichiometry, chemical equilibria, solubility of gases in water, carbonate system, organic chemistry, nuclear chemistry, nuclear fission and fusion, basic atmospheric properties, fundamentals of microbiology.

Population and Economic Growth: The nature of human population growth, population parameters, industrialization, urbanization, sustainable development, sustainable consumption, resettlement and rehabilitation issues, health and the environmental impacts.

Solid and Hazardous Waste Management: Integrated solid waste management, hazardous waste management, biomedical waste treatment technologies and disposal options, e-waste management, waste minimization for sustainability, waste management- Indian Scenario.

Pollution and Monitoring: Water resources, characteristics of water, water pollutants, oxygen demanding wastes, surface water quality, ground water quality, water and waste water treatment systems. Air quality standards, emission standards, Criteria pollutants, air pollution and meterology, atmospheric dispersion, emission controls. Effect of noise on people, rating systems, community noise and criteria, traffic noise prediction, noise control.

Books Recommended:

1. Mackenzie L. Davis and David A. Cornwell 2010. Introduction to Environmental Engineering. 4e. Tata Mc Graw hill education Pvt Ltd. New Delhi.
2. Gilbert M. Masters. 2007. Introduction to environmental engineering and science, 2e. Pearson education. Dorling Kindersley (India) Pvt. Ltd. Delhi.
3. J. Glynn Henry and Gary W. Heinke. 2004. Environmental Science and Engineering. 2e. Pearson education (Singapore) Pvt ltd.

ENGINEERING GRAPHICS [CHD-125]

L	T	P
1	0	3

1. Basic Concepts:- IS Drawing conventions, Classification of Lines, Layout of Drawing Sheets, Principles and Conventions of Dimensioning

2. Basic Elements:- Significance and Scope of drawing, Methods of Dimensioning, Different types of Scales and their uses, Different types of projections and their uses, Introduction to Orthographic projection.

3. Orthographic Projections-I:- Projection of points and lines in different quadrant, Traces, Inclinations, True lengths of line, Projection on auxiliary plane, Shortest distance, Intersecting and Non Intersecting lines.

4. Orthographic Projections-II:- Planes other than reference planes-perpendicular and oblique planes, traces, inclinations etc., projection of lines lying in the plane, conversion of oblique plane to auxiliary plane and related demonstrative problems.

5. Orthographic Projections-III:- Different cases of plane figures of different shapes and making different angles with one or both reference planes and lines lying in the plane figure making different given angles, Obtaining true shapes of plane figure by projection

6. Orthographic Projections-IV:- Projection of solids, simple cases of solid placed in different positions, axes faces and lines lying in the faces of solids making given angles, Development of Surfaces- development of simple objects like Tetrahedron, Cube, Octahedron, square based pyramid and Pentagonal based prism.

7. Method of drawing Metric Projections:- Isometric, Axometric and Elevation oblique projections

8. Sections:- Importance, Principles, Types, Cutting plane representation, section lines and conventional practices. Demonstrative examples showing sections of Cube, Cylinder, Pyramid and Prism.

Text Books:-

1. Engineering Drawing- N.D. Bhatt
2. Engineering Drawing- P. Bali
3. Machine Drawing- N.D. Bhatt and Panchall
4. Engineering Drawing- P.S. Gill

WORKSHOP PRACTICE [CHD-128]

L	T	P
1	0	2

TRADES FOR EXERCISES:

1. Carpentry
2. Fitting
3. Welding
4. Sheet Metal Work
5. Foundry

Semester III

INDUSTRIAL INSTRUMENTATION [CHD-211]

L	T	P
3	1	0

Principal of Measurement: Definition of instrumentation, Concept of an instrument, Funtional elements and functions of an instrument, Error analysis, Static & Dynamic characteristics of measurement. Dynamic response of I & II order instruments.

Temperature Measurement: Expansion Thermometers, Thermocouples, Resistance Temperature Detectors, Thermistors & Pyrometers and Calibrations.

Pressure Measurement: Manometers, Bourdon tubes, Bellows, Measurement of gage pressure, vacuum. Measurement of absolute Pressure, Mc Leod Gage, Pirani Gage, Ionization Gage. Vacuum sensor, Thermal vacuum sensor, Response of mechanical pressure gages, Strain Gages & LVDT.

Building Blocks of an Instrument: Transducer, amplifier, signal conditioner, signal isolation, signal transmitter, display, data acquisition modules, I/O devices, interfaces.

Sensor and Transducers: Classification, principals and applications, interpretation of performance specification of transducers.

Liquid Level Measurement: Direct level measurement, interface measurement, Hydrostatic head level measurement in pressure vessels, Ultrasonic level devices, Point & Continuous level measurement using radioactive devices, Capacitance type devices, resistance sensors, Nuclear radiation type level gages & level switches.

Analytical Instrumentation: Gas Chromatography, operating principles, type, components & applications, High performance liquid chromatography; Refractive index, pH, viscosity, density & conductivity measurement; Gas Analyzers.

Books Recommended:

1. Johnson C., "Process Control Instrumntation Technology", 8th Ed. Prentice-Hall. (2005)
2. Eckman D.P., Industrial Instrumentation, McGraw Hill Publications (1975)
3. Nakra B.C. and Chaudhary K.K., "Instrumentation, Measurement and Analysis, 2nd Ed. Tata-McGraw Hill (2004).
4. Andrew W. G. "Applied Instrumentation in the Process Industries" Vol. I, II & III Ed. Gulf Publication (1993).
5. Jain R.K., Mechanical and Industrial Measurements, Khanna

FLUID MECHANICS [CHD-212]			L	T	P
			3	1	0

Introduction: Ideal and real fluids, Extensive and Intensive Properties, Specific Weight, Mass density and Specific gravity, Viscosity, Surface Tension and Capillarity, Evaporability and Vapor pressure, Newtonian & Non Newtonian fluids.

Fluids Static: Pressure, Hydrostatics law, Pascal's Law, Different types of manometer, Continuous gravity Decanter, Centrifugal decanter and other pre- measuring equipments, Determination of meta centric height.

Fluids Kinematics and Dynamics: Classification of fluid flows, streamline, streak line, and Path lines, Flow rate & continuity equation, Bernoulli's Theorem, Kinetic energy correction factor and momentum correction factor in Bernoulli's equation.

Internal Incompressible Viscous Flow: General characteristics of pipe flow-laminar, turbulent, entrance region, fully developed: Hagen-Poiseuille Law, Fully developed laminar/turbulent flow in pipe, duct and orifice-shear stress distribution and velocity profiles; Energy correction factors; Energy and hydraulic grade lines; Major and minor losses in pipes, fittings, noncircular ducts; vena contracta; Friction factor, pipe roughness; Moody chart.

Flow Measurements: Flow rate and velocity measurements Pitot tube, orifice meter, venturimeter, rotameter, notches and weirs, etc.

Dimensional Analysis, Similitude and Modeling: Dimensional homogeneity and analysis; Methods of finding dimensionless numbers; Selection of variables, Rayleigh and Buckingham's π method; Common dimensionless numbers and their physical significance; Model and Prototypes; Complete and incomplete similarity.

Hydraulic pumps: Pump Classification & Applications, Centrifugal pumps verses Reciprocating pumps, pump losses and Efficiencies, Multistage pumps, Work and power Input, Cavitation and maximum Suction lift, specific and minimum speed.

Flow around Immersed Bodies: Drag force, lift and drag coefficients, drag on Flat Plate, Circular Cylinder and Sphere.

Books Recommended:

1. Smith J C, McCabe W L and Harriot P H, "Unit Operations of Chemical Engineering", McGraw Hill (2001).
2. Kumar D S, "Fluid Mechanics & Fluid pwer engineering", S K Kataria & Sons (2004).
3. Timoshenko S P and Young D H "Engineering Mechanics", McGraw Hill (1937).
4. Modi P N and & Seth S M, "Hydraulics and Fluid Mechanics", Delhi Standard Publishers Distributors (2002) .
5. Perry's, "Handbook of Chemical Engineering", 7th Ed., McGraw Hill (1997).
6. Brown G G "Unit Operations", 1st Ed., CBS Publisher (2004).

CHEMICAL PROCESS CALCULATION [CHD-213]

L	T	P
3	1	0

Introduction to Chemical Engineering Calculations: Units and dimensions, mole concept, conventions in methods of analysis and measurement, basis, temperature, pressure, the chemical equations and stoichiometry, limiting and excess reactant, conversion and yield.

Material Balance: Material balance, program of analysis of material balance problems, solving material balance problems that do not involve chemical reactions, solving material balances problems involving chemical reactions, multiple subsystems, recycle, bypass, and purge calculations.

Gases Vapors, Liquids and Solids: Ideal gas law calculations, real gas relationships, vapor pressure and liquids, saturation, partial saturation and humidity.

Energy Balances: Concepts and units, calculation of enthalpy changes, application of the general energy balance without reactions occurring energy balances that account for chemical reaction, reversible processes and the mechanical energy balances, heats of solution and mixing, psychometric charts and their use.

Simultaneous Material and Energy Balances: Degrees of freedom analysis for multicomponent systems, combined steady state material and energy balances for units with multiple sub-systems.

Books Recommended

1. Himmelblau D M, "Basic Principles and Calculations in Chemical Engineering", Prentice Hall (1998).
2. Haugen O A, Watson K M and Ragatz R A, "Chemical Process Principles (Part-I): Material and Energy Balances", Asia Publishing House (1995).
3. Bhatt B I and Vora S M, " Industrial Stoiciometry", Tata McGraw Hill Publishing, New Delhi (1987).
4. Reklaitis G V, "Introduction to material and energy balances", Wiley, New York (1983).
5. Felder R M and Rousseau R W, "Elementary principles of Chemical Processes", Wiley, New York 2nd Edition (1986).

MECHANICAL UNIT OPERATION [CHD-214]

L	T	P
3	1	0

Size Reduction: Particle size and shape, particle mass, size and shape distributions, measurement and analysis, concept of average diameter, size reduction, crushing, grinding and law of grindings.

Screening: Screening equipment, capacity and effectiveness of screen, effect of mesh size on capacity of screen.

Settling: Flow around a single particle, drag force and drag coefficient, settling velocity of particles in a fluid, hindered and free settling of particles, thickening gravity separation, Flotation, Magnetic Separation.

Filtration: Classification of filters, various types of cake filters, principle of cake filtration, clarification filters, liquid clarification, centrifugal settling process.

Agitation & Mixing: Agitation of liquids, axial flow impellers, radial flow impellers, velocity and power consumption of agitated vessels, blending & mixing.

Fluidization: Packed beds, bed porosity, flow though a bed of particles, fluidization & fluidized bed, conditions for fluidization minimum velocity, types of fluidization.

Solid Handling: Flow of solid by gravity, transport of solids by screw / belt conveyers, cyclones, bag filters, electrostatic precipitators, particulate collection system.

Books Recommended

1. Smith J C, Mccabe W L and Harriot P H, "Unit Operations of Chemical Engineering", McGraw Hill (2001).
2. Bhattacharya B C and Narayanan C M "Mechanical Operation for Chemical Engineers"
3. Perry's, "Handbook of Chemical Engineering", 7th Ed, McGraw Hill (1997).
4. Brown G G "Unit Operations" 1st Ed., CBS Publisher (2004)
5. Richardson and Coulson "Chemical Engineering Vol II", 5th Ed., Butterworth-Heinemann (2003).

L	T	P
3	1	0

MATERIAL SCIENCE AND ENGINEERING [CHD-215]

1. STRUCTURE OF MATERIALS: Space lattice and unit cells, crystal system, Symmetry operation, Structures of common metallic, Semiconductor ceramic and superconductor materials, Miller Indices, Representation of Directions and planes, Packing fractions, Structure determination using X-ray diffraction, Braggs law, and lattice parameter determination. Bonding in solids, coordination number, ceramics, silicates and clay structures, glass transition temperature, non-crystalline materials.

2. IMPERFECTION IN SOLIDS: Point defects: Impurities, Colour Centre, Polariton and exciton, dislocation: edge and screw dislocation, Stacking faults, grain boundaries, twins/ twist boundaries, volume defects, concentration of point defects, effect of defects on material properties.

3. PHASE DIAGRAMS AND PHASE TRANSFORMATION: Definition of diffusivity, concept of activation energy, Fick's Law of diffusion, Diffusion mechanism and their applications diffusion process, Solid solution, Intermediate phases and inter metallic compounds, Phase, phase rule, unary, binary phase diagrams, phase diagrams of some important metals and ceramics, microstructure changes during cooling, lever rule, invariant reactions, iron-iron carbide phase diagram. Nucleation and growth of phases, Introduction to TTT curves, heat treatment processes, annealing, hardening, tempering, normalization, embitterment, characterization of materials.

4. MECHANICAL BEHAVIOR: Elastic behavior of materials, concept of engineering and true stress and true strain, tensile property, yield point phenomenon, elastic modulus, and work hardening, strengthening mechanism, fracture, creep and fatigue, hardness. Atomic model of elastic behavior, plastic deformation in single and polycrystalline crystal, mechanism of slip, critical resolved shear stress, ductile and brittle failure, Griffith's theory of brittle fracture.

5. MAGNETIC AND DIELECTRIC PROPERTIES OF MATERIALS: Origin of magnetism, dia, Para, Ferro, antiferro and ferrimagnetisms, soft and hard magnetic materials, dielectric properties, Piezo, pyro and Ferro electricity.

6. ELECTRICAL AND ELECTRONICS PROPERTIES. Electricity conductivity, free electron theory, density of states, Fermi energy, FermiDirac Statistic, Band theory of solids, metals Semiconductors, Insulators, Semiconductors: Intrinsic and Extrinsic semiconductors, structure of elements and compounds, conductivity as a function of temperature, doping, hall effect, carrier concentration of semiconductors.

TEXT BOOKS: 1. Materials Science and Engineering, William D Callister Jr.

2. Elements of Materials science & Engineering, L.H.Van Vlack.

REFERENCE BOOKS:

1. Askeland, Donald R; Pradeep p. Phule (2005). The science & Engineering of materials, 5th edition, Thomson Engineering.

2. Solid state Physics: Properties of Materials, M.A. Wahab, Narosa Publishing.

3. Fundamentals of materials Science & Engineering, William F Smith

CHEMICAL ENGINEERING THERMODYNAMICS-I [CHD-216]

L	T	P
3	1	0

Fundamental concepts and definitions - closed, open and isolated system - intensive and extensive properties - path and state functions – reversible and irreversible process - temperature - Zeroth law of thermodynamics - First law of thermodynamics - internal energy - enthalpy - heat capacity - first law for cyclic, non-flow and flow processes - applications

P-V-T behaviour of pure fluids - ideal gases and ideal gas processes - equations of state - vander Waals equation, Redlich-Kwong equation, Virial equation - principle of corresponding states - critical and pseudo critical properties - Compressibility charts.

Heat effects in chemical reactions - standard heat of formation, combustion and reaction - effect of temperature on heat of reaction - temperature of reactions - adiabatic reaction temperature.

Second law of thermodynamics - limitations of first law - general statements of second law - concept of entropy - calculation of entropy changes - Carnot's principle - absolute scale of temperature - Clausius inequality - entropy and irreversibility - statistical explanation of entropy - Third law of thermodynamics.

Refrigeration and liquefaction - COP - refrigeration cycles - Carnot, vapour compression, air compression and absorption refrigeration cycle - general properties of refrigerant - Joule-Thomson expansion and liquefaction processes - powercycles - steam-power plant cycles - internal combustion engine cycles - gas-turbine power plant cycle.

Text Books:

1. Smith J M, Van Ness H C, Abbott M M, "Introduction to Chemical Engineering Thermodynamics", McGraw Hill (TMH Edition), 6th ed (2003).
2. Rao Y V C, "Chemical Engineering Thermodynamics", First Edition, Universities Press (India) Ltd., Hyderabad (1997).
3. Narayanan K. V., A Textbook of Chemical Engineering Thermodynamics, Prentice-Hall of India

Name of the Laboratory: Fluid Mechanics Laboratory Lab code: CHD – 217

Name of the equipment available in the existing laboratory

L	T	P
0	0	3

1. Verification of Bernoulli's Theorem.
2. Pitot static tube apparatus.
3. Reynolds Apparatus.
4. Venturimeter, Orificemeter & Rotameter calibration set-up.
5. Losses due to friction in pipe lines.
6. Losses due to Pipe fitting, Sudden enlargement & Contraction.
7. Flow visualization apparatus (Laminar flow table).
8. Reciprocating pump test rig.
9. Gear pump test rig.
10. Jet pump test rig.
11. Pressure measuring devices.

Name of the experiments:

1. To verify Bernoulli's equation experimentally.
2. To study the velocity distribution in a pipe and also to compute the discharge by integrating the velocity profile.
3. a) To visualize different flow conditions.
b) To obtain the Reynolds number in different flow conditions.
4. a) To calibrate Venturimeter, by establishing the relationship between flow rate and pressure difference and to find its coefficient of discharge.
b) To calibrate Orifice meter, by establishing the relationship between flow rate and pressure difference and to find its coefficient of discharge.
c) To determine the percentage error in Rotameter with the actual flow rate.
5. To find the friction factor for pipes of different diameter of same material.
6. To determine the minor head loss coefficient for different pipe fittings.
7. To draw flow net for irrotational flow past a cylinder (or any other geometry) using Hale –Shaw apparatus.
8. To draw the characteristics curve of reciprocating pump and also to determine efficiency of given reciprocating pump.
9. To draw the characteristics curve of gear pump and also to determine efficiency of given gear oil pump.
10. To draw the characteristics curve of Jet pump and also to determine efficiency of given Jet pump.
11. Study of Pressure measurement

MAT LAB CHD-219

L	T	P
0	0	3

1 MATLAB basics - The MATLAB environment - Basic computer programming - Variables and constants, operators and simple calculations - Formulas and functions - MATLAB toolboxes Exercises

2 Matrices and vectors - Matrix and linear algebra review - Vectors and matrices in MATLAB - Matrix operations and functions in MATLAB Exercises

3 Computer programming - Algorithms and structures - MATLAB scripts and functions (m-files) - Simple sequential algorithms - Control structures (if…then, loops)

4 MATLAB programming - Reading and writing data, file handling - Personalized functions - Toolbox structure - MATLAB graphic functions Exercises

5 Hands-on session Interactive hands-on-session where the whole class will develop one or more MATLAB scripts that solve an assigned problem

Semester IV

L	T	P
3	1	0

HEAT TRANSFER [CHD-221]

Introduction: Introduction to Heat transfer and general concept of heat transfer by conductions, convections and radiations.

Conduction: Basic concepts of conduction in solid liquid and gases. One dimensional heat conduction with out heat generation through plane walls, cylindrical and spherical surfaces, composite layers etc. insulating materials, critical and optimum thickness of insulation. Extended surfaces, fins and their practical applications. Introduction to unsteady state heat transfer.

Convection-Basic concept, natural and forced convection, Hydrodynamic and thermal boundary layers, Laminar and turbulent heat transfer inside and out side of tubes, Dimensional analysis, determination of individual and overall heat transfer coefficient, fouling factors. Heat transfer in molten metals.

Condensation of mixed and pure vapors, film wise and drop wise condensation, loading in condensers and basic calculation on condensers. Heat transfer in boiling liquids, boiling heat transfer coefficient, radiation heat transfer, Black body and gray body concept, Kirchoff's law, radiation between surfaces, combined heat transfer between surfaces.

Heat exchangers – classification and design criteria, types of exchanges ie Double pipe, shell and tube, plate type etc. mean temperature difference, LMTD correction factor for multiple pass exchangers, NTU and efficiency of heat exchangers, use of efficiency chart.

Evaporation Elementary principle, Types of evaporators, Single and multiple effect operation, material and energy balance in evaporators, boiling point elevation, Duhrings rule, effect of liquid head, thermo compression.

Books Recommended:

1. W.L McCabe and J.C. Smith, "Unit Operations In Chemical Engineering", 4th Edn., McGraw Hill Publishing Co., 1985.
2. D.Q. Kern, Process Heat Transfer, McGraw Hill Publishing, Co., New York, 1950
3. J.P Holman, Heat Transfer, Mc Graw Hill Education Co., India, 2014.
4. Yunus A cengel, Heat Transfer:A Practicalo Approach, McGraw Hill Publishing, Co. 2002.

L	T	P
3	1	0

CHEMICAL ENGINEERING THERMODYNAMICS-II [CHD-222]

Thermodynamic Properties of Fluids: Maxwell relations, Relationships among the thermodynamic properties of single phase systems, table of thermodynamic of gases.

Thermodynamics of Flow Processes: Compressible fluids, compressors and ejectors.

Equilibrium and Stability: Criteria of equilibrium, Chemical potential, Application of equilibrium criteria, Clausius clapeyon equation.

Phase Equillibria: Critical, fugacity, composition of phases in equillibria, fugacity of pure components, fugacity charts, effects of temperature on fugity, the Gibb's-Duhem Equation in terms of activity coefficients for two component system, relating activity coefficient with composition, theoretical calculation of activity coefficient, relation for excess free energy, thermodynamic consistency tests, Margule and Van –laar equation, various methods to calculate Van-Laar and Margule's constants.

Chemical Reaction Equilibrium: Reaction ordinate for single & multiple reactions , condition of equilibrium for a chemical reactions, Standard states and G, Temperature dependence of the equilibrium constant , Estimation of equilibrium rate constant , Homogeneous gas phase reactions, Heterogeneous chemical equilibrium.

Books Recommended

1. Smith J M, Van Ness H C, Abbott M M, "Introduction to Chemical Engineering Thermodynamics", McGraw Hill (TMH Edition), 6th ed (2003).
2. Kyle B G, "Chemical and Process Thermodynamics", Third Edition, Prentice Hall PTR, Upper Saddle River, New Jersy (1999).
3. YVC Rao, Chemical Engineering Thermodynamics First Edition Universities Press (India) Ltd. Hyderabad (1997).
4. K.V. Narayanan, A Text book of Chemical Engineering Thermodynamics, Prentice-Hall of India.

ENERGY MANAGEMENT [CHD-223]

L	T	P
3	1	0

Survey of different sources of energy and their utilization

Solid Fuels: Principle Solid Fuels – Coal, origin, composition & classification of coal, Properties of coal, terms used in analysis of coal, classification of Indian coals, and petrology of coal.

Coal Preparation: Dry and Wet processes, storage of coal. Coal carbonisation: mechanism of carbonisation, high temperature and low temperature carbonization briquetting, gasification of coal, Lurgi process, Winkler process, Kopper –Totzek process, liquefaction of solid fuels.

Liquid Fuels: Petroleum and related products, origin, occurrence and reserves, nature of petroleum crudes, classification and characteristics of petroleum, Refining Unit Process: Cracking, Thermal Cracking ,Catalytic cracking, Hydro cracking, Reforming Thermal and Catalytic Reforming, Alkylation, Polymerization Isomerization, petroleum products: naphtha, motor gasoline, aviation gasoline, kerosene, diesel oil, gas oil, fuel oil, lubricants, petroleum waxes, petroleum coke.

Gaseous Fuels: Classification, Wobbe Index natural gas, methane from coal mines, producer, water, carbureted water gas, coal, blast furnace, refinery gases, LPG.

Combustion: General Principles of combustion, stoichiometry & heat balance calculations, coal burning equipments, stokers, pulverized fuel burners gas and oil burners, fluidized bed combustion.

Alternate Energy Systems: Solar Energy – Photovoltaic cells, solar collectors. Nuclear energy: nuclear reactions, fuel materials, moderators and structural materials, reactors, wind energy, tidal energy, and geothermal energy.

Energy Management: Energy management strategy, Energy audit, types and methodology. Introduction of pinch technology, Nanotech.

Books Recommended

1. Brame J S and King J C, “Fuels- Solid, Liquid and Gaseous” , St. Martin Press
2. Sarkar S, “Fuels and combustion”, Longman publishers India Ltd.., IInd Edition
3. Haslam R T and Russel R P, “Fuels and their combustion” , McGraw Hill
4. C. Kashkare, Energy-Resources, Demand and Conservation with Special reference to India, Tata-McGraw Hill.

ENGINEERING MATHEMATICS-I1I [CHS-224]

L	T	P
3	1	0

1.PARTIAL DIFFERENTIAL EQUATIONS Formation and solutions of partial differential equations, Lagrange's linear equation of the first order, Non-linear equations, Charpit's method, Homogeneous linear equations with constant coefficients, Non-homogeneous linear equations, Nonlinear equations of the second order (Monge's method), Method of separation of variables, Solution of wave equations, Heat flow equations, La lace's equations and transmission line equations and their applications to engineering problems. p

2. SPECIAL FUNCTIONS Series solutions about ordinary and singular point, Series solutions of Bessel's and Legendre's equations, Bessel's functions and Legendre's, polynomials, Modified Bessel's functions, Recurrence relations, generating functions and orthogonal properties, Equations reducible to Bessel's equation, Ber and Bei functions.

3. INTEGRAL TRANSFORMS Definitions and Types of Integral Transforms, Application of Laplace transform to IVP and BVP, Periodic functions, Fourier transforms, Finite Fourier Sine and Cosine Transforms, Properties of Fourier Transforms, Applications of Integral Transforms to simple engineering problems. Hankel Transforms and its applications

4. PROBABILITY Introduction to probability, Conditional Probability, Total Probability, Bay's theorem, Random variables, probability distribution: Binomial, Poisson Normal Distribution and Gamma distribution.

5. STATISTICS Mean, Medium, Mode and standards deviation. Correlation and regression rank correlation, Regression, skewness and kurtosis, Principle of least squares, Tests based on Normal, t,Chi -Square and F distributions. Analysis of variance —one-way and two-way classifications.

TEXT BOOKS

1. Advanced Engineering Mathematics: by Erwin Kreyszig John Wiley and Sons, NC, NewYork.
2. Partial Differential Equation for Engineers and Scientists: by J.N. Sharma and Kehar Singh Narosa Publishing House, New Delhi/ Alpha Science Int. Ltd, UK.
3. Engg. Mathematics, Babu Ram, Pearson Education
4. Advanced Engineering Mathematics: by R. K. Jain & S. R. K Iyengar, Narosa Pub. House.
5. A First Course in Probability: by Ross, S, Pearson Education.
6. Miller, I. and Freund, E. F. "Probability and Statistics for Engineers", Prentice Hall, Inc.

REFERENCE BOOKS

1.Elements of Partial Differential Equations: by Ian N. Sneddon, McGraw-Hill, Singapore.
2. Differential Equations: by Shepley L. Ross, John Wiley & Sons, New York.
3. Advanced Engineering Mathematics by Chandrika Prasad.
4. Higher Engg. Mathematics, B. V. Ramana TMH
5. Probability, Statistics and Random Processes: by Verrarajan, T., Tata McGra Hill Publication.

CHEMICAL TECHNOLOGY [CHD-225]

L	T	P
3	1	0

CHLOR-ALKALI INDUSTRIES: Manufacture of Soda ash, Manufacture of caustic soda and chlorine - common salt.

ACIDS: Sulphur and Sulphuric acid; Mining of sulphur and manufacture of sulphuric acid. Manufacture of hydrochloric acid.

NATURAL PRODUCTS PROCESSING: Gasification of coal and chemicals from coal, Fermentation processes, Refining of edible oils, Manufacture of Sugar.

PULP AND PAPER INDUSTRIES: Pulp and paper manufacturing Industry, Rayon.

CEMENT: Types and Manufacture of Portland cement. **Glass:** Manufacture of glasses and special glasses. **Ceramics:** Refractories.

INDUSTRIAL GASES: Carbon dioxide, Nitrogen, Hydrogen, Oxygen and Acetylene - Manufacture of paints - Pigments.

NITROGEN FERTILIZERS: Synthetic ammonia, nitric acid, Urea, Ammonium Chloride, CAN, Ammonium Sulphate - Phosphorous Fertilizers: Phosphate rock, phosphoric acid, Super phosphate and Triple Super phosphate, MAP, DAP. Potassium Fertilizers: Potassium chloride and Potassium sulphate.

FIBRES AND ELASTOMERS: Polyamides, polyesters and acrylics from monomers. Production of natural and synthetic rubbers.

SOAPS AND DETERGENTS: Raw materials and Reaction Chemistry, Continuous process for manufacture of fatty acids, soaps and glycerine.

BOOKS RECOMMENDED

1. Austine G.T. – Shreeves Chemicals Process Industries – 5th Ed. McGraw Hill 1984.
2. Dryden C.E., M. Gopala Rao – Outlines of Chemical Technology-3rd Ed. Affiliated East West Press, New Delhi.
3. Pandey G.N. – Chemical Technology Volume – I – Lion Press, Kanpur.

COMPUTATIONAL METHODS IN CHEMICAL ENGINEERING [CHD-226]

L	T	P
3	1	0

Treatment of engineering data-graphical representation. empirical equations, Interpolation, Newton's formula, Lagrange's interpolation formula, extrapolation, integration, graphical Integration, graphical construction of integral curves, numerical integration.

Interpretation of Engineering Data- significant figure, classification of measurements, propagation of errors, variation and distribution of random errors, properties of variance, confidence limits for small samples.

Ordinary Differential Equations – formulation, application of law of conservation of mass– mixing in flow process. Classification of ordinary differential equations and its applications to common chemical engineering problem.

Numerical Solutions of Ordinary Different Equations– linear second– order equations with variable coefficients, numerical solution by Runge kutta method. its application to higher– order equations

Formulation of partial different equations, finite difference, linear finite difference equations, non-linear difference equations, optimization, types of methods, its application relating to chemical processes.

Books Recommended

1. Mickley HS, Sherwood and Reed, Applied Mathematics in Chemical Engineering, TMH pub.
2. Jenson & Jeffrey's, Mathematical Methods in Chemical Engineering, Mc Graw Hill
3. Luyben WL, Process Modeling, Simulation and Control for Chemical Engineering, Mc Graw Hill

CHEMICAL TECHNOLOGY LAB [CHD 227]

Name of the experiments:

L	T	P
0	0	3

1. Preparation and properties of soap
2. Determination of hardness of water
3. Preparation of azo dye
4. Preparation of urea and phenol formaldehyde
5. Preparation of prussian blue and chrome yellow
6. Preparation of pigments (barium white, malchite green and chromium oxide green)

Heat Transfer Laboratory [CHD 228]

L	T	P
0	0	3

Name of the equipments available in the existing laboratory

1. Double pipe heat exchanger
2. Shell and tube heat exchanger
3. Composite wall apparatus
4. Forced convection apparatus
5. Natural convection apparatus
6. Drop wise and film wise condensation apparatus
7. Stefan-Boltzman's apparatus
8. Emissivity measurement apparatus
9. Vertical and horizontal condenser
10. Single effect evaporator
11. Plate type heat exchanger
12. Unsteady state heat transfer apparatus

COMPUTATIONAL METHODS IN CHEMICAL ENGINEERING LAB [CHD-229]

L	T	P
0	0	3

1. Quadratic Equations": Linear Algebraic Equations: - Gauss Seidel, Gauss Jordan, Gauss Elimination, Ordinary Differential equations, Runge-Kutta 4^{th} order Method.
2. Polynomial root finding Techniques- "Newton Raphson Method, Secant Method".
3. Regula Falsi "Method, Power Method" to find dominant Eigen Value
4. Numerical Integration-Trapezoidal" Rule, Simpsons 1/3 and 3/8 rule,
5. Heat transfer problems

TEXT BOOK

1. Davis. M.E., "Numerical Methods and Modeling for Chemical Engineers", Wiley 1984.

2. Alan. L,.Myers and Warren. D Seider., "Introduction to Chemical Engineering and Computer Calculations", Prentice Hall, Engle Wood Cliffs (N.J), 1976.

3. Robert Lafore, Object Oriented Programming in C++, Galgotia Book House, 1994.

Semester V

	L	T	P
MASS TRANSFER-I [CHD-311]	**3**	**1**	**0**

Diffusion: Classification of mass transfer operation, choice of separation methods, Diffusion in Mass Transfer; Steady state molecular diffusion in fluids at rest and in laminar flow, molecular diffusion in gases, molecular diffusion in liquids, diffusivity in liquids and gases, momentum and heat transfer in laminar flow.

Interphase Mass Transfer: Mass Transfer Coefficient: Local and overall mass transfer coefficient, heat and mass transfer analogy, eddy diffusivities, film theory, penetration theory, surface renewal theories, combination film theory and surface stretch theory.

Equilibrium, local two phase mass transfer coefficients, Local overall Mass Transfer coefficients, material balance for co current & counter current processes, cascades and concept of Ideal stage and stage efficiencies, continuous contact equipments.

Gas Absorption: Choice of solvent, Estimation of number of ideal stages – Graphical and Analytical methods, Minimum solvent flow rate, Significance of absorption factor, number of transfer units and height of a transfer unit (NTU& HTU) concepts, packed column for absorption, rate of absorption, height of column based on condition in gas film and liquid film, height based on overall coefficients, equipment for gas absorption.

Drying: Equilibrium in drying, batch drying and rate of batch drying, time of drying, Through circulations drying & continuous drying, batch & continuous drying equipments.

Adsorption: Introduction and the nature of adsorbent, adsorption equilibria, the Langmuir isotherm, BET isotherm and Gibbs isotherm, potential theory and adsorption equipments.

Books Recommended:

1. Treybal R E , “Mass Transfer Operations” 3rd ed. , McGraw Hill (1980)
2. Geankopolis C J, “Transport Processes and Separation Process Principles”, Prentice Hall of India, 4th Edition, Eastern Economy Edition (2004).
3. Coulson J M and Richardson J F “Chemical Engineering , Vol. 2, 5”, McGraw Hill (1999)

CHEMICAL REACTION ENGINEERING-I [CHD-312]

L	T	P
3	1	0

Introduction: Kinetics of homogeneous chemical and biochemical reactions, single and multiple reactions, order & molecularity, rate constant, elementary and non elementary reactions, temperature dependent term of rate equation,

Interpretation of Batch Reactor: Constant volume batch reactor, integral method of analysis of data, series and parallel reactions, reversible reactions, Variable volume batch reactor, Differential methods of analysis, Temperature and reactions rate.

Introduction to Reactor Design: Ideal batch reactor, mixed flow reactor, plug flow reactor, holding and space time, design for single reactions, size comparison (analytical and graphical method, plug flow reactors in series & parallel, mixed reactor in series , recycle reactors.

Design for Multiple Reactions: Reactions in parallel and series in C.S.T.R, reactions in parallel and series in Plug flow reactor, yield & selectivity.

Temperature and Pressure Effect: General design procedure, optimum temperature progression, adiabatic operation, non adiabatic operation, semi batch reactors.

Non Catalytic Fluid Solid Reactions: Selection of model, unreacted core model for spherical particles, diffusion through gas film control, diffusion through ash layer control, chemical reaction control, Design.

Books Recommended:

1. Levenspiel O, "Chemical Reaction Engineering", 3rd Ed, John Wiley & Sons, Singapore (1999).
2. Fogler H Scott, "Elements of Chemical Reaction Engineering", 3rd ed, Prentice Hall Inc. (1999).
3. Smith J M, "Chemical Engineering Kinetics", McGraw Hill, 3rd ed. (1981).
4. Hill, C G, "Chemical Engineering Kinetics and Reactor Design", John Wiley (1977).

PROCESS DYNAMIC CONTROL [CHD-313]

L	T	P
3	1	0

Laplace Transform: Transforms of simple function, Transforms of Derivative, Initial value theorem and Final value theorem, Transform of Integral.

Response of First order system: Mercury thermometer & its transfer function, U-tube Manometer, Forcing functions, Liquid Level System, Liquid Level Process with constant flow out let, Linearization, Mixing tank & R.C. Circuit, Process Identification.

Higher order Systems: Non interacting tank System, Interacting tank System, Transfer function of second order system, step response of second order system, under, over and critically damped System, Impulse and Sinusoidal response of Second order system, Transportation lag, Inverse response, N-capacities in series.

Hardwares for Process Control: Measuring elements, Transducer, Transmitters, Control Valve and its characteristic curve, Proportional controller, Integral & Derivative controller, Comparison, Reset wind up, PI and PID Controllers.

Control System: Components of control system, block diagram, Negative and Positive feed back, Servo problem and Regulation Problem, Development of Block diagram.

Closed Loop Transfer functions: Determination of transfer function, Transient response of control system: Proportional control for set point change, Proportional control for load change, Proportional Integral control for load change, Proportional Integral Control for set point change. Controller Tuning by time integral performance criteria, one quarter decay ratio and Cohen and Coon method.

Stability: Concept of stability, Routh test for stability, Poles and Zeros..

Introduction to frequency response: Bode diagram for first order, Bode diagram for proportional, Integral and derivative control, Second order system, Nyquist plot.

Control System Design by frequency response: Bode stability criteria, Gain and phase Margin, Ziegler Nichols Controller tuning, Nyquist Stability and controller tuning.

Introduction to State-Space Methods: State Variables, State space description, selection of state variables.

Books Recommended:

1. Coughanower D R, "Process System Analysis and Control", McGraw Hill, 2nd ed. (1991)
2. Seborg, Edgar, and Mellichamp, "Process Dynamics & Control", John Wiley 2nd. Ed. (2004)
3. Harriot, " Process Control", Tata Mcgraw Hill (2000)

4. Stephanopoulos," Chemical Process Control - An Introduction To Theory & Practice", Ist Ed., Prentice Hall of India Private Limited (2003).
5. Luyben W L, "Essentials Of Process Control" McGraw Hill (1997).

PROCESS EQUIPMENT DESIGN-I [CHD-314]

L	T	P
3	1	0

Introduction: Introduction to principles involved inthe design and construction of plant.

Design preliminaries: Design codes, pressure, temperature, factor of safety, corrosion allowance, weld joint efficiency factor, design loadings, Poisson's ratio, dilation of pressure vessels, criteria of failure, material of construction.

Storage tanks: Introduction to Indian standards for storage tanks and their use to design cylindrical and spherical vessels under internal pressure, fixed roof and open roof tanks.

Mechanical design: Mechanical design of tall vessels for distillation and absorption columns.

Design of supports: Design of supports for vertical and horizontal vessels.

Books Recommended:

1. Bhattacharya B C, "Chemical Equipment Design", CBS Publisher (1985).
2. Sinnott R K, Coulson & Richardson, "Chemical Engineering (Vol.6)", 2nd Ed, Butterworth Heinemann, Oxford (1998).
3. Ludwig E E, "Applied Process Design for Chemical and Petrochemical Plants (Vol. 1, 2 and 3)", 3rd Ed., Gulf Publishing Company, Houston (1995).
4. Perry's, "Handbook of Chemical Engineering", 7th Ed, McGraw Hill (1997).
5. Ulrich, G D, "A Guide to Chemical Engineering Process Design and Economics", John Wiley (1984).

INDUSTRIAL SAFETY AND HAZARD MANAGEMENT [CHD-315]

L	T	P
3	1	0

Introduction: Concept of Loss prevention, acceptable risks, accident and loss statistics, nature of accident process, inherent safety.

Toxicology: Toxic materials and their Properties, Dose vs response, toxicants entry route, models for dose and response curves, TLV and PEL, material safety data sheets.

Industrial Hygiene: Identification, Material safety data sheets, Industrial hygiene evaluation, and control

Basics of Fires and Explosion: Fire triangle, definitions, flammability characteristics of liquid and vapors, LOC and inerting, types of explosions, Fire and explosion hazards, causes of fire and preventive methods.

Designs for fire prevention: Propagation of fire and effect of environmental factors, ventilation, dispersion, purifying and sprinkling, safety and relief valves

Hazard identification: Hazard survey, checklist, HAZOP, safety reviews, what if analysis

Risk Assessment: probability theory, event tree, fault tree, QRA and LOPA, Dow's fire and explosion index, Mond index, Dow's Chemical release model

Accident Investigations:

Case Histories: Bhopal gas tragedy, flixborough disaster, Pasadena accident, IOCL disaster

Recommended Books

1. Crowl D A, Louvar J F, " Chemical Process Safety Fundamentals with applications", 2nd Prentice Hall, NJ (2002).
2. Lees F P, Loss prevention in process Industries, 2nd ed, Butterworth, London, (1996).
3. Wells G L, Safety in process Plant Design, George godwin ltd., New York, (1980).
4. Wentz, C.A., "Safety health and environmental protection," McGraw Hill, 2001.

COMPUTATIONAL FLUID DYNAMICS [CHO-316(a)]

L	T	P
3	1	0

Conservation equations for mass, momentum and energy; Comparison of various numerical techniques for CFD; Review of finite difference and finite element methods; Solution to discretised algebric equation; Finite-volume method for diffusion problems; Finite-volume method for convection and diffusion problems-pressure velocity coupling; Construction of geometry and discreation using Gambit-Fluent‟s manuals; Commercial CFD solvers; Turbulance modeling; Implementation of boundary conditions; Introduction to multiphase flow; Customizing commercial CFD solver; Unsteady state simulations.

Books Recommended

1. Anderson, J.D., “Computational Fluid Dynamics: The Basics with Application” McGraw-Hill Co. Inc.
2. Anderson, D.A., Tannehill, J.C. and Pletcher, R.H., “Computational Fluid Mechanics and Heat Tranasfer”, Hemisphere Publishing Corporation.
3. Versteeg, H.K. and Malalasekera, W., “An Introduction to Computational Fluid Dynamics: The Finite Volume Method”, Prentice-Hall Inc.

Electrochemical Energy Engineering [CHO - 316 (b)]

L	T	P
3	1	0

Module 1: Introduction and overview of electrode processes, thermodynamics of electrochemical reaction, kinetics of electrochemical reaction

Module 2: Electrochemical techniques, Electrochemical impedance spectroscopy (EIS) and its application, cycling voltammetry and linear polarization, galvanostatic intermittent titration

Module 3: Principle of battery, advanced rechargeable battery, Li-ion batteries, nanostructured materials for Li-ion batteries

Module 4: Principle of fuel cells, types of fuel cells, new materials for proton exchange membrane fuel cell, alkaline fuel cell and solid oxide fuel cell, applications of fuel cells, fuel cell, battery and supercapacitor hybrid power systems, electrochemical reduction technologies.

Texts/References:

1. Electrochemical Methods, 2nd Ed., A.J. Bard and L.R.Faulkner, John Wiley & Sons, Inc., 2001.
2. Modern batteries, 2nd Ed., C.A.Vincent and B. Scrosati, John Wiley & Sons, Inc., 1997.
3. Principles of Fuel Cels, Xianguo Li, Taylor & Francis, 2005.
4. Fuel cell Systems Explained, 2nd Ed., James Larminie and Andrew Dicks, John Wiley & Sons, Inc., 2003.
5. Impedance Spectroscopy : Emphasizing Solid Materials and Systems J. Ross MacDonald and William R. Kenan, John Wiley & Sons, Inc. (1987)

SEPARATION PROCESSES [CHO-316(c)]

L	T	P
3	1	0

Fundamentals of Separation Processes: Limitations of convectional Separation processes, mechanisms of phase separation, component recovery and product purities, selection of feasible separation process, Keller's correlation, ease of scale up.

Membrane separation processes: Principles of membrane separation process classification, characterization and preparation of membrane, Analysis and modeling of membrane separation, Membrane modules and application. Reverse Osmosis and ultrafiltration, membrane characteristics and applications, ion selective membranes and their application in electrolysis. Dialysis and eleactrodialysis. Membrane distillation, Membrane fouling, remedial measures, design aspects. Per vaporization and gas separation using membranes, Liquid membrane, Industrial applications.

Separation of foam and surfactants: Foam and bubble separation, principle, classification, foam and surfactants, Separation techniques, Column Separations.

Zone melting and Zone refining, electrophoresis, desalting by freezing, centrifugation

Parametric pumping, thermal parametric pumping, batch, continuous pumping, multi-component separation, pH-parametric pumping, heatless parametric pumping

Text Books

1. Seader J. D. and HenleyE. J.,Separation process principles (Wiley).
2. Genkoplis J., Transport phenomena and separation process principles, 4th edition, PHI(2015).
3. Kaushik Nath, Membrane Separation Processes, PHI (2012)

Reference Books

1. King J., Separation Process – McGraw Hill.
2. Kaup E.C., Design Factors In reverse osmosis – Chemical Engineering 80 (1973).
3. Arden T.V., Water Purification By ION Exchange – Butterworth, London, 1968.
4. Sivasankar V., Bioseparations :principles and techniques (PHI)
5. McCabe W.L., Smith J.C. and Harriott P., Unit Operation of Chemical Engineer-V Edition, Tata McGraw – Hill, New York.

PROCESS DYNAMIC CONTROL LAB [CHD 318]

L	T	P
0	0	3

Name of the experiments:

1. Level control trainer
2. Dead weight pressure gauge
3. Control valve characteristics
4. Interacting and non-interacting systems
5. Temperature controller
6. Flow controller
7. Study of PI and IP converter

Semester VI

ENGINEERING ECONOMICS AND MANAGEMENT [CHH-321]

L	T	P
3	1	0

UNIT-I

Introduction to Economics-Flow in an Economy, Law of Supply and Demand, Concept of Engineering Economics - Engineering Efficiency, Economic Efficiency, Scope of Engineering Economics, Elements of Costs, Marginal Cost, Marginal Revenue, Sunk cost, Opportunity cost, Break-Even Analysis, P/V ratio, Elementary Economics Analysis- Material selection for product, Design selection for a product, Building material selection, Process Planning,

UNIT-II

Make or Buy Decision, Value Engineering-Function, Aims, Value Engineering procedure, Interest Formulas and their Applications - Time Value of Money, Single Payment Compound Amount Factor, Single Payment Present Worth Factor, Equal Payment Series Compound Amount Factor, Equal Payment, Series Sinking Fund Factor, Equal Payment Series Present Worth Factor, Equal Payment Series Capital Recovery Factor, Uniform Gradient Series Annual Equivalent Factor, Effective Interest Rate, Examples in all the methods.

UNIT-III

Methods of Comparison of Alternatives- Present Worth Method (Revenue Dominated Cash Flow Diagram, Cost Dominated Cash Flow Diagram), Future Worth Method (Revenue Dominated Cash Flow Diagram, Cost Dominated Cash Flow Diagram), Annual Equivalent Method (Revenue Dominated Cash Flow Diagram, Cost Dominated Cash Flow Diagram), Rate of Return Method, Examples in all the methods

UNIT-IV

Replacement and Maintenance Analysis- Types of Maintenance, Types of Replacement Problem, Determination of Economic Life of an Asset, Replacement of an Asset with a New Asset - Capital Recovery with Return and Concept of Challenger and Defender,Simple Probabilistic Model for items which fail Completely.

UNIT -V

Depreciation - Introduction, Straight Line Method of Depreciation, Declining Balance, Method of Depreciation, Sum-of-the-Years-Digits Method of Depreciation, Sinking Fund Method of Depreciation/Annuity Method of Depreciation, Service Output Method of Depreciation, Evaluation of Public Alternatives-Introduction, Examples, Inflation Adjusted Decisions- Procedure to Adjust Inflation, Examples on comparison of alternatives and Determination of Economics Life of asset.

Books Recommended

1. Pannerselvam, R., Engineering Economics, Prentice-Hall of India Pvt. Ltd., New Delhi 2001.
2. Degarmo, E.P., Sullivan, W.G. and Canada, J.R.. Engineering Economy, Macmillan, New York, 1984.

3. Grant, E.L., Ireson,.W.G. and Leavenworth, R.S.,Principles of Engineering Economy, Ronald Press, New York, 1976.

MASS TRANSFER-II [CHD-322]

L	T	P
3	1	0

Mass Transfer equilibria for vapour - liquid, liquid – liquid, solid - liquid and solid- gas systems

Distillation: Raoult's Law and Dalton's law, partial vaporisation and partial condensation, relative volatility, differential distillation & flash distillation, steam distillation, Lewis Sorel and McCabe–Thiele methods & numerical, Ponchon Savarit method, Underwood and Fenske equations, total reflux , minimum and optimum reflux ratios, multiple feeds and side streams.

Liquid – Liquid Extraction: Ternary phase diagrams & choiceof solvent, single stage and multistage cross current, co-current and counter current extraction operation for immiscible and miscible solvents, related numerical problems, continuos contact extractors.

Leaching: Mass transfer in leaching, equipment for leaching, single stage and multistage cross current, co-current and countercurrent leaching operations, related numerical problems

Crystallization: Formation of nuclei, nuclei growth and properties of crystals, effect of impurities on crystals formation, effect of temperature on solubility, caking of crystals, yield of crystals, crystallisers, related numerical problems.

Books Recommended

1. Geankopolis C J, "Transport Processes and Separation Process Principles", Prentice Hall of India, 4th Edition, Eastern Economy Edition (2004)
2. Treybal R E , "Mass Transfer Operations" 3rd ed. , McGraw Hill (1980).
3. Coulson J M and Richardson J F "Chemical Engineering , Vol. 2, 5", McGraw Hill (1999).
4. Walter L, Badger & Julius T.Banchero "Introduction to Chemical Engineering", McGraw Hill (1997).

CHEMICAL REACTION ENGINEERING-II [CHD-323]	L	T	P
	3	1	0

Non Ideal Flow: Non ideal flow patterns, E, F & C Curve, Mean residence time, Models for non ideal flow, N Tanks in series model, conversion in a reactor using RTD data. Heterogeneous Process: Global rates of reaction, Types of Heterogeneous reactions Catalysis, The nature of catalytic reactions, Mechanism of catalytic reactions. Physical Adsorption and Chemisorption : Physical adsorption and Chemisorption, Adsorption isotherms, Assumptions,Rates of adsorption isotherm, problems.

Solid Catalysts: Determination of surface area, Void volume and solid density, Pore volume distribution, Theories of heterogeneous catalysis, Classification of catalysts, catalyst preparation, Promoter and inhibitors, Catalysts Deactivation

Rate Equations for Fluid solid catalytic reactions: Rates of Adsorption, Surface reaction, Desorption, Rate limiting step, Power Law, Langmuir Hishelwood rate, Eley Rideal mechanism, Packed bed reactor and fluidized bed reactor, Numerical Problems

Intra Pellet Mass Transfer: Gaseous diffusion in single cylindrical pore, Different modes of diffusion: Bulk diffusion, Knudsen diffusion and surface diffusion, Diffusion in Liquids, Diffusion in Porous Catalyst, Concepts of effective thermal conductivity and effective diffusivity, Effectiveness factors

Reactors: Fixed Bed Catalytic Reactor, Single and multi bed adiabatic reactors, Multi tubular fixed bed reactor.

Introduction to Fluid Reactions: Kinetic Regimes for Mass Transfer and Reaction, Film Conversion parameter, Clues to the kinetic Regime from solubility data, Clues to the Kinetic Regime from equipment, Applications to design.

Books Recommended

1. Levenspiel O, "Chemical Reaction Engineering", 3rd Ed, John Wiley & Sons, Singapore (1999).
2. Fogler H Scott, "Elements of Chemical Reaction Engineering", 3rd Ed, Prentice Hall Inc. (1999).
3. Smith J M, "Chemical Engineering Kinetics", McGraw Hill , 3rd ed. (1981).

PETROLEUM REFINERY & PETROCHEMICAL ENGINEERING [CHD-324]

L	T	P
3	1	0

Petroleum Industry: Introduction to petroleum industry, World petroleum resources, petroleum industries in India. Scope and Purpose of Refining: Global and Indian refining scenario, Petroleum refining industry in India practice and prospects, An overview of the entire spectrum of the refinery products, refinery configuration development, Physiochemical characteristics of Petroleum and Petroleum products.

Refinery Distillation Processes: Classification of crude oil, Desalting and Stabilization of crude, Process description of typical simple distillation, Fractional distillation, crude oil distillation, vacuum distillation etc, Degree of separation (5-95 gap) and degree of difficulty of separation (Δt 50), Packie charts, ASTM, TBP and EFV Distillation.

Fuel Refining: Cracking, coking, reforming, alkylation, isomerisation, polymerization, sweetening, visbreaking, Hydro processing: Hydro cracking, hydro treating, hydro finishing.

Refinery Feedstock: Nature and effect of different types of refinery feedstock and their impurities on refinery configuration and operation.

Petrochemicals: Natural gas, production of petrochemical recursors - synthesis gas, hydrogen, acetylene, ethylene, propylene, butylene, aromatics and naphthenes. Petrochemical derivatives and products.

Polymer Based Industries And Their Characteristics: Plastics; Production of thermoplastic and thermosetting resins such as polyethylene, polypropylene, phenolic resins and epoxy resins; Polymers and their applications in engineering practice.

Environmental And Safety Aspects In Refinery And Petrochemicals: Waste water and effluent gases treatment from alkylation units and petrochemical units, safety aspects in the above industries.

Books Recommended

1. Nelson, WL, “Petroleum Refinery Engineering”, McGraw-Hill, New York, 1961.
2. Watkins R N, “Petroleum Refinery Distillation”, Gulf Publishing Co.
3. B. K. Bhaskara Rao, "Modern Petroleum Refining Processes", 2nd Edn., Oxford and IBH Publishing Company, New Delhi, 1990.

TRANSPORT PHENOMENA [CHD-325]

L	T	P
3	1	0

Summary of Vector and Tensor Notation: Vector operations from a geometrical view point. Vector operation from an analytical view point, the vector differential operations, second order tensors, vector and tensor components in curvilinear coordinates, differential operations in curvilinear coordinates.

Momentum Transport: Viscosity and the mechanism of momentum transport, Newton's law of viscosity, non- Newtonian fluids, pressure and temperature dependence of viscosity, theory of viscosity of gases at low density, theory of viscosity of liquids.

Velocity Distributions in Laminar Flow: Shell momentum balances: boundary conditions, flow of a falling film, flow through a circular tube, flow through an annulus, adjacent flow of two immiscible fluids.

The Equations of Change for Isothermal Systems: To equation of continuity, the equation of motion, the equation of mechanical energy.

Thermal Conductivity and the Mechanism of Energy Transport: Fourier's Law of heat conduction, temperature and pressure dependence of thermal conductivity in gases and liquids, theory of thermal conductivity of gases at low density, theory of thermal conductivity of liquids, thermal conductivity of solids.

Temperature Distributions in solids and in Laminar Flow: Shell energy balances; boundary conditions, heat conduction with anelectrical heat source, heat conduction with a chemical heat source, heat conduction through composite walls: Addition of Resistance, Forced Convection, Free Convection.

The Equations of change for Non isothermal systems: The equations of energy, the energy equation in curvilinear coordinates, the equations of motion for forced and free convection in nonisothermal flow, summary of the equations of change, use of equation of change to set up steady – state heat transfer problems.

Diffusivity and the Mechanism of Mass Transport: Definition of concentrations, velocities and mass fluxes, fick's law of diffusion,theory of ordinary diffusion in gases at low density, theory of ordinary diffusion in liquids.

Concentration Distributions in Solid and in Laminar Flow: Shell mass balances: boundary conditions, diffusion through a stagnant gas film, diffusion with heterogeneous chemical reaction, diffusion with homogeneous chemical reaction, diffusion into a falling liquid film l forced – convection mass transfer, Analogies between Heat, mass and momentum and transfers

Books Recommended

1. Bird R B, Stewart W E and Light fort R N,"Transport Phenomena", John Wiley and Sons (2002).
2. Welty J R , Wilson R E and Wicks C E , "Fundamentals of Momentum, Heat and Mass Transfer",4th ed,John Wiley and Sons (2001).
3. John C Slattery, "Momentum, Energy and Mass transfer in continua", McGraw Hill, Co. (1972).

INDUSTRIAL SAFETY AND RISK MANAGEMENT [CHO-326(a)]

L	T	P
3	1	0

UNIT I CONCEPTS AND TECHNIQUES: History of Safety movement –Evolution of modern safety concept - Incident Recall Technique (IRT), disaster control, safety analysis, safety survey, safety inspection, safety sampling. Safety Audits-components of safety audit, types of audit, audit methodology, non conformity reporting (NCR), audit checklist – identification of unsafe acts of workers and unsafe conditions in the industry.

UNIT II OCCUPATIONAL HEALTH AND TOXICOLOGY: Concept and spectrum of health, functional units and activities of occupational health services, occupational related diseases and levels of prevention of diseases. Toxicology- local, systemic and chronic effects, temporary and cumulative effects, carcinogens entry into human systems.

UNIT III HAZARD IDENTIFICATION & RISK ASSESSMENT: The process of risk management, hazard identification, evaluation (risk assessment, risk matrix), risk control implementation, action and recommendation.

UNIT IV ACTS AND RULES: Indian Boiler Act 1923, static and mobile pressure vessel rules (SMPV), motor vehicle rules, mines act 1952, workman compensation act, rules – electricity act and rules – hazardous wastes (management and handling) rules, 1989, with amendments in 2000-the building and other construction workers act 1996., Petroleum rules, Explosives Act 1983-Pesticides Act, Factories Act 1948, Air Act 1981 and Water Act 1974.

UNIT V SAFETY EDUCATION AND TRAINING: Importance of training-identification of training needs-training methods – programmes, seminars, conferences, competitions – method of promoting safe practice - motivation – communication - role of government agencies and private consulting agencies in safety training – creating awareness, awards, celebrations, safety posters, safety displays, safety pledge, safety incentive scheme, safety campaign – Domestic Safety and Training.

TEXT BOOKS:

1. Heinrich H.W. “Industrial Accident Prevention” McGraw-Hill Company, New York, 1980.
2. Krishnan N.V. “Safety Management in Industry” Jaico Publishing House, Bombay,1997.
3. Lees, F.P., “Loss Prevention in Process Industries” Butterworth publications, London, 2nd edition, 1990.
4. John Ridley, “Safety at Work”, Butterworth and Co., London, 1983.
5. Crowl D A, Louvar J F, “Chemical Process Safety Fundamentals with applications”, 2nd Prentice Hall, NJ (2002).

L	T	P
3	1	0

ENGINEERING OPTIMIZATION [CHO-326(b)]

Introduction: Optimization and calculus based classical optimization techniques.

One dimensional Minimization Methods: Elimination methods- equally spaced points method, Fibonacci method and golden section method; Interpolation methods-quadratic interpolation and cubic interpolation, Newton and quasi-Newton methods.

Linear Programming: Graphical representation, simplex and revised simplex methods, duality and transportation problems.

Multivariable Non –Linear Programming: Unconstrained- univariate method, Powell's method, simplex, method, rotating coordinate method, steepest descent method, Fletcher Reeves method, Constrained- complex method, feasible directions method, GRG method, penalty function methods and augmented Lagrange multiplier method.

Dynamic Programming: Multistage processes- acyclic and cyclic, suboptimization, principle of optimality and applications.

Geometric Programming (GP): Differential calculus and Arithmetic- Geometric Inequality approach to unconstrained GP; Constrained GP minimization; GP with mixed inequality constraints and Complementary GP.

Emerging Optimization Techniques: Genetic algorithm, simulated annealing, particle swarm and ant colony optimization.

Text Books:

(1) Edgar T.F., Himmelblau D.M and Lasdon L.S, "Optimization of Chemical Processes", 2nd Ed,(2001), Mc Graw Hill.
(2) Beveridge G.S.G and Schechter R.S. " Optimization: Theory and Practice", (1970) McGraw Hill.

Reference Books:

(1) Rao S.S., "Engineering Optimization Theory and Practice", 4th Ed.(2009), Wiley.
(2) Ravindran A, Ragsdell K.M Reklaitis G.V "Engineering Optimization, Methods and Applications"Johnwiely & Sons (2006).

L	T	P
3	1	0

FOOD TECHNOLOGY [CHO-326(c)]

INTRODUCTION Characteristics of food industry and role of Engineers, Constituents of food-Carbohydrates, Proteins, Fats and Oils and additional food constituents, Nutritive aspects of food constituents, Food additives, Quality factors in foods and Quality standards

UNIT OPERATION IN FOOD PROCESSING Material handling; Heat exchanging-Heating,Cooling, Evaporation, Drying; Forming, Packaging, Controlling; Overlapping unit operations; Energy conservation and new processes.

DETERIORATION AND PRESERVATION Deteriorative factors and their control; Kinetics of chemical reactions in foods; Preservation by heat and cold; Dehydration, concentration, drying, Irradiation, Microwave heating.

FOOD PRODUCTS Bakery, confectionary and chocolate products, Soft and alcoholic beverages, Dairy products; Meat, Poultry and fish products, Cereal, grains, pulses, vegetables, fruits, and spices.

PACKING METHODS AND WASTE DISPOSAL Principles of food packaging- Requirements of effective food packaging, Types of containers, Food packaing materials and forms, Package testing, Packages with special features. Factory Hygiene - Wastewater disposal and pollution control in food industry

TEXT BOOK 1. Potter. JH, Hotchkiss NN, “Food Science”, 5th edn., The CBS Publishing Co, Delhi, 2007.

2. Toldeo. RT, “The Fundamentals of Food Engineering”, The CBS Publishing Co, Delhi, 2000.

REFERENCES 1. Sivasankar.,B, “Food Processing and Preservation”, Prentice-Hall of India, New Delhi, 2002.

2. “Desrosier, NW., “The Technology of Food Preservation,” The CBS Publishers & Distributors, 1998

CHEMICAL REACTION ENGINEERING LABORATORY [CHD 328]

L	T	P
0	0	3

Name of the equipments available in the existing laboratory

Continuous stirred tank reactor (CSTR) set up

- Plug flow reactor (PFR) set up (2 Nos.)
- Packed bed reactor (PBR) set up (2 Nos.)
- **Name of the experiments:**

1. Study of a non-catalytic homogeneous reaction in a CSTR under isothermal conditions.
2. Study of a non-catalytic homogeneous reaction in a PFR under isothermal conditions.
3. Study of a non-catalytic homogeneous reaction in a PBR under isothermal conditions.
4. Residence time distribution (RTD) study in a PFR
5. Residence time distribution (RTD) study in a PBR

MASS TRANSFER LABORATORY [CHD 327]

Name of the equipments available in the existing laboratory

L	T	P
3	1	0

1. Diffusion of organic vapors (CCL4) in Air

2. Water Cooling Tower

3. Sieve Plate Distillation

4. Packed Bed Distillation Column

5. VLE Apparatus

6. Mass Transfer with/without chemical reaction apparatus

7. Wetted Wall Column

Name of the experiments:

1. (a) Determination of the diffusion coefficient of an organic vapor in air Diffusion of organic vapors (CCL4) in Air.

(b) To study the effect of temperature on the diffusion coefficient.

2. To study the heat and mass transfer in water cooling tower for different flow and thermodynamic conditions.

3. (a) To investigate the basic principles and calculation techniques of Sieved plate distillation.

(b) To determine the number of theoretical plates via the McCabe-Thiele Method and to determine the column efficiency.

4. (a) To investigate the basic principles, calculation techniques and efficiency of column of packed bed distillation.

5. To prepare the VLE curve for CClO4-tolune mixture.

6. To study the dissolution of benzoic acid in aqueous NaOH solution without chemical reaction and with chemical reaction.

7. To study the evaluation of mass transfer coefficient in wetted wall column.

Semester VII

PROCESS MODELING AND SIMULATION [CHD-411]

L	T	P
3	1	0

Introduction: Definition of mathematical model, lumped parameter models, distributed parameter models, uses of mathematical models, scope of coverage, principles of formulation.

Fundamental laws: Continuity equations, energy equations, equation of motion, equations of state, equilibrium, chemical kinetics.

Mathematical Models for Chemical Engineering Systems: Series of isothermal constant holdup CSTRs, CSTRs with variable holdups, Non-isothermal CSTR, Batch reactor, Batch distillation with holdup, Ideal binary distillation column, Lumped parameter model of gas absorber, Model for heat exchanger, Model for interacting & non-intracting tanks.

Simulation: Meaning of simulation, Simulation examples of isothermal CSTR, non-isothermal CSTR. Batch reactor. Computer programming of various iterative convergence methods such as Newton-Raphson, False position, wegstein, Muller methods.

Books recommended

1. Luyben W L, "Process Modeling Simulation and Control for Chemical Engineers", international ed. McGraw Hill (1990).
2. Russell T.W.F., "Introduction to Chemical Engineering Analysis", John Wiley & Sons New – York.
3. Bequette, "Process Dynamics- Modelling, Analysis and Simulation", PHI International (2003).
4. Rase H F, "Chemical Reactor Design for Process Plants, Vol II: Case Studies and Design Data", 1st Ed., John Wiley and Sons, New York (1997)

PROCESS ECONOMICS AND PLANT DESIGN [CHD-412]

L	T	P
3	1	0

Cost Estimation: Factors affecting investment & production costs, Capital investments (Fixed and working capital), Types of capital cost estimates, Cost Indexes, Estimating equipment costs by scaling 6/10 Factor Rule, Purchase Equipment Installation , Insulation costs, Instrumentation & Control, Piping , Electrical Installation , Service facilities, Land, Engineering . & Supervision, Start –up expenses. Methods of Estimating Capital Investment, Estimation of total product cost, Different costs involved in the total product for a typical Chemical Process plant.

Interest & Investment Costs: Types of interest (simple & compound interest), Nominal & Effective Rates of interest, Continuous interest, Present worth & discounts, perpetuities, capitalized costs, Interest & Investment costs. Taxes & Insurance: Types of taxes, Property taxes, excise taxes, income taxes, Types of Insurance & Legal Responsibility.

Depreciation: Purpose of Depreciation as cost, Types of Depreciation, Depletion, Service life., Salvage value, Present value, Methods of Determining Depreciation , Straight- line method, Declining Balance Method, Sum of the years Digits method, Sinking Fund Method, Single Unit & Group Depreciation. Profitability, Alternative Investments & Replacement: Profitability standards, Mathematical methods of profitability evaluation: Rate of return on investment, Discounted cash flow method, Net Present worth, Capitalised costs, pay out period. Determination of Acceptable investment, Alternatives when an investment must be made, Alternative analysis by method of return on incremental investment, Alternative analysis incorporating minimum return as a cost, Replacements, Balance sheets & Income statement.

Optimum Design: General procedure for Determining optimum conditions, Procedure with one variable, Procedure with Two or More variables,Break even chart for production schedule and its significance for optimum analysis. Examples of optimum design in a Chemical Process Plant.

Books Recommended

1. Peters, M S & Timmerhaus K D,"Plant Design and Economics for Chemical Engineers", McGraw Hill , New York , 4th Edition (2003).
2. Ulrich, G D,"A Guide to Chemical Engineering Process Design and Economics", John Wiley (1984).
3. Guthrie K M, "Process Plant Estimation, Evaluation and Control", Craftsman Solano Beach, California (1974).
4. Douglas, " Conceptual Design of Chemical Processes", McGraw Hill (1998)

PROCESS EQUIPMENT DESIGN-II [CHD-413]

L	T	P
3	1	0

Heat exchangers: Classification of shell and tube heat exchanger, material of construction, cleaning of heat exchangers, heat transfer fluid, agitated vessels, description of shell, tubes, bonnet and channel, pass partition plate, nozzle, baffles, tie rods, baffle spacers, flanges, gaskets and expansion joints.

Design of heat exchangers: Energy balance, heat duty consideration and process design of double pipe and shell and tube heat exchangers.

Mass Transfer Equipments: Types of mass transfer equipments, packed and tray type towers.

Tray Hydraulics: Bubble cap columns, perforated plate columns and packed towers.

Process Design: Process design of tray and packed towers.

Books Recommended

1. Kern D Q, "Process Heat Transfer", McGraw Hill (2001).
2. Perry's, "Handbook of Chemical Engineering" McGraw Hill, 7^{th} Ed (1997).
3. Coulson J M and Richardson R E, "Chemical Engineering" Vol 2 and 6, Pergamon Press (1998).

Department Electives: I

POLYMER SCIENCE AND ENGINEERING [CHE-414(a)]

L	T	P
3	1	0

Introduction: Concepts and classification of polymers Functionality, Glass transition temperature, Addition, condensation, step- growthand chain –growth polymerization

Molecular weight estimation: Average molecular weight – Number and weight average, Sedimentation and viscosity average molecular weights, Molecular weight and degree of polymerization, Significance of molecular weight.

Polymerization Processes: Bulk, solution, emulsion and suspension polymerization, Comparison of polymerization processes.

Polymerization Kinetics: Chemistry of step reaction polymerization, Mechanism and kinetics of polycondensation reactions and free-radical chain polymerization.

Synthetic Fibres: Types of Fibres, Spinning Techniques, Manufacturing Technology and Applications of different types of fibres: cellulosic fibres, polyamides,acrylics, vinyls and vinylidines, fluorocarbons.

Plastics: Manufacturing Technology and applicationsof different types of plastics: Polyester, polyethylene, Phenolics, Rubbers, structure, properties and preparation natural rubber synthetic rubbers: SBR, rubber compounding and reclaiming.

Books Recommended:

1. Gowariker V R, Viswanathan N V and Sreedhar J "Polymer Science" New Age International Publishers (1996).
2. Billmeyer F W, "Text Book of Polymer Science" Wiley Tappers (1994).
3. Ghosh P, "Polymer Science and Technology of plastics and rubber" Tata McGraw Hill (2001).
4. Gupta R K and Anil Kumar, " Fundamentals of Polymer Engineering", 2nd Ed., Marcel Dekkar (2003).

L	T	P
3	1	0

Optimization of Chemical Processes [CHE-414(b)]

Introduction: Optimization and calculus based classical optimization techniques.

One Dimensional Minimization Methods: Elimination methods- equally spaced points method, Fibonacci method and golden section method; Interpolation methods- quadratic interpolation and cubic interpolation, Newton and quasi-Newton methods.

Linear Programming: Graphical representation, simplex and revised simplex methods, duality and transportation problems.

Multivariable Non-Linear Programming: Unconstrained- univariate method, Powell's method, simplex method, rotating coordinate method, steepest descent method, Fletcher Reeves method, Newton's method, Marquardt's method and variable metric (DFP and BFGS) methods; Constrained- complex method, feasible directions method, penalty function methods and augmented Lagrange multiplier method.

Dynamic Programming: Multistage processes- acyclic and cyclic, suboptimization, principle of optimality and applications.

Geometric Programming (GP): Differential calculus and Arithmetic-Geometric inequality approach to unconstrained GP; Constrained GP minimization; GP with mixed inequality constraints and Complementary GP.

Emerging Optimization Techniques: Genetic algorithm, simulated annealing, particle swarm and ant colony optimization

Text Books:

Edgar T.F., Himmelblau D.M. and Lasdon L.S., "Optimization of Chemical Processes", 2nd Ed.(2001) , McGraw Hill

Rao S.S., "Engineering Optimization Theory and Practice", 4th Ed. (2009) Wiley.

Reference Books:

Ravindran A., Ragsdell K.M., Reklaitis G.V., " Engineering Optimization, Methods and Applications" Jhon Wiely & Sons(2006).

Beveridge G.S.G. and Schechter R.S., "Optimization: Theory and Practice", McGraw Hill(1970).

L	T	P
3	1	0

FOOD TECHNOLOGY [CHE-414(c)]

INTRODUCTION Characteristics of food industry and role of Engineers, Constituents of food- Carbohydrates, Proteins, Fats and Oils and additional food constituents, Nutritive aspects of food constituents, Food additives, Quality factors in foods and Quality standards

UNIT OPERATION IN FOOD PROCESSING Material handling; Heat exchanging- Heating,Cooling, Evaporation, Drying; Forming, Packaging, Controlling; Overlapping unit operations; Energy conservation and new processes.

DETERIORATION AND PRESERVATION Deteriorative factors and their control; Kinetics of chemical reactions in foods; Preservation by heat and cold; Dehydration, concentration, drying, Irradiation, Microwave heating.

FOOD PRODUCTS Bakery, confectionary and chocolate products, Soft and alcoholic beverages, Dairy products; Meat, Poultry and fish products, Cereal, grains, pulses, vegetables, fruits, and spices.

PACKING METHODS AND WASTE DISPOSAL Principles of food packaging- Requirements of effective food packaging, Types of containers, Food packaing materials and forms, Package testing, Packages with special features. Factory Hygiene - Wastewater disposal and pollution control in food industry

TEXT BOOK 1. Potter. JH, Hotchkiss NN, “Food Science”, 5th edn., The CBS Publishing Co, Delhi, 2007.

2. Toldeo. RT, “The Fundamentals of Food Engineering”, The CBS Publishing Co, Delhi, 2000.

REFERENCES 1. Sivasankar.,B, “Food Processing and Preservation”, Prentice-Hall of India, New Delhi, 2002.

2. “Desrosier, NW., “The Technology of Food Preservation,” The CBS Publishers & Distributors, 1998

Elective-II

FERTILIZER TECHNOLOGY [CHE-415(a)]

L	T	P
3	1	0

Elements required for plants growth, Classification of fertilizers, Compound, Complex & bulk blended fertilizers. N-P-K values & calculations.

Nitrogenous Fertilizers: Manufacturing Processes for Ammonia, Effects of various factors on the process. Manufacture of ammonium sulphate, ammonium chloride, Ammonium phosphate, Ammonium nitrate, nitric acid, Urea etc. Economics & other strategies, Material of construction & corrosion problem.

Phosphatic Fertilizers: Calculation of percentage tricalcium phosphate of lime in phosphatic rock. Manufacture of triple super phosphate & single super phosphate, Nitrophosphate, Sodium phosphate, phosphoric acid & other phosphatic fertilizers.

Potash Fertilizers: Manufacture of potash fertilizers like potassium sulphate, potassium chloride etc.

Books Recommended:

1. Dryden C E, "Outlines of Chemical Technology", East –West Press Pvt. Ltd., New Delhi, 2nd Edition (1973).
2. Austin G T, "Shreve's Chemical Process Industries", McGraw Hill Book Company, New Delhi 5th Edition (1986).
3. Chemical Engineering Education Development Centre– "Chemical Technology I, II, III, IV, Manual of Chemical Technology, Indian Institute of Technology, Madras".
4. Shukla S D and Pandey G N, "A text book of Chemical Technology Vol lI", Vikas Publishing House Pvt. Ltd., New Delhi

INTRODUCTION TO COLLOID AND INTERFACE SCIENCE [CHE-415(b)]

L	T	P
3	1	0

Surface Tension, Adhesion and Capillarity: Concepts of surface and interfacial energies and tensions; Apolar (van der Waals) and polar (acid-base) components of interfacial tensions. Young-Laplace equation of capillarity; Kelvin equation; Stability of equilibrium solutions; Contact angle and Young's equation; Determination of apolar (van der Waals) and acid-base components of surface/interfacial tensions.

Intermolecular, nanoscale and interfacial forces in organic, polymeric, niological and aqueous systems: Van der Waals, Electrostatic double layer, Acid-base interactions including hydrophobic attraction and hydration pressure.

Mesoscale thermodynamics: Gibbs treatment of interfaces; Concept of excess concentration; Variation of interfacial tensions with surfactant concentration.

Mesoscale phenomena in soft matter and applications: Adhesion, wetting, nucleation, flotation, patterning of soft material by self-organization and other techniques.

Stability of nanoparticle dispersions: DLVO and DLVO like theories and kinetics of coagulation plus general principles of diffusion in a potential field/Brownian movement.

Nanofluidics: Stability of thin (<100nm) films; self-organization in confined systems; meso-patterning.

Advanced and Functional Interfaces: Super hydrophobicity, functional coatings, structural colors, nano-adhesives; nano-composites.

Books Recommended:

P.C Hiemenz and R.Rajagopalan, Principles of Colloid and Surface Chemistry, Marcel Dekker, New York, 1997.

J.C Berg, An Introduction to Interfaces and Colloids: The Bridge to Nanoscience, World ScientificSingapore,2010.

Process Intensification [CHE 415(c)]

L	T	P
3	1	0

Basics of Process Intensification:

Definition of Process Intensification (PI). Benefits of PI, Techniques for PI application: active and passive techniques. Spinning disc reactor (SDR): Operating principle and development of models for thin film flow on rotating disc.Examples of application of SDR to a range of processes.

Rotatory &Oscillatory Systems

Rotary packed bed (RPBs): Operating principle of rotating Contactors. Development of models for counter-current multiphase flow in rotating systems, Examples of the application of multiphase Contactors. Oscillatory flow reactor (OFR): Description & operating principles, Explanation of niche applications. Design, Case studies.

Heat Exchangers

Compact heat exchangers (CHE): Definition of CHEs‟, Construction and main properties, Applications, Basic design procedures, the printed circuit heat exchanger (PCHE), Plate heat exchangers (PHEs).

Micro Reactors

Micro-reactors: Description and operating principles, oscillatory baffled reactor, mixing-limited reactor involving mass transfer and membrane reactors.

Text Book: 1. Re-Engineering the Chemical Processing Plant- Process Intensification,Stankiewicz, A., and Moulijn, Marcel Dekker Inc., New York, 2003.

Reference Book: 1. Engineering for Efficiency, Sustainability and Flexibility- Process Intensification, David Reay, Colin Ramshaw and Adam Harvey, Butterworth Heinemann, Elsevier Ltd., 2008

Semester VIII

SEPARATION PROCESSES [CHD-421]

L	T	P
3	1	0

Unit-I

Limitations of common separation techniques-sedimentation, screening, filtration, evaporation, distillation, absorption, liquid-liquid and soild-liquid extraction.

Unit-II

Principles of membrane separation process classification, characterization and preparation of membrane, Analysis and modeling of membrane separation, Membrane modules and application.

Unit-III

Reverse Osmosis and ultra filtration, membrane characteristics and applications, lon selective membranes and their application in electrolysis. Per vaporization and gas separation using membranes, Liquid membrane, Industrial applications.

Unit-IV

Foam and bubble separation, principle, classification, foam and surfactants, Separation techniques, Column Separations.

Unit-V

Zone melting and Zone refining, electrophoresis, desalting by freezing, centrifugation.

Unit-VI

Parametric pumping, thermal parametric pumping, batch, continuous pumping, multi-component separation, pH-parametric pumping, heatless parametric pumping.

Books Recommended:

1. The McCabe WL and Smith JC-Unit Operation of Chemical Engineer-ING-V Edition, Tata McGraw – Hill, New York.
2. King J. – Separation Process – McGraw Hill.
3. Kaup EC – Design Factors In reverse osmosis – Chemical Engineering 80 (1973).
4. Arden TV – Water Purification By ION Exchange – Butterworth, London, 1968.

INDUSTRIAL POLLUTION ABATEMENT [CHD-422]

L	T	P
3	1	0

Unit-I

Interaction of man and environment, overall picture of environmental pollution, environmental air and water quality criteria, standards and acts, effects of pollution.

Unit-II

Air and Noise Pollution: dispersion of pollutant in the atmosphere, meteorological factors of air, stability and inversion of atmosphere, control of air pollution, air pollution control equipments. Methods of measuring and sampling of gaseous and particulate pollutants in ambient air and industrial waste gases. Noise Pollution: noise control criteria, noise exposure index, Control.

Unit-III

Water Pollution: Sources, types of pollutants in liquid wastes of chemical industries, methods for the treatment of liquid wastes to control pollution, selection of pollution control equipment, Methods of sampling of waste water. Odour and its control.

Unit-IV

Solid Waste Disposal: Characterization of solid wastes, problems of collection and handling, various processing techniques used in solid waste management, solid waste as resource material.

Unit-V

Detailed considerations of wastes from industries such as textile (Cotton, wool, rayon, synthetics), sugar, pulp and paper, distilleries, oil refineries, petrochemicals, pharmaceuticals, dairy, food processing, soaps and detergents, mining, iron and steel, pickling, plating, galvanizing, tanning slaughterhouse, fertilizers, pesticides, dyes and dye intermediates, radioactive wastes. Recovery of byproducts, reuse of wastewaters with or without treatment.

Books Recommended:

1. Environment Pollution Control and Environmental Engg C.S. Rao.
2. Environmental Engineering. Peavy and Row.
3. Air Pollution-Engg. Control of Air Pollution Vol IV A.C.Stern.
4. Environmental Chemistry J.O.M Bockris
5. Pollution Control In Process Industries S.P Mahajan

COMPUTATIONAL FLUID DYNAMICS [CHD-423]

L	T	P
3	1	0

Conservation equations for mass, momentum and energy; Comparison of various numerical techniques for CFD; Review of finite difference and finite element methods; Solution to discretised algebric equation; Finite-volume method for diffusion problems; Finite-volume method for convection and diffusion problems-pressure velocity coupling; Construction of geometry and discreation using Gambit-Fluent‟s manuals; Commercial CFD solvers; Turbulance modeling; Implementation of boundary conditions; Introduction to multiphase flow; Customizing commercial CFD solver; Unsteady state simulations.

Books Recommended

4. Anderson, J.D., “Computational Fluid Dynamics: The Basics with Application” McGraw-Hill Co. Inc.
5. Anderson, D.A., Tannehill, J.C. and Pletcher, R.H., “Computational Fluid Mechanics and Heat Tranasfer”, Hemisphere Publishing Corporation.
6. Versteeg, H.K. and Malalasekera, W., “An Introduction to Computational Fluid Dynamics: The Finite Volume Method”, Prentice-Hall Inc.

Elective-III

BIO CHEMICAL ENGINEERING [CHE-424(a)]

L	T	P
3	1	0

Unit-I

Introduction To Bioscience: Types of Microorganisms: Structure and function of microbial cells. Fundamentals of microbial growth, batch and continuous culture. Isolation and purification of Enzymes from cells, Assay of enzymes.

Unit-II

Functioning Of Cells And Fundamental Molecular Biology: Metabolism and bio-energetics, Photosynthesis, carbon metabolism, EMP pathway, tricarbocyclic cycle and electron transport chain, aerobic and anaerobic metabolic pathways. Synthesis and regulation of biomolecules, fundamentals of microbial genetics, role of RNA and DNA.

Unit-III

Enzyme Technology And Kinetics: Applied Enzyme catalysis , Applications of enzymes in industry and medicine. Immobilization of enzymes. Kinetics of enzyme catalytic reactions involving isolated enzymes. Reversible inhibition.

Unit-IV

Reactions Catalysed By Enzymes, Reactors, Analysis: Reactor Design and Analysis for soluble enzyme systems. Cofactor regeneration. Membrane reactor. Effect of mass transfer in immobilised enzyme particle systems. Reactors for immobilised enzyme systems.

Unit-V

Bio Reactors, Effect Of Transport Processes: Introduction to Bioreactor design: Continuously Stirred aerated tank bioractors. Mixing power correlation .Determination of volumetric mass transfer rate of oxygen from air bubbles and effect of mechanical mixing and aeration on oxygen transfer rate, heat transfer and power consumption. Multiphase bioreactors and their applications. Downstream processing and product recovery in bioprocesses.

Books Recommended:

1. J. E. Bailey and D. F. Ollis. " Biochemical Engineering Fundamentals", 2nd Edn., McGraw Hill, New York , 1986.
2. Trevan, Boffey, Goulding and Stanbury," Biotechnology", Tata McGraw Hill Publishing Co., New Delhi, 1987.
3. M. L. Shuler and F. Kargi, “Bio Process Engineering: Basic concepts”, 2nd Edn., Prentice Hall of India, New Delhi, 2002.

Piping engineering [CHD 424(b)]

L	T	P
3	1	0

UNIT 1 Analysis of pipe flow: Energy losses in pipe lines, concept of equivalent length and equivalent pipes, problems in pipe flow, hydraulic power transmission through a pipe line.

UNIT 2 Negative pressure in pipe lines, Siphon, Multiple pipe systems, working pressure, design pressure, choice of pipe materials, hydraulic analysis of complex pipe networks.

UNIT 3 Aids in selecting pipe valves and fittings, standards for piping design, Dimensional and mechanical standards for pipe valves and fittings.

UNIT 4 Process piping arrangement plant layout and equipment arrangement, criteria for equipment layout, piping layout and arrangement.

UNIT 5 Pipe fabrication, vibration, its prevention and control in piping systems.

Books: 1. King, R. C. and Croker, S., "Piping Handbook", McGraw Hill.

2. Kellogg, M. W Company., "Design of Piping Systems", Pullman Power Products, New York (1976).

Corrosion Science and Engineering [CHD 424(c)]

L	T	P
3	1	0

Module 1 Introduction , Definition of corrosion, environment, corrosion damage, appearance, maintenance and operating costs, plant shut downs, contamination of product, loss of valuable products, effects on safety and reliability, classification of corrosion principle – introduction, rate expression, electrochemical reaction, polarization passivity, environmental affect, effect of oxygen and oxidizers, velocity, temperature, corrosive concentration, effect of galvanic coupling, metallurgical aspects, metallic properties, ringworm corrosion.

Module 2 Modern theory – principles, thermodynamics, cell potentials and EMF series, applications of thermodynamics to corrosion, electrode kinetics, exchange current density, activation polarization, combined polarization, concentration polarization, mixed potential theory, mixed electrodes, passivity forms of corrosion – uniform attack, galvanic corrosion, revise corrosion, pitting, inter granular corrosion and hydrogen damage.

Module 3 Corrosion control aspects, electrochemical methods of protection – theory of cathodic protection, design of cathodic protection, sacrificial anode, impressed current anode, anodic protection, corrosion inhibitors for acidic neutral and alkaline media , cooling water system – boiler water system organic coating, surface preparation, natural, synthetic resin, paint, formulation and application design aspects in corrosion prevention, corrosion resistance materials.

Module 4 Corrosion testing, monitoring and inspection, laboratory corrosion test, accelerated chemical tests for studying different forms of corrosion, electrochemical methods of corrosion rate measurements by DC and AC methods, corrosion monitoring methods, chemical and electrochemical removal of corrosion products, newer techniques to study corrosion process, inspection methods by NDT, surface analytical techniques such as AES, ESCA, SEM, evaluation of paints by conventional and electrochemical methods.

Reference

1. Roberge P R , Corrosion Engineering, McGraw Hill, New York, 1999.

2. Fontana, Corrosion Engineering, Int. Student Edn., 3rdEdn., McGraw Hill, 1986.

3. Uhling H H and Revie R W, Corrosion Control, John Wiley & sons. INC., 1985.

4. Banerjee S N, Introduction to Science of Corrosion and its Inhibition, Oxonian Inhibitors, Oxonian Press Ltd., New Delhi, 2004.

5. Trethewy & Chamberlain, Corrosion for Science and Engineering, Longman Sc& Tech; 2nd revised edition edition, 1996.

Elective-IV

HETEROGENEOUS CATALYSIS AND CATALYTIC PROCESSES [CHE-425(a)] **L T P**
3 1 0

UNIT I

Review of Heterogeneous Catalysis.

UNIT II

Transport Processes: Analysis of external transport processes in heterogeneous reactions in fixed bed, fluidized bed and slurry reactors. Intrapellet mass transfer, heat transfer, mass transfer with chemical reaction and simultaneous mass and heat transfer with chemical reaction.

UNIT III

Catalyst Selectivity: Effect of intrapellet diffusion on selectivities in complex reactions, effect of external mass transfer on selectivities.

UNIT IV

Catalyst Deactivation: Modes of deactivation – poisoning, fouling and sintering. Determination of deactivation routes, combined effect of deactivation and diffusion on reaction rates, effect of deactivation on selectivity.

UNIT V

Reactor Design: Design calculation for ideal catalytic reactor operating at isothermal, adiabatic and non-adiabatic conditions. Deviations from ideal reactor performance. Design of industria J fixed-bed, fluidized bed and slurry reactors. Thermal stability of packed bed and fluidized bed reactors.

Books Recommended:

1. Lee, H. H., "Heterogeneous Catalytic Reactors," Butterworth.
2. Tarhan, M. O., "Catalytic Reactor Design," McGraw-Hill, NY, 1983.
3. Anderson, J. R. and Boudart, M., "Catalysis, Science and Technology," Vol. 7, Springer Verlag, NY.
4. Thomas, J. M. and Thomas, W. J., "Introduction to the Principles of Heterogeneous Catalysis," Academic Press, 1967.

Instrumental Analytical Techniques [CHE 425(b)]

L	T	P
3	1	0

Introduction to Chemical Analysis

Qualitative and Quantitative analysis, fundamental theory of solution reactions i.e. chemical equilibrium, buffer solutions, Error, accuracy, precision, significant figures, correlation, regression, analysis of variance, mean and standard deviation

Spectroscopic Analysis

Introduction, theory and principles of UV-Vis Spectroscopy, Atomic Absorption Spectroscopy, Atomic Emission Spectroscopy, Mass Spectroscopy, Nuclear Magnetic Response Spectroscopy, Infrared Spectroscopy, Raman Spectroscopy

Chromatographic Analysis

Preparative, analytical chromatography, theory, principles and methodology of Thin Layer Chromatography, Liquid Chromatography (normal phase versus reversed phase chromatography), ion exchange, gel permeation and Gas Chromatography

Thermal Analysis

Introduction, theory, principles and methodology of Thermo Gravimetric (TG), Differential Thermo Gravimetric (DTG), Derivative Thermal Analysis (DTA) and Differential Scanning Calorimetry (DSC)

Electrochemical Analysis

Introduction, theory, principles and methodology of Electrogravimetric analysis, Coulometry, Potentionmetry, Voltammetry

Morphology and Crystallography Analysis

Introduction, theory, principles and methodology of X-ray diffraction (XRD), scanning electron microscope (SEM), Transmission electron microscopy (TEM)

Recommended Books

1. Willard, Merritt, Dean, Settle, “Instrumental Methods of Analysis”, CBS Publisher and Distributors. (1986).
2. Haines J., Blackie, “Thermal methods of Analysis, Principles, Application and Problems”, Academic and Professional, (1994).
3. Braithwaite A., Smith F. J., “Chromatographic Methods”, Fifth Edition, Blackie Academic and Professional, London, (1996).
4. Skoog, Holder, Nieman, “Principles of Instrumental Analysis”, Fifth Edition, Thomson Books, (1998).
5. Chatwal G R, Anand SK, “Instrumental Methods of Chemical Analysis” Fifth Edn. Himalaya Publishing House, (2005).