Chemical Engineering

Curricula for B.Tech. in Chemical Engineering
June-2017

Semester 1

S. No	Code	Course Title	L	T	P	Total	Credit
01	HMTS1101	Business English	2	0	0	2	2
02	PHYS1001	Physics-I	3	1	0	4	4
03	MATH1101	Mathematics-I	3	1	0	4	4
04	ECEN1001	Basic Electronics Engineering	3	1	0	4	4
05	MECH1101	Engineering Mechanics	3	1	0	4	4
Total							**18**

LABORATORY

S. No	Code	Course Title	L	T	P	Total	Credit
01	PHYS1011	Physics-I lab	0	0	3	3	2
02	ECEN1011	Basic Electronics Engineering Lab.	0	0	3	3	2
03	MECH1011	Workshop Practice	1	0	3	4	3
Total							**7**

SESSIONAL

S. No	Code	Course Title	L	T	P	Total	Credit
01	HMTS1111	Language Practice lab (Level 1)	0	0	2	2	1
02	HMTS1121	Co- Curricular activities	0	0	2	2	1
Total							**2**
TOTAL CREDIT							**27**

Semester 2

S. No	Code	Course Title	L	T	P	H	Credit
01	CSEN 1201	Introduction to Computing	3	1	0	4	4
02	CHEM 1001	Chemistry- I	3	1	0	4	4
03	MATH 1201	Mathematics- II	3	1	0	4	4
04	ELEC 1001	Basic Electrical Engineering	3	1	0	4	4
05	MECH 1201	Engineering Thermodynamics and Fluid Mechanics	3	1	0	4	4
Total							**20**

LABORATORY

S. No	Code	Course Title	L	T	P	H	Credit
01	CSEN 1211	Introduction to Computing Lab	0	0	3	3	2
02	CHEM 1011	Chemistry–I Lab	0	0	3	3	2
03	ELEC 1011	Basic Electrical Engineering Lab.	0	0	3	3	2
04	MECH 1012	Engineering Drawing	1	0	3	4	3
Total							**9**
TOTAL CREDIT							**29**

Semester 3

S. No	Code	Course Title	L	T	P	H	Credit
01	CHEN 2101	Mechanical Operation	3	1	0	4	4
02	CHEN 2102	Fluid Mechanics	3	1	0	4	4
03	CHEN 2103	Energy Engineering	3	1	0	4	4
04	CHEN 2104	Industrial Stoichiometry	3	1	0	4	4
05	CHEM 2001	Basic Environmental Engineering & Ecology	3	0	0	3	3
06	HMTS 2002	Indian Culture and Heritage	2	0	0	2	1
Total							**20**

LABORATORY

S. No	Code	Course Title	L	T	P	H	Credit
01	CHEN 2111	Energy lab	0	0	3	3	2
02	CHEN 2112	Fluid Mechanics Lab	0	0	3	3	2
03	CHEN 2113	Mechanical Operation Lab	0	0	3	3	2
04	CHEN 2114	Chemical Engineering Drawing Laboratory	0	0	3	3	2
Total							**8**
TOTAL CREDIT							**28**

Semester 4

S. No	Code	Course Title	L	T	P	H	Credit
01	HMTS 2001	Human values and Professional Ethics	2	0	0	2	2
02	CHEM 2201	Chemistry -II	3	0	0	3	3
03	CSEN 2206	Data Structure and Database Concept	3	1	0	4	4
04	CHEN 2201	Process Heat Transfer	3	1	0	4	4
05	CHEN 2202	Separation Process - I	3	1	0	4	4
06	CHEN 2203	Chemical Engineering Thermodynamics	3	1	0	4	4
Total							**21**

LABORATORY

S. No	Code	Course Title	L	T	P	H	Credit
01	CSEN 2211	DBMS lab	0	0	3	3	2
02	CHEN 2211	Heat Transfer lab	0	0	3	3	2
03	HMTS 2011	Language Practice Lab (Level 2)	0	0	3	3	2
Total							**6**
TOTAL CREDIT							**27**

Semester 5

S. No	Code	Course Title	L	T	P	H	Credit
01	HMTS 3101	Economics for Engineers	3	0	0	3	3
02	CHEN 3101	Chemical Process Technology-I	3	0	0	3	3
03	CHEN 3102	Chemical Reaction Engineering	3	1	0	4	4
04	CHEN 3103	Separation Process - II	3	1	0	4	4
05	CHEN 3104	Numerical Methods of Analysis	3	1	0	4	4
06	CHEN 3131 to 3133	Professional Elective-I	3	0	0	3	3
Total							**21**

LABORATORY

S. No	Code	Course Title	L	T	P	H	Credit
01	CHEN 3111	Mass Transfer laboratory	0	0	3	3	2
02	CHEN3113	Chemical Reaction Engineering Laboratory	0	0	3	3	2
Total							**4**

SESSIONAL

S. No	Code	Course Title	L	T	P	H	Credit
01	CHEN3112	PEDD- I	0	0	4	4	3
TOTAL CREDIT							**28**

Professional Elective I (CHEN 3131 to 3133)	CHEN 3131 Polymer Science & Engineering	CHEN 3132 Petrochemical Technology	CHEN 3133 Material Science & Engineering

Semester 6

S. No	Code	Course Title	L	T	P	H	Credit
01	CHEN 3201	Process Dynamics, Instrumentation and Control	3	1	0	4	4
02	CHEN 3202	Project Engineering	3	0	0	3	3
03	CHEN 3203	Chemical Process Technology II	3	0	0	3	3
04	CHEN 3204	Mathematical Methods in Chemical Engineering	3	1	0	4	4
05	CHEN 3231to 3233	Professional Elective-II	3	0	0	3	3
06	HMTS 3201	Principles of Management	2	0	0	2	2
Total							**19**

LABORATORY

S. No	Code	Course Title	L	T	P	H	Credit
01	CHEN 3212	Numerical Methods Laboratory	0	0	3	3	2
Total							**2**

SESSIONAL

S. No	Code	Course Title	L	T	P	H	Credit
01	CHEN 3211	PEDD- II	0	0	4	4	
02	HMTS 3221	Personality Development	0	0	1	1	1
03	CHEN 3221	Seminar I	0	0	0	3	2
Total							**3**
TOTAL CREDIT							**24**

Professional Elective II (CHEN 3231 to 3233)	CHEN 3231 Nano Technology	CHEN 3232 Computational Fluid Dynamics	CHEN 3233 Bioprocess Engineering

Semester 7

S. No.	Code	Course Title	L	T	P	H	Credit
01	CHEN 4101	Transport Phenomena	3	1	0	4	4
02	CHEN 4103	Modeling Simulation & optimization	3	0	0	3	3
03	CHEN 4141to 4143	Professional Elective III	3	0	0	3	3
04	FE 4181-4184	Free Elective-I	3	0	0	3	3
Total							**13**

LABORATORY

S. No.	Code	Course Title	L	T	P	H	Credit
01	CHEN 4112	Instrumental Methods of Analysis Lab	0	0	3	3	2
02	CHEN 4113	Process Control Laboratory	0	0	3	3	2
Total							**4**

SESSIONAL

S. No.	Code	Course Title	L	T	P	H	Credit
01	CHEN 4191	Project –I	0	0	6	6	4
02	CHEN 4131	Industrial Training	**4 wks - 6th -7th Sem-break**				2
03	CHEN 4132	Seminar II	0	0	0	3	2
04	HMTS 4121	Professional Development	0	0	3	3	2
Total							**10**
TOTAL CREDIT							**27**

Professional Elective III	CHEN 4141 Reactor Design	CHEN 4142 Industrial Safety & Hazard Analysis	CHEN 4143 Advanced Separation Process	
Free Elective I for Chemical Engineering students	BIOT 4182 Biopolymer	AEIE 4181 Instrumentation & Telemetry	ELEC 4182 Circuit Theory Analysis	MATH 4182 Linear Algebra

Semester 8

S. No.	Code	Course Title	L	T	P	H	Credit
01	CHEN 4241 - 4244	Professional Elective-IV	3	0	0	3	3
02	FE 4281 - 4283	Free Elective-II	3	0	0	3	3
03	HMTS 4201	Organizational Behaviour	2	0	0	2	2
Total							**8**

LABORATORY

S. No.	Code	Course Title	L	T	P	H	Credit
Total							**0**

SESSIONAL

S. No.	Code	Course Title	L	T	P	H	Credit
01	CHEN 4291	Project –II	0	0	8	8	8
02	CHEN 4221	Plant Design	0	0	4	4	4
03	CHEN 4231	Comprehensive Viva Voce	0	0	3	3	3
Total							**15**
TOTAL CREDIT							**23**

Professional Elective IV	CHEN 4241 Catalysis & Catalytic Reactor Design	CHEN 4242 Total Quality Management	CHEN 4243 Environmental Engineering & Pollution Control.	CHEN 4244 Operations Research – Engineering Applications
Free Elective II for Chemical Engineering students		BIOT 4281 Computational Biology	AEIE 4282 Control System and Applications	MATH 4281 Probability and Stochastic Processes

List of Free Electives offered by Chemical Engineering Department for non-CHE students

FREE ELECTIVE (7TH SEMESTER)	FREE ELECTIVE (8TH SEMESTER)
CHEN 4181 Safety and Hazard Analysis	CHEN 4281 Catalytic Reactor Design
CHEN 4182 Project Management	CHEN 4282 Total Quality Management & Assurance

Chemical Engineering

B.TECH. PROGRAMME IN CHEMICAL ENGINEERING
SYLLABUS
June 2017

Semester 1

THEORY

Subject Name: Business English					
Paper Code: HMTS1101					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	2	**0**	**0**	**2**	**2**

Course Outcome:

1. Analyse the dynamics of business communication and communicate accordingly.
2. Write business letters and reports
3. Learn to articulate opinions and views with clarity
4. Appreciate the use of language to create beautiful expressions
5. Analyse and appreciate literature.
6. Communicate in an official and formal environment.

Module I : 5L

Communication Skill
Definition, nature & attributes of Communication
Process of Communication
Models or Theories of Communication
Types of Communication

Levels or Channels of Communication
Barriers to Communication

Module II : 12L

Business Communication- Scope & Importance
Writing Formal Business Letters.
Writing Reports
Organizational Communication: Agenda & minutes of a meeting, notice, memo, circular
Project Proposal Technical
Report Writing
Organizing e-mail messages E-
mail etiquette
Tips for e-mail effectiveness

Module III : 10L

Language through Literature
Modes of literary & non-literary expression
Introduction to Fiction, (An Astrologer's Day by R.K. Narayan and Monkey's Paw by

W.W. Jacobs), Drama (The Two Executioners by Fernando Arrabal) or (Lithuania by Rupert Brooke) & Poetry (Night of the Scorpion by Nissim Ezekiel and Palanquin Bearers by Sarojini Naidu)

Module IV : 3L

Grammar in usage (nouns, verbs, adjectives, adverbs, tense, prepositions, voice change) -to

be dealt with the help of the given texts.

References:

1. Armand Matterlart and Michele Matterlart, Theories of Communication: A Short Introduction, Sage Publications Ltd., 1998.
2. Chan, Janis Fisher, and Diane Lutovich. Professional Writing Skills. San Anselmo, CA:Advanced Communication Designs, 1997.
3. Geffner, Andrew P. Business English. Hauppauge, **New York: Barron's** Educational Series, 1998.
4. Good, Edward C. Mightier Than the Sword. Charlottesville: Word Stone Publications, 1989.
5. Edward P.Bailey, Writing and Speaking at Work: A Practical Guide for Business Communication, Prentice-Hall, 7th edn, 2004.
6. Kitty O. Locker, Business and Administrative Communication, McGraw-Hill/ Irwin, 7th edn, 2004.
7. Lillian Chaney and Jeanette Martin, Intercultural Business Communication, Prentice Hall, 4th edn, 2005.
8. Yudkin, Marcia. Persuading on Course Name. Lansing, IL: Infinity Publishing, 2001.

Subject Name: Physics-I					
Paper Code: PHYS1001					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**1**	**0**	**4**	**4**

Course Outcome

1. Interpret oscillations under different conditions, with the understanding of Resonance phenomena followed by calculation of Q factor.
2. Analyze the Quantum phenomenon like Black body radiation , Compton effect and origin of X-ray spectrum.
3. Understand the wave character of light through the phenomenon of interference, diffraction and polarization.
4. Study of various crystal structures and classification of different crystal planes.
5. Explain the working principle of LASER, and apply the knowledge in different lasing system and their engineering applications in holography
6. Understand the dual nature of matter, Heisenberg's uncertainty relation and it's various application.

Module I: 22 L

Optics

1.Interference :

The principle of superposition of waves, Superposition of waves: Two beam superposition, Multiple-beam superposition, coherent and incoherent superposition.

Two source interference pattern (Young's double slit), Intensity distribution. Interference in thin films, wedge shaped films and Newton's rings, applications of interference. Newton's rings: Determination of wavelength of light, refractive index of liquid.

Diffraction:

Diffraction of light waves at some simple obstacles. Fraunhoffer diffraction through double slit and diffraction grating, grating spectra, resolving power of grating.

Polarisation & Fibre Optics:

Elementary features of polarization of light waves.Production and analysis of linearly, elliptic and Circularly polarized light, polaroids and application of polarizations. fibre optics - principle of operation, numerical aperture, acceptance angle

Laser

Characteristics of Lasers, Spontaneous and Stimulated Emission of Radiation, Meta-stable State, Population Inversion, Lasing Action, Einstein's Coefficients and

Relation between them, Ruby Laser, Helium-Neon Laser, Semiconductor Diode Laser, Applications of Lasers.

Module II : 8L

Waves & Oscillation

Superposition of two linear SHMs (with same frequency), Lissajous' figures. Damped vibration – differential equation and its solution, Critical damping, Logarithmic decrement, Analogy with electric circuits. Forced vibration – differential equation and solution, Amplitude and Velocity resonance, Sharpness of resonance and Quality factor. Progressive wave- Wave equation and its differential form, Difference between elastic (mechanical) and electromagnetic waves.

Module III : 9L

Quantum Mechanics

Need for Quantum physics-Historical overviews, Particle aspects of radiation-Black body radiation, Compton scattering, pair production., Origin of X-ray spectrum. Wave aspect of particles- matter wave, de Broglie Hypothesis, Heisenberg Uncertainty principles- Statement, Interpretation and application.

Module IV: 6L

Introduction of Crystallography

Space Lattice**,** Unit Cell, Lattice Parameters, Crystal Systems, Bravais Lattices, Miller Indices and its applications, Crystal Planes and Directions, Inter Planar Spacing of Orthogonal Crystal Systems, Atomic Radius, Co-ordination Number and

Packing Factor of SC, BCC, FCC. Bragg's law and its applications.

Text Books:

1. Atomic Physics Vol 1 – S.N. Ghoshal
2. Optics – Ajoy Ghak
3. Waves & Oscillation – N.K. Bajaj
4. Quantum Physics of Atoms , Molecules, Solids, Nuclei and particles – Eisberg and Resnick

Reference Books:

1. Introduction to Special Relativity – Robert Resnick
2. Prespective on Modern Physics - Arthur Beiser
3. Optics – Jenkins and White
4. University Press – Sears & Zemansky
5. Introduction to modern Physics – Mani and Meheta
6. Optics – Brijlal and Subrahmanyam

Subject Name: Mathematics I					
Paper Code: MATH1101					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**1**	**0**	**4**	**4**

Course Outcome:

1. Apply the concept of rank of matrices to find the solution of a system of linear simultaneous equations.
2. Develop the concept of eigen values and eigen vectors.
3. Use Mean Value Theorems for power series expansions of functions of one variable.
4. Analyze the nature of sequence and infinite series.
5. Describe the concept of differentiation and integration for functions of several variables with their applications in vector calculus.
6. Combine the concepts of gradient, curl, divergence, directional derivatives, line integrals, surface integrals and volume integrals.

Module I : 10L

Matrix:

Matrices and their basic attributes, Determinant of a square matrix, Minors and Cofactors, Laplace's method of expansion of a determinant, Product of two determinants, Adjoint of a determinant, Jacobi's theorem on adjoint determinant.

Singular and non-singular matrices, Adjoint of a matrix, Inverse of a non-singular matrix and its properties, Orthogonal matrix and its properties, Special Complex Matrices: Hermitian, Unitary, Normal(definition only), Rank of a matrix and its determination using elementary row and column operations, Solution of simultaneous linear equations by :Cramer's Rule and Matrix inversion method,

Consistency and inconsistency of a system of homogeneous and inhomogeneous linear simultaneous equations, Characteristic Equation and computation of eigenvalues and eigenvectors of a square matrix (of order 2 or 3), Cayley-Hamilton theorem and its applications(with special reference to higher power of matrices, e.g. Idempotent and Nilpotent matrices)

Module II : 10 L

Mean Value Theorems & Expansion of Functions:

Rolle's theorem: its geometrical interpretation and its application, Concavity and Convexity of curves, Mean Value theorems – Lagrange & Cauchy and their application, Taylor's theorem with Lagrange's and Cauchy's form of remainders and its application, Expansions of functions by Taylor's and Maclaurin's theorem,

Maclaurin's infinite series expansion of the functions:

$\sin x, \cos x, e^x, \log(1+x), (a+x)^n$, n being an integer or a fraction (assuming that the

remainder R_n-> 0 as n->∞ in each case).

Infinite Series:
Preliminary ideas of sequence, Infinite series and their convergence/divergence,

Infinite series of positive terms, Tests for convergence: Comparison test, Cauchy's Root test, D' Alembert's Ratio test(statements and related problems on these tests), Raabe's test, Proof of ^{e} being irrational, Alternating series, Leibnitz's Test

(statement, definition) illustrated by simple examples, Absolute convergence and Conditional convergence,

Module III : **10 L**
Successive differentiation:
Higher order derivatives of a function of single variable, Leibnitz's theorem (statement only and its application, problems of the type of recurrence relations in derivatives of different orders and also to find $(y_n)_0$) .

Calculus of Functions of Several Variables:
Recapitulation of some basic ideas of limit and continuity of functions of single variable, Introduction to functions of several variables with examples, Knowledge of limit and continuity, Determination of partial derivatives of higher orders with examples, Homogeneous functions and Euler's theorem and related problems up to three variables, Chain rules, Differentiation of implicit functions, Total differentials and their related problems, Jacobians up to three variables and related problems, Maxima, minima and saddle points of functions and related problems.

Module-IV : **10 L**
Multiple Integration and Vector Calculus:
Concept of line integrals, Double and triple integrals. Vector function of a scalar variable, Differentiation of a vector function, Scalar and vector point functions, Gradient of a scalar

point function, divergence and curl of a vector point function, Directional derivative, Related problems on these topics, Green's theorem, Gauss Divergence Theorem and Stoke's theorem (Statements and applications).

Reduction formula:
Reduction formulae both for indefinite and definite integrals of types:

$$\int \sin^n x, \int \cos^n x, \int \sin^m x \cos^n x, \int \cos^m x \sin nx, \int \frac{dx}{(x^2+a^2)^n}, m, n \text{ are positive integers.}$$

References:

1. Advanced Engineering Mathematics: Erwin Kreyszig by Wiley India
2. Engineering Mathematics: B.S. Grewal (S. Chand & Co.)
3. Higher Engineering Mathematics: John Bird (Elsevier)
4. Advanced Engineering Mathematics: Wiley and Barrett (Tata McGraw-Hill)
5. Calculus: M. J. Strauss, G. L. Bradley and K. L. Smith (Pearson Education)
6. Engineering Mathematics: S. S. Sastry (PHI)
7. Advanced Engineering Mathematics: M.C. Potter, J.L. Goldberg and E.F.
8. Abonfadel (OUP),Indian Edition.

9. Linear Algebra(Schaum's outline series): Seymour Lipschutz, Marc Lipson
10. (McGraw Hill Education)
11. Vector Analysis(Schaum's outline series): M.R. Spiegel, Seymour Lipschutz,
12. Dennis Spellman (McGraw Hill Education)
13. Introduction to Real Analysis: S.K.Mapa (Sarat Book Distributors) .

Subject Name: Basic Electronics Engineering					
Paper Code: ECEN1001					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**1**	**0**	**4**	**4**

Course Outcome:

1) Categorize different semiconductor materials based on their energy bands and analyze the characteristics of those materials for different doping concentrations based on previous knowledge on semiconductors acquired.
2) Describe energy band of P-N Junction devices and solve problems related to P-N Junction Diode both from device and circuit perspectives.
3) Design different application specific circuits associated with diodes operating both in forward and reverse bias.
4) Analyze various biasing configurations of Bipolar Junction Transistor and categorize different biasing circuits based on stability.
5) Categorize different field-effect transistors based on their constructions, physics and working principles and solve problems associated with analog circuits based on operational amplifiers.
6) Design and implement various practical purpose electronic circuits and systems meant for both special purpose and general purpose and anlayze their performance depending on the type of required output and subsequently the applied input.

Module I : 10 L

Semiconductors:

Crystalline material, Energy band theory, Fermi levels; Conductors, Semiconductors and Insulators: electrical properties, band diagrams. Semiconductors: intrinsic and extrinsic, energy band diagram, electrical conduction phenomenon, P-type and N-type semiconductors, drift and diffusion carriers.

Diodes and Diode Circuits:

Formation of P-N junction, energy band diagram, built-in-potential forward and reverse biased P-N junction, formation of depletion zone, V-I characteristics, Zener Diode and its Application, Zener and Avalanche breakdown.

Simple diode circuits, load line, piecewise linear model; Rectifier circuits: half wave, full wave, PIV, DC voltage and current, ripple factor, efficiency, idea of regulation.

Module II : 10 L

Bipolar Junction Transistors:

Formation of PNP / NPN junctions, energy band diagram; transistor mechanism and principle of transistors, CE, CB, CC configuration, transistor characteristics: cut-off, active and saturation modes of operation, transistor action, input & output characteristics, load line & amplifier operation and current amplification factors for CB and CE modes. Biasing and Bias stability: calculation of stability factor.

Module III : 9 L

Field Effect Transistors:

Junction field effect transistor (JEET): Principle of operation, JFET parameters, eqv. Circuit, JFET biasing, self bias, design of bias circuits, load line, amplifier characteristics.

MOSFETs:

Construction & principle of operation of p- & n-channel enhancement & depletion mode MOSFETs, drain & transfer characteristics, threshold voltage & its control.

Cathode Ray Osilloscope:

Construction and working principle of CRO, Lissajous pattern.

Module IV : 9 L

Feed Back Amplifier:

Concept-block diagram, properties, positive and negative feedback, loop gain, open loop gain, feedback factors; topologies of feedback amplifier; effect of feedback on gain, condition of oscillation, Barkhausen criteria.

Operational Amplifier:

Introduction to integrated circuits, operational amplifier and its terminal properties; Application of operational amplifier; Concept of op-amp saturation, inverting and non-inverting mode of operation, Adders, Subtractors, Voltage follower, Integrator, Differentiator, Basic Comparator Circuit.

References:

1. Boylestad & Nashelsky:Electronic Devices & Circuit Theory
2. R.A Gayakwad:Op Amps and Linear I**C's, PHI**
3. D. Chattopadhyay, P. C Rakshit : Electronics Fundamentals and Applications
4. Adel S. Sedra, Kenneth Carless Smith: Microelectronics Engineering
5. Millman & Halkias: Integrated Electronics.
6. Salivahanan: Electronics Devices & Circuits.
7. Albert Paul Malvino: Electronic Principle.

Subject Name: Engineering Mechanics					
Paper Code: MECH 1101					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**1**	**0**	**4**	**4**

Course Outcome:

1. Understand basic concepts of vector algebra as applied to engineering mechanics.
2. Analyze free body diagram of a system under equilibrium / non equilibrium along with the consideration of frictional forces.
3. Interpret dynamics of members/ links in a mechanism and evaluate inertia force with the help of D' Alembert's principle.
4. Know how to evaluate mechanical stability from CG calculations.
5. Apply MI values required for engineering design calculations.
6. Apply the principles of work - energy and impulse- momentum for analysis of dynamic systems.

Module I : 10L

Importance of Mechanics in Engineering ; Definition of Mechanics; Concepts of particles & rigid bodies;

Vector and scalar quantities; Vector algebra –definition and notation; Types of vectors – equal , equivalent , free , bound , sliding ; Addition , subtraction of vectors ; Parallelogram law , triangle law , vector polygon ; Scalar multiplication of vectors ; system ; Unit vector, unit co–ordinate vectors ($\hat{i}$, $\hat{j}\hat{k}$) ; Direction cosines ; Addition/ subtraction of vectors in components form.

Definition of force vector ; Dot product , cross product and the application ; Important vector quantities (position vector , displacement vector) ; Moment of a force about a point and about an axis , moment of a couple ;

Representation of force and moments in items of $\hat{i}$, $\hat{j}\hat{k}$. Principle of transmissibility of force (sliding vector); Varignon's theorem for a system of concurrent forces with proof; Resolution of a force by its equivalent force-couple system; Resultant of forces.

Module II : 10L

Type of forces – collinear, concurrent, parallel, concentrated, distributed; Active and reactive forces, different types of reaction forces; Free body concept and diagram; Concept and equilibrium of forces in two dimensions; Equations of equilibrium; Equilibrium of three concurrent forces -- Lami's theorem.

Concept of friction: Laws of Coulomb's friction; Angle of friction, angle of repose, coefficient of friction -- static and kinematic.

Module III : 12L

Distributed force system; Centre of gravity; Centre of mass & centroid; Centroid of an arc; Centroid of plane areas – triangle, circular sector, quadrilateral and composite area consisting of above figures.

Area moment of inertia: Moment of inertia of a plane figure; Polar moment of inertia of a

plane figure; Parallel axes theorem.

Concept of simple stress and strain ; Normal stress , shear stress , normal strain, shear strain; Hooke's law; Poisson's ratio; stress- strain diagram of ductile and brittle material; Proportional limit, elastic limit, yield point , ultimate stress, breaking point; Modulus of elasticity.

Module III : 16L

Introduction to dynamics: Kinematics & kinetics; Newton's laws of motion; Law of gravitation and acceleration due to gravity; Rectilinear motion of particles with uniform & non – uniform acceleration.

Plane curvilinear motion of particles: Rectangular components (projectile motion), normal and tangential components.

Kinetics of particles: D'Alembert's principle and free body diagram; Principle of work & energy; Principle of conservation of energy.

Impulse momentum theory: Conservation of linear momentum

References:

1. Engineering Mechanics:- Statics and Dynamics by Meriam & Kreige , Wiley india
2. Engineering Mechanics:- Statics and Dynamics by I.H. Shames,P H I
1. Engineering Mechanics by Timoshenko , Young and Rao , TMH
2. Element of strength of materials by Timoshenko & Young, E W P
3. Fundamentals of Engineering Mechanics by Nag & Chanda – Chhaya Prakashani.

LABORATORY

Subject Name: Physics-I lab					
Paper Code: PHYS1011					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	**0**	**3**	**3**	**2**

Experiments:

1. Determination of Young's modulus by Flexure Method and calculation of bending moment and shear force at a point on the beam.
2. Determination of modulus of rigidity by Static/Dynamic Method.
3. Determination of thermal conductivity of a good conductor by Searle's Method.
4. Determination of thermal conductivity of a bad conductor by Lee's and Chorlton's Method.
5. Determination of dielectric constant of a given dielectric material.
6. Use of Carey Foster's bridge to determine unknown resistance.
7. Determination of wavelength of light by Newton's ring method.
8. Determination of wavelength of light by Fresnel's biprism method.
9. Determination of wavelength of light by Laser diffraction method.
10. Determination of dispersive power of the material of a given prism.
11. Determination of co-efficient of viscosity of a liquid by Poiseulle's capillary flow method.

Subject Name: Basic Electronics Engineering Lab					
Paper Code: ECEN1011					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	**0**	**0**	**3**	**2**

Experiments:

1. Familiarisation with passive and active electronic components such as Resistors, Inductors, Capacitors, Diodes, Transistors (BJT) and electronic equipment like DC power supplies, multimeters etc.
2. Familiarisation with measuring and testing equipment like CRO, Signal generators etc.
3. Study of I-V characteristics of Junction diodes.
4. Study of I-V characteristics of Zener diodes.
5. Study of Half and Full wave rectifiers with Regulation and Ripple factors.
6. Study of I-V characteristics of BJTs in CB mode
7. Study of I-V characteristics of BJTs in CE mode
8. Study of I-V characteristics of Field Effect Transistors.
9. Determination of input-offset voltage, input bias current and Slew rate of OPAMPs.
10. Determination of Common-mode Rejection ratio, Bandwidth and Off-set null of OPAMPs.
11. Study of OPAMP circuits: Inverting and Non-inverting amplifiers, Adders, Integrators .

Subject Name: Workshop Practice					
Paper Code: MECH1011					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	1	**0**	**3**	**4**	**3**

Job 1: General awareness of a typical workshop.

Theory requirements: Workshop definition, various shops in a typical workshop, Carpentry, Fitting, Foundry; Sheet Metal Shop, Welding and Brazing Shop, Machine Shop , Forging & Blacksmithy, Safety precautions to be followed in a workshop, Familiarization of Various safety devices and their uses.

Job 2: Making of a wooden pattern.

Theory requirements: Market forms of converted Timber ,eg, log, balk, plank,batten, beam ,Types of Wood, Hard Wood, Soft Wood, particle board; Seasoning of wood, Natural seasoning, Artificial seasoning, Carpentry Tools-Marking Tools, Cutting Tools, Planing Tools, Boring Tools, Striking Tools , Holding & Misc. Tools, Carpentry Processes (marking, sawing, planning, chiselling, boring, grooving, joining etc.), Safety precautions in Carpentry Shop.

Job 3: Making of a matched profile form MS plate.

Theory requirements: Work Bench, Fitting Tools (Bench Vice,Chisel,Hammer,Different types of Files, (Rough,Bastard, Second Cut, Half Round, Triangular File),Saw(Hack saw etc.), Scriber, Punch, Try Square, Angle Plate, caliper (outside & inside), Universal Surface Gauge, Centre Punch, Prick Punch, Drill (Flat,straight fluted, taper shank twist drill).

Fitting Operations,Filing, Marking, Drilling, Tapping (Rougher,Intermediate, Finisher taps), Tap Drill size (D=T-2d), Sawing, Dieing . Safety precautions in Fitting Shop.

Job 4: Making of an internal and external thread.

Theory requirements : Thread standards and thread classifications, Internal Thread,External Thread, Thread Nomenclature (Major dia, Minor dia, Pitch dia, pitch, Lead, TPI, Metric, BSP , Nominal size), Specifications of threaded fasteners (in Metric System). Safety precautions in Dieing and Tapping.

Job 5: Making of a green sand mould using the pattern made under Job no. 2.

Theory requirements: Mould making, Preparation of sand, (silica, clay, moisture,and misc items and their functions), Properties of a good sand mould, General procedure for making a good sand mould, Different tools used for preparation of a mould, Explanation of various terms , Cope and Drag Box, Runner, Riser, Gating and its utility, Parting sand, Vent holes.

Job 6: Demonstration of metal melting and casting

Theory requirements: Metal melting furnaces: Ladles, Using of Tongs, Molten metal pouring procedure, Safety precautions in pouring molten metal in a mould.

Job 7. Making of a stepped pin in a centre lathe. (2 Classes)

Theory requirements: Machining and common machining operations , Lathe M/c and its specifications, Head stock, Tailstock, Chuck-Self centering chuck , 4 jaw chuck, Bed, Carriage, Feed mechanism, Screw cutting mechanism, various lathe operations like turning, facing, grooving, chamfering, taper turning ,Thread cutting, Knurling, Parting, Cutting speed, Feed, Depth of cut , Different types of cutting tools-Safety precautions in a machine shop.

Job 8: Making of square prism from a round shaft by Shaping Machine

Theory requirements: Description of a Shaping machine, Base , Column, Saddle,Clapper box, Quick return mechanism, Feed Mechanism, Table, Rotation of table, Adjustment of stroke length, Adjustment of starting point of cut. Safety Precautions while working in Shaping Machine.

Job 9: Making of square prism from a round shaft by Milling Machine

Theory requirements: Description of a milling machine, Specification of a Milling machine, Types of Milling-Up Milling, Down Milling, Vertical Milling Machine, Horizontal Milling Machine , Safety precautions while working in Milling Machine.

Job 10 : Arc Welding practice and making of a welded joint

Theory requirements: Welding, Weldability, Types of Welding, MMAW, Gas Welding, Electrode , Functions of Flux, Equipment for MMAW, Different types of Flames in Gas Welding and Gas Cutting (Neutral-Oxidising-Reducing Flames), Different types of welding joints, AC Welding , DC Welding; Safety precautions in Welding Shop.

Job 11 : Sheet Metal forming & Brazing

Theory requirement: Specification of sheet metal, SWG vs. mm, HR sheet, CR sheet, GI Sheet, Stainless Steel Sheet, Aluminum sheets, Tin Plates, Sheet metal working Tools, Micrometer, Chisels, Punches, Hammers, Mallets, Hand Shear or Snippets, Various sheet metal forming operations, Shearing, Marking, Punching, Drilling, Bending, Drawing, Brazing, Safety precautions in Sheet Metal Working Shop.

References:

1. Elements of Workshop Technology (Vol- I and II)- Hajra Choudhury, Media Promoter &Publishers Privet Limited.
2. Workshop Technology (Vol- I and II) – Chapman , Viva Books Privet Limited.

SESSIONAL

Subject Name: Language Practice lab (Level 1)					
Paper Code: HMTS1111					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	**0**	**2**	**2**	**1**

Module I : 3P
Introduction to Linguistics (Phonology)

Phonetics-Vowel and Consonant Sounds (Identification &articulation)
Word- stress

Intonation (Falling and rising tone)
Voice Modulation

Accent training

Module II : 3P
Listening Skills
Principles of Listening
Approaches to listening
Guidelines for Effective Listening
Listening Comprehension
Audio Visual (Reviews)

Module III : 2P
Discourse Analysis-
Spoken Discourse

Conversational Skills/Spoken Skills
Analysing Speech dynamics (Political
Speeches

Formal Business Speeches)

Module IV : 9P
Writing Skill-

Descriptive, narrative and expository writing

Writing with a purpose---Convincing skill, argumentative skill/negotiating Skill (These skills will be repeated in oral skills).

Writing reports/essays/articles—logical organization of thoughts
Book review.

References:

1. Munter, Mary. Guide to Managerial Communication. 5th ed. Upper Saddle River, NJ: Prentice Hall, 1999.
2. Cypr**es, Linda. Let's Speak Business English. Hauppauge, NY: Barron's**

   Educational Series, 1999. Crystal, David. 1971. Linguistics. Baltimore: Penguin Books.

3. Larsen-Freeman, D. (1986). "Techniques and principles in language teaching." Oxford: Oxford University Press.

4. Littlewood, W. (1981). "Language teaching. An introduction." Cambridge: Cambridge University Press.

5. Savignon, S. J., & Berns, M. S. (Eds.). (1983). "Communicative language teaching: Where are we going? Studies in Language Learning," 4(2). (EDRS No. ED 278 226, 210 pages)

Subject Name: Co- Curricular activities					
Paper Code: HMTS1121					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	**0**	**2**	**2**	**1**

Objective: This course aims at instilling a sense of responsibility. This objective can be achieved by bringing in awareness about the contemporary issues relevant to the GenX and Gen Y through enlightened discussions and active participation. Since the course has 1 credit detailed planning regarding the area of activities and method of evaluation should be charted at the start of the semester.

Module I:
Project Work
Development of projects based on integral and holistic developmental models to be implemented in rural areas or underdeveloped areas in the peripheral areas of cities. This could include a wide area of activity –
from taking up a research projects to analyse the need of a particular under-developed area to trying to implement a project already formulated. This could also relate to mobilizing funds for a specific project.

Module II:
Action-oriented schemes
e.g.Organising Blood –donation camps
Conducting child –healthcare services
Helping the old and sick
(in coordination with NGOs and other institutes)

Module III:
Society and Youth
Developing Awareness among the youth about social issues both local and global for e.g. Eradication of social evils like drug abuse, violence against women and others.

Module IV:
Youth and Culture
Generating new ideas and help the participants to be creative and innovative for e.g.Enacting street plays, encouraging creative writing by organizing workshops and competitions. Active participation of the students in the nation building process by making positive changes in the social and individual space.

Semester 2

THEORY

Subject Name: Introduction to Computing					
Paper Code: CSEN 1201					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**1**	**0**	**4**	**4**

Learning Objective: Introduction to the concept of computer and computation and solving of problems using C as a programming language. Coverage of C will include basic concepts, arithmetic and logic, flow control, and data handling using arrays, structures, pointers and files.

Course Outcome:

1. Understand and remember functions of the different parts of a computer.
2. Understand and remember how a high-level language (C programming language, in this course) works, different stages a program goes through.
3. Understand and remember syntax and semantics of a high-level language (C programming language, in this course).
4. Understand how code can be optimized in high-level languages.
5. Apply high-level language to automate the solution to a problem.
6. Apply high-level language to implement different solutions for the same problem and analyze why one solution is better than the other.

Module I: 13L

Fundamentals of Computer

History of Computers, Generations of Computers, Classification of Computers.

Basic Anatomy of Computer System, Primary & Secondary Memory, Processing Unit, Input & Output devices. Assembly language, high level language, compiler and assembler (basic concepts).

Binary & Allied number systems (decimal, octal and hexadecimal) with signed and unsigned numbers (using 1's and 2's complement) - their representation, conversion
and arithmetic operations. Packed and unpacked BCD system, ASCII. IEEE-754 floating point representation (half- 16 bit, full- 32 bit, double- 64 bit). Binary Arithmetic & logic gates. Boolean algebra – expression, simplification, Karnaugh Maps.

Basic concepts of operating systems like MS WINDOW, LINUX. How to write algorithms & draw flow charts.

Module II: 5L

Basic Concepts of C

C Fundamentals:

The C character set identifiers and keywords, data type & sizes, variable names, declaration, statements.

Operators & Expressions:

Arithmetic operators, relational and logical operators, type, conversion, increment and decrement operators, bit wise operators, assignment operators and expressions, precedence and order of evaluation. Standard input and output, formatted output -- printf, formatted input scanf.

Module III: 8L

Program Structures in C

Flow of Control:

Statement and blocks, if-else, switch-case, loops (while, for, do-while), break and continue, go to and labels.

Basic of functions, function prototypes, functions returning values, functions not returning values. Storage classes - auto, external, static and register variables – comparison between them. Scope, longevity and visibility of variables.

C preprocessor (macro, header files), command line arguments.

Module IV: 14L

Data Handling in C

Arrays and Pointers:

One dimensional arrays, pointers and functions – call by value and call by reference, array of arrays. Dynamic memory usage– using malloc(), calloc(), free(), realloc(). Array pointer duality.

String and character arrays; C library string functions and their use.

User defined data types and files:

Basic of structures; structures and functions; arrays of structures.

Files – text files only, modes of operation. File related functions – fopen(), fclose(), fscanf(), fprintf(), fgets(), fputs();

Text Books :

1. Schaum's outline of Programming with C – Byron Gottfried
2. Teach Yourself C- Herbert Schildt
3. Programming in ANSI C – E Balagurusamy

Reference Books:

2. C: The Complete Reference – Herbert Schildt
3. The C Programming Language- D.M.Ritchie, B.W. Kernighan

Subject Name: Chemistry 1					
Paper Code: CHEM 1001					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**1**	**0**	**4**	**4**

Course Outcome:

1. Knowledge of understanding the operating principles and reaction involved in batteries and fuel cells and their application in automobiles as well as other sectors to reduce environmental pollution.
2. An ability to design and conduct experiments, as well as to organize, analyzes, and interprets data
3. An ability to identify and formulate polymers and have a knowledge of various polymers like polyethene, PVC, PS, Teflon, Bakelite, Nylon which have engineering applications
4. Knowledge of synthesizing Nanomaterials and their applications in industry, carbon nano tube technology is used in every industry now-a-days
5. An ability of synthesizing bio fuels as a renewable and environment friendly alternative source for natural fuel
6. Elementary knowledge of IR and UV spectroscopy is usable in structure elucidation and characterisation of various molecules

Module I : 10 L

Thermodynamics & Spectroscopy

Chemical Thermodynamics & Thermochemistry

Concept of Thermodynamic system, Introduction to first law of thermodynamics, Enthalpy Heat Capacity, Reversible and Irreversible processes, Adiabatic changes, Application of first law of thermodynamics to chemical processes, 2nd law of thermodynamics, Evaluation of entropy, Work function and free energy, Phase Changes, Clausius Clapeyron Equation, Chemical Potential, Gibbs Duhem Relation, Activity and Activity coefficient.

Spectroscopy

Electromagnetic Radiation, Basic idea of UV-visible & IR spectroscopy.

Module II : 10 L

Structure & Bonding

Chemical Bonding

Covalent bond, VSEPR Theory, Molecular Orbital Theory, Hydrogen bond, Intermolecular forces-vander Waals forces, Ionization energy, Electronegativity, Electron affinity, Hybridisation, Dipole moment

Solid State Chemistry

Introduction to stoichiometric defects (Schottky & Frenkel) and non – stoichiometric defects (Metal excess and metal deficiency). Role of silicon and germanium in the field of semiconductor.

Ionic Equilibria and Redox Equlibria

Acid Base Equilibria in water, Strength of acids and bases, Hydrogen ion exponent, Ionic product of water, Salt Hydrolysis and Henderson Equation, Buffer solutions, pH indicator, Common ion Effect, Solubility product, Fractional Precipitation, Redox Equilibria,

Structure and reactivity of Organic molecule
Inductive effect, resonance, hyperconjugation, electromeric effect, carbocation, carbanion and free radicals.
Brief study of some addition, eliminations and substitution reactions.

Module III : 10 L
Electrochemistry & Reaction Dynamics
Conductance:
Conductance of electrolytic solutions, specific conductance, equivalent conductance, molar conductance, ion conductance, effect of temperature and concentration (Strong and Weak electrolyte). Kohlrausch's law of independent migration of ions, transport numbers and hydration of ions. Conductometric titrations: SA vs SB & SA vs WB; precipitation titration KCl vs $AgNO_3$.

Electrochemical Cel:
Cell EMF and thermodynamic derivation of the EMF of a Galvanic cell (Nernst equation), single electrode potentials, hydrogen half-cell and calomel half cell (construction, representation, cell reaction, expression of potential, discussion, application) Storage cell, fuel cell (construction, representation, cell reaction, expression of potential, discussion, application). Application of EMF measurement on a) the change in thermodynamic function (ΔG, ΔH, ΔS) b) the equilibrium constant of a reversible chemical reaction c) the valency of an ion.
Kinetics:
Reaction laws: rate expression, order and molecularity, zero, first and second order kinetics. Pseudounimolecular reaction, Arrhenius equation.
Mechanism and theories of reaction rates (Collision theory and Transition state theory,).
Catalysis: Homogeneous catalysis (Definition, example, mechanism, kinetics).

Module IV : 10 L
Industrial Chemistry & Polymeraization
Industrial Chemistry
Solid Fuel: Coal, Classification of coal, constituents of coal, carbonization of coal (HTC and LTC), Coal analysis: Proximate and ultimate analysis.
Liquid fuel: Petroleum, classification of petroleum, Refining, Petroleum distillation, Thermal cracking, Octane number, Cetane number, Aviation Fuel (Aviation Gasoline, Jet Gasoline), Bio-diesel.
Gaseous fuels: Natural gas, water gas, coal gas, bio gas.
Polymerization:
Concepts, classifications and industrial applications. Polymer molecular weight (number avg. weight avg. viscosity avg.: Theory and mathematical expression only), Poly dispersity index (PDI). Polymerization processes (addition and condensation polymerization), degree of polymerization, Copolymerization, stereo-regularity of polymer, crystallinity (concept of T_m) and amorphicity (Concept of T_g) of polymer.
Preparation, structure and use of some common polymers: plastic (PE: HDPE, LDPE, PVC, Bakelite, PP), rubber (natural rubber, SBR, NBR) and Vulcanization., fibre(nylon 6.6, Nylon 6, Polyester).
Conducting and semi-conducting polymers.

Text Books:
1. Engineering Chemistry, Gourkrishna Dasmohapatra, Vikas Publishing House

2. A Text book of Engineering Chemistry, Shashi Chawla, Dhanpat Rai & Co Pvt Ltd
3. Engineering Chemistry, K. L. Chugh, Kalyani Publishers.

Reference Books:

1. General & Inorganic Chemistry, R. P. Sarkar, Fuels and Combustion, New Central Book Agency P Ltd
2. L. Finar, Organic Chemistry, Addison Wesley Longman, Inc
3. Organic Chemistry, Morrison & Boyd, Prentice Hall of India
4. Physical Chemistry, K. L. Kapoor, McMillan
5. P. C. Rakshit, Physical Chemistry, Sarat Book House (7th Edition).

Subject Name: Mathematics- II					
Paper Code: MATH 1201					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**1**	**0**	**4**	**4**

Course Outcome:

1. Construct differential equation as a mathematical model of a physical phenomena.
2. Choose proper method for finding solution of a specific differential equation.
3. Discuss the elementary concepts of graph theory, for example, walk, path, cycle, Eulerian graph, Hamiltonian graph and tree.
4. Apply basic graph algorithms for searching and finding minimal spanning tree and shortest path.
5. Solve improper integrals and initial value problems with the help of Laplace transformation.
6. Evaluate distance, angle between planes and shortest distance between two skew lines in three dimension.

Module I : 10 L

Ordinary differential equations (ODE)-

First order and first degree: Exact equations, Necessary and sufficient condition of exactness of a first order and first degree ODE (statement only), Rules for finding Integrating factors, Linear and non-linear differential equation, Bernoulli's equation.

General solution of ODE of first order and higher degree (different forms with special reference to Clairaut's equation).

Second order and first degree:

General linear ODE of order two with constant coefficients, C.F. & P.I., D-operator methods for finding P.I., Method of variation of parameters, Cauchy-Euler equations.

Module II:[10L]

Basics of Graph Theory

Graphs, Digraphs, Weighted graph, Connected and disconnected graphs,Complement of a graph, Regular graph, Complete graph, Subgraph,; Walks, Paths, Circuits, Euler Graph,Cut sets and cut vertices, Matrix representation of a graph, Adjacency and incidence matrices of a graph,Graph isomorphism, Bipartite graph.

Tree:

Definition and properties, Binary tree, Spanning tree of a graph, Minimal spanning tree, properties of trees, Algorithms: Dijkstra's Algorithm for shortest path problem, Determination of minimal spanning tree using DFS, BFS, Kruskal's and Prim's algorithms.

Module III : 10L

Improper Integral:

Basic ideas of improper integrals, working knowledge of Beta and Gamma functions (convergence to be assumed) and their interrelations.

Laplace Transform:

Introduction to integral transformation, functions of exponential order, Definition and

existence of LT (statement of initial and final value theorem only), LT of elementary functions, Properties of Laplace Transformations , Evaluation of sine , cosine and exponential integrals using LT, LT of periodic and step functions Definition and properties of inverse LT Convolution Theorem (statement only) and its application to the evaluation of inverse LT, Solution of linear ODEs with constant coefficients (initial value problem) using LT.

Module IV : 10L

Three Dimensional Geometry

Equation of a plane. General form. Transformation to the normal form. Intercepts. Equation of the plane through three given points. Equation of a plane passing through the intersection of two planes. Angle between two intersecting planes. Bisectors of angles between two intersecting planes. Parallelism and perpendicularity of two planes.

Canonical equation of the line of intersection of two intersecting planes. Angle between two lines. Shortest distance between two lines. Condition of coplanarity of two lines. Length of the perpendicular from a point to a given line.

References:

1. Advanced Engineering Mathematics, Erwin Kreyszig, (Wiley Eastern)
2. Graph Theory: V. K. Balakrishnan, (Schaum's Outline, TMH)
3. A first course at Graph Theory: J. Clark and D. A. Holton (Allied Publishers LTD)
4. Introduction to Graph Theory: D. B. West (Prentice-Hall of India)
5. Graph Theory: N. Deo (Prentice-Hall of India)
6. Engineering Mathematics: B.S. Grewal (S. Chand & Co.)
7. Higher Engineering Mathematics: John Bird (4th Edition, 1st Indian Reprint 2006, Elsevier)
8. Calculus: Strauss, Bradley and Smith (3PrdP edition, Pearson Education)
9. Engineering Mathematics (Volume 2): S. S. Sastry (Prentice-Hall of India)
10. Introductory Course in Differential Equations: Daniel A. Murray (Longmans & Green).
11. Co-ordinate Geometry – S. L. Loney.
12. Analytical Geometry And Vector Algebra- R M Khan

Subject Name: Basic Electrical Engineering					
Paper Code: ELEC1001					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**1**	**0**	**4**	**4**

Course Outcome:

1. Analyze DC circuits using KCL, KVL and network theorems like Superposition Theorem, Thevenin's Theorem, Norton's Theorem and Maximum Power Transfer Theorem.
2. Analyze DC Machines; Starters and Speed control of DC motors.
3. Analyze magnetic circuits and apply Gauss' law for electric field and potential calculation.
4. Analyze single and three phase AC circuits.
5. Analyze the operation of single phase transformers.
6. Analyze the operation of three phase induction motors.

Module I :12L

DC Network Theorem: Kirchhoff's law, nodal analysis, mesh analysis, Superposition theorem, Thevenin's theorem, Norton theorem, Maximum power transfer theorem, star-delta conversion.

DC Machines: Construction, EMF equation, Principle of operation of DC generator, open circuit characteristics, external characteristics, Principle of operation of DC motor, Speed-torque characteristics of shunt and series machine, starting of DC motor, speed control of dc motor.

Module II : 8L

Electrostatics: Gauss's law and its applications to electric field and potential calculation. Capacitor, capacitance of parallel plate capacitor, spherical capacitor and cylindrical capacitor.

Electromagnetism: Amperes law, Biot-savart's law, Ampere's circuital law and their applications, Magnetic circuits, analogy between magnetic and electric circuits, Faraday's law, self and mutual inductance. Energy stored in a magnetic field, Hysteresis and Eddy current losses.

Module III : 10L

AC single phase system: concept of alternating signal, average and RMS values of alternating signal, peak factor, form factor, phase and phase difference, phasor representation of alternating quantities, phasor diagram, AC series , parallel and series parallel circuits, Active power, Reactive power, power factor, Resonance in RLC series and parallel circuit, Q factor, bandwidth.

Three phase system: balanced three phase system, delta and star connection, relationship between line and phase quantities, phasor diagrams. Power measurement by two wattmeter method.

Module IV : 10L

Single phase transformer: Construction, EMF equation, no load and on load operation and their phasor diagrams, Equivalent circuit, Regulation, losses of a transformer, open and short

circuit tests, efficiency.
3-phase induction motor: Concept of rotating magnetic field, principle of operation, Construction, equivalent circuit and phasor diagram, torque-speed/slip characteristics, Starting of Induction Motor.

Text Books:

1. Basic Electrical engineering, D.P Kothari & I.J Nagrath, TMH, Second Edition
2. Basic Electrical Engineering, V.N Mittle & Arvind Mittal, TMH, Second Edition
3. Basic Electrical Engineering, Hughes
4. Electrical Technology, Vol-I,Vol-II,Surinder Pal Bali, Pearson Publication
5. A Text Book of Electrical Technology, Vol. I & II, B.L. Theraja, A.K. Theraja, S.Chand & Company

Reference Books:

1. Electrical Engineering Fundamentals, Vincent Del Toro, Prentice-Hall
2. Advance Electrical Technology, H.Cotton, Reem Publication
3. Basic Electrical Engineering, R.A. Natarajan, P.R. Babu, Sictech Publishers
4. Basic Electrical Engineering, N.K. Mondal, Dhanpat Rai
5. Basic Electrical Engineering, Nath & Chakraborti
6. Fundamental of Electrical Engineering, Rajendra Prasad, PHI, Edition 2005.

Subject Name: Engineering Thermodynamics and Fluid					
Paper Code: MECH 1201					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**1**	**0**	**4**	**4**

Course Outcome:

1. To analyze a thermodynamic system and calculate work transfer in various quasi-static processes.
2. To understand and apply the first law and 2nd law of thermodynamics.
3. To analyze thermal efficiency of Otto, Diesel cycles.
4. To understand physical properties of fluids
5. To apply mass, momentum and energy conservation principles to incompressible fluid flow.
6. To describe fluid flow and analyze acceleration of fluid particles.

Module I : 10 L

Basic concepts of Thermodynamics:
Introduction; Macroscopic and microscopic concept; Definition of Thermodynamic systems; Surrounding, universe; Open, closed and isolated systems; Concept of control volume; Thermodynamic properties: intensive, extensive & specific properties; state.
Thermodynamic equilibrium; Change of state; Thermodynamic processes and cycles; Quasi-static processes; Reversible processes; Zeroth law of Thermodynamics -concept of temperature.

Heat & Work:
Definition of Thermodynamic work; Work transfer-displacement work for a simple compressible system, path function, PdV work in various quasi-static processes(isothermal, isobaric, adiabatic, polytropic, isochoric); Free expansion; Indicated diagram (P-V diagram)
.
Definition of heat; Heat transfer-a path function; Similarities and dissimilarities between heat and work.

Module II : 8 L

First law of Thermodynamics:
Statement; 1^{st} law for a closed system executing a cycle; Concept of stored energy; Energy as a property, different forms of stored energy, internal energy, first law for a non-flow process; Flow work; Definition of enthalpy, C_p, C_v; Energy of an isolated system; Flow energy; First law for an open system - steady flow energy equation; Examples of steady flow devices(nozzle and diffuser, turbine, pump, compressor, boiler, condenser and throttling device); PMM-I.

Module III : 10 L

Second law of Thermodynamics:
Qualitative difference between heat and work; Definition of source & sink: cyclic heat

engine, heat pump and refrigerator, thermal efficiency of heat engine, C.O.P of heat pump and refrigerator; Kelvin-Plank and Clausius statements of second law; Equivalence of the two statements.
Reversible process; Irreversible process; Factors for irreversibility; Carnot cycle and Carnot efficiency; Reversible heat engine and heat pump; PMM-ll
Entropy: Mathematical statement of Clausius Inequality: Entropy as a property; Entropy principle; T-s plot for reversible isothermal, adiabatic, isochoric & isobaric processes.
Air standard Cycles:
Otto cycle & Diesel cycle, P-V & T-s plots, Net work done and thermal efficiency.

Module IV : 10 L
Properties & Classification of Fluid:
Definition of fluid; Concept of Continuum; Fluid properties- density, specific weight, specific volume, specific gravity; Viscosity : definition , causes of viscosity , Newton's law of viscosity, dimensional formula and units of viscosity, kinematic viscosity; Variation of viscosity with temperature. Ideal and Real fluids; Newtonian and Non-Newtonian fluids; No-slip condition.
Compressibility and Bulk modulus of elasticity.
Difference between compressible and incompressible fluids.

Fluid Statics:
Introduction; Pascal's Law--statement and proof; Basic Hydrostatic Law and its proof; Variation of pressure with depth in incompressible fluid, piezometric head, pressure head; Unit and scales of pressure measurement.
Measurement of fluid pressure: Piezometer, Manometers -Simple and Differential U-tube manometer, Inverted tube manometer, Inclined tube manometer. Characteristics and choice of manometric fluid.

Module V : 10 L
Fluid Kinematics:
Definition; Flow field and description of fluid motion(Eulerian & Lagrangian method), steady and unsteady flow, uniform and non-uniform flow-examples.
Acceleration of a fluid particle-local acceleration, convective acceleration. Stream line, Stream tube, Path line and Streak line; Laminar and Turbulent flow, Reynolds Number. Equations of streamlines and path lines.
Continuity equation for unidirectional flow and for differential form in 3-D Cartesian coordinate system.
Dynamics of Ideal fluids:
Introduction, Euler's equation of motion along a streamline; Bernoulli's equation-assumptions and significance of each term of Bernoulli's equation.
Application of Bernoulli's equation-problem on pipe line. Measurement of flow rate: Venturimeter and orificemeter .

Static pressure, Dynamic pressure, Stagnation pressure-measurement of velocity by Pitot tube.

References:
1. Engineering Thermodynamics- Nag, P.K. - T. M.H
2. Fundamentals of Thermodynamics- Sonntag, Borgnakke & Van Wylen,Wiley India
3. Thermodynamics- an Engineering approach - 6e, Cengel & Boles, TM

4. Fluid Mechanics & Hydraulic Machines – R.K. Bansal, Laxmi Publications Ltd, India
5. Introduction to Fluid Mechanics and Fluid Machines- S.K. Som, G. Biswas, & S. Chakraborty , T.M.H
6. Fluid Mechanics – A.K. Jain, Khanna Publishers.

LABORATORY

Subject Name: Introduction to Computing Lab					
Paper Code: CSEN 1211					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	**0**	**3**	**3**	**2**

Basic Computation & Principles of Computer Programming Lab

Softwares to be used: Cygwin and notepad++, Tiny C

Day 1: LINUX commands and LINUX based editor
Day 2: Basic Problem Solving
Day 3: Control Statements (if, if-else, if-elseif-else, switch-case)

Day 4: Loops - Part I (for, while, do-while)
Day 5: Loops - Part II
Day 6: One Dimensional Array
Day 7: Array of Arrays
Day 8: Character Arrays/ Strings

Day 9: Basics of C Functions
Day 10: Recursive Functions
Day 11: Pointers
Day 12: Structures and Unions
Day 13: File Handling

Subject Name: CHEMISTRY I LAB					
Paper Code: CHEM 1011					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	**0**	**3**	**3**	**2**

1. To determine the alkalinity in a given water sample.
2. Estimation of iron using $KMnO_4$: self indicator.
3. Estimation of iron using $K_2Cr_2O_7$: redox sensitive indicator.
4. To determine total hardness and amount of calcium and magnesium separately in a given water sample.
5. To determine the value of the rate constant for the hydrolysis of ethyl acetate catalyzed by hydrochloric acid.
6. Heterogeneous equilibrium (determination of partition coefficient of acetic acid between n-butanol and water).
7. Conductometric titration for determination of the strength of a given HCl solution by titration against a standard NaOH solution.
8. pH- metric titration for determination of strength of a given HCl solution against a standard NaOH solution.
9. Iodometric estimation of Cu^{2+}.
10. To determine chloride ion in a given water sample by Argentometric method (using chromate indicator solution)

Subject Name: Basic Electrical Engineering Lab					
Paper Code: ELEC 1011					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	**0**	**3**	**3**	**2**

1. Characteristics of Fluorescent lamps
2. Characteristics of Tungsten and Carbon filament lamps
3. **Verification of Thevenin's & Norton's theorem.**

4. Verification of Superposition theorem
5. Verification of Maximum Power Transfer theorem
6. Calibration of ammeter and voltmeter.
7. Open circuit and Short circuit test of a single phase Transformer.
8. Study of R-L-C Series / Parallel circuit
9. Starting and reversing of speed of a D.C. shunt Motor
10. Speed control of DC shunt motor.
11. No load characteristics of D.C shunt Generators
12. Measurement of power in a three phase circuit by two wattmeter method.

Subject Name: Engineering Drawing					
Paper Code: MECH 1012					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	1	**0**	**3**	**4**	**3**

1. Importance of engineering drawing; Acquaintance with different drafting equipment & accessories;

2. Introduction to lines : Practising different types of lines; Basic concepts in Lettering : Practising vertical & inclined letters (Practice Sheet 1)

3. Different systems of dimensioning with practice.Introduction to the concept of scale of drawing. (Practice Sheet 2)

4. Introduction to concept of orthographic projection: 1st angle and 3rd angle projection method; Symbols; projection of points. (Practice Sheet 3)

5. Projection of straight lines for different orientation including inclined to both the planes. (Practice Sheet 4)

6. Projection of plane surfaces inclined to HP and parallel to VP; Inclined to VP and Parallel to HP (Practice Sheet 5)

7. Projection of solids: Cube, rectangular prism, Hexagonal prism, Cylinder, Pyramid, Cone. (Practice Sheet 6)

8. Section of solids and their projections on principal and auxiliary planes for true shape: Cylinder, hexagonal pyramid. (Practice Sheet 7)

9. Isometric projections: Basic concepts, isometric scale; Isometric projection and view.

10. Practice with simple laminar and solid objects. (Practice Sheet 8)

References:

1. "Elementary Engineering Drawing" by Bhatt, N.D; Charotan Book Stall, Anand

2. "Engineering Graphics" by Narayana, K.L. and Kannaaiah P; TMH

3. "Engineering Graphics" by Lakshminarayanan,V. and Vaish Wanar, R.S, JainBrothers.

Semester 3

THEORY

Subject Name: Mechanical Operations					
Paper Code: CHEN 2101					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**1**	**0**	**4**	**4**

Module I : 10 L

Particulate solids : Characterization of solid particles, particle shape, particle size, average particle size of particulate solids in terms of mean diameters like arithmetic mean diameter, mass-mean diameter, volume-mean diameter, volume-surface mean diameter. Mixed particle sizes and size analysis, specific surface of mixture.

Screen analysis : Types and Standards of screens, ideal screen, real screen, screen effective ness, differential and cumulative analysis, screen capacity, relation of screen capacity to screen effectiveness.

Screening equipment: stationary screens and grizzlies, gyrating screens, vibrating screens and other industrial screens like trammels.

Transportation and storage of solids : Concepts of Conveyor and Elevator, Studies on performance and operation of different conveyor systems like Belt, Screw, Apron, Flight, pneumatic conveyor, pipe conveyor and bucket elevators; Storage of solids and discharge pattern from storage bin, theory and measurement of granular solid flow through orifice.

Module II : 10 L

Comminution of solids (Size Reduction) : Factors affecting comminution, comminution laws :

Kick's law, Rittinger's law and Bond's law and their limitations. Crushing efficiency & power consumption.

Size reduction equipment : Primary crusher – Jaw crusher, Gyratory crusher, Secondary crusher – Roll crusher (both smooth roll & toothed roll) its selection and capacity, Angle of Nip of Smooth Roll crusher. Grinder – Construction and operation of Hammer mill, Ball mill for dry and wet grinding, Rod mill, Attrition mill, Vertical Roller Mill for dry grinding, Agitated mill and their materials suitability, Ultra-fine grinder – Fluid energy mill, Close circuit and Open circuit operation.

Module III : 10 L

Separation based on particle Mechanics through liquids : Free settling and Hindered settling,

Stoke's law & Newton's law regimes of settling, Expression for Settling rate in hindered settling. Gravity settling processes, gravity classifiers, sorting classifiers (Spizkasten, Elutriator, Rake classifier), differential settling methods. Clarifiers and thickeners e.g. Lamelar clarifiers, Hirate thickeners, flocculation, batch sedimentation, rate of sedimentation. Equipment for sedimentation: thickeners. Clarifier and thickener design, sedimentation zones in continuous thickeners, Concepts of Kynch's theory. Cyclones, hydrocyclones, centrifugal decanters.

Mixing : Principles and utilities of agitation, agitation equipment, flow patterns: prevention of swirling/vortex, draft tubes, Standard turbine design, power consumption, power correlation, significance of dimensionless groups, effect of system geometry, calculation of power consumption in Newtonian liquids. Solid-solid mixing equipment, Mixing effectiveness and Mixing index. Agitator scaleup.

Froth Flotation : Theory, operation, types, Flotation agents, Flotation cells.

Module IV : 10 L

Theory and principle of solid liquid filtration, cake filters, discontinuous pressure filter: principle and working of filter press, filter press with horizontal plates, compressible and incompressible filter cakes, filter-medium resistance, constant pressure filtration, constant rate filtration, principles of cake filtration, pressure drop through filter cake, cake washing and filtration cycle, continuous vacuum filter: principle and working of rotary drum filters, continuous vacuum belt filter, centrifugal filter: theory & working principle of centrifugal filters, filter media, filter aids, Filtration of solid from gas – bag filter.

Text books:

1. Unit Operations in Chemical Engineering - W.L.McCabe, J.C.Smith and P.Harriot, McGraw-Hill, 4th Edition, 1984.
2. Chemical Engineering - J.M.Coulson, Richardson, Volume 2, 3rd Edition, Pergamon Press, 1977.
3. Mechanical Operations - R.S.Hiremath & A.Kulkarni, Volume1.

References:

1. Introduction to Chemical Engineering - Badger and Bencharo, McGraw Hill.
2. Mechanical Operations for Chemical Engineers - C.M.Narayanan & B.C.Bhattacharya, Khanna.

Subject Name: Fluid Mechanics					
Paper Code: CHEN 2102					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**1**	**0**	**4**	**4**

Module I : 10 L

Fundamental Concepts: Introduction to Fluid mechanics: Definition of Fluid, Continuum concept of fluid, concept of Knudsen number, Fluid properties : density, specific gravity, viscosity, Newtonian fluid; Non-Newtonian fluid

Fluid Statics: Basic equation of fluid statics; pressure variation in a static field; pressure measuring devices–manometer, U-tube, inclined tube, force on submerged bodies (straight, inclined), centre of pressure.

Fluid kinematics: Eulerian and Lagrangian approach, Streamline, pathline, streak line, concept of velocity and acceleration, material, temporal derivatives

Fluid dynamics: Concept of velocity –local, average, maximum, flow rate – mass, volumetric, velocity field; dimensionality of flow; flow visualization – stress field; Reynold's number—its significance, laminar, transition and turbulent flows, steady, unsteady and uniform, non-uniform flows.

Basic equations in integral form: Basic laws for a system; relation of system derivatives to the control volume formulation; conservation of mass; continuity equation.

Module II : 10L

Momentum balance equation: Derivation of momentum balance equation-Introduction to

Navier Stoke's equation in rectangular, cylindrical coordinates, Introduction to rotational and irrotational flow, momentum correction factor.

Internal incompressible viscous flow: Navier Stokes equation and its applications in fluid flow through various geometries.

External incompressible viscous flow: Boundary layer, Basic concepts of hydrodynamic boundary layer

Introduction to Euler's Equation, Bernoulli's equation- applications of Bernoulli's equation, kinetic energy correction factor; head loss; friction factor-Fanning and Darcy, Moody diagram; major and minor losses.

Module III : 10 L

Flow measurement: Introduction; general equation for internal flow meters; Orifice meter; Venturimeter; concept of area meters: rotameter; Local velocity measurement: Pitot tube. Hot wire anemometer, mass flowmeter.

Open channel flow: Introduction, Flow classification, importance of Froude number, Chezy formula, Manning roughness correction, flow measurement by weirs.

Fluid moving machines: Introduction; Basic classification of pumps: Non-Mechanical Pumps—acid egg, steam jet ejector, air lift pump, Mechanical pump: Centrifugal pumps- cavitation, NPSH, Positive displacement pumps (rotary, piston, plunger, diaphragm pumps); pump specification; basic characteristics curves for centrifugal pumps; fan, blower and compressor.
Valves and fittings: Pipe fittings and valves, schedule no, equivalent diameter.

Module IV: 10L

Fluidization: Introduction; different types of fluidization; minimum fluidization velocity; governing equation; pneumatic conveying and other industrial uses.

Fluid flow about immersed bodies: Introduction; concept of drag and lift; variation of drag coefficient with Reynolds number; stream-lined body and bluff body.
Packed bed: concept of sphericity; Ergun equation, modified friction factor.

Introduction to compressible flow: concept of speed of sound, Mach number, subsonic, supersonic flow, isentropic flow, applications.

Introduction to turbulent flow: Basic concepts, Prandtl mixing length, concept of shear velocity,

Reynold's stresses.

Text book:

4. Introduction to Fluid Mechanics - Fox and McDonald, 8th Edition, Wiley Publishers.
5. Unit Operations - Mccabe Smith and Harriot, McGraw Hill Chemical Engineering Series.

References:

3. Fluid Mechanics -A.K.Jain, Khanna Publishers.
4. Transport Phenomena –R.B. Bird, W.E. Stewart, E.N. Lightfoot, John Wiley &Sons.

Subject Name: Energy Engineering					
Paper Code: CHEN 2103					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**1**	**0**	**4**	**4**

Module I: 10L

Introduction: Conventional (fossil energy) and non-conventional (alternative energy) resources & reserves. Global Energy production & consumption pattern. Production &consumption pattern in India.

Solid Fuels: Biomass, Wood and Charcoal. Classification & Rank of Coal, Peat ,Lignite, Sub-Bituminous coal, Bituminous coal, Anthracite coal, Cannel &Bog head coal.

Coal Reserves in India

Physical Properties of coal, Proximate & Ultimate Analysis of Coal, Cleaning, washing & Storage of coal.

Theory of coal pyrolysis and Carbonization: Low Temperature Carbonization (LTC), High Temperature Carbonization (HTC), Horizontal & Vertical Gas Retorts, Coke Ovens-Beehive& Byproduct Slot type. Recovery of byproducts. Details of Structural configuration and Operating principles.of Coke ovens including Charging and Discharging Mechanism.

Module II: 10L

Liquid Fuels: Constitution of petroleum, theory of formation of crude petroleum oil.

Characterization of crude oil & petroleum fuels, on shore and off-shore oil exploration.

Parameters and testing logistics of petroleum products—Octane no., Cetane no., Pour point, Smoke point, Cloud point, Flash point, Fire point, Aniline point and Diesel index.

Processes of a typical Indian refinery involving Operation and flow-sheet of crude distillation plant; Thermal & catalytic cracking and reforming processes; coking, visbreaking, Fluid catalytic cracking and Hydrocracking.

Concept of Modern Refinery integrated with downstream petrochemicals units which manufacture naphtha-based aromatics as well as propylene-based polymers.

Liquid fuel from coal: Fischer Tropsch process.

Module III: 10L

Gaseous Fuels: Classification of gaseous fuel; Physico-chemical principles, Calorific Value, Wobbes index, and flame speed.

Producer gas, Water gas with Carburetion, oil gas, coke-oven gas, blast furnace gas, Flow sheet & operation of Natural Gas and LPG. Coal Bed Methane. Integrated Gasification Combined Cycle.

Bio Gas: Principles and Operation of Aerobic & Anaerobic digestors, Biogas generation and management& flow sheet with special reference to waste utilization.

Module IV: 10 L

Solar Energy: Devices for measurement of solar flux. Solar thermal and solar PV, Different types of Solar collectors (Flatplate, parabolic, concentric & heliostat), Solar Pond, Photovoltaic cells, Chemical storage, Efficiency of Solar devices – Tracking .

Geothermal Energy & Wind Energy: Utilization of Geo thermal Energy; Ocean Thermal Energy Conversion (OTEC).

Nuclear energy: Sources of Nuclear fuels, Indian scenario; Nuclear reactions and power generation by Nuclear reactors- Breeder reactor- reaction &operation.

Fuel Cells – Types, Construction, Principle of Operation, Applications.

Fuels from Renewable Sources – Bio Fuels 1

Preliminary concepts of Illumination Engineering—CFL and LED lights.

Text Books:

1. Fuels and Combustion (3rd Edition) – Dr. Samir Sarkar, Universities Press.
2. Elements of Fuels, Furnaces and Refractories – Prof. O.P. Gupta, Khanna publishers
3. Understanding Renewable Energy Systems - Volker Quaschning - Earthscan Ltd

Reference Books:

1. Solar energy – S.P.Sukhatme – Tata McGraw Hill
2. Fuel Cells: From Fundamentals to Applications **-** Supramaniam Srinivasan - Springer

Subject Name: Industrial Stoichiometry					
Paper Code: CHEN 2104					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**1**	**0**	**4**	**4**

Module I: **10L**
Units and Dimensions:, Conversion of Equations, Systems of Units, Dimensional Homogeneity and Dimensionless Quantities, Buckingham Pi-theorem for Dimensional Analysis, , Concentration of different forms, Conversion from one form to another, Raoult's Law, Henry's law, Antoine's Equation. Clausius Clapeyron Equation.
Mathematical Requisites: Use of log-log and semi-log graph paper, Triangular Diagram, Graphical Differentiation and Graphical Integration, Least Square Method, Curve Fitting, Method of Regression.

Module II: 10L
Introduction to Chemical Engineering Calculations: Basis, Mole Fraction and Mole Percent, Mass Fraction and Mass Percent, Material Balance without Chemical Reaction: Material Balance during Mixing, Humidity and Application of Psychrometric Chart, Material balance calculation of the following unit operations: Crystallization, Evaporator, Distillation Column, Absorption Column, Drier, Liquid - Liquid and Solid - Liquid Extraction Units

Module III: 10L
Material Balance with Chemical Reaction: Single Reaction, Multiple Reactions, Reactions with Recycle, Purge and By pass, Combustion Reaction, Calculation of Excess Air, Material Balance of Unsteady State Reaction systems.

Module IV: 10L
Energy Balance: Enthalpy calculation for systems (single component and multi components) without Chemical Reaction with Mean and Temperature dependent Heat Capacity, Enthalpy calculation for systems with Chemical Reactions. Heat of Reaction from Heat of Formation and Heat of Combustion Data, Effect of Temperature and Pressure on Heat of Reaction, Hess's Law, Adiabatic Reaction Temperature, Theoretical Flame Temperature Energy calculation in transient condition Case Studies: Combined Material and Energy Balances of Industrial Process.

Text Books :

1. Chemical Process Principles (Part I), 2nd. Ed., O. A. Hougen, K. M. Watson, and R. A. Ragatz. John Wiley (Asian Edn.).
2. Basic Principles and Calculations in Chemical Engineering, 6th. Ed., D.M. Himmelblau: Prentice Hall,

References :

1. Stoichiometry, 4th. Ed., B.I.Bhat and S.M.Vora, McGraw Hill,.
2. Elementary Principles of Chemical Processes, 3rd.Ed., R.M. Felder and R. W. Rousseau, Wiley India Edition.

Subject Name: Basic Enviromental Engineering and Ecology					
Paper Code: CHEM 2001					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**0**	**0**	**3**	**3**

Module I : 9L

Environment & Ecology general discussion. Basic ideas of environment and its component. Mathematics of population growth: exponential and logistic and associated problems, definition of resource, types of resource, renewable, non-renewable, potentially renewable, Population pyramid and Sustainable Development.

General idea of ecology, ecosystem – components, types and function.

Structure and function of the following ecosystem: Forest ecosystem, Grassland ecosystem, Desert ecosystem, Aquatic ecosystems, Mangrove ecosystem (special reference to Sundarban); Food chain (definition and one example of each food chain), Food web.

Biogeochemical Cycle- definition, significance, flow chart of different cycles with only elementary reaction (Oxygen, carbon, Nitrogen, Phosphorus, Sulphur).

Biodiversity- types, importance, Endemic species, Biodiversity Hot-spot, Threats to biodiversity, Conservation of biodiversity.

Module II : 9L

Air pollution and control

Atmospheric Composition: Troposphere, Stratosphere, Mesosphere, Thermosphere, Tropopause and Mesopause.

Green house effects: Definition, impact of greenhouse gases on the global climate and consequently on sea water level, agriculture and marine food. Global warming and its consequence, Control of Global warming. Acid rain: causes, effects and control. Earth's heat budget, carbon capture, carbon footprint

Lapse rate: Ambient lapse rate, adiabatic lapse rate, atmospheric stability, temperature inversion (radiation inversion). Atmospheric dispersion, Maximum mixing depth.

Definition of pollutants and contaminants, Primary and secondary pollutants: emission standard, criteria pollutant. Sources and effect of different air pollutants- Suspended particulate matter, oxides of carbon, oxides of nitrogen, oxides of sulphur, particulate, PAN.

Smog: Photochemical smog and London smog. Depletion Ozone layer: CFC, destruction of ozone layer by CFC, impact of other green house gases, effect of ozone modification. Standards and control measures: Industrial, commercial and residential air quality standard, control measure (ESP, cyclone separator, bag house, catalytic converter, scrubber (ventury), Statement with brief reference).

Module III : 9L

Water Pollution and Control : Hydrosphere, Hydrological cycle and Natural water. Pollutants of water, their origin and effects: Oxygen demanding wastes, pathogens, nutrients, Salts, thermal application, heavy metals, pesticides.

River/Lake/ground water pollution: River: DO, 5 day BOD test, Unseeded and Seeded BOD test, BOD reaction rate constants, COD.

Lake: Eutrophication (Definition, source and effect). Ground water: Aquifers, hydraulic gradient, ground water flow (definition only).

Water Treatment system (coagulation and flocculation, sedimentation and filtration, disinfection, hardness and alkalinity, softening) Waste water treatment system, primary and secondary treatments (Trickling filters, rotating biological contractor, Activated sludge, sludge treatment, oxidation ponds)

Water pollution due to the toxic chemicals effects: Lead, Mercury, Cadmium, Arsenic.

Noise Pollution, Definition of noise, effect of noise pollution, noise classification (Transport noise, occupational noise, neighbourhood noise). Definition of noise frequency, noise pressure, noise intensity, noise threshold limit value, equivalent noise level, L10 (18hr Index), effective perceived noise level.

Noise pollution control.

Module IV : 9L

Land Pollution Solid Waste: Municipal, industrial, commercial, agricultural, domestic, pathological and hazardous solid wastes, electronic waste.

Recovery and disposal method- Open dumping, Land filling, incineration, composting, recycling.

Social Issues, Health and Environment Environmental disasters: Bhopal gas tragedy, Chernobyl disaster, Three Mile Island disaster, cancer and environment: carcinogens, teratogens and mutagens (general aspect).

Environmental impact assessment, Environmental audit, Environmental laws and protection act of India.

Energy audit, Green building, Green sources of energy, Concept of Green Chemistry, Green catalyst, Green solvents (replacement of VOC).

References/Textbooks :

1. Introduction to Environmental Engineering and Science - G.M. Masters, Prentice-Hall of India Pvt. Ltd., 1991.
2. Environmental Chemistry - A. K.De, New Age International.
3. Environmental Chemistry with Green Chemistry - Asim K. Das, Books and Allied P. Ltd.
4. Environmental Science - S. C. Santra, New Central Book Agency P. Ltd.
5. Basic Environmental Engineering and Elementary Biology - GourKrishna Das Mahapatra, Vikas Publishing House P. Ltd.

Subject Name: Indian Culture and Heritage					
Paper Code: HMTS 2002					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	2	**0**	**0**	**2**	**1**

Module I : 8L
Indian Religion &Philosophy: Orthodox Indian Philosophy, Unorthodox Indian philosophy, Essentials of Hinduism, An overview of Jainism, Buddhism, Sikhism, Islam, Christianity religions.

Module II : 8L
Values and Personality : Aspects of Indian Values, Essentials of Personality Building, Ethics at work place, Aspects of Leadership qualities.

Module III : 8L
Indian Scriptures: Selections from the Vedas, Select verses from Upanishad, An overview of Gita, XVIth chapter of Gita.

Module IV : 8L
Indian Psychology: Aspects of Yoga Philosophy, Mind and its workings according to Yoga, Law of Karma, Selections from Manusmriti.

References / Text Books:

1. Indian Philosophy - S.C. Chatter and D. M. Dutta, Calcutta University Press.
2. Spiritual Heritage of India - Swami Prabhavananda, Sri Ramakrishna Math, Chennai.
3. Raja Yoga - Swami Vivekananda, Advaita Ashrama, Mayavati.
4. Vedic Selection - Calcutta University Press.
5. Gita - Swami Swarupananda, Advaita Ashrama, Kolkata.
6. Upanishads - Any press.
7. Carving a Sky (MSS) - Samarpan .
8. Essentials of Hinduism (MSS) - Samarpan.
9. The Call of the Vedas - Bharatiya Vidya Bhavan.

LABORATORY

Subject Name: Energy Laboratory					
Paper Code: CHEN 2111					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	**0**	**3**	**3**	**2**

At least eight experiments are to be performed

1. Proximate analysis of Coal.
2. Determination of carbon residue of fuel oil.
3. Determination of aniline point of a fuel oil.
4. Determination of moisture content of fuel oil by Dean & Stark apparatus.
5. Atmospheric Distillation of a petroleum product.
6. Determination of Flash Point & Fire Point of an oil by Abel apparatus.
7. Determination of Flash Point & Fire Point of oil by closed-cup Pensky Marten apparatus.
8. Determination of kinematic viscosity of oil by Redwood Viscometer.
9. Determination of calorific value of gaseous fuel by Junker's apparatus.
10. Determination of calorific value of solid and liquid fuel by Bomb Calorimeter.
11. Determination of vapour pressure of petroleum product using Reid apparatus.
12. Experiments on Non-conventional Energy Source using Solar Cooker/Flat Plate
13. Analysis of a gaseous mixture by Orsat apparatus.
14. Calibration of Pyrometer.

Subject Name: Fluid Mechanics Lab					
Paper Code: CHEN 2112					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	**0**	**3**	**3**	**2**

At least eight experiments are to be performed

1. Determination of coefficient of discharge at various Reynold's number during fully developed fluid flow through orificemeter.
2. Determination of coefficient of discharge at various Reynold's number during fully developed fluid flow through venturimeter.
3. Determination of loss coefficient of pitot tube and construction of fully developed velocity profile through pipe in laminar and turbulent flow regime.
4. Measurement of open channel flow and determination of coefficient of discharge V-notch and rectangular notch.
5. Determination of pressure drop for flow through packed bed and verification of Ergun equation.
6. Determination of characteristic curve of a centrifugal pump.
7. Experiments on Reynold's apparatus for determination of flow regime and construction of fanning's friction factor vs Reynold's number plot.
8. Determination of pressure drop and bed height profile with varying modified Reynold's number during flow through a fluidized bed. Determination of incipient fluidization.
9. Calibration of rotameter.
10. Determination of viscosity of Newtonian and non-Newtonian fluid.
11. Assembling of pipe line and fitting according to a given layout.

Subject Name: Mechanical Operations Laboratory					
Paper Code: CHEN 2113					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	**0**	**3**	**3**	**2**

At least eight experiments are to be performed

1. Sieve Analysis: To analyze a given powder for its particle size distribution. / Cumulative and Differential methods of particle size distributions.

2. Overall Screen Effectiveness: To find out screen efficiency through a suitable material balance with respect to a single screen.

3. Jaw Crusher: To find out the reduction ratio and capacity and to verify Rittinger's Law.

4. Ball Mill: To determine the reduction ratio, capacity and the critical speed of the ballmill.

5. Rod Mill: To determine the reduction ratio and capacity and compare the reduction atio for the same feed sample to that in a ball mill.

6. Hammer Mill: To find out the reduction ratio and capacity.

7. Batch sedimentation: To determine the settling and sedimentation characteristics of given slurry.

8. Elutriator: To study the sorting of a given mixture in an elutriator.

9. Filtration: To determine the specific cake resistance and filter medium resistance in the given plate and frame filtration.

10. Mixing: To determine the power number and power consumption for a given liquid in an agitated vessel.

11. Cyclone Separator: Demonstration of the operation of a cyclone separator and determination of its overall collection efficiency.

12. Hard Grooved Instrument: To determine the work index of a given brick sample.

Subject Name: Chemical Engineering Drawing Lab					
Paper Code: CHEN 2114					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	**0**	**3**	**3**	**2**

1. Introduction to AUTOCAD software for drawing in 2D: Drawing and editing commands. Knowledge of setting up layers, dimensioning, hatching, making block, plotting and printing, working with external reference file.

2. Drawing any three of the following item using AUTOCAD software.

a) Flange coupling for shaft and vessel or pipe.

b) Pipe joints and fittings, single line and double line pipe line assembly

c) Stuffing box.

d) Detailed cut section drawing of Globe valve and Stop valve.

e) Piping and instrumentation diagram of any given chemical process.

3. Assembly drawing of a single stirred jacketed pressure vessel with all its accessories using AUTOCAD software**.**

4. Introduction to AUTOCAD software for drawing in 3D: Working in 3-dimensions, Drawing and editing commands, viewing 3D objects, basic solid and wireframe models, extruding, simple revolved objects. Generation of orthographic projections from 3D drawing.

Semester 4

THEORY

Subject Name: Human Values and Professional Ethics					
Paper Code: HMTS 2001					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	2	**0**	**0**	**2**	**2**

Module I : 8L

Human society and the Value System:

Values, definition, importance and application. Formation of Values: The process of Socialization, Self and the integrated personality Morality, courage, integrity.

Types of Values: Social Values, Justice, Rule of Law, Democracy, Indian Constitution, Secularism Aesthetic Values: Perception and appreciation of beauty.

Organizational Values: Employee: Employer--- rights, relationships, obligations .
Psychological Values: Integrated personality and mental health.

Spiritual Values &their role in our everyday life.

Value Spectrum for a Good Life, meaning of Good Life .

Value Crisis in Contemporary Society:Value crisis at Individual Level, Societal Level, Cultural Level.

Value Crisis management - Strategies and Case Studies.

Module II : 8L

Ethics and Ethical Values.
Principles and theories of ethics.

Consequential and non-consequential ethics.

Egotism,Utilatirianism, Kant's theory and other non-consequential perspectives..
Ethics of care, justice and fairness, rights and duties.

Ethics: Standardization,Codification, Acceptance,Application .

Types of Ethics:Ethics of rights and Duties, Ethics of Responsibility, Ethics and Moral judgment, Ethics of care,Ethics of justice and fairness,Work ethics and quality of life at work.

Professional Ethics:
Ethics in Engineering Profession;moral issues and dilemmas, moral autonomy(types of inquiry).
Kohlberg's theory, Giligan's theory(consensus and controversy).
Code of Professional Ethics Sample Code of ethics like ASME, ASCE. IEEE,Institute of Engineers,Indian Institute of materials management, Institute of Electronics and telecommunication engineers.
Violation of Code of Ethics: conflict, causes and consequences
Engineering as social experimentation, engineers as responsible experimenters (computer ethics, weapons development);Engineers as managers, consulting engineers, engineers as experts, witnesses and advisors, moral leadership; Conflict between business demands and professional ideals,social and ethical responsibilities of technologies.
Whistle Blowing: Facts, contexts, justifications and case studies
Ethics and Industrial Law.
Institutionalizing Ethics: Relevance, Application, Digression and Consequences.

Module III : 8L
Science, Technology and Engineering as knowledge and profession ; Definition, Nature, Social Function and Practical application of science.
Rapid Industrial Growth and its Consequences.
Renewable and Non- renewable Resources: Definition and varieties.
Energy Crisis.
Industry and Industrialization.
Man and Machine interaction.
Impact of assembly line and automation .
Technology assessment and Impact analysis.
Industrial hazards and safety.
Safety regulations and safety engineering.
Safety responsibilities and rights.
Safety and risk, risk benefit analysis and reducing risk.
Technology Transfer: Definition and Types, The Indian Context.

Module IV : 8L
Environment and Eco- friendly Technology :Human Development and Environment; Ecological Ethics/Environment ethics;Depletion of Natural Resources: Environmental degradation
Pollution and Pollution Control
Eco-friendly Technology: Implementation, impact and assessment
Sustainable Development: Definition and Concept
Strategies for sustainable development
Sustainable Development--- The Modern Trends
Appropriate technology movement by Schumacher and later development Reports of Club of Rome.

Textbook/References :

1. Human Values, New Age International - A.N.Tripathi, New Delhi, 2006.
2. Classical Sociological Theory - G.Ritzer, The McGraw Hill Companies, New York, 1996.
3. Postmodern Perspectives on Indian Society - S.L.Doshi, Rawat Publications, New Delhi, 2008.
4. Sustainable Development - D.K.Bhatnagar, Cyber Tech Publications, New Delhi, 2008.
5. The age of Spiritual Machines - R.Kurzwell, Penguin Books, New Delhi, 1999.
6. Social Problems in Modern Urban Society - Weinberg, Prentice Hall, Inc., USA, 1970.
7. Sociology - Anthony Giddens, London: Polity Press 2009.

Subject Name: Chemistry II					
Paper Code: CHEM 2201					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**0**	**0**	**3**	**3**

Module I : 9L
Colloids: Introduction; Classification of colloids; Size and shape; preparation of sols; Origin of charge in Colloidal particles; Stability of Colloids; Kinetic, Optical & electrical properties; Electrokinetic phenomena; Electrical Double Layer; Ultracentrifuge and Molecular weight determination of Macromolecules.
Kinetic theory of gases, Van der Waals Equation of state, Maxwell distribution law, vapour-liquid equilibrium
Adsorption: Introduction; Gibb's adsorption equation; Surface Excess; Adsorption isotherms: Freundlich, Langmuir, BET adsorption equations; Surface Films; Langmuir Balance; two dimensional equation of state.

Module II : 9L
Solution thermodynamics: Duhem Margulas equation and its application, concept of fugacity, activity and activity coefficients and their measurements.
Colligative properties of dilute solutions: vapour pressure lowering and osmotic pressure, thermodynamic derivation of their relationship, semipermeability, reverse osmosis, elevation of boiling point and depression of freezing point, van't Hoff factor, molar mass and colligative properties, experimental determination of colligative properties.

Module III : 9L
Preparation and synthetic application Grignard's reagent.
Common organic reactions i.e. Friedel-Crafts, Cannizaro, Aldol condensation, Beckmann, Schmidt, Lossen, Curtius Rearrangements.
Industrial Preparation: Synthesis of commercially important compounds (e.g. industrial reactions of phthalic anhydride from xylene and naphthalene, DDT from chlorobenzene, aspirin and methyl salicylate from phenol).

Module IV : 9L
Aminoacids: Classification; General methods of preparation and properties of amino acids, polypeptide synthesis.
Carbohydrate: Classification, Glucose and fructose, Disaccharides: Sucrose & maltose.

Text Books:
1. Physical Chemistry - G.W.Castellan, Narosa.

2. Organic Chemistry - I.L.Finar, Vol I & II, Pearson Education.
3. Organic Chemistry - Morrison & Boyd, PHI/Pearson Education.
4. Physical Chemistry – P. C. Rakshit, Sarat Book House 7th Edition

Reference Books:

1. Physical Chemistry - P. W. Atkins, Oxford.
2. A Text book of Physical Chemistry - K. L. Kapoor, Macmillan.
3. A guide Book to Mechanism in Organic Chemistry - Peter Sykes.
4. Organic Chemistry – Loudon, Oxford.

Subject Name: Data Structure & Database Concept					
Paper Code: CSEN 2206					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**1**	**0**	**4**	**4**

DATA STRUCTURE

Module I : 10L

Linear Data structures:
Sequential Representation, Arrays, Lists, Stacks, Queues, Circular Queue, De-queue Linked List Representations: Linear Linked List, Circular Linked List, Doubly Linked List and their Application.
Implementation of Stack, Queue and their variations using linked list
Recursion: Design of Recursive algorithm, Tail Recursion.

Module II : 13L

Non-Linear Data Structures:Trees : Binary Trees, Traversals, Binary Search Trees- Insertion and Deletion algorithms, AVL Tree, Heap(Definition and basic concepts)
Graphs: Breadth First Search (BFS) and Depth First Search (DFS). Sorting Algorithms: Bubble sort, Insertion sort, Selection sort, Quick sort.
Searching Algorithms: Linear search, Binary search.

DATABASE CONCEPT

Module III : 10L

Introduction to Database Concepts, File Processing System and Database Management System , DBMS Architecture and Data Independence,.
Data Model: Basic Concepts, Entity-Relationship Diagram, Keys, Cardinality, Weak Entity Set.
Introduction to relational algebra & SQL: Operators like select, project, rename, artesian product, join, union, intersect, minus, DDL, DML.

Module IV : 12L

Relational Database Design: Functional Dependencies, Normalization: Different anomalies in database designing 1NF, 2NF, 3NF and BCNF, Lossless-Join Decomposition and Dependency Preservation,
Introduction to Transaction Processing Concepts: ACID properties, Serializability and Recoverability

Text Books :
Data Structures:

1. Data Structures - Seymour Lipschutz, Publication: Tata McGraw-Hill (India)
2. Data Structures and Program Design in C. - Kruse Robert L., Robert Kruse, Cl Tondo, Pearson Education India.

Database Concept:

1. Fundamentals of Database Systems - Elmasri Ramez and Navathe Shamkant, Publication: Pearson.
2. Database System Concepts - A. Silberschatz, H.F Korth, S.Sudarshan, McGraw Hill Education (India) Private Limited.

Reference Books:

Data Sturucture:

1. Data Structures using C. - A.S.Tanenbaum, Y. Langsam, M.J.Augenstein, Publication: Pearson
2. The Art of Computer Programming - Donald E. Knuth , Addison-Wesley Professional.

Database Concept:

1. Introduction to Database Management - Vol. I, II, III, Date C. J.,Publication: Addison Wesley.
2. Principles of Database Systems - J.D.Ullman, Galgottia Publication.

Subject Name: Process Heat Transfer					
Paper Code: CHEN 2201					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**1**	**0**	**4**	**4**

Module I : 10L
Introduction to basic modes of heat transfer and their application in chemical process, heat transfer by conduction: Fourier law, thermal conductivity, thermal resistance; general heat conduction equation, thermal diffusivity; steady state heat conduction with heat generation for plane wall, cylindrical body and spherical body; conduction-convection system: critical insulation thickness of curved surface, steady state heat conduction through fin, fin efficiency, unsteady state heat conduction in solid with large thermal conductivity, significance of Biot no and Fourier no, transient heat conduction in solid.

Module II : 10L
Convective heat transfer without phase change: Newton-Rikhman law, local and average heat transfer coefficient, Reynold-Colburn analogy, concept of individual heat transfer coefficient and overall heat transfer coefficient, LMTD, empirical correlation for heat transfer coefficient in forced convection; elementary concept of thermal boundary layer, temperature distribution in laminar flow, analysis of free convection and correlation of free convection, Grashof number.

Module III : 10L
Heat transfer with phase change: filmwise and dropwise condensation, laminar film condensation on vertical plate, Nusselt equation; analysis of heat transfer during boiling, different boiling regimes during pool boiling.
Characteristics of radiation, properties of radiating surface, black body radiation: Plank's distribution law, Total emissive power: Stefan-Boltzman law, use of radiation function table; Wien's displacement law; Kirchoff's law; emissivity of black body, gray body and real body; radiation between surfaces: view factor, Electrical network approach for radiation heat exchange, radiation shields and their application, radiation heat exchange for three radiating surfaces; radiation heat transfer through absorbing emitting medium.

Module IV : 10L
Heat exchangers and their classification, performance analysis of heat exchanger: fouling factor, LMTD correction factor, effectiveness and NTU of heat exchangers, sizing and rating problems of heat exchangers, construction details of shell and tube heat exchanger, Shell and Tube heat exchanger design, elementary note on heat exchanger network.

Evaporators and their classification, capacity and steam economy, BPE, material and energy balance of single effect evaporator, classification of multiple effect evaporator, design of single

effect and multiple effect evaporator.

Text Books:

1. Process Heat Transfer - D. Q. Kern, MGH.
2. Heat Transfer Principles and Application - B. K. Dutta, PHI.
3. Units Operations of Chemical Engineering - McCabe & Smith and Harriot, MGH.

References:

1. Heat Transfer - A Basic Approach: M. Necati Ozisik, McGraw-Hill International Edition, Singapore.

Subject Name: Separation Processes I					
Paper Code: CHEN 2202					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**1**	**0**	**4**	**4**

Module I : 10L

Principles of molecular diffusion and diffusion between phases, Fick's Law, Diffusivity, Equation of continuity, Diffusion in solids, Knudsen diffusion. A definition of Mass transfer coefficient, other definitions of mass transfer coefficient, Correlation involving mass transfer coefficients, Theories of mass transfer, Mass transfer across interfaces, Two-resistance theory, Analogy between momentum, heat and mass transfer.

Module II :10L

Introduction to distillation , Vapor -liquid equilibria, Relative volatility, Ideal and non -ideal solutions, Batch Distillation, Rayleigh equation, Flash distillation, Steam distillation, Rectification of binary systems, Reflux ratio, Boil-up ratio, Fenske's Equation, Flooding, Dumping, Coning in a plate column, Calculation of number of plates in a distillation column by Mc Cabe-Thiele method, Enthalpy- concentration diagram, Calculation of number of plates in a distillation column by Ponchon -Savarit method, Optimum reflux ratio, **,** Plate efficiency.

Module III : 10L

Introduction to absorption, The mechanism of absorption, Absorption equipment, Limiting gas-liquid ratio, Flooding, loading in packed column, Diameter and height calculations for packed columns, H. E. T. P., H. T. U. and N. T. U. concepts, Packed tower design, Gas film coefficient, Liquid film coefficient, Height of column based on overall coefficients, Number of plates and Diameter of Plate type towers, Absorption factor, Number of plates by use of absorption factor, Kremser equation.

Different types of Gas-liquid contacting devices for absorption and distillation operation: gas continuous-liquid dispersed and liquid continuous-gas dispersed.

Module IV : 10L

a. Distillation Column internals and sizing, Azeotropic & Extractive distillation, Multi-component distillation.

b. Adsorption: Introduction, Nature of adsorbents, Batch adsorption, Adsorption isotherms, Adsorption equipment, Breakthrough curves, Scale up, Length of unused bed, Design of fixed bed adsorption column.

Text Books :

1. Mass Transfer Operations: Robert E. Treybal, MGH, International Student Edition.
2. Principles of Mass Transfer and Separation Processes, Binay K. Dutta
3. 3. Unit Operations in Chemical Engineering : McCabe, Smith, and Harriot. MGH, Sixth Edn.

References :

1. Transport process and Unit Operations: Geankoplis. 3rd Edn., PHI.
2. The Elements of Fractional Distillation: Robinson, C. S. and Gilliland, E. R. MGH.
3. Separation Processes: King, C. J. MGH.
4. Separation Process Principles : J.D.Seader, E.J. Henley.
5. Coulson & Richardson's Chemical Engineering, Vol.2.
6. Distillation Design, Henry Kister, MGH.

Subject Name: Chemical Engineering Thermodynamics					
Paper Code: CHEN 2203					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**1**	**0**	**4**	**4**

Module I :10L
Introduction-Macroscopic and microscopic approaches; Units; Basic concepts of system, property, force, temperature, pressure, work, energy, heat and equilibrium from thermodynamic aspect.

Application of 1st law of thermodynamics to chemical process: open and closed system energy balance equations, SFEE, compressible flow through a nozzle, working principle of single stage and multistage compressor.

P-V-T behaviour of pure substances, equation of state: virial equation of state, cubic equation of state, law of corresponding states, generalised correlations for gases and liquids, acentric factor, compressibility factor.

Module II : 10L
Application of second law of thermodynamics to chemical process, entropy generation and irreversibility, clausius inequality.

Ideal power cycle, Rankine cycle, reheat cycle, regenerative cycle, and working principle of IC engine: Otto cycle, diesel cycle, brayton cycle.

Ideal refrigeration cycle, vapour compression cycle, Bell-Coleman cycle, absorption refrigeration cycle, isenthalpic expansion: Linde and Claude liquefaction cycle.

Module III : 10L
Thermodynamic property relations of pure fluid: Maxwell relations. The Jacobian Method, residual property, physical significance of Gibb's free energy and work function, concept of fugacity.

Solution thermodynamics: partial molar properties, chemical potential, Gibbs-Duhem equation, effect of temperature and pressure on chemical potential, fugacity in solution, Lewis-Randall rule and Henry's law, Raoult's law, excess property, activity and activity coefficient, property change on mixing, Excess Gibbs free energy models – Margules, Redlick – Kister, Whol's, Van Laar, Wilson & NRTL, UNIQUAC, Group Contribution methods, modified Raoult's law, P-x-y and T-x-y diagram of binary liquid solution, azeotrope calculation, thermodynamic consistency checking of data.

Module IV : 10L

Chemical reaction equilibria: Reaction Stoichiometry, reaction coordinate, criteria of reaction equilibrium, equilibrium constant, standard Gibbs energy change and equilibrium constant, effect of temperature on equilibrium constant, effect of pressure on equilibrium constant, effect of inert material, excess reactant and product on equilibrium constant, heterogeneous reaction equilibria, phase rule and Duhem theorem for reacting syst

Text Books:

1. Introduction to Chemical Engineering Thermodynamics: Smith, J.M., Van ness, H.C. and Abbot, M.M., 6th Edn. MGH., 2001.
2. A Text Book of Chemical Engineering Thermodynamics, Narayanan, PHI

References:

1. Chemical Engineering Thermodynamics: Y.V.C. Rao.
2. Chemical Process Principles (Vol-2): O.A.Hougen, K.M. Watson and R.A.Ragatz.
3. Chemical and Process Thermodynamics: Kyle PHI.

LABORATORY

Subject Name: DBMS Laboratory					
Paper Code: CSEN 2211					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	**0**	**3**	**3**	**2**

Experiments on Database on RDBMS Platform (Oracle):

1. DDL Commands: Creating Tables along with constraints like: Primary Key, Foreign Key, unique, Not Null, Check. Altering Table Structure like adding and modifying constraints, adding and modifying column data types, etc..

2. DML: Inserting rows, Updating rows, Deleting rows

3. SQL Query: Cartesian Product, Join, Union, Intersect, Minus, Single Row functions, multiple row functions using GROUP BY clause, ORDER BY Clause, Nested Sub-Queries

4 Introduction to PL/SQL: Programming Language Constructs in PL SQL like variable declaration, Conditional Statements, different types of loop structures, functions, etc. Programming using Cursors, Creating different types of Triggers.

Reference Books:

1. SQL, PL/SQL: The Programming Language Of Oracle (With CD-ROM) (English) 4th Revised Edition: Ivan Bayross,Publisher: BPB Publications.

Subject Name: Heat Transfer lab					
Paper Code: CHEN 2211					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	**0**	**3**	**3**	**2**

At least eight experiments are to be performed

1. Determination of thermal conductivity of a metal bar using Fourier's heat conduction equation.
2. Estimation of heat loss through a lagged pipe and determination of thermal conductivity of insulating material.
3. Determination of thermal conductivity of insulating powder during heat transfer in a spherical vessel.
4. Determination of heat transfer coefficient of air during forced convection heat transfer and to study the effect of air velocities on heat transfer coefficient.
5. Determination of overall heat transfer coefficient in a Counter current & Parallel flow double pipe heat exchanger and to study the effect of fluid flow rate on overall heat transfer coefficient.
6. Determination of overall heat transfer coefficient and efficiency of a Shell and Tube heat exchanger and to study the effect of fluid flow rate on overall heat transfer coefficient.
7. Determination of emissivity of a given radiating surface applying Kirchhoff's law of thermal radiation.
8. Determination of Stefan's Boltzman constant experimentally.
9. Determination of economy, capacity and overall heat transfer coefficient of a single effect evaporator.
10. Determination of Biot number for a conductive convective system and validation of lumped system assumption.
11. Determination of heat transfer co-efficient in film-wise & drop-wise condensation.

Subject Name: Language Practice Lab Level II					
Paper Code: HMTS 2011					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	**0**	**3**	**3**	**2**

Module I : 8L
Formal verbal communication: Introduction to formal verbal communication, Interpersonal Skills & Public Speaking: Building Positive Relationships, Focusing on Solving Problems, Time Management, Dealing with Criticism: Offering Constructive Criticism, Responding to Criticism – Managing Conflict: Approaches to Conflict, Resolving Conflict.

Conversational skills in the business scenario: One-to-one and Group communication, Gender and Culture Sensitivity, Etiquette, Sample Business Conversation, Telephonic Conversation.

Module II : 8L
Presentation skills:
Speech Purposes : General Informative Speeches, Persuasive Speeches, Entertaining Speeches, Methods of Speaking: Speaking from a Manuscript, Speaking from Memory, Impromptu Delivery, Extemporaneous Delivery, Analyzing the Audience, Nonverbal Dimensions of Presentation.

Organising the Presentation: the Message Statement, Organising the Presentation: Organizing the Speech to Inform, The Conclusion, Supporting Your Ideas – Visual Aids: Designing and Presenting Visual Aids, Selecting the Right Medium, Post- presentation Discussion.

Module III : 8L
Group Discussion
Introduction to Group Communication
Factors in Group Communication, Status – Group Decision Making: Reflective Thinking, Brainstorming, Body Language, Logical Argument, The Planning Process, Strategies for Successful GDs, Role of Social Awareness (Newspapers, Magazines, Journals, TV News, Social Media), Practice GDs.

Module IV : 8L
Job Application and Personal Interview: Job Application Letter: Responding to Advertisements and Forced Applications, Qualities of Well-Written Application Letters: The You-Attitude, Length, Knowledge of Job Requirement, Reader-Benefit Information, Organization, Style, Mechanics – Letter Plan: Opening Section, Middle Section, Closing Section.

Resume and CV: Difference, Content of the Resume – Formulating Career Plans: Self Analysis,

Career Analysis, Job Analysis, Matching Personal Needs with Job Profile – Planning your Resume – Structuring the Resume: Chronological Resume, The Functional Resume, Combination Chronological and Functional .Resume – Content of the Resume: Heading, Career Goal or Objectives, Education, Work Experience, Summary of Job Skills/Key Qualifications, Activities, Honours and Achievements, Personal Profile, Special Interests, References .

Interviewing: Types of Interviews, Format for Interviews: One-to-one and Panel Interviews, Employment Interviews, Frequently Asked Questions, Dress Code, Etiquette, Questions for the Interviewer, Simulated Interviews.

References:

1. The Cambridge guide to Teaching English to Speakers of Other Languages - R.Carter, And D.Nunan, (Eds) CUP, 2001.
2. Writing and Speaking At Work: A Practical Guide for Business Communication - Edward P. Bailey, , Prentice Hall, 3rd Ed., 2004.
3. Guide to Managerial Communication: Effective Business Writing and Speaking - M.Munter, Prentice Hall, 5th Ed., 1999.
4. Technical Communication: Principles and Practice - M.Raman and S.Sharma, 2nd Ed., 2011.

Semester 5

THEORY

Subject Name: Economics for Engineers					
Paper Code: HMTS-3101					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**0**	**0**	**3**	**3**

Module 1: 6L
Market: Meaning of Market, Types of Market, Perfect Competition, Monopoly, Monopolistic and Oligopoly market.
The basic concept of economics – needs, wants, utility.
National Income-GDP, GNP. Demand & Supply, Law of demand, Role of demand and supply in price determination, Price Elasticity.
Inflation: meaning, reasons, etc.

Module 2: 4L
Business: Types of business, Proprietorship, Partnership, Joint-stock company, and cooperative society – their characteristics.
Banking: role of commercial banks; credit and its importance in industrial functioning. Role of central bank: Reserve Bank of India.
International Business or Trade Environment.

Module 3: 8L
Financial Accounting-Journals. Ledgers, Trial Balance, Profit & Loss Account,
Balance Sheet. Financial Statement Analysis (Ratio and Cash Flow analysis).
Cost Accounting**-** Terminology, Fixed, Variable and Semi-variable costs.
Break Even Analysis. Cost Sheet. Budgeting and Variance Analysis.
Marginal Cost based decisions. **(6L)**

Module 4: 12L
Time Value of Money**:** Present and Future Value, Annuity, Perpetuity.
Equity and Debt, Cost of Capital. **(4L)**
Capital Budgeting**:** Methods of project appraisal - average rate of return - payback period - discounted cash flow method: net present value, benefit cost ratio, internal rate of return.
Depreciation and its types, Replacement Analysis, Sensitivity Analysis. **(8L)**

Evaluation: Max marks-100
Internal Test-30
Semester Test-70

Suggested Readings:

1. R**.** Narayanswami, Financial Accounting- A Managerial Perspective. Prentice-Hall of India Private Limited. New Delhi
2. Horne, James C Van, Fundamentals of Financial Management. Prentice-Hall of India Private Limited, New Delhi
3. H. L. Ahuja., Modern Economic Theory. S. Chand. New Delhi.
4. Newman, Donald G., Eschenbach, Ted G., and Lavelle, Jerome P. Engineering Economic Analysis. New York: Oxford University Press. 2012.

Subject Name: Chemical Process Technology-I					
Paper Code: CHEN 3101					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**0**	**0**	**3**	**3**

Module I: 10 L

Water treatment**:** Water for the chemical process industry, Boiler feed-water, Cooling tower water, Demineralised water, Drinking water; Treatment methodology: Conventional water-treatment procedures, Ion-exchange, Membrane technology etc.

Chlor-alkali industries: Production and consumption pattern, manufacture of Chlorine-caustic soda: Raw materials, principles of manufacture, Mercury-cathode & Membrane process: flow-sheet and sequence of operation, other processes, advancement of process technology and major engineering problems, uses.

Soda-ash **:** Production and consumption pattern, Raw materials, Solvay process Physico-chemical principles of manufacture, carbonation and ammonia recovery step, flow-sheet and sequence of operation, other processes, advancement of process technology and modified Solvay process, major engineering problems, uses.

Module II: 10 L

Industrial Acids:

Hydrochloric Acid: Manufacturing methods: By product Recovery from other production processes, conventional raw materials and principles of manufacture, flow-sheet and sequence of operation, major engineering problems, uses.

Sulfuric acid: Raw materials resources, sulfuric acid production processes, Contact process, Physico-chemical principles and general theory of contact reaction with thermodynamic and reaction engineering aspects, different types of catalyst – preparation methodology and relative merits, flow-sheet and sequence of operation, details of major equipments, advancement of process technology and major engineering problems, DCDA process, uses.

Nitric Acid: Raw materials resources, Ostwald Process–physico-chemical principles, catalyst, process flow sheet and sequence of operation, details of major equipments, uses.

Phosphoric Acid**:** Raw materials, manufacturing process with process flow sheet, details of major equipments, uses.

Module III: 10 L

Fertilizer Industries:

Nitrogenous fertilizers: Ammonia-Source of hydrogen; methods of obtaining hydrogen from

different sources, source of nitrogen-liquefaction of air and distillation of liquid air;
Synthesis of ammonia- physico chemical principles, catalyst for synthesis of ammonia, process flow sheet and sequence of operation, details of major equipments.

Urea **-** Raw materials, manufacturing process with flow sheet, sequence of operation, major equipments details.

Ammonium sulphate: Raw materials, manufacturing process with flow sheet, major equipments details.
Phosphatic fertilizers: Manufacturing process of super phosphate of lime, single and triple super phosphate, Diammonium phosphate.
Mixed fertilizers: NPK –manufacturing process, details of major equipments;

Module IV: 10 L
Ceramic and ceramic materials:

Cement: Chemical composition of Portland cement, raw materials, dry and wet process for manufacturing cement clinker, setting and hardening of cement.

Glass: Composition of glass, raw materials, manufacturing method of glass- pot furnace and tank furnace, annealing of glass.

Ceramic**:** Basic raw materials, white-wares, manufacturing process of porcelain and their forming operations.
Refractories: Properties of Refractories, raw materials, manufacturing techniques of acid refectories, basic Refractories, sintered and fused refractories, insulating refractories.

Text Books :

1. Dryden, C. E., and Rao, M.G. (Ed.), Outlines of Chemical Technology Affiliated East West Press
2. Austins, G.T., Sherve's Chemical Process Industries, McGraw-Hill, 5th Edn.

References:

1. Venkateswarlu, S. (Ed.) Chemtech (II) Chemical Engineering Development Centre, Indian Institute of Technology, Madras
2. Kirk & Othmer (Ed.), Encyclopedia of Chemical Technology.

Subject Name: Chemical Reaction Engineering					
Paper Code: CHEN 3102					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**1**	**0**	**4**	**4**

Module I: 10L

Introduction; Definition of reaction rate; Kinetics of homogeneous reaction: Concentration-dependent term of a rate equation, single and multiple reactions, rate equation from given mechanisms.

Elementary & Nonelementary reactions, Molecularity and order of reaction, Representation of reaction rate, Kinetics for non elementary reactions, related problems, Temperature dependent term of a rate equation: Arrhenius law, Collision theory, Transition-state Theory, related problems.

Interpretation of batch reactor data: Constant-volume batch reactor, Integral method of analysis of data: General Procedure, Irreversible unimolecular-type first-order reaction, Irreversible bimolecular-type second-order reactions, rate equation for enzymatic reaction, Zero-order reactions, Over-all order of irreversible reactions from the Half-life method, Initial rate method of analysis.

Irreversible Reactions in parallel, Autocatalytic reactions, Irreversible reactions in series, First-order Reversible Reactions, Differential method of Analysis of data: Analysis of the Complete Rate Equation, Partial analysis of rate equation,

Variable-Volume reaction system: Its Integral method of analysis for Zero-order reactions, First order reaction, Second-order reactions;

Module II: 10L

Single ideal Reactors: Introduction; Basic division of ideal reactors, Ideal Batch Reactor, Concept of flow reactors, Space-time and Space-velocity,

Steady-state Mixed Flow Reactor: Design Equation, Graphical Representation of Design Equation, related problem;

Steady-state Plug Flow Reactor: Design equation, graphical representation, related problem;Design for Single Reactions: Size and comparison of single reactors: Batch Reactor, PFR, MFR, General Graphical Comparison;

Multiple-Reactor Systems: PFRs in Series and/or in Parallel, Equal-size MFRs in Series, MFRs of different sizes in Series, Determining the best size combination of reactor size for a given

combination, Reactors of Different Types in Series,

Recycle Reactor: Definition of Recycle Ratio, Design Equation, and Optimum Recycle ratio.

Module III: 10L

Design for Multiple Reactions: Introduction, Reactions in Parallel, Qualitative aspects of Product Distribution,

Quantitative Treatment of Product Distribution and of Reactor Size: Definition of Instantaneous and Overall fractional yield, graphical representation; Reactions in Series: Successive First-Order Reactions, Product Distribution, Quantitative Treatment of PFR, MFR and Batch Reactor.

Solid-Catalyzed Reaction: Introduction; Basic idea of catalysis, Catalyst properties, Steps in catalytic reaction:

Qualitative discussion on Pore Diffusion, Adsorption, Surface reaction and Desorption, Concept of Rate limiting step;

Design of reactors for gas-solid reactions: Design equation and data analysis of heterogeneous system; Quantitative aspects of Pore diffusion controlled reactions (single cylindrical pore, first-order reaction): Material balance for the elementary slice of catalyst pore, Definition of Thiele Modulus and Effectiveness Factor.

Different methods of catalyst preparation. Catalyst surface area and pore volume measurement

Fluid-Particle Reactions: Introduction; Different behavior of reacting solid particles; Selection of a Model; Qualitative discussion on Progressive Conversion Model & Unreacted Core Model;

Introduction to non isothermal reactions: adiabatic and temperature programmed reactions.

Module IV: 10L

Distribution of Residence Times for Chemical Reactors: General Characteristics; Residence-Time Distribution (RTD) Function;

Measurement of the RTD: Pulse Input; Related problems; Characteristics of RTD: Integral Relationships, Mean Residence Time, Different Moments of RTD; RTD in Ideal Reactor: RTD in Batch and PFR, Single CSTR, PFR/CSTR series RTD; Concept of Macromixing & Micromixing, Zero Parameter Model: Segregation Model & Maximum Mixedness Model.

Models for Nonideal Reactors: Introduction; One-Parameter Models: Tanks in Series Model, Dispersion Model: Basic Formulation, Definition of Peclet Number & Vessel Dispersion Coefficient, Boundary Conditions (Closed-Closed & Open-Open), Correction for Sloppy Tracer Input, Relation between Flow, Reaction and Dispersion.

Text Books :

1. Elements of Chemical Reaction Engineering, 4th. Edition, H. Scott Fogler, Prentice Hall
2. Chemical Reaction Engineering, 2nd. & 3rd. editions, O Levenspiel.: Wiley Eastern Ltd.

References:

1. Chemical Reactor Analysis and Design Fundamentals, J. B. Rawlings and J. G. Ekerdt. Nob Hill Publishing.
2. Chemical Engineering Kinetics, 3rd. Edition, J.M. Smith, MGH.
3. Chemical Engineering Kinetics and Reactor Design, C.G. Hill, Wiley
4. The Engineering of Chemical Reactions, 2nd. Edition, L. D. Schmidt, Oxford
5. Experiments in Catalytic Reaction Engineering, J. N. Berty, Elsevier.

Subject Name: Separation Process – II					
Paper Code: CHEN 3103					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**1**	**0**	**4**	**4**

Module I : 10L
Humidification & Dehumidification Processes:
Introduction to Humidification and dehumidification operations, Characteristics of saturated and unsaturated vapor gas mixtures, Dry and wet bulb thermometry, Psychrometric chart, Adiabatic saturation curves, Psychrometric ratio, Gas liquid contact, Design of humidifiers, Dehumidification operation, Principle and design of cooling towers -Natural draft, forced draft and induced draft cooling towers.

MODULE II : 10L
Liquid-Liquid Extraction & Leaching:

Introduction to Extraction, Liquid- liquid equilibria, Triangular diagram, Selectivity and choice of solvents, Stage-wise contact, Co- current & counter-current extractor, Stage type extractors and differential extractors, Determination of number of equilibrium stages by graphical method for multistage extraction, Supercritical Fluid Extraction.

Introduction to leaching, General principle, Factors affecting the rate of extraction, Calculation of number of stages, Batch processes, Counter-current washing, Stage calculation methods.

MODULE III :10L
Drying & Crystallization**:**

Introduction to drying, Rate of drying, Batch drying mechanism, Time of drying, the mechanism of moisture movement during drying, Classification and selection of dryer, Batch dryer and continuous dryer.

Introduction to crystallization, Theory of Crystallization, Formation and growth of crystals, Crystal yield, Rate of crystallization, Crystallizers.

MODULE IV: 10L
Membrane Separation Processes:

Introduction to membrane separation processes, Classification of membranes and membrane processes, Dialysis, Ultra filtration- Concentration Polarization, Application of Ultrafiltration Process, Reverse Osmosis, Reverse osmosis in water treatment plant, Pervaporation, Electrodialysis, Membrane fouling, Liquid membrane.

Text Books:

1. Mass Transfer Operations: Robert E. Treybal, McGraw Hill, International Student Edition, 1981.
2. Principles of Mass Transfer and Separation Processes, Binay K. Dutta, Prentice Hall of India, 2007.
3. Transport Process and Unit Operations: Christie J. Geankoplis. 3rd Edition., 1993, Prentice Hall of India.

References:

1. Separation Processes: King, C. J., McGraw Hill, Chemical Engineering Series.
2. Separation Process Principles, 3rd Edition, J.D. Seader, Earnest J. Henley, D. Keith Roper, 2010.
3. Unit Operations in Chemical Engineering: Mc Cabe and Smith, Harriot., McGraw Hill, Seventh Edition.
4. 4.Coulson and Richardson's Chemical Engineering, Volume 2, Fifth Edition, J. F. ,Richardson and J.H. Harker with J.R. Backhurst, Pergamon Press.
5. Perry's Chemical Engineers' Handbook, , 8th Edition, McGraw Hill.

Subject Name: Numerical Methods of Analysis					
Paper Code: CHEN 3104					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**1**	**0**	**4**	**4**

Module I: **10L**
Approximation in numerical computation: Truncation and rounding errors, Fixed and floating-point arithmetic, Propagation of errors.
Interpolation: Newton forward/backward interpolation, Lagrange's and Newton's divided difference Interpolation.

Numerical integration: Trapezoidal rule, Simpson's 1/3 rule, Expression for corresponding error terms.

Module II: **10L**
Numerical solution of a system of linear equations: Gauss elimination method, Matrix inversion, LU Factorization method, Gauss-Seidel iterative method.

Bisection method, Secant method, Newton-Raphson method.

Module III: **10L**
Numerical solution of ordinary differential equation: Euler's method, Runge-Kutta methods, Predictor-Corrector methods.

Module IV: **10L**
Numerical Differentiation – Forward and Backward difference algorithms, First and Second order derivatives. Finite Difference methods for Boundary Value Problems, Parabolic PDEs.

Textbook:

1. Numerical Methods for Engineers – R. Chapra and S. Canale, Sixth Edition 6th Edition, McGraw-Hill Science/Engineering/Math, 2009.

Reference:

1. Mathematical Methods in Chemical Engineering – V.G. Jenson and G.V. Jeffreys, Academic Press, 2nd Edition.

Professional Elective-I

Subject Name: Polymer Science & Engineering					
Paper Code: CHEN 3131					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**0**	**0**	**3**	**3**

Module I: 10 L
Definitions and concepts of terms used in polymer engineering, Classification of polymers; Polymer structures, functionality; polymerization reactions – mechanism of polymerization; stereospecific polymerization, copolymerization.
Introduction to nano-polymers: Characterisation techniques: XRD, FESEM and AFM

Module II: 10 L
Polymerization reactors, polymerization processes, characterization of polymers: DSC, DTGA, DMA, Creep Test analysis of polymerization reactions, polymer degradation.

Module III: 10 L
Molecular weight and molecular weight distribution in polymers, properties of polymers – physical, chemical, mechanical and electrical properties of polymers, elementary idea on polymer rheology, polymer blends.

Module IV: 10 L
Polymer processing: modeling – compression & transfer, injection & jet; casting; extrusion, calendaring, lamination, spinning & finishing.

Text Books:

1. Text Book of Polymer Science, 2nd Ed., F. W. Billmeyer, Jr., Wiley–Interscience, New York, 1971.
2. Polymer Science & Technology, P. Ghosh, Publisher: McGraw Hill Education (India) Private Limited; edition (26 November 2010)

References:

1. The elements of Polymer Science & Engineering, Alfred Rudin, Academic Press, 2nd Edition, 1999
2. Introduction to Polymers, 2nd edition, by (second edition) R. J. Young and P. A. Lovell Chapman and Hall, London, 1991.

Professional Elective-I

Subject Name: Petrochemical Technology					
Paper Code: CHEN 3132					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**0**	**0**	**3**	**3**

Module I : 10L

Evolution of petrochemical industry in India, recent trend of petrochemical industry in India, Petrochemical industry feedstock: overview of petroleum refinery industry and its product, natural gas processing; impurities in feedstock for petrochemical industry and the process of their removal.

Synthesis gas production and its use: Steam reforming operation of Naphtha and natural gas, fuel oil partial oxidation method, Methanol production, synthetic liquid fuel production by Fischer-Tropsch process, aldehyde and alcohol production from synthesis gas, ammonia production and its application.

Module II : 10L

Steam cracking operation of naphtha and C_2 to C_4 saturates, downstream separation scheme of naphtha cracking. Manufacture of Petrochemicals based on Ethylene: EDC, VCM, VAM, Ethylene oxide, Ethanol amine Manufacture of Petrochemicals based on Propylene: Acrylonitrile, Acrolein, Propylene oxide, glycerine (acrolein route, allyl chloride route, propylene oxide route), Isopropanol

Production of Butadiene from C_4 cut.

Module III : 10L

Catalytic reforming of naphtha, catalyst and process variable of BTX reformer, separation of Benzene, Toluene and Xylene from BTX reformate, pyrolysis gasoline hydrogenation and separation of aromatics, separation of meta xylene from mixed xylenes, alkylation of benzene, production of styrene, cumene and phenol, production of Phthalic anhydride. Synthetic detergent and its classication, production of linear alkyl beanzene and keryl benzene sulfonate from kerosene cut, additives for detergent.

Module IV : 10L

Overview of plastic industry: Production of LDPE, LLDPE, HDPE, PP, PVC, Polystyrene and their application.

Comparative study of Plastic, fibre and elastomer; production of SBR, Butadiene rubber, production of ABS plastic, polyamide, polyester, acrylic fibre, polycarbonates, production of phenol-formaldehyde resin; overview of polymer processing.

Text Books:

1. A Text on Petrochemicals: B.K.B. Rao, Khanna Publishers, 2011, ISBN 9788174090447 / 8174090444
2. Advanced Petrochemicals: Dr. G. N. Sarkar, Khanna Publishers, 2008, ISBN 8174090967
3. Introduction to Petrochemicals, Sukumar Maity. Oxford and IBH Publishing Co, 2002 ISBN 8120415558

References:

1. The Petroleum chemicals Industry: R. F. Goldstein and A. L. Waddams, E & F N Spon (An imprint of Routledge), 1967, ISBN 0419025308.
2. Petrochemical processes: Chauvel , Gulf Publishing Co, 1989, ISBN 0872017729.

Professional Elective-I

Subject Name: Material Science & Engineering					
Paper Code: CHEN 3133					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**0**	**0**	**3**	**3**

Module I: 10L
Structure of materials-Various types of bonds; Crystalline Structure of Solids- concepts of unit cell and space lattice, packing factor;

X-ray diffraction for determining crystal structure; Mechanical properties: Strength, hardness, toughness, ductility, brittleness of Engineering Materials**;** Elastic, Anelastic and visco-elastic behaviour of materials; Electrical, Electronic, Optical & Optoelectronic properties of material; Inorganic & organic amorphous materials and their structural & property characteristics; Optical fibers.

Module II: 10 L
Mechanism of plastic deformation, slip and twinning, structural imperfections: elementary concepts of point, line, surface & volume imperfections; Influence of dislocations/Line imperfections on the mechanical properties of materials**;** Strain hardening and recrystallisation; Elementary aspects of creep, fatigue, fracture; Phase Diagrams- Solidification and structure of metals, Grain boundaries; Phase equilibrium and phase diagrams of binary alloys; Phase diagram of ternary systems; Iron-Carbon diagram; Heat Treatment –Introduction and purposes of heat treatment; T-T-T diagram; Corrosion-Concepts and forms of corrosion; Corrosion Mechanism and prevention; Protective materials and coating.

Module III: 10 L
Basic principles of metal extraction: Pyrometallurgy: Smelting, calcinations, roasting—oxidizing, predominance area diagrams, multiple hearth, flash and fluo-solid, sintering, smelting, slag and its classification.

Steelmaking process flow diagram: Iron making (Operation involved in Blast furnace)– Steel making (oxygen blown converter –LD) – Secondary steel making / refining (ladle processing, vacuum degassing, ladle furnace processing) – Continuous casting – with emphasis on application of the concepts of physicochemical principles involved, moving/packed bed reactor, gas-liquid two-phase flow, heat transfer with phase change (solidification).

Module IV: 10 L
Principles of Hydrometallurgy and Electrometallurgy, Extraction of Aluminum: Hall-Heroult

process, Electrolytic refining; Sources of Zinc & Copper: Pyro & Hydro metallurgical extraction of copper & Zinc; Extraction of Lead, Recent development in Lead smelting.

Text Books:

1. Raghavan, V. Material Science and Engineering, (5th Edition) V. Raghavan Prentice-Hall of India Pvt. Ltd., 2004;
2. Ray, Sridhar & Abraham. Extraction of non ferrous metal, 1985, EWP, New Delhi. Sevryukov N.,

References:

1. Elements of Material Science and Engineering, by Lawrence, H. Vanvlack; Published by Pearson Education, 1980.
2. Engineering Physical metallurgy; Lakhtin, Y. Published by MIR Publishers, Moscow, 1975.
3. The Reduction of Iron Ores, by L. Von Bogdandy and H.J Engell Published by Springer-Verlag, New York.
4. Engineering in Process Metallurgy, by R.I.L Guthrie Oxford University Press (Paperback edition 1992).

LABORATORY

Subject Name: Mass Transfer laboratory					
Paper Code: CHEN 3111					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	**0**	**3**	**3**	**2**

At least eight experiments are to be performed

1. Study of simple batch distillation to verify Rayleigh's equation.
2. Experiment on wetted wall column to determine mass transfer co-efficient.
3. To study the performance of a distillation (sieve tray/ bubble cap) column.
4. To study gas absorption in a packed tower to determine volumetric mass transfer coefficient and is variation with change in liquid rate.
5. To study the drying rate characteristics curve under constant drying condition in a tray dryer.
6. Experiment on batch adsorption and verification of adsorption isotherms.
7. Experiment on liquid-liquid extraction (to determine the overall mass transfer coefficient for counter current operation)
8. To study drying characteristics in a Rotary Dryer.
9. Determination of psychrometric properties air-water vapour system.
10. To determine the diffusivity of a volatile solid in gas.
11. Determination of diffusivity of volatile liquids in air using Stefan tube.

Subject Name: PEDD- I					
Paper Code: CHEN 3112					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	**0**	**4**	**4**	**3**

1. Design and Drawing Pressure Vessel - thin and thick cylinder design, design of cylinder head, cover plate, selection of gasket, design of bolt and flange.

2. Design and Drawing of Reactor.

Each student shall be allotted design problems on sl. no 1& 2 at the beginning of the 5th semester and the student shall carryout complete process and mechanical design under supervision of a faculty. The student shall also prepare engineering drawing of the equipment and submit two copies of the design report in tight and bound form 7 days before commencement of 5th semester examination. Assessment would be made on the basis of the submitted report and the viva voce examination conducted by a board of examiners constituted by the Departmental Academic Committee consisting of two faculty members and class teachers with Head of the Department as Chairman during 5th. Semester examination.

Text Book / References:

1. Process Equipment Design – Brownell and Young, John Wiley and sons.
2. Chemical Engineering Design, Fourth Edition: Chemical Engineering Volume 6 (Coulson & Richardson's Chemical Engineering) 4th Edition - by R K Sinnott (Author), Butterworth-Heinemann; 4 edition.

Subject Name: Chemical Reaction Engineering Laboratory					
Paper Code: CHEN 3113					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	**0**	**3**	**3**	**2**

At least eight experiments are to be performed

1. Experimental studies on kinetics of a non catalytic homogeneous liquid phase reaction in an isothermal batch reactor
2. Experimental studies on kinetics of a homogeneous liquid phase reaction in an isothermal semi batch reactor
3. Experimental studies on kinetics of a non catalytic homogeneous liquid phase reaction in a Spiral plug flow reactor.
4. Experimental studies on kinetics of a non catalytic homogeneous liquid phase reaction in an isothermal CSTR.
5. Experimental studies on kinetics of a non catalytic homogeneous liquid phase reaction in a packed bed reactor.
6. Experimental studies on RTD in a tubular PFR using pulse input of tracer and measurement of axial dispersion coefficient.
7. Experimental studies on kinetics of a heterogeneous catalytic reaction in a UV photoreactor.
8. Experimental studies on RTD in a packed bed reactor using pulse input of tracer and measurement of axial dispersion coefficient.
9. Experimental studies on kinetics of hydrolysis of ethyl acetate in presence of acid catalyst in an adiabatic batch reactor.
10. Experimental studies on kinetics of sulfonation of toluene in an isothermal batch reactor.

Semester 6

THEORY

Subject Name: Process Dynamics, Instrumentation and Control					
Paper Code: CHEN 3201					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**1**	**0**	**4**	**4**

Module I: 10 L

Introduction: Principles of measurement. Error Analysis, Static and dynamic characteristics of instruments.

Temperature measurement: Filled system Thermometer, Thermocouples, Resistance Thermometers, radiation and optical pyrometers;

Pressure: Manometers: U tube manometer, inclined limb manometer, Ring balance manometer, Elastic deformation: bourdon, bellows, diaphragm and electrical type gauges: strain gauge, piezoelectric, pressure transducers.

Vacuum gauges: mechanical, electrical and ionization types;

Flow: Head flow meters, area flow meters, positive displacement flow meters, mass and magnetic flow meters;

Level: Direct and inferential type; composition.

Module II: 10L

Introduction to process control, Use of Laplace transforms in process control, Different forcing functions: Step, Pulse, Impulse, Ramp, Sinusoidal and frequency inputs & their graphical representation.

First order system; Transfer function; Examples of First Order Systems, Pure capacitive system, Response of different forcing functions; First order systems in series- non- interacting & interacting. Second order system- Under- damped, critically damped & over damped, Second order system examples - Damped vibrator, Control valve, U-tube manometer, terms related to under damped system, Transportation lag.

Module III: 10 L

Feedback control loop and its components, advantages and disadvantages of feedback control system Simple process models and their transfer functions**:** stirred tank heater, continuous stirred tank reactor, heat exchanger, distillation column, U-tube manometer

State-space representation of linear systems

Different types of controllers and their applications: P, PI, PD, PID & their transfer function, servo and regulatory control, transient responses of feedback control systems

Block diagram: Block diagram of different chemical process units, block diagram reduction,

open loop & closed loop transfer function, concept of poles and zeros

Control valves: construction, types of control valves, characteristic curves & transfer function, valve sizing, applications
Elementary idea of feed forward, cascade, ratio control.

Module IV: 10L
Definition of stability, concept of bound and unbound function
Stability Analysis of Feedback control systems: Routh-Hurwitz stability criterion, Direct Substitution method, Root Locus Analysis, Frequency response analysis, Bode plot and Bode stability criterion, Nyquist stability criteria.
Performance Criteria for good control (ISE, ITAE, IAE etc), concept of empirical process models, development of empirical process models: FOPDT, SOPDT etc and evaluation of their performance, Process reaction curve method, Zeigler-Nichols and Cohen Coon controller tuning rules, and determination of controller settings.

Adaptive & digital control, concept of PLC & DCS.

Text books:

1. Process system analysis & Control-D.R. Coughanowr, McGraw-Hill, Inc., 2nd ed., 1991.
2. Chemical Process Control: An Introduction to Theory and Practice-George Stephanopoulos, pHI, 1st ed., 1984.
3. Industrial Instrumentation-D. P. Eckman, Wiley Eastern Ltd., 1st ed., 2004.

References:

1. Principles of Industrial Instrumentation-D. Patranabis, Tata McGraw Hill, Publishing Ltd., 1st ed., 1999.
2. Process Dynamics and Control-D.E. Seborg, T.F. Edgar, and D.A. Mellichamp, John Wiley & Sons,2nd ed., 2004.
3. Industrial Instrumentation Fundamentals-A.E. Fribance, McGraw-Hill, Kogakusha, 1962.
4. Process Control Modelling, Design and Simulation-B. Wayne Bequette, Prentice Hall, 1957.
5. Process Modelling, Simulation and Control for Chemical Engineers-William L. Luyben, McGraw Hill, 1990.

Subject Name: Project Engineering					
Paper Code: CHEN 3202					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**0**	**0**	**3**	**3**

Module I: 10L

Role of a Project Engineer, Development of Laboratory bench scale experiment to pilot & semi-commercial plant operation, scale up and scale down techniques, pre-design cost estimations, fixed capital and working capital, manufacturing cost, plant location and plant lay out, plant utilities, safety measures.

Time value of money, simple interest, nominal and effective interest rates, compound and continuous interest, present worth and discount, annuity, perpetuity and capitalized costs, Pay out period.

Module II: 10L

Depreciation: Types of depreciation, Depletion, concepts of service life, salvage value, and book value, straight-line method, Declining balance method, sum of the years digit method and sinking fund method for determination of depreciation, modified accelerated cost recovery system (MACRS),

Alternative investment, Choices among various alternatives, Replacements, Methods of profitability evaluation for replacements, Return on investment, Net present worth (NPW), Discounted cash flow rate of return (DCFR), Effect of inflation on profitability, income taxes, GDP and national growth..

Module III: 10L

Optimum Design and Design strategy: Basic principle of Optimum Design, general procedure for determining optimum conditions, Breakeven analysis, Optimum production rate in plant, determination of optimum economic pipe diameter and optimum flow rate in condenser, minimum cost analysis, economics in selection of materials.

Basic concepts of process integration, Pinch analysis.

Module IV: 10L

Project scheduling: Bar chart, Milestone chart, Concept of network analysis: Numbering network, PERT, CPM, statistical distribution associated with PERT network, Earliest expected time and latest allowable occurrence time calculation, Slack, determination of critical path, concept of float.

Text Book:

1. Plant Design and Economics for Chemical Engineers -- Peters and Timmerhaus and West, Mc Graw Hill, 5th Ed., 2003
2. PERT and CPM – Principles and Applications, Affiliâted East West, 3rd Ed., 1989

References:

1. Chemical Engineering Design – Coulson and Richardson, Volume 6, Elsevier, 5th Ed., 2009

Subject Name: Chemical Process Technology II					
Paper Code: CHEN 3203					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**0**	**0**	**3**	**3**

Module I : 10 L
Oils and Fats : Elementary idea, Composition (Fatty acid profile), Methods of extracting vegetable oils; Hydrogenation of oils, Major engineering problems and improved technology; Transesterification and Interesterification through enzymatic route; their applications.

Soaps, Detergents & Glycerin : Classification of cleansing compounds, uses; Methods of soap production, Methods of detergent manufacture, Methods of production of Glycerin (Process description and flow sheet of each process).

Module II: 10 L
Sugar and starch industries: Manufacturing process of sugar with flow diagram, Sugar refining, Manufacturing process of starch and their different by-products; Glucose, Sorbitol and Polyols. Fermentation industries: Industrial alcohol, Absolute alcohol, their production processes with flow diagram.

Agrochemical industries: Elementary ideas on Pesticides, Insecticides, Fungicides, Herbicides, DDT manufacturing process with flow sheet.

Module III: 10 L
Organic synthesis: nitration, sulfonation, amination, halogenation, hydrolysis with examples. Petrochemicals: Methanol, Vinyl chloride, Ethylene oxide, Isopropanol, Butadiene, Phenol and Pthalic anhydride – their manufacturing process with flow diagram and engineering problems

Paints & pigments: Domestic and industrial paints- their compositions including ingredients and additives in relation to their applications – Paint manufacturing processes.

Module IV: 10L
Polymerisation: Principles of polymerization, Different methods of polymerization, manufacturing process and flow diagram for Polyethylene, PVC and Phenol formaldehyde. Rubber industry: Natural and synthetic rubber (SBR, Butyl rubber). Synthetic Fibre industry: Rayon, Nylon, Terelyne – Methods of production and flow diagrams.

Polymer forming processes- their suitability for the type of polymer feedstock and the size and shape of the products.

Text books:

2. Shreve's Chemical Process Industries – R. N. Shreve, G. T. Austin, McGraw Hill, Ed. 5, 1984.
3. Dryden, C. E., and Rao, M.G. (Ed.), Outlines of Chemical Technology Affiliated East West Press

References:

1. Enzymes in Food Processing: Fundamentals and Potential Applications – P. S. Panesar, S. S. Marwaha, H. K. Chopra, I. K. international Publishing House Pvt. Ltd., 2010.

Subject Name: Mathematical Methods in Chemical Engineering					
Paper Code: CHEN 3204					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**1**	**0**	**4**	**4**

Module I : 10L
Solution of linear algebraic equations; Matrix series; Differentiation & Integration of matrix; Lamda matrix; Characteristics equation; Eigenvalue Problem; Solution of systems of linear differential equations by matrix. Representation of the problems: Solvent extraction in two stages, Solvent extraction in N stages, Simple water still with preheated feed, unsteady state operations; Dependent and Independent variables and parameters; boundary conditions.

Linear & simultaneous differential equations, related problems. Series and parallel reactions in CSTR.

Module II : 10L
Solution by series: Introduction; Infinite series; Power series; Method of Frobenius and Related problems: Temperature distribution in a transverse fin, Tubular gas preheater; Bessel's Equation, Problem of heat loss through pipe flanges, properties of Bessel function.

Module III : 10L
Partial differentiation & Partial Differential Equations: Introduction; Interpretation of partial derivatives, Formulation of partial differential equations; Boundary conditions; Particular solutions of partial differential equations; Orthogonal functions; Method of separation of variables; Laplace transform method.

Module IV: 10L
Boundary layer theory; Applications in Laminar Flow along a flat plate; Forced Convection heat transfer in a sphere in creeping flow. Diffusion and Chemical reaction in isothermal laminar flow along a flat plate.

Textbook:

1. Mathematical Methods in Chemical Engineering – V.G. Jenson and G.V. Jeffreys, Academic Press, 2nd Edition
2. Advanced Engineering Mathematics - Michael D. Greenberg, Pearson Publisher 1998.
3. Transport Phenomena - R. Byron Bird, Warren E. Stewart and Edwin N. Lightfoot, John Wiley & Sons, Inc, 2nd edition, 2006.

Professional Elective II

Subject Name: Nanotechnology					
Paper Code: CHEN 3231					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**0**	**0**	**3**	**3**

Module I : 10 L
Introduction to the physics of solid state; Structure & Bonding.
Elements of nanoscience & nanotechnology.

Module II : 10 L
Synthesis of nanomaterials: General approaches, Physical Methods, Chemical Methods & Biological Methods;

Properties of nanomaterials: Mechanical, Structural, Thermal, Electrical & Optical properties.

Module III : 10 L
Characterization techniques of nanomaterials: Microscopy; Spectroscopy; & Diffraction techniques; Some special nanomaterials: Carbon nanotubes, Porous silicon, Zeolites, Aerogels, Core-shell nanoparticles.

Module IV : 10 L
Application: Nanolithography, Nanocomposites, Nanoparticles as catalyst, conducting polymers; nanotechnology: DNA Nanowires, Nanomedicines.

Text book:

1. NANOTECHNOLOGY: Principles & Practices; Sulabh K. Kulkarni, Springer International Publishing, 2015

Professional Elective II

Subject Name: Computational Fluid Dynamics					
Paper Code: CHEN 3232					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**0**	**0**	**3**	**3**

Module I : 10 L
Conservation Principles – Convervation of Mass, Momentum, Energy in dimensional and non-dimensional forms – Lagrangian and Eulerian forms ; Conservative and Non-conservative forms of transport equations ; Equations – Elliptic, Parabolic and Hyperbolic Understanding the convection and diffusion terms ; Generalized Advection-Diffusion Equation with source term Initial condition and Boundary conditions (three kinds).

Module II : 10 L
Concept of discretization – Taylor series FDM and CV based FVM – one-dimensional unsteady state heat diffusion equation - Treatment of boundary conditions; Numerical solution of PDE - Explicit method – Stability – Convergence – Consistency ; Direct Method - Thomas (Tri-diagonal Matrix) Algorithm. Iterative method - ADI method. Coupled Equation and Their Solution.

Module III : 10 L
Interpolation in Finite Volume Methods. Discretization of the convection term - Upwind scheme - Central Difference scheme - Hybrid scheme - Power law scheme. Special Featuers of the Navier Stokes Equation - Discretization of Convective and Viscous Terms, Discretization of Pressure Terms and Body Forces. Arrangment on Grid – Colocated and Staggered Arrangement. Multigrid Methods.

Module IV: 10 L
Methods for Unsteady Problems. Calculation of Pressure – Explicit and Implicit Time Advance Schemes. Pressure Correction Methods.
Evaluation of pressure from Equation of Continuity ; Velocity correction ;SIMPLE Algorithm – Residues in solution – Relaxation Iterative scheme – Over and under relaxation - quick updation ; Discussion on SIMPLER, SIMPLE-C .
Other methods – Artificial Compressibility method.

Test Books/ References:

1. Numerical Heat Transfer and Fluid Flow: S V Patankar. Taylor & Francis (Paperback Ed)
2. Computational Fluid Mechanics and Heat Transfer: J C Tannehill, D A Anderson and R H Pletcher. Taylor & Francis (1997)

3. Computational Methods for Fluid Dynamics: J H Ferziger and M Peric. Springer-Verlag (1999)

Professional Elective II

Subject Name: Bioprocess Engineering					
Paper Code: CHEN 3233					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**0**	**0**	**3**	**3**

Module I : 10 L
Principles of enzyme catalysis Proteins as enzymes; Michaelis-Menten kinetics; Briggs Halden theory Kinetics and Statistics; Inhibition; Effect of pH and temperature; Enzymology; methods of immobilization, diffusional limitations in immobilized enzyme systems.

Module II : 10 L
Microbial growth Introduction to metabolism; Nutrient transport; Glycolysis; TCA cycle and other pathways; Control of metabolism; Factors affecting microbial growth; Stoichiometry: mass balances; Stoichiometry: energy balances; Growth kinetics; Measurement of growth.
Agitation and aeration**:** types of impellors and sparger, oxygen transfer rate,
oxygen uptake rate, volumetric oxygen transfer rate (kLa), measurement of k_La,
power requirement for agitation in gaseous and non gaseous systems.

Module III : 10L
Bioreactors Introduction to bioreactors; Batch and Fed-batch bioreactors, Continuous bioreactors; Immobilized cells; Bioreactor operation; Sterilization; Aeration; Sensors; Instrumentation; Culture-specific design aspects: plant/mammalian cell culture reactors.
Scale up, operation and control of bioreactors**:** Concepts of various bioreactor configurations, scale-up, various criteria for scale-up, scale-down, bioreactor instrumentation and control.

Module IV : 10 L
Bioseparations Biomass removal; Biomass disruption; Membrane-based techniques;
Extraction; Adsorption and Chromatography.
Industrial Processes and Process economics Description of industrial processes; Process flow sheeting; Process economics.

Texts/References:

1. Michael Shuler and Fikret Kargi, Bioprocess Engineering: Basic Concepts, 2nd Edition, Prentice Hall, Englewood Cliffs, NJ, 2002.
1. Pauline Doran, Bioprocess engineering principles, 1 Edition, Academic Press, 1995.
2. Biochemical Engineering, Marcel Dekkar, Inc, 2007

3. Roger Harrison et al., Bioseparations Science and Engineering, Oxford University Press, 2003.

Subject Name: Principles of Management					
Paper Code: HMTS-3201					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	2	**0**	**0**	**2**	**2**

Module 1: 4L
Management: Definition, nature, purpose and scope of management, Skills and roles of a Manager, functions, principles; Evolution of Management Thought: Taylor Scientific Management, Behavioral Management, Administrative Management, Fayol's Principles of Management, Hawthorne Studies.

Module II : 8L
a) Planning: Types of plans, planning process, Characteristics of planning, Traditional objective setting, Strategic Management, premising and forecasting.
b) Organizing: Organizational design and structure, Coordination, differentiation and integration.
c) Staffing: Human Resource Management and Selection, Performance appraisal and Career strategy, Managing Change.
d) Decision-Making**:** Process, Simon's model of decision making, creative problem solving, group decision-making.
e) Coordinating: Concepts, issues and techniques.
f) Controlling: Concept, planning-control relationship, process of control, Types of Control, Control Techniques .

Module III : 4L
Span of management, centralization and de-centralization Delegation, Authority & power - concept & distinction, Line and staff organizations.

Module IV: 8L
Organization Behaviour**:** Motivation, Leadership, Communication, Teams and Team Work**.**
Management by Objectives (MBO): Management by exception; Styles of management: (American, Japanese and Indian), McKinsey's 7-S Approach, Self Management.

Evaluation:
Max. Marks-100
Internal Test-30
Semester End Test-70

Suggested Readings:

1. Harold Koontz & Heinz Weihrich, Essentials of Management, TMH.
2. Stoner, Freeman, Gilbert Jr., Management, PHI.
3. Bhatt & Kumar, Principles of Management, OUP.

LABORATORY

Subject Name: PEDD II					
Paper Code: CHEN 3211					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	**0**	**4**	**4**	**3**

1. Design and Drawing of Heat Exchanger.

2. Design and Drawing of Orifice meter / Venturi meter/ Rotameter (Anyone).

Text Book / References:

1. Process Equipment Design – Brownell and Young, John Wiely and sons.

2. Chemical Engineering Design, Fourth Edition: Chemical Engineering Volume 6 (Coulson & Richardson's Chemical Engineering) 4th Edition - by R K Sinnott (Author), Butterworth-Heinemann; 4 edition.

Subject Name: Numerical Methods Laboratory					
Paper Code: CHEN 3212					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	**0**	**3**	**3**	**2**

Module- I: Numerical Methods (Programming language: Matlab)

1. Solution of Linear System by Gauss Elimination method and Gauss-Seidel iterative method: Steadystate solution of isothermal CSTR in Series in which a first-order reaction is taking place.
2. Solution of a non-linear equation by Newton-Raphson method.

3. Solution of a set of non-linear equations by Newton method: steady-state solution of a non-isothermal CSTR in which a first-order reaction is taking place.

4. Solution of one-dimensional unsteady state heat conduction problem using Taylor series based Finite Difference Method – Explicit scheme, Implicit scheme using Tri-diagonal Matrix Algorithm (TDMA).
5. Numerical solution of ODEs by Runge-Kutta method : Unsteady-state solution of Multiple reactions in a CSTR or Binary distillation column.

SESSIONAL

Subject Name: Personality Development					
Paper Code: HMTS 3221					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	**0**	**1**	**1**	**1**

Module I : 1L/week
Self-Growth
i) Self Growth- Maslow's Hierarchy of Needs Theory
ii) Anger, Stress & Time Management- Theories and application
iii) SWOT Analysis

Module II : 1L/week
Stepping Up
i) Growth & Environment
ii) Competitive Spirit
iii) Responsibility Factor

Module III : 1L/week
Professional Communication
i) Impression Management- theory on social psychology
ii) Employability Quotient
iii) Cross-cultural communication

Module IV: 1L/week
Leadership & Team Playing
i) Leadership & Team Playing: Theories, Styles, Stages
ii) Motivation, Negotiation Skills, Conflict Management
iii) Planning & Envisioning: Initiative and Innovation in the Work Environment- De Bono's Six Thinking Hats

Methodology: Assignment and project

Suggested Reading:

1. Personality Development and Soft Skills by Barun K. Mitra, Oxford University, 2011
2. Soft Skills: An Integrated Approach to Maxmise Personality by Gajendra Singh Chauhan and Sangeeta Sharma, Wiley, 2016
3. The Ace of Soft Skills: Attitude, Communication and Etiquette for Success by Gopalaswamy Ramesh and Mahadevan Ramesh, Pearson, 2010

Subject Name: Seminar I					
Paper Code: CHEN 3221					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	**0**	**0**	**0**	**2**

A Seminar topic will be allotted to individual student according to his/her subject of interest. A thorough report should be prepared based on which seminar presentation and question-answer session will be conducted. Assessment of the student would be done by the faculty members on the basis of presentation, performance in the question - answer session and the report submitted, giving equal weightage on each component.

Semester 7

THEORY

Subject Name: Transport Phenomena					
Paper Code: CHEN 4101					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**1**	**0**	**4**	**4**

Module I : 10L
Concept of unified approach to Momentum, Heat and Mass Transport through Transport Phenomena - Assumptions of Transport phenomena; Similarity of Mass, Momentum and Energy transfer, momentum, heat and mass diffusivities, momentum, heat and mass transport theorem

Review of vectors & Tensors: Vector operation from geometrical view point, Dot and Cross product of vectors, multiple product of vectors, unit vectors, Tensor operation in terms of components, the unit dyads, dyadic product, scalar product of tensors, tensor product of tensors, vector product of tensor, vector tensor differential operation.

Module II : 10L
Newton's law of viscosity, pressure and temperature dependence of viscosity, shell momentum balance and boundary condition, Equations of Continuity and Motion in rectangular (Cartesian) coordinate system, Expression of stress tensor for Newtonian and non-Newtonian fluids; Special forms of equation of Motion – Euler equation, Navier-Stokes equation, Concept of hydrodynamic boundary layer and boundary layer equation. Concept of turbulence, velocity distribution in vertical falling film, velocity distribution in laminar and turbulent flow through a tube, concept of friction factor and drag coefficient

Module III : 10L
Fourier law of heat conduction, temperature and pressure dependence of thermal conductivity, shell energy balance and boundary condition, energy equation in rectangular (Cartesian) coordinate system, Use of the Energy equation – Unsteady state heat conduction in finite and semi-infinite slabs, concepts of thermal boundary layer and thermal boundary layer equation, temperature distribution during film condensation on vertical surface, temperature distribution in laminar and turbulent flow through a tube, concept of heat transfer coefficient

Module IV : 10L
Fick's law of molecular diffusion, temperature and pressure dependence of diffusivity, shell mass balance and boundary condition, equation of continuity for a multicomponent mixture in rectangular (Cartesian) coordinate system, unsteady state diffusion through finite and semi-infinite slab, concepts of concentration boundary layer and boundary layer equation, concentration distribution during mass transfer through falling film, use of equation of

change for mixtures- simultaneous heat and mass transport, concentration profile in tubular reactor, catalytic gas phase reactive system, concept of mass transfer coefficient.

Text Book:

1. R. Byron Bird, Warren E. Stewart and Edwin N. Lightfoot, Transport Phenomena, Wiley, Revised 2nd Edition,

References:

1. R.S.Brodkey and H.C. Herskey, Transport Phenomena, McGraw- Hill, 1988.
2. C.J. Geankoplis, Transport Processes and Unit Operations, Prentice Hall of India, III Edition, 1993.
3. S.C. Roy and C. Guha, Introduction to Transport Phenomenon, Dhanpat Rai & Co., 2014.

Subject Name: Modeling Simulation and Optimization					
Paper Code: CHEN 4103					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**0**	**0**	**3**	**3**

Module 1 : 10 L
Principles and methods of steady state flowsheet simulation, Principles and methods of of batch flowsheet simulation. Heuristics for process synthesis in : Distribution of Chemicals, Separations, Heat removal from and addition to reactors, Heat exchanges and furnaces; Optimal design of batch process units : design of reactor-separator process, design of single product process.

Module II : 10L
Reactor design and reactor network synthesis: Reactor Models for stoichiometry, extent of reaction, equilibrium, kinetics. Ideal kinetic reactor models for CSTR and PFR. Example Problems. Reactor design using the attainable region: construction of attainable region, principle of reaction invariant.

Module III : 10 L
Synthesis of separation trains: Criterion for selection of separation methods; selection of separation equipment for absorption, stripping and distillation, liquid-liquid extraction, membrane separation, adsorption, leaching, crystallization and drying; Sequencing of distillation column for the separation of nearly ideal fluid mixture; separation of systems for gas mixtures.

Module IV: 10 L
Optimization of Process flow sheet - General formulation of the optimization problem; Linear programming, Non-linear programming with a single variable ; Conditions for NLP with gradient method for two or more decision variables; Optimization algorithm ; Flowsheet optimization – case studies.

Text Books:

1. W. D. Sieder, J. D. Seader and D. R. Lewin, Product and Process Design Principles, John Wiley and Sons, 3rd edition, 2008

References:

1. H. Scott Fogler, Elements of Chemical Reaction Engineering, Prentice Hall International. Series, 3rd Edition. 1999
2. J.D. Seader, Earnest J. Henley, D. Keith Roper, Separation Process Principles, 3rd Edition. 2013.
3. Thomas F. Edgar and David. M. Himmelblau, Optimization of Chemical Processes,
2. McGraw-Hill Higher Education; 2nd Edition. 2001.

Professional Elective III

Subject Name: Reactor Design					
Paper Code: CHEN 4141					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**0**	**0**	**3**	**3**

Module I : 10L
General Requisites of the study: Stoichiometry, Rate equations, Effect of temperature on reaction rate by Arrhenius, Collision and Transition State Theory, Basic methods of Evaluation of kinetic parameters by differential, integral and half life methods with reference to Constant volume and variable volume problem.

Reactors: Types of reactors, Advantages and Disadvantages, Reactor Selection, Applications Homogeneous Reactor Design: Formulation of ideal reactor design equations for simple models of batch, mixed flow and plug flow reactors.

Module II : 10L
Combination of reactors of various types in either series or parallel operation Selection of proper contacting patterns for multiple reactions occurring in either series or parallel

Description of heterogeneous catalytic reactors, e.g. packed bed reactor, tubular reactor, mixed flow reactor, slurry reactor, trickle bed reactor.

Design of heterogeneous catalytic reactors: calculation of catalyst requirement, flow regimes, pressure drop. Design of Fluidized Bed Reactor.

Module III : 10L
Basic Principles applied in Bio Reactors – Enzyme Kinetics based upon Rapid Equilibrium and Quasi Steady State Assumptions, Evaluation of Kinetics parameters.

Design of bioreactors with emphasis on Cell growth kinetics, Substrate limited growth, the logistic equation, rate loss, stoichiometry, mass balances, design equations, numerical problems, wash out, oxygen limited fermentation, scale up concepts of bio-reactors, chemostat and its applications.

Module IV: 10L
Reactor Internals: component and use.
Evaluation of conversion in non ideal reactors from RTD study using experimental data and model equations. Introduction to non isothermal reactor design, Energy balance equations for batch and flow reactors, Evaluation of batch and flow reactor volumes for adiabatic reaction.

Reactor Safety and Runway Reaction

Text Books:

1. J.M, Smith, Chemical Engineering Kinetics, Mc-Graw Hill, 3rd Edition.
2. H. Scott Fogler , Elements of Chemical Reaction Engineering, Prentice Hall India, 4th Edition
3. Shuler, Michael L., Kargi, Fikret, Bioprocess Engineering, Pearson Education, 3rd Edition, (2015).

References:

1. O. Levenspiel, Chemical Reaction Engineering, Wiley Eastern Ltd., 2nd & 3rd Editions
2. J.B. Rawlings, J.G. Ekerdt, Chemical Reactor Analysis and Design Fundamentals, Nob Hill Publishing, 2nd Edition.
3. C.G. Hill, Introduction to Chemical Engineering Kinetics And Reactor Design, Wiley 1977
4. L.D. Schmidt, The Engineering of Chemical Reactions, Oxford University Press, 2nd Edition

Professional Elective III

Subject Name: Industrial Safety and Hazard Analysis					
Paper Code: CHEN 4142					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**0**	**0**	**3**	**3**

Module I : 10L
Definition of safety, Hazard and Risk, Safety program, Engineering ethics, Inherent safety, Safety regulations, OSHA, Process safety management, Hazards due to fire, explosions and toxic chemicals, Distinction between fire and explosion, Upper Flammability limit and Lower Flammability Limit, Fire Triangle, BLEVE, Runaway reaction.

Module II : 10L
Tools for hazards identification: HAZOP, Fault Tree, Event Tree, FMEA, Dow Fire and Explosion Index, Mond Index. .

Module III : 10L
Risk analysis concept and methodology: Risk concept and measure of risk, Risk acceptance criteria, Quantitative risk analysis, Probit number.

Module IV: 10L
Control of chemical plant hazards, Intensification and attenuation of hazardous materials, Industrial plant layout, Ventilation, Fire prevention, Personnel protection devices, Laboratory safety, Emergency safety, Safety systems and disaster management. Case studies, Flixborough (England), Bhopal (India), Seveso (Italy), Pasadona (Texas)

Text Book:

1. D.A. Crowl and J.F. Louvar, Chemical Process Safety: Fundamentals with Applications:, Prentice Hall, 1990

References:

1. O.P. Kharbanda, E. A Stallworthy, Safety in Chemical Process Industries: Heinmann
2. Professional Publishing LTD.1988
3. C.A. Wentz, Hazardous Waste management: Mc-Graw Hill, ISBN-13: 978-0070692916
4. S.L Cutter. Environmental Risks & Hazards, Prentice Hall,1994
5. Trevor A. Kletz, What went wrong? Case Histories of Process Plant Disasters and How They Could Have Been Avoided,5th Edition, ISBN: 978-1-85617-531-9

Professional Elective III

Subject Name: Advanced Separation Process					
Paper Code: CHEN 4143					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**0**	**0**	**3**	**3**

Module I : 10 L
Basic membrane separation process: Size exclusion based membrane separation process (Microfiltration, ultrafiltration, nanofiltration, reverse osmosis); transport equations (concept of knudsen diffusivity and molecular diffusion); Type of membrane and fabrication of membrane (Inorganic and organic); overview on phase inversion technique; Difference, between symmetric membrane and composite membrane in view of the mechanical properties of the membrane; Membrane characterization techniques; Applications of different membrane modules and a concept of shear enhanced membrane modules like VSEP.

Module II : 10L
Advanced membrane separation processes: Concept of dialysis and fabrication of dialysis membrane; Understanding VLE and its application in pervaporation and membrane distillation; difference with gas separation technique; Concept of chromatographic separation techniques like gel filtration model ; Overview on membrane chromatography process.

Module III : 10 L
Advanced membrane separation process based on liquid membrane: Role of surfactants and types of surfactants, emulsion preparation, concept of HLB; Preparation of emulsion liquid membrane – Emulsion membrane, Bulk liquid membrane, and supported liquid membrane; Development of transport equation; Concept of micelle; Overview of micelle enhanced ultrafiltration process and its application overview.

Module IV: 10 L
Concept of isoelectric point and its importance in protein separation; Basics of electrophoresis – Detailed elaboration on vertical and horizontal electrophoresis side-by-side; Basic overview on isoelectric point focusing (IEF) techniques and its application in protein separation; Basic difference between ion-exchange chromatography and IEF techniques.

Text Books:

1. J.D. Seader, Ernet J. Henley and D. Keith Roper, Separation Process Principles, Wiley Publication, 1997.
2. Vladimir S. Kislik (Ed.), Liquid Membranes, Principles and Applications in Chemical Separations and Wastewater Treatment, Elsevier Publication, 2009.
3. Elsa Lundanes, Leon Reubsaet and Tyge Greibrokk, Chromatography Basic Principles, Sample Preparations and Related Methods, Wiley Publication, 2013.

References:

1. P.M. Bungay, H.K. Lonsdale and M.N. de Pinho, Synthetic Membranes:: Science, Engineering and Applications, Springer, 1986.
2. W. S. W Ho and K. K. Sircar, Membrane Handbook, Springer, 1992.
3. Kaushik Nath, Membrane Separation Processes, Prentice Hall Learning Pvt. Ltd., 2008.
4. Munir Cheriyan, Ultrafiltration and Microfiltration Handbook, CRC Press, 1998.
5. K. Wilson and J. Walker, Principles and Techniques of Practical Biochemistry, Cambridge Univ. press, 2000.

LABORATORY

Subject Name: Instrumental Methods of Analysis Laboratory					
Paper Code: CHEN 4112					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	**0**	**3**	**3**	**2**

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At least any six of the following experiments are to be performed

1. Determination of Turbidity of Water using Nephelo Turbidity Meter.
2. Construction of standard curve (Absorbance vs. concentration) of a pure protein by Folin's Method using Spectrophotometer.
3. Determination of Fe3+ by Colorimeter Method.
4. Determination of Dissolved Oxygen from water by DO Meter.
5. Kinetic study of a Biochemical Reaction by UV Spectrophotometer.
6. Estimation of mixture of Ethanol & Water by Abbe Refractometer.
7. Determination of concentration of any optically active substance in presence of non-active species by a Polarimeter.
8. Determination of TDS of water sample by Conductivity Meter.
9. Demonstration of analysis of gas mixtures by Gas Chromatography.
10. Demonstration of analysis of liquid mixture using HPLC.
11. Determination of functional groups in the solid/liquid using FTIR.

Subject Name: Process Control Laboratory					
Paper Code: CHEN 4113					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	**0**	**3**	**3**	**2**

At least any eight of the following experiments are to be performed

1. Study on the dynamic characteristics of first order liquid level system.
2. Study on the dynamic characteristics of U-tube manometer (second order system).
3. Study on the dynamic characteristics of compound (interacting) second order system.
4. Study on the dynamic characteristics of compound (non-interacting) second order system.
5. Study on the response of controlled variable for a feedback control system with P, PI & PID controller.
6. Study on the flow characteristics and determination of discharge coefficient for different type pneumatic control valves.
7. Experiment on calibration of a load cell.
8. Liquid level measurement using air-purge method.
9. Determination of time constant of thermocouple during temperature measurement.
10. Experiment on calibration of pressure gauge using Dead-weight tester.
11. Experiment on flow measurement using wet gas meter.

SESSIONAL

Subject Name: Project –I					
Paper Code: CHEN 4191					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	**0**	**6**	**6**	**4**

Each student shall be required under the supervision of a faculty to carry out a project work or investigation on an industrial research problem. The project/research work has to be carried out by the student himself occasionally consulting his supervisor. The project/research problem will be allotted to the student at the beginning of the seventh semester indicating the jobs to be done by the student. The report in duplicate has to be submitted in typed and bound form one week before the commencement of the VIIth semester examination. The examination shall include oral presentation of the research work and a viva-voce before a committee of at least two members of faculty appointed by the HOD including the Supervisor. Equal weightage shall be given on oral presentation and viva voce.

Subject Name: Industrial Training					
Paper Code: CHEN 4131					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	-	**-**	**-**	**-**	**2**

Students sent for Industrial Training during Summer Recess after 6th Semester for a minimum duration of four weeks will submit two copies of Training Report (only Hard /Spiral bound is allowed) on or before a notified date, to the Faculty In-charge, In-plant Training. The Viva voce would be held before commencement of Practical Examination. Report should consist of:

1. Copy of Training Certificate & allotment order (if any)
2. A general overview of the Plant.
3. The products and raw material sources of the Plant.
4. Process description/flow diagram of individual units
5. Environment & Safety Aspects, Techno-economics /Corporate Social Responsibility work of the organization if any.
6. For Training in R & D organizations/project Work, overview of work with sketches, Objectives, Materials & Methods, Result & Discussions are to be included instead of items mentioned in points 2-5.

Subject Name: Seminar II					
Paper Code: CHEN 4132					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	**0**	**0**	**3**	**2**

A Seminar topic will be allotted to individual student according to his/her subject of interest. A thorough report should be prepared based on which seminar presentation and question-answer session will be conducted. Assessment of the student would be done by the faculty members on the basis of presentation, performance in the question - answer session and the report submitted, giving equal weightage on each component.

Subject Name: Professional Development					
Paper Code: HMTS 4121					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	**0**	**0**	**3**	**2**

Module I:Professional Growth
Goal Setting- Characteristic of goals, Short-term and long-term goals, Goal-achievement timeline
Skill identification and Skill up gradation- Washington Accord and Skills for engineers (generic and specific), Local and global skills, Knowledge sources such as MOOC, NPTEL
Career Planning- Vision and mission, Skill mapping to job profile, Basic and add-on qualifications, Career growth, Self-appraisal, Lifelong learning
Assessment - Activity

Module II:Entrepreneurship
The start-up ecosystem in India- Why entrepreneurship?, Indian tech start-up landscape, Stand-up India policies, funding agencies, market development, trends and best practices
E-Commerce- India as a growing E-commerce market, Possibilities of growth, funding, niche retailers
Make in India- New processes, Investments, Focus sectors, Makers of Make In India, Opportunities, Policies
Assessment-Project (30 marks)

Module III: Industry specific opportunities
Industry prospects in India and Beyond
Industry-specific job opportunities
Research & Development
Other opportunities
Assessment---Presentation

Module IV:Working and living happily
Managing crisis- Organisational and personal crisis, Analysing crisis, Turnaround strategies, Learning from crisis as opportunity
Work-life balance- Performance-expectation management, Personal and professional goal-mapping
Understanding happiness- Components, Conflicts, Happiness Index
Assessment: Activity/case

Suggested Reading:
1. Basic Managerial Skill for All by E. H. McGrath.SJ. Pub:PHI, New Delhi.
2. The Start-up Equation by Steven Fisher and Jae-Nae Duane. Pub: Mc Graw Hill Education (India) Pvt. Ltd. New Delhi.

3. Live Happily, Work Happily by Siddhartha Ganguli. Pub: Allied Publishers Pvt.Ltd. New Delhi.
4. Crisis Management: Planning for the Inevitable by Steven Fink. Pub: iUniverseInc.USA.
5. Influencer:The New Science of Leading Change by Joseph Grenny&Kerey Patterson. Pub:McGraw Hill Education , USA.

THEORY
Semester 8

Professional Elective IV

Subject Name: Catalysis & Catalytic Reactor Design					
Paper Code: CHEN 4241					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**0**	**0**	**3**	**3**

Module I : 10L
Introduction to homogeneous and heterogeneous catalysis, Factors affecting heterogeneous catalytic reaction; Methods for finding rates- Integral Analysis, Differential Analysis
Types of catalytic Reactor- Differential Reactor, Integral Reactor and their performance equations.
Pore diffusion resistance combined with surface Kinetics. Concept of Thiele modulus and Weisz modulus, Concept of effectiveness factor.

Module II : 10L
External mass and heat transfer in catalyst particles. Design of Packed bed reactor, fluidized bed reactor, Basket type reactor. Description of slurry reactor; Trickle bed reactor.
Diferent steps in a catalytic reaction, Langmuir adsorption isotherm
Catalysis mechanism; Langmuir-Hinshelwood mechanisms, Eley –Rideal mechanisms
Enzyme kinetics: Michaelis and Menten equation, Briggs Halden equation, numerical problems on enzymatic reactions

Module III : 10L
Determination of Catalyst surface area and particle size; Brunauer, Emmett, Teller (BET) equation, Concept of void volume and solid density-Helium mercury method. Pore volume Distribution-mercury penetration method, Nitrogen desorption method.
General methods for preparation of catalysts: precipitation, sol-gel, mixing components with water milling, impregnation, Concept of Promoter & Inhibitor;

Module IV: 10L
Catalyst Deactivation: Fouling and poisoning; Mechanisms of Catalyst Deactivation, Rate equation, activity of catalyst, Parallel deactivation, Series deactivation, Side by side deactivation, independent deactivation.
Biocatalyst and Bioreactor Design:
Cell growth kinetics, Substrate limited growth, the logistic equation, rate loss, stoichiometry, mass balances, design equations, numerical problems, oxygen limited fermentation, scale up concepts of bio-reactors, chemostat and its applications, Wash Out, continuous culture devices, case studies on penicillin production.

Text Books

1. O. Levenspiel, Chemical Reaction Engineering; 3rd. ed. Wiley Eastern Ltd.1998
2. H. Fogler, Elements of Chemical Reaction Engineering, 4th. Ed. Prentice Hall of India, 2005
3. J.M. Smith, Chemical Engineering Kinetics, 3rd.ed. McGraw Hill.1981

References:

1. James J Carberry, Chemical and catalytic reaction engineering, McGraw Hill.2001
2. G.F Froment., K.B Bischoff, Chemical Reactor Analysis and design-.; John Wiley & Sons.1979
3. Lanny D Schmidt, The Engineering of Chemical Reactions-; Oxford University Press.2004

Professional Elective IV

Subject Name: Total Quality Management					
Paper Code: CHEN 4242					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**0**	**0**	**3**	**3**

Module I : 10L
Basic concepts– Three paradigms of management and evolution of concept of quality management, Organization: its basic objectives and goal, Mission and Vision, customer and secondary customer, Deming's wheel, bottom line: profit vs quality, historical defilements: Juran, Deming, Ischikawa and Taguchi, Kaizen, JIT. Basic statistical concepts associated with quality management, measurement of central tendency and dispersion, range versus variance, quality and process capability, probability distributions, concept of statistical quality control.

Module II : 10L
Use of control charts and process engineering techniques for implementing the quality plan: X—R chart, moving average chart, p-chart, c-chart and control chart for continuous production Acceptance sampling: single–double and multiple sampling, AOQ, AQL, LTPD, Chain sampling plan, Dodge-Romig plan.

Module III : 10L
Tools and techniques for improvement in TQM: type A techniques with a special reference to FPC & FD, QFD, SWOT analysis; type B techniques with a special reference to brainstorming, stratification, Ischikawa diagram, check sheet, Pareto diagram Philosophy and concept of quality circle: formation, steering committee, power and functions of leader, dy. Leader, coordinator, facilitator, case studies.

Module IV: 10L
Different standards: ISO, BS and Bureau of Indian Standards, details of ISO 9000 series, ISO 14000 series and SA 8000 and the certification authorities, productivity control management.

Text Books:

1. Statistical Quality Control, 6th Edition, by Eugene Grant and Richard Leavenworth, Mc-Graw Hill. 1996

References:

1. H. Lal Total Quality Management- A Practical Approach (1st Edition): New Age International, 1990
2. S R Udpa, Quality Circle 1981.
3. S. M. Sundararaju, Total Quality Management – A Primer: S. M. Sundararaju, Tata Mc- Graw Hill.
4. 4. Amitava Mitra Fundamentals of Quality Control and Improvement, 2nd Edition.; Prentice- Hall of India, 1998.
4. Subburaj Ramasamy, Total Quality management, Mc-Graw Hill Education (India) Pvt. Ltd, 2012.

Professional Elective IV

Subject Name: Environmental Engineering & Pollution Control					
Paper Code: CHEN 4243					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**0**	**0**	**3**	**3**

Module I : 10 L
Types of environments and their pollutants. Classification of pollutants. Legislative aspects including Bengal Smoke Nuisance Act, Water Act. 1974, Air Act 1981 and effluent standards, Genesis and Role of EPA

Air pollution : Sources and effects of different air pollutants, Sampling and analysis of air pollutants, Air pollution control methods and equipment, Cyclone Separator, Baghouse, ESP, Venturi Scrubber

Module II : 10 L
Water pollution: Sources, sampling and classification of water pollutants, determination of basic parameters and computations associated with: BOD, COD, TS, TDS, SS;

Waste water treatment: primary, secondary, tertiary and advanced; aerobic treatment with special reference to activated sludge, trickling filter, RBDC and RBRC, EA; non conventional: WSP, anaerobic treatment with special reference to AFFR, UASB

Module III : 10 L
Solid waste management: Sources and classification, public health aspects, Methods of collection and disposal methods: open dumping, landfill, incineration, composting, vermiculture; Solid waste management using bioremediation for specific pollutants like chromium. Mercury, ammonia / urea, phenolic sludges. Management and handling of Bio-medical waste; E-waste – classification and re-use and disposal; Hazardous waste management – Electro-chemical and photo-chemical oxidation - dye waste, chrome slag – case studies.

Module IV: 10 L
Pollution control in selected process industries – fertilizer industries, petroleum refineries and petrochemical units, pulp and paper industries, Tanning industries, Sugar industries, Dairy, Alcohol industries, Electroplating and metal finishing industries, Radioactive wastes, Root Zone and Reed Bed Treatment for Effluents of small scale industries, Ranking of wastewater treatment alternatives. Case Studies.

Text Books:

1. C.S. Rao, Environmental Pollution Control Engineering, New Age International, 2nd Edition,
2. Metcalf & Eddy, Wastewater Engineering, Tata Mc-Graw Hill - 2002
3. S.J. Arceivala, Wastewater treatment for pollution control, TMH, 2nd Edition

References:

1. S.P. Mahajan, Pollution Control in Process Industries, Tata Mc Graw Hill, 2008
2. M. Davis, Cornwell, D, Introduction to Environmental Engineering, Tata Mc Graw Hill, 2012
3. M. N. Rao, H V N Rao, Air Pollution, Tata Mc Graw HilL, 2007
4. Standard Methods for Examination of Water and Wastewater, APHA /AWWA, 20th Edition

Professional Elective IV

Subject Name: Operations Research – Engineering Applications					
Paper Code: CHEN 4244					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**0**	**0**	**3**	**3**

Module I: 8L
Introduction to Linear Programming Problem (LPP), Mathematical Requisites, Formulation of the problem related to Chemical Engineering. Graphical solution of Two and Three Variables of LPP, Different types of Solution, Canonical and standard Forms of LPP, Development of Simplex Method with examples, The Charnes' Big M Method with examples

Module II: 8L
Introduction to Transportation Problems, Balanced and unbalanced Transportation Problems, Formation of Basic Feasible Solutions with NW Corner rule, Optical Solution of Transportation Problems with examples, Assignment Problems – Introduction, Formulation and solution with numerical examples. Theories on Duality with numerical problems.

Module III: 8L
Dynamic Programming, its need, Formulation, problems and solution methodologies, Game Theory with problems and solution methodologies. Correlation and Regression. ANOVA – One way model; Response Surface Methodologies with numerical problems.

Module IV: 8L
Queuing Models – Development of Models (Model I, II and III only), Numerical Problems and their solution. l PERT & CPM: Development of Network Theory from Gantt/ Milestone Chart, Numbering the network, Calculation of Earliest Expected Time, Latest Allowable Occurrence time, Critical Path computation with problems.

Text Books:

1. K.V. Mittal and C Mohan, Optimization Methods in Operations Research and Systems Analysis, 3rd Ed. New Age International, 2004.
2. Douglas Montgomery, Design and Analysis of Experiments, John Wiley & Sons, Eighth edition.
3. L.S. Srinath, PERT & CPM – 3rd Ed, Affiliated East West Press.
4. K Swarup, P.K Gupta & Man Mohan Operations Research-–Sultan Chand & Sons, ISBN 13: 9789351610496.

References:

1. H.A. Taha, Operations Research- An Introduction-7th edition, - Prentice Hall of India.
2. Hillier, Lieberman, Nag and Basu, Introduction to Operations Research, TMH, Ninth Edition.

Subject Name: Organizational Behaviour					
Paper Code: HMTS 4201					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	2	**0**	**0**	**2**	**2**

Module I : 5L

Introduction to Organizational Behaviour-Concept, Importance, Challenges and Opportunities (1L)

Personality-Meaning of Personality, Personality Determinants and Traits, Psychoanalytic Theory, Argyris Immaturity to Maturity Continuum Impact on organization.(2L)

Attitude-Concept, Components, Cognitive Dissonance Theory, Attitude Surveys. (2L)

Module II : 6L

Perception- Concept, Nature and Importance, Process of Perception, Factors influencing perception, Perceptual Selectivity, Shortcuts to Judge Others: Halo Effect, Stereotyping, Projection and Contrast Effects, Impact on Organization. (2 L)

Motivation-Definition, Theories of Motivation-Maslow's Hierarchy of Needs Theory,McGregor's TheoryX&Y, Herzberg's Motivation-Hygiene Theory, Alderfer's ERG Theory, McClelland's Theory of Needs, Vroom's Expectancy Theory.(4L)

Module III : 8L

Leadership-Concept, Leadership Styles, Theories-Behavioural Theory: Ohio Studies, Michigan Studies, Blake & Mouton Managerial Grid; Contingency Theory: Fielder Theory. (4L)

Group Behaviour: Definition, Characteristics of Group, Types of Groups: Formal & Informal; Stages of Group Development, Group Decision making, Group Decision MakingVs Individual Decision Making. (4L)

Module IV : 5L

Organizational Design-Various organizational structures and their pros and cons.

Concepts of organizational climate and culture, Organizational Politics-Concept, Factors influencing degree of Politics (2L)

Conflict management- Concept,Sources of conflict, Stages of conflictprocess, Conflict resolution techniques,Tools-Johari Window to analyse and reduce interpersonal conflict, Impact on organization. (3L)

Suggested Readings:

1. Organization Behaviour by Stephen Robbins
2. Organization Behaviour by Luthans
3. Organization Behaviour by L.M. Prasad
4. Organization Behaviour: Text, Cases &Games by AswathappaK.

SESSIONAL

Subject Name: Project –II					
Paper Code: CHEN 4291					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	**0**	**8**	**8**	**8**

Each student shall continue to work on the project work/research problem allotted to him at the beginning of the seventh semester under supervision of a faculty member. After completion of all assigned jobs, the report in duplicate has to be submitted by the student in typed and bound form one week before the commencement of the eight semester (final) examination. The examination shall include oral presentation and viva voce giving equal weightage to both. The examination shall be conducted in presence of external expert and the student's supervisor.

Subject Name: Plant Design					
Paper Code: CHEN 4221					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	**0**	**4**	**4**	**4**

Each student shall be required to prepare a report on a topic of design under the supervision of a faculty. The design problem has to be solved by the student himself occasionally consulting his supervisor. The design problem shall b e allotted to the student at the beginning of the eighth semester. The report in duplicate has to be submitted in typed and bound form one week before the commencement of the 8^{th} (final) semester examination. The examination shall include oral presentation of the design report and a viva-voce. Equal weightage shall be given on oral presentation and viva-voce.

Subject Name: Comprehensive Viva Voce					
Paper Code: CHEN 4231					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	0	**0**	**3**	**3**	**3**

Viva – Voce examination shall be conducted to ascertain the students' overall grasp of the principles of Chemical Engineering and allied subjects. Evaluation of students would be conducted by a panel consisting of at least four Faculty members.

Free Elective – 7th Semester
(For non-CHEStudents)

Subject Name: Safety and Hazard Analysis					
Paper Code: CHEN 4181					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**0**	**0**	**3**	**3**

Module I : 10 L
Definition of safety, Hazard and Risk, Safety program, Engineering ethics, Inherent safety, Safety regulations, OSHA, Process safety management, Hazards due to fire, explosions and toxic chemicals, Distinction between fire and explosion, Upper Flammability limit and Lower Flammability Limit, Fire Triangle, BLEVE, Runaway reaction.

Module II : 10 L
Tools for hazards identification: HAZOP, Fault Tree, Event Tree, FMEA, Dow Fire and Explosion Index, Mond Index. .

Module III : 10 L
Risk analysis concept and methodology: Risk concept and measure of risk, Risk acceptance criteria, Quantitative risk analysis, Probit number.

Module IV: 10L
Control of chemical plant hazards, Intensification and attenuation of hazardous materials, Industrial plant layout, Ventilation, Fire prevention, Personnel protection devices, Laboratory safety, Emergency safety, Safety systems and disaster management. Case studies, Flixborough (England), Bhopal (India), Seveso (Italy), Pasadona (Texas)

Text Books :

1. D.A Crowl and J. F Louvar Chemical Process Safety: Fundamentals with Applications:, Prentice Hall, 1990

References:

1. O.P. Kharbanda and Stallworthy E. A, Safety in Chemical Process Industries:, Heinmann
2. Professional Publishing LTD.,1988
3. C. A, Wentz Hazardous Waste management: Mc Graw-Hill, 1989.
4. S.L Cutter.Environmental Risks & Hazards, Prentice Hall,1994

5. Trevor A. Kletz, What went wrong? Case Histories of Process Plant Disasters and How They
6. Could Have Been Avoided,5th Edition, ISBN: 978-1-85617-531-9

Free Elective – 7th Semester
(For non-CHEStudents)

Subject Name: Project Management					
Paper Code: CHEN 4182					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**0**	**0**	**3**	**3**

Module I : 10L
Project Management Fundamentals: Definition of a Project, Project Management, Scope Management, Program Management, Portfolio Management, Stakeholder Management: Identify Stakeholders, Plan Stakeholder Management; Manage Stakeholder Engagement, Control Stakeholder Engagement, Organization Structure; Project Lifecycle vs. Product Lifecycle; Feasibility Analysis; Project Evaluation Techniques; Summary Illustrative Review Problems / Incidents.

Module II : 10L
Project Network Techniques: PERT/CPM; Project Planning & Scheduling; Project Work Breakdown Structure & networking; Project Network Techniques PERT / CPM, Time & Cost based calculations using PERT, Scheduling Projects, Resourcing Projects, Budgeting Projects, Project Risk Planning, Project Quality Planning and Project Kickoff, Summary Illustrative Review Problems / Incidents.

Module III : 10L
Planning Projects: Stakeholder Analysis and Communication; Planning & Defining Scope, Capital Estimates, Investment Analysis and Justification; Project scheduling with unlimited Resources, Project scheduling with limited Resources, Risk Management: Planning Risk Management, Risk Identification, Qualitative & Quantitative Risk Analysis, Planning Risk Responses; Risks Control; Summary Illustrative Review Problems / Incidents.

Module IV: 10L
Project Resource Allocation: Project Human Resource, Procurement & Materials Management; Project Organization Structure, Leadership Style, Effective Project Teams, Managing Conflicts;
Project Total Quality Management, Project Contract Management, Project Procurement & Materials Management, Computer Based Project Management, Project Management using MS Project & Prinavera, Software Project Management, Project Monitoring & Control, Project Case Study Project Integration Management; Summary Illustrative Review Problems / Incidents.

Text Books:

1. M. Peter, K. Timmerhaus, R. West, Plant Design and economics for Chemical Engineers, McGraw-Hill Science/Engineering/Math, 5th Edition,2002.
2. 2. K. Nagarajan, Project Management, 2nd edition, New Age International publisher, 01-Jan- 2004, ISBN: 81-224-1557-1
3. Eugene Grant and Richard Leavenworth, Statistical Quality Control, 6th Edition, publisher: McGraw-Hill 1996.

Reference:

1. 1. R. K. Sinnott, Coulson and Richardson's Chemical Engineering, Volume 6, Second Edition: Chemical Engineering Design (Chemical Engineering Technical Series), 2nd Edition, Pergamon,1993.
2. P.C.Jain, Handbook for new entrepreneur, Oxford University Press, 2012.
3. 3. V.G. Patel, The Seven-Business Crisis. How to beat them? Tata McGraw-Hill Co. Ltd, 1995.
4. Daniel Goleman, Working with emotional intelligence; Butam Books, 2000.
5. John Happel, Donald G. Jordan, Chemical process economics, 2nd Edition, Marcel Dekker, Inc., New York, 1976.
6. Ernest E. Ludwig, Applied project management for the process industries, Gulf Pub. Co. 1974.
7. Jack R. Meredith, Samuel J. Mantel, Jr., Scott M. Shafer, “Project Management: A Managerial Approach”, 9th Edition International, Student Version, February 2015, ©2014.
8. 8. Russell Darnall and John M. Preston, Project Management: from Simple to Complex, ©2016 Flat World Education, Inc. v. 1.0,Version: 1.0, Pub Date: May 2010, eISBN: 978-1-4533- 2704-3.

Free Elective – 8th Semester
(For non-CHE Students)

Subject Name: Catalytic Reactor Design					
Paper Code: CHEN 4281					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**0**	**0**	**3**	**3**

Module I : 10L
Introduction to homogeneous and heterogeneous catalysis, Factors affecting heterogeneous catalytic reaction; Methods for finding rates- Integral Analysis, Differential Analysis
Types of catalytic Reactor- Differential Reactor, Integral Reactor and their performance equations.
Pore diffusion resistance combined with surface Kinetics. Concept of Thiele modulus and Weisz modulus, Concept of effectiveness factor.

Module II : 10L
External mass and heat transfer in catalyst particles. Design of Packed bed reactor, fluidized bed reactor, Basket type reactor. Description of slurry reactor; Trickle bed reactor.
Diferent steps in a catalytic reaction, Langmuir adsorption isotherm.
Catalysis mechanism; Langmuir-Hiselwood mechanisms, Eley –Rideal mechanisms
Enzyme kinetics: Michaelis and Menten equation, Briggs Halden equation, numerical problems on enzymatic reactions

Module III : 10L
Determination of Catalyst surface area and particle size; Brunauer, Emmett, Teller (BET) equation, Concept of void volume and solid density-Helium mercury method, Pore volume Distribution-mercury penetration method, Nitrogen desorption method.
General methods for preparation of catalysts: precipitation, sol-gel, mixing components with water milling, impregnation, Concept of Promoter & Inhibitor;

Module IV: 10L
Catalyst Deactivation: Fouling and poisoning; Mechanisms of Catalyst Deactivation, Rate equation, activity of catalyst, Parallel deactivation, Series deactivation, Side by side deactivation independent deactivation.
Biocatalyst and Bioreactor Design: Cell growth kinetics, Substrate limited growth, the logistic equation, rate loss, stoichiometry, mass balances, design equations, numerical problems, oxygen limited fermentation, scale up concepts of bio-reactors, chemostat and its applications, Wash Out, continuous culture devices, case studies on penicillin production.

Text Books:

1. O. Levenspiel, Chemical Reaction Engineering; 3rd. ed. Wiley Eastern Ltd.1998
2. H. Fogler , Elements of Chemical Reaction Engineering,4th. Ed. Prentice Hall of India, 2005
3. J.M Smith, Chemical Engineering Kinetics, 3rd.ed. McGraw Hill.1981

References:

1. James J Carberry, Chemical and catalytic reaction engineering, McGraw Hill.2001
2. G.F. Froment, K.B Bischoff, Chemical Reactor Analysis and design-.; John Wiley & Sons.1979
3. Lanny D Schmidt, The Engineering of Chemical Reactions-; Oxford University Press. 2004

Free Elective – 8th Semester
(For non-CHE Students)

Subject Name: Total Quality Management &Assurance					
Paper Code: CHEN 4282					
Contact Hours Per Week	**L**	**T**	**P**	**Total**	**Credit Points**
	3	**0**	**0**	**3**	**3**

Module I : 10L
Basic concepts–Organization: its basic objectives and goal, Mission and Vision, customer and secondary customer, Bottom line: profit vs quality, Basic statistical concepts associated with quality management, measurement of central tendency and dispersion, range versus variance, quality and process capability, probability distributions, concept of statistical quality control.

Module II : 10L
Case Studies: Use of control charts and process engineering techniques for implementing the quality plan: X—R chart, moving average chart, p-chart, c-chart and control chart for continuous production. Case Studies: Acceptance sampling: single–double and multiple sampling, AOQ, AQL, LTPD, Chain sampling plan, Dodge-Romig plan.

Module III : 10L
Tools and techniques for improvement in TQM: type A techniques with a special reference to FPC & FD, QFD, SWOT analysis; type B techniques with a special reference to brainstorming, stratification, Ischikawa diagram, check sheet, Pareto diagram Philosophy and concept of quality circle: formation, steering committee, power and functions of leader, dy. Leader, coordinator, facilitator, case studies.

Module IV: 10L
Six Sigma: philosophy and concepts, Case Studies: Six Sigma implementation in business process, service sector & manufacturing industry.
Implementation methodologies of Different standards: ISO, BS and Bureau of Indian Standards, details of ISO 9000 series, ISO 14000 series and SA 8000 and the certification authorities, productivity control management.

Text Books:

1. Statistical Quality Control, 6th Edition, by Eugene Grant and Richard Leavenworth, Mc-Graw Hill. 1996

References:

1. H. Lal .,Total Quality Management- A Practical Approach (1st Edition): New Age International, 1990
2. S R Udpa Quality Circle:, 1981.
3. S. M. Sudarraju Total Quality Management – A Primer:, Tata Mc-Graw Hill, 2001.
4. 4. Amitava Mitra, Fundamentals of Quality Control and Improvement, 2nd Edition.; Prentice- Hall of India, 1998,
5. Subburaj Ramasamy, Total Quality management;, Mc.Graw Hill Education (India) Pvt. Ltd, 2012.