NATIONAL INSTITUTE OF TECHNOLOGY ANDHRA PRADESH

SCHEME OF INSTRUCTION AND SYLLABI
FOR B.TECH PROGRAM

Effective from 2015-16

DEPARTMENT OF CHEMICAL ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY ANDHRA PRADESH

VISION

Towards a Global Knowledge Hub, striving continuously in pursuit of excellence in Education, Research, Entrepreneurship and Technological services to the society.

MISSION

- Imparting total quality education to develop innovative, entrepreneurial and ethical future professionals fit for globally competitive environment.
- Allowing stake holders to share our reservoir of experience in education and knowledge for mutual enrichment in the field of technical education.
- Fostering product oriented research for establishing a self-sustaining and wealth creating centre to serve the societal needs.

DEPARTMENT OF CHEMICAL ENGINEERING

VISION

To attain global recognition in research and training students for meeting the challenging needs of chemical & allied industries and society.

MISSION

- Providing high quality education in tune with changing needs of industry.
- Generating knowledge and developing technology through quality research in frontier areas of chemical and interdisciplinary fields.
- Fostering industry-academia relationship for mutual benefit and growth.

GRADUATE ATTRIBUTES

The Graduate Attributes are the knowledge skills and attitudes which the students have at the time of graduation. These attributes are generic and are common to all engineering programs. These Graduate Attributes are identified by National Board of Accreditation.

1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. Problem analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. Design/Development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. Project management and Finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

DEPARTMENT OF CHEMICAL ENGINEERING

B.TECH IN CHEMICAL ENGINEERING

PROGRAM EDUCATIONAL OBJECTIVES

PEO1.	Apply theoretical knowledge and experimental skills of basic sciences, mathematics and program core to address challenges faced in chemical engineering and allied areas.
PEO2.	Plan, design, fabricate and operate chemical process systems to improve quality of life.
PEO3.	Analyze issues related to safety, energy and environment.
PEO4.	Communicate effectively and demonstrate leadership skills.
PEO5.	Pursue life-long learning as a means of enhancing knowledge base and skills.

Mapping of Departmental Mission Statements with Program Educational Objectives

PEO / **Mission Statement**	PEO1	PEO2	PEO3	PEO4	PEO5
Providing high quality education in tune with changing needs of industry.	3	3	3	3	3
Generating knowledge and developing technology through quality research in frontier areas of chemical and interdisciplinary fields.	3	2	2	-	-
Fostering industry-academia relationship for mutual benefit and growth.	-	2	-	3	2

Mapping of Program Educational Objectives with Graduate Attributes

GA / PEO	GA1	GA2	GA3	GA4	GA5	GA6	GA7	GA8	GA9	GA10	GA11	GA12
PEO1	3	2	-	2	-	-	1	3	-	2	-	2
PEO2	3	1	-	1	-	1	2	3	-	2	2	2
PEO3	2	1	3	3	3	2	3	3	2	2	3	2
PEO4	3	3	2	-	3	2	3	3	3	3	3	3
PEO5	2	2	3	3	3	-	-	3	-	2	-	2

PROGRAM OUTCOMES: At the end of the program, the student will be able to:

PO1	Solve complex chemical engineering problems using knowledge of mathematics, science, engineering basics and program core.
PO2	Identify critical issues in petroleum refining, petrochemicals, fertilizers, dyes & intermediates, bulk & fine chemicals, bio-products and pharmaceuticals.
PO3	Design chemical and allied processes.
PO4	Design equipment and plants for chemical and allied processes.
PO5	Perform feasibility analysis for starting a new process plant.
PO6	Apply modeling, simulation and optimization tools for process development.
PO7	Identify measures for energy, environment, health, safety and society following ethical principles.
PO8	Understand organizational behavior and its project &financial management.
PO9	Work and lead teams in multidisciplinary areas with professional responsibility.
PO10	Apply management techniques for effective completion of projects.
PO11	Communicate effectively in written, graphical and oral forms.
PO12	Pursue life-long learning as a means of enhancing the knowledge and skills.

Mapping of Program Outcomes with Program Educational Objectives

PEO / PO	PEO1	PEO2	PEO3	PEO4	PEO5
PO1	3	3	2	1	2
PO2	3	3	3	-	1
PO3	3	3	3	-	-
PO4	2	3	3	-	1
PO5	3	3	2	1	-
PO6	1	2	3	-	2
PO7	-	-	3	2	1
PO8	-	-	-	2	2
PO9	-	2	2	2	-
PO10	1	3	2	3	1
PO11	2	2	1	3	2
PO12	2	2	2	1	3

CURRICULAR COMPONENTS

Degree Requirements for B. Tech in Chemical Engineering

Category of Courses	Credits Offered	Min. credits to be earned
Basic Science Core (BSC)	32	32
Engineering Science Core (ESC)	33	33
Humanities and Social Science Core (HSC)	07	07
Program Core Courses (PCC)	88	88
Departmental Elective Courses (DEC)	24	18
Open Elective Courses (OPC)	6	6
Program Major Project (PRC)	6	6
EAA: Games and Sports (MDC)	0	0
Total	**196**	190

SCHEME OF INSTRUCTION

B.Tech. (Chemical Engineering) Course Structure

I - Year I - Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	MA101	Mathematics – I	4	0	0	4	BSC
2	HS101 ME102	English for Communication (or) Engineering Graphics	3 2	0 0	2 3	4 4	HSC ESC
3	PH101 CY101	Physics (or) Chemistry	4 4	0 0	0 0	4 4	BSC BSC
4	EC101 EE101	Basic Electronics Engineering (or) Basic Electrical Engineering	3 3	0 0	0 0	3 3	ESC ESC
5	 ME101	Environmental Science & Engineering (or) Basic Mechanical Engineering	3 3	0 0	0 0	3 3	ESC ESC
6	CS101 CE101	Problem Solving and Computer Programming (or) Engineering Mechanics	4 4	0 0	0 0	4 4	ESC ESC
7	PH102 CY102	Physics Lab (or) Chemistry Lab	0 0	0 0	3 3	2 2	BSC BSC
8	CS102 ME103	Problem Solving and Computer Programming Lab (or) Workshop Practice	0 0	0 0	3 3	2 2	ESC ESC
9	EA101	EAA: Games and Sports	0	0	3	0	MDC
		TOTAL	**21**	**0**	**11**	**26**	
			20	**0**	**12**	**26**	

I - Year II - Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	MA151	Mathematics – II	4	0	0	4	BSC
2	ME102 HS101	Engineering Graphics (or) English for Communication	2 3	0 0	3 2	4 4	ESC HSC
3	CY101 PH101	Chemistry (or) Physics	4 4	0 0	0 0	4 4	BSC BSC
4	EE101 EC101	Basic Electrical Engineering (or) Basic Electronics Engineering	3 3	0 0	0 0	3 3	ESC ESC
5	ME101 CE102	Basic Mechanical Engineering (or) Environmental Science & Engineering	3 3	0 0	0 0	3 3	ESC ESC
6	CE101 CS101	Engineering Mechanics (or) Problem Solving and Computer Programming	4 4	0 0	0 0	4 4	ESC ESC
7	CY102 PH102	Chemistry Lab (or) Physics Lab	0 0	0 0	3 3	2 2	BSC BSC
8	ME103 CS102	Workshop Practice (or) Problem Solving and Computer Programming Lab	0 0	0 0	3 3	2 2	ESC ESC
9	EA151	EAA: Games and Sports	0	0	3	0	MDC
		Total	**20**	**0**	**12**	**26**	
			21	**0**	**11**	**26**	

II - Year I - Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	MA201	Mathematics – III	4	0	0	4	BSC
2	CY201	Physical and Organic Chemistry	3	1	0	4	BSC
3	CH201	Principles of Stoichiometry	3	1	0	4	PCC
4	CH202	Fluid and Particle Mechanics	3	1	0	4	PCC
5	CH203	Mechanical Operations	3	0	0	3	PCC
6	CH204	Energy Technology and Conservation	3	0	0	3	PCC
7	CH205	Fluid and Particle Mechanics Lab	0	0	3	2	PCC
8	EE235	Basic Electrical Engineering Lab	0	0	3	2	ESC
		TOTAL	**19**	**3**	**6**	**26**	

II - Year II - Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	MA251	Mathematics – IV	4	0	0	4	BSC
2	CH251	Chemical Technology	4	0	0	4	PCC
3	CH252	Chemical Engineering Thermodynamics – I	3	1	0	4	PCC
4	CH253	Heat Transfer	3	1	0	4	PCC
5	CH254	Process Instrumentation	3	0	0	3	PCC
6	CH255	Petroleum Refining and Petrochemicals	3	0	0	3	PCC
7	CH256	Chemical Technology Lab	0	0	3	2	PCC
8	CH257	Heat Transfer Lab	0	0	3	2	PCC
		TOTAL	**19**	**3**	**6**	**26**	

III - Year I – Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	CH301	Chemical Reaction Engineering – I	3	1	0	4	PCC
2	CH302	Chemical Engineering Thermodynamics – II	3	1	0	4	PCC
3	CH303	Industrial Safety and Hazard Mitigation	3	0	0	3	PCC
4	CH304	Mass Transfer – I	3	1	0	4	PCC
5		Elective – I	3	0	0	3	DEC
6		Elective-II	3	0	0	3	DEC
7	CH305	Computational Methods in Chemical Engineering Lab	0	0	3	2	PCC
8	CH306	Chemical Reaction Engineering Lab	0	0	3	2	PCC
		TOTAL	**18**	**3**	**6**	**25**	

III - Year II - Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	SM335	Engineering Economics and Accountancy	3	0	0	3	HSC
2	CH351	Mass Transfer – II	3	1	0	4	PCC
3	CH352	Chemical Reaction Engineering – II	3	0	0	3	PCC
4		Elective – III	3	0	0	3	DEC
5		Elective – IV	3	0	0	3	DEC
6		Open Elective – I	3	0	0	3	OPC
7	CH353	Process Equipment Design and Drawing	0	2	3	4	PCC
8	CH354	Mass Transfer Lab	0	0	3	2	PCC
		TOTAL	**18**	**3**	**6**	**25**	

IV - Year I - Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	ME435	Industrial Management	3	0	0	3	ESC
2	CH401	Process Dynamics and Control	3	1	0	4	PCC
3		Elective-V	3	0	0	3	DEC
4		Open Elective-II	3	0	0	3	OPC
5	CH402	CAD and Simulation Lab	0	1	3	3	PCC
6	CH403	Instrumentation and Process Control Lab	0	0	3	2	PCC
7	CH449	Project Work Part-A	0	0	3	2	PRC
		TOTAL	**12**	**2**	**9**	**20**	

IV - Year II - Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	CH451	Elements of Transport Phenomena	3	1	0	4	PCC
2	CH452	Plant Design and Process Economics	3	1	0	4	PCC
3		Elective – VI	3	0	0	3	DEC
4		Elective – VII	3	0	0	3	DEC
5		Elective – VIII	3	0	0	3	DEC
6	CH491	Seminar	0	0	3	1	PCC
7	CH499	Project Work Part-B	0	0	6	4	PRC
		TOTAL	**15**	**2**	**9**	**22**	

List of Electives

III Year I Semester

CH311 Nuclear Process Engineering

CH312 Renewable Energy Sources

CH313 Fuel Cell Engineering

CH314 Piping Engineering

CH315 Corrosion Engineering

CH316 Nanotechnology

III Year II Semester

CH361 Pharmaceuticals and Fine Chemicals

CH362 Pollution Control in Process Industries

CH363 Fertilizer Technology

CH364 Food Technology

CH365 Green Technology

CH366 Pulp and Paper Technology

IV Year I Semester

CH411 Biochemical Engineering

CH412 Interfacial Science

CH413 Statistical Thermodynamics

CH414 Non-Newtonian Flow and Rheology

IV Year II Semester

CH461 Microscale Unit Operations

CH462 Process Design Principles

CH463 Plant Utilities

CH464 Polymer Technology

CH465 Biotechnology

CH466 Mathematical Methods in Chemical Engineering

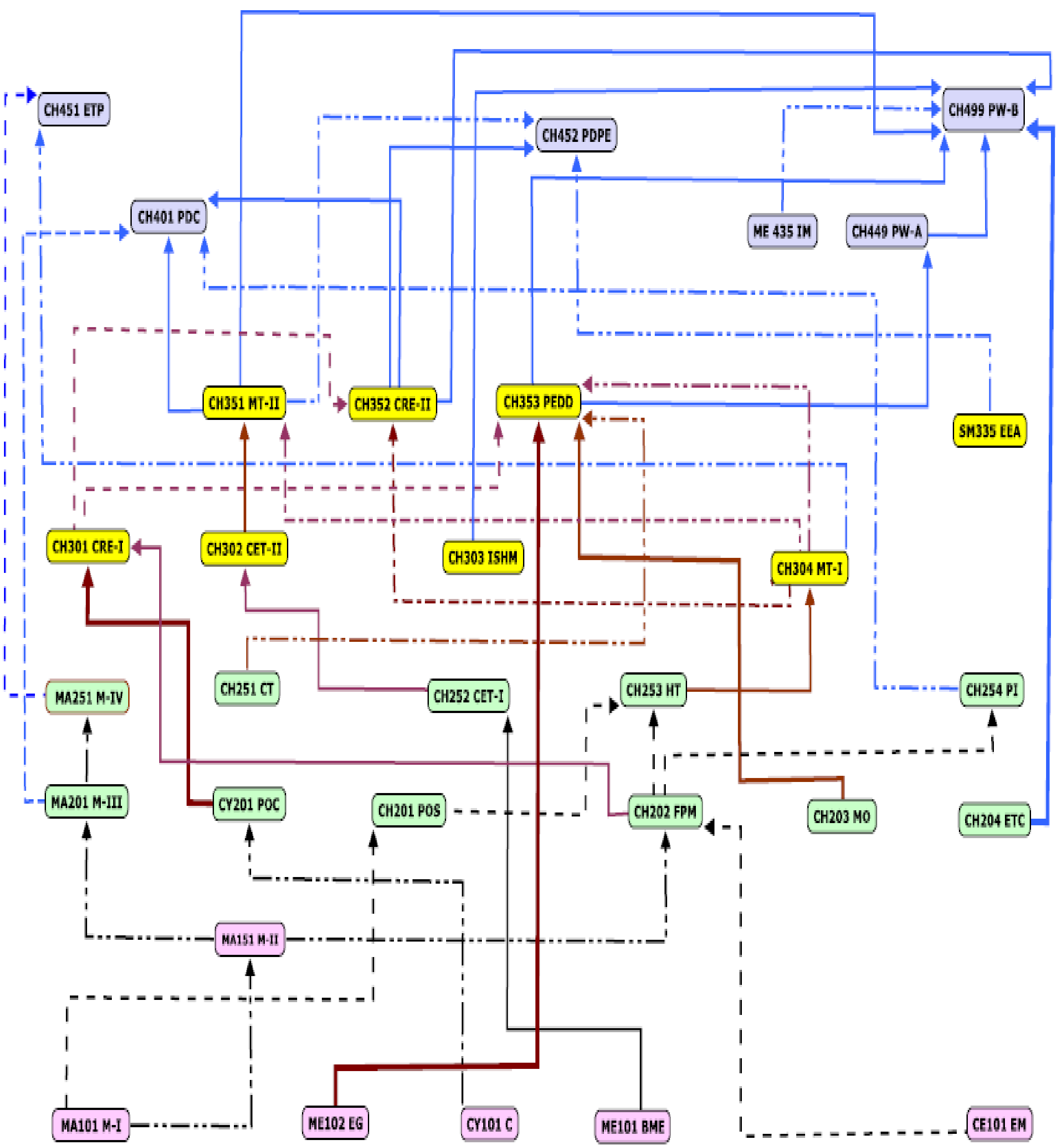
CH467 Membrane Technology

CH468 Chemical Process Optimization

CH469 Scale up Methods

B.TECH IN CHEMICAL ENGINEERING

PRE-REQUISITE CHART



DETAILED SYLLABUS

MA101	MATHEMATICS – I	BSC	4 – 0 – 0	4 Credits

Pre-requisites: None

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

CO1	Solve linear system equation
CO2	Determine the Eigen values and vectors of a matrix
CO3	Determine the power series expansion of a function
CO4	Estimate the maxima and minima of multivariable functions
CO5	Solve any given first order ordinary differential equation
CO6	Solve any higher order linear ordinary differential equation with constant coefficients

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	2	-	3	-	-	-	-	-	-
CO2	3	-	-	2	-	3	-	-	-	-	-	-
CO3	3	-	-	2	-	3	-	-	-	-	-	-
CO4	3	-	-	2	-	3	-	-	-	-	-	-
CO5	3	-	-	2	-	3	-	-	-	-	-	-
CO6	3	-	-	2	-	3	-	-	-	-	-	-

Detailed Syllabus:

Matrix Theory: Elementary row and column operations on a matrix, Rank of matrix – Normal form – Inverse of a matrix using elementary operations –Consistency and solutions of systems of linear equations using elementary operations, linear dependence and independence of vectors - Characteristic roots and vectors of a matrix-Caley-Hamillton theorem and its applications, Complex matrices, Hermitian and Unitary Matrices - Reduction to diagonal form - Reduction of a quadratic form to canonical form – orthogonal transformation and congruent transformation.

Differential Calculus: Rolle's theorem; Mean value theorem; Taylor's and Maclaurin's theorems with remainders, Expansions; Indeterminate forms; Asymptotes and curvature; Curve tracing; Functions of several variables, Partial Differentiation, Total Differentiation, Euler's theorem and generalization, maxima and minima of functions of several variables (two and three variables) – Lagrange's method of Multipliers; Change of variables – Jacobians.

Ordinary differential equations of first order: Formation of differential equations; Separable equations; equations reducible to separable form; exact equations; integrating factors; linear first order equations; Bernoulli's equation; Orthogonal trajectories and Newton's law of cooling.

Ordinary linear differential equations of higher order : Homogeneous linear equations of arbitrary order with constant coefficients - Non-homogeneous linear equations with constant coefficients; Euler and Cauchy's equations; Method of variation of parameters; System of linear differential equations, Vibrations of a beam.

Reading:

1. Jain R.K. and Iyengar S.R.K, Advanced Engineering Mathematics, Narosa Pub. House, 2008.
2. ErwynKreyszig, Advanced Engineering Mathematics, John Wiley and Sons, 8^{th} Edition, 2008.
3. Grewal B.S, Higher Engineering Mathematics, Khanna Publications, 2009.

HS101	ENGLISH FOR COMMUNICATION	HSC	3 – 0 – 2	4 Credits

Pre-requisites: None

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

CO1	Understand basic grammar principles
CO2	Write clear and coherent passages
CO3	Write effective letters for job application and complaints
CO4	Prepare technical reports and interpret graphs
CO5	Enhance reading comprehension
CO6	Comprehend English speech sound system, stress and intonation

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	-	-	3	3	-	3	3
CO2	-	-	-	-	-	-	-	3	3	-	3	3
CO3	-	-	-	-	-	-	-	3	3	-	3	3
CO4	-	-	-	-	-	-	-	3	3	-	3	3
CO5	-	-	-	-	-	-	-	3	3	-	3	3
CO6	-	-	-	-	-	-	-	3	3	-	3	3

Detailed syllabus

Grammar Principles and Vocabulary Building: Exposure to basics of grammar- parts of speech, with emphasis on tenses - active and passive voice- their usage- reported speech - Idioms and Phrases - their meanings and usage, Vocabulary development through prefixes, suffixes and word roots

Effective Sentence Construction - clarity and precision in construction - strategies for effectiveness in writing

Paragraphs: Definition- structure- Types and Composition-unity of theme- coherence-organization patterns

Note-making - its uses- steps in note-making - identification of important points-reduction to phrases –selection of suitable note format- types of notes - tree diagram, block list, table.

Letter Writing: Business, Official and Informal letters - communicative purpose-strategy-letter format and mechanics - letters of request, complaint and invitation.

Reading techniques: Skimming and Scanning – quick reading for gist and –suggesting titles - looking for specific information

Description of Graphics- kinds of graphs- their construction and use and application in scientific texts- interpretation of graphs using expressions of comparison and contrast

Reading Comprehension – reading to retrieve information - techniques of comprehension - find clues to locate important points- answering objective type questions - inference, elimination

Technical Report-Writing - kinds of reports-proposals, progress and final reports- their structure- features- process of writing a report-editing

Book Reviews- Oral and written review of a chosen novel/play- a brief written analysis including summary and appreciation- oral presentation of the novel before class

Reading

A Textbook of English for Engineers and Technologists (combined edition, Vol. 1 & 2); Orient Black Swan 2010.

PH101	PHYSICS	BSC	4 – 0 – 0	4 Credits

Prerequisites: None.

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

CO1	Solve engineering problems using the concepts of wave and particle nature of radiant energy
CO2	Understand the use of lasers as light sources for low and high energy applications
CO3	Understand the nature and characterization of acoustic design, nuclear accelerators and new materials
CO4	Apply the concepts of light in optical fibers, light wave communication systems, and holography and for sensing physical parameters
CO5	Construct a quantum mechanical model to explain the behavior of a system at microscopic level

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	-	-	2	-	-	2	-	-	-
CO2	3	-	-	-	-	2	-	-	2	-	-	-
CO3	3	-	-	-	-	2	-	-	2	-	-	-
CO4	3	-	-	-	-	2	-	-	2	-	-	-
CO5	3	-	-	-	-	2	-	-	2	-	-	-

Detailed Syllabus:

Interference: Superposition principle, Division of amplitude and wave front division, Interferometers (Michelson, Fabry-Perot, Mach-Zehnder), Applications; Diffraction:Fraunhoffer diffraction (single, double & multiple slits), Resolving power, Dispersive power, Applications.

Polarization: Production & detection of polarized light, wave plates, optical activity, Laurents Half-shade polarimeter, photoelasticity and applications; LASERS: Basic principles of Lasers, He-Ne, Nd-YAG, CO_2 and semiconductors lasers, applications of lasers, Holography and holographic NDT.

Optical fibers: Light propagation in Optical fibers, types of optical fibers, optical fibers for communication and sensing.

Functional materials: Fiber reinforced plastics, fiber reinforced metals, surface acoustic wave materials, biomaterials, high temperature materials, smart materials and their applications, Introduction to Nano materials.

Modern physics: Qualitative review of different experiments, de-Broglie waves, Dual nature of matter, Schrodinger wave equation, wave function and its interpretation, potential well problems in one dimension, Tunneling, Uncertainty principle, Particle Accelerators: Cyclotron, Synchro Cyclotron, Betatron and applications.

Acoustics: Introduction, Reverberation and reverberation time, growth and decay of energy, Sabine's formula, absorption coefficient and its measurement, factors affecting architectural acoustics, Production, detection and applications of Ultrasound.

Reading:

1. Halliday, Resnic and Walker, Fundamentals of Physics, 9th Ed., John Wiley, 2011.
2. Beiser A, Concepts of Modern Physics, 5th Ed., McGraw Hill International, 2003.
3. Ajoy Ghatak, Optics, 5th Ed., Tata McGraw Hill, 2012.
4. M.Armugam, Engineering Physics, Anuradha Agencies, 2003.

CY101	CHEMISTRY	BSC	4 – 0 – 0	4 Credits

Pre-requisites: None

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

CO1	Understand and apply the concepts in electrochemistry and corrosion science
CO2	Understand the concepts in molecular interactions
CO3	Understand the synthesis and analysis of modern materials
CO4	Apply the concepts of organic chemistry for synthesis
CO5	Understand the synthesis and applications of polymer science
CO6	Identify the structure of organic molecules using photo chemistry and chemical spectroscopy

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	-	2	-	2	-	2	-	-	-
CO2	3	3	3	-	2	-	2	-	2	-	-	-
CO3	3	3	3	-	2	-	2	-	2	-	-	-
CO4	3	3	3	-	2	-	2	-	2	-	-	-
CO5	3	3	3	-	2	-	2	-	2	-	-	-
CO6	3	3	3	-	2	-	2	-	2	-	-	-

Detailed Syllabus:

Electrochemistry - Review of the concepts of electrode potentials, Nernst equation, Reference electrodes, Ion selective electrodes – Concept – Glass electrode – Determination of pH of a solution using a glass electrode – Derivation of equation between E_{cell} and pH, Determination of F^- ion using fluoride electrode (Numerical calculations), Chemically modified electrodes (CMEs) – Concept, CMEs as potentiometric and amperometric sensors, Electrochemical energy systems, Electrochemistry of secondary cells e.g. Lead – acid and Ni-Cd cells, Rechargeable lithium batteries, Fuel cells – Electrochemistry of a H_2–O_2 fuel cell, methanol–O_2 fuel cell.

Corrosion and Its Prevention - Electrochemical theory of corrosion, Corrosion due to dissimilar metal cells (galvanic cells), Corrosion due to differential aeration cells, Uniform corrosion, pitting corrosion and stress corrosion cracking, Effect of pH, Potential-pH diagram for Iron, temperature and dissolved oxygen on corrosion rate, Corrosion prevention and control by cathodic protection.

Molecular Interactions - Molecular orbital theory applicable to understanding of bonding in heteronuclear diatomic molecules, e.g. CO and NO, Molecular orbital energy diagram of an Octahedral complex, MO diagram of a molecule involving charge transfer (e.g. $KMnO_4$), Nature of supramolecular interactions: ion-ion interactions, ion-dipole interactions, dipole-dipole interactions, hydrogen bonding, cation-л interactions, л-л interactions, van der Walls forces, Concept of self-assembly involving different types of interactions (Micellar formation; Membrane Formation; Surface films).

Chemistry of Nanomaterials - Introduction to Nanomaterials, Chemical synthesis of nanomaterials: sol-gel method, Reverse micellar method, electrolytic method, Characterization of nanoparticles by BET method, Characterization of nanomaterials by TEM (includes basic principle of TEM), Applications of nanomaterials in Industry as drug delivery materials, as catalysts, in water treatment.

Basic Principles Of Organic Chemistry – Introduction, Homolytic and Heterolytic cleavages and free radicals Carbocations, carbanions and addition reactions Elimination and substitution reactions.

Stereochemistry: chirality, optical activity, enantiomers and diastereomers, Projection formulae and geometrical isomerism, Reactions - Hofmann reaction and Riemer-Tiemann reaction, Diels-Alder reaction and Cannizaro reaction, Skraup synthesis.

Polymer Chemistry - Concept of polymerization – Types of polymerization, Chain growth polymerization – mechanisms of free radical and cationic polymerizations, Mechanisms of simple anionic polymerization and co-ordination anionic polymerization (complex forming mechanism), Step-growth polymerization ,Mechanism and examples.

Thermoplastic resins and Thermosetting resins- examples and applications, conducting polymers: Mechanism of conduction in polymers – Examples – and applications.

Review Of Chemical Spectroscopy - Review of electromagnetic spectrum, Quantization of energy, Born – Oppenheimer approximation, Frank Condon Principle Vibrational spectra (Infra-red) of diatomic molecules – Selection rules Determination of force constant Problems, Identification of functional groups using IR spectroscopy Electronic spectroscopy - Types of electronic transitions –calculation of chromophoric absorptions For Diene and ene-one chromophors Qualitative analysis by electronic spectroscopy, Lambert – Beer's law-Applications in Quantitative analysis and problems.

NMR spectroscopy: Basic principles, Concept of chemical shift. Concept of spin-spin splitting and examples, Applications of UV,I.R and ^1H NMR spectra in the determination of structures of Ethyl alcohol, Dimethyl ether, Acetic acid and Benzyl alcohol.

Photo Chemistry – Principles of photochemistry – Rates of intermolecular processes, Jablonski diagram – fluorescence, phosphorescene and Chemiluminescence, Types of Photochemical Organic reactions, Laws of photochemistry and quantum yields-problems, Photosensitized reactions.

Reading:

1. P. W. Atkins & Julio de Paula, Atkins' Physical Chemistry, Oxford University Press York, 7thEdn, 2002.

2. ShashiChawla, A Text Book of Engineering Chemistry, 3rd Edition, DhanpatRai& Co New Delhi, 2007.
3. S. Vairam, P. Kalyani&Suba Ramesh, Engineering Chemistry, Ist Edn, John Wiley & Sons, India, 2011.
4. Lee J.D., Concise Inorganic Chemistry, 7th Edn, Blackwel Science Publications Oxford, London, 2004.
5. Jerry March., Advanced Organic Chemistry, 6thEdn, John Wiley & Sons, New Jersy, 2007.
6. FehFuYen, Chemistry for Engineers, Imperial College Press, 2008.
7. Octave Levenspiel, Chemical Reaction Engineering, 2nd Edition, Wiley India, 2006.
8. Smith J.M., Chemical Engineering Kinetics, 3rd Edition, McGraw Hill, 1981.

EC101	BASIC ELECTRONICS ENGINEERING	ESC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Characterize semiconductors, diodes, transistors and operational amplifiers
CO2	Design simple analog circuits
CO3	Design simple combinational and sequential logic circuits
CO4	Understand functions of digital multimeter, cathode ray oscilloscope and transducers in the measurement of physical variables
CO5	Understand fundamental principles of radio communication

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	-	-	-	-	-	1	-	-	-
CO2	3	-	-	-	-	-	-	-	1	-	-	-
CO3	3	-	-	-	-	-	-	-	1	-	-	-
CO4	3	-	-	-	-	-	-	-	1	-	-	-
CO5	3	-	-	-	-	-	-	-	1	-	-	-

Detailed Syllabus:

Electronics Systems: Introduction to electronics, review of p-n junction operation, diode applications, Zener diode as regulator.

Transistor and applications: Introduction to transistors, BJT Characteristics, biasing and applications, simple RC coupled amplifier and frequency response. Cascaded amplifiers, FET and MOSFET characteristics and applications.

Feedback in Electronic Systems: open loop and closed loop systems, Negative and positive feedback merits and demerits, Principle of oscillators, LC and RC oscillators.

Integrated Circuits: Operational amplifiers, Applications: adder, subtractor, Integrator and Differentiators.

Digital Circuits: Number systems and logic gates, Combinational Logic circuits, Flip-Flops, counters and shift registers, data converters, Analog to Digital and Digital to Analog converters (ADC/DAC's).

Electronic Instrumentation: Measurement, Sensors, Laboratory measuring instruments: digital multi-meters and Cathode Ray Oscilloscopes (CRO's).

Principles of Communication: Need for Modulation, Modulation and Demodulation techniques.

Reading:

1. Neil Storey, “Electronics A Systems Approach”, 4/e - Pearson Education Publishing Company Pvt Ltd, 2011.
2. Salivahanan, N Suresh Kumar, “Electronic Devices and Circuits” 3/e, McGraw Hill Publications, 2013.
3. Bhargava N. N., D C Kulshreshtha and S C Gupta, “Basic Electronics & Linear Circuits”, Tata McGraw Hill, 2/e, 2013.

EE101	BASIC ELECTRICAL ENGINEERING	ESC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Analyze and solve electric and magnetic circuits
CO2	Identify the type of electrical machines for a given application
CO3	Recognize the ratings of different electrical apparatus
CO4	Identify meters for measuring electrical quantities

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	-	-	-	-	-	1	-	-	-
CO2	3	-	-	-	-	-	-	-	1	-	-	-
CO3	3	-	-	-	-	-	-	-	1	-	-	-
CO4	3	-	-	-	-	-	-	-	1	-	-	-

Detailed Syllabus:

DC Circuits: Kirchhoff's Voltage & Current laws, Superposition Theorem, Star – Delta Transformations.

AC Circuits: Complex representation of Impedance, Phasor diagrams, Power & Power Factor, Solution of Single Phase Series & Parallel Circuits. Solution of Three Phase circuits and Measurement of Power in Three Phase circuits.

Magnetic Circuits: Fundamentals and Solution of Magnetic Circuits, Concepts of Self and Mutual Inductances, Coefficient of Coupling.

Single Phase Transformers: Principle of Operation of a Single Phase Transformer, EMF equation, Phasor diagram, Equivalent Circuit, Determination of Equivalent Circuit Parameters, Regulation and Efficiency of a single phase transformer. Principle of operation of an Auto Transformer.

DC Machines: Principle of Operation, Classification, EMF and Torque equations, Characteristics of Generators and Motors, Speed Control Methods and Starting Techniques.

Three Phase Induction Motor: Principle of Rotating Magnetic Field, Principle of Operation of 3-φ I.M., Torque-Speed Characteristics of 3-φ I.M., Starting Methods and Applications of Three Phase Induction Motors.

Measuring Instruments: Moving Coil and Moving Iron Ammeters and Voltmeters, Dynamometer Type Wattmeter and Induction Type Energy Meter.

Reading:

1. Edward Hughes, Electrical Technology, 10^{th} Edition, ELBS, 2010.
2. Vincent Del Toro, Electrical Engineering Fundamentals, 2^{nd} Edition, PHI, 2003.
3. V.N. Mittle, Basic Electrical Engineering, TMH, 2000.

CE101	ENGINEERING MECHANICS	ESC	4 – 0 – 0	4 Credits

Pre-requisites: None

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

CO1	Determine the resultant force and moment for a given system of forces
CO2	Analyze planar and spatial systems to determine the forces in members of trusses, frames and problems related to friction
CO3	Calculate the motion characteristics of a body subjected to a given force system
CO4	Determine the deformation of a shaft and understand the relationship between different material constants
CO5	Determine the centroid and second moment of area

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	2	-	-	-	-	-	-	-	-
CO2	3	-	-	2	-	-	-	-	-	-	-	-
CO3	3	-	-	2	-	-	-	-	-	-	-	-
CO4	3	-	-	2	-	-	-	-	-	-	-	-
CO5	3	-	-	2	-	-	-	-	-	-	-	-

Detailed syllabus:

Introduction - Specification of force vector, Formation of Force Vectors, Moment of Force – Cross product – Problems, Resultant of a general force system in space, Degrees of freedom - Equilibrium Equations, Kinematics – Kinetics – De' Alemberts principle, Degree of Constraints – Free body diagrams.

Spatial Force systems - Concurrent force systems - Equilibrium equations – Problems, Problems (Vector approach) – Tension Coefficient method, Problems (Tension Coefficient method), Parallel force systems - problems, Center of Parallel force system – Problems.

Coplanar Force Systems - Introduction – Equilibrium equations – All systems, Problems on Coplanar Concurrent force system, Coplanar Parallel force system, Coplanar General force system – Point of action, Method of joints, Method of sections, Method of sections, Method of members, Friction – Coulombs laws of dry friction – Limiting friction, Problems on Wedge friction, Belt Friction-problems.

Mechanics of Deformable Bodies - Stress & Strain at a point- Normal and shear stresses, Axial deformations – Problems on prismatic shaft, tapered shaft and deformation due to self-weight, Deformation of Stepped shaft due to axial loading, Poisson's Ratio – Bulk Modulus - Problems, change in dimensions and volume.

Centroid & Moment of Inertia - Centroid & M.I – Arial & Mass M.I – Radius of Gyration, Parallel axis– Perpendicular axis theorem – Simple Problems.

Dynamics of Particles - Rectilinear Motion – Kinematics Problems, Kinetics – Problems, Work & Energy – Impulse Moment, Direct Central Impact – coefficient of restitution, Curvilinear Motion – Projectile Motion, Work & Energy in Curvilinear motion.

Dynamics of Rigid Bodies - Rigid body rotation – Kinematics - Kinetics, Problems – Work & Energy in Rigid body rotation, Plane Motion – Kinematics, Problem – Instantaneous center of rotation.

Reading:

1. J.L. Meriam and L.G. Kraige, Engineering Mechanics, 7th Ed, John Wiley &Sons, 2012.
2. Timoshenko and Young, Engineering Mechanics, 3rd Ed, McGraw Hill Publishers, 2006.
3. Gere and Timoshenko, Mechanics of Materials, 2nd Ed, CBS Publishers, 2011.

CE102	ENVIRONMENTAL SCIENCE AND ENGINEERING	ESC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand environmental problems arising due to developmental activities
CO2	Identify the natural resources and suitable methods for conservation and sustainable development
CO3	Realize the importance of ecosystem and biodiversity for maintaining ecological balance
CO4	Identify the environmental pollutants and abatement mechanisms

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	-	3	-	3	-	2	-	-	-
CO2	3	-	-	-	3	-	3	-	2	-	-	-
CO3	3	-	-	-	3	-	3	-	2	-	-	-
CO4	3	-	-	-	3	-	3	-	2	-	-	-

Detailed syllabus:

Nature and scope of Environmental Problems: Environment and society, environmental disturbances, role of technology, sustainable development, quantification of environmental issues.

Population and Economic growth: Economic growth and industrialization urbanization, Resource consumption, Renewable and nonrenewable resources, Energy requirement and development.

Global Atmospheric systems: Concept of climate change, green-house effect, global energy balance, global warming, carbon cycle, Intergovernmental Panel for Climate Change (IPCC) emission scenarios, impact of climate change.

Mass balance and Environmental chemistry: Mass and Energy balance, Particle dispersion, oxygen demand, carbon emission, enthalpy in environmental systems, chemical equilibria.

Ecology and Biodiversity: Energy flow in ecosystem, food chain, nutrient cycles, eutrofication, value of biodiversity, biodiversity at global, national and local levels, threats for biodiversity, conservation of biodiversity

Water Pollution: water pollutants, effects of oxygen demanding waste on water, water quality in lakes, reservoirs and groundwater, contaminant transport, self-cleaning capacity of streams and water bodies, water quality standards, principles of water and wastewater treatment.

Air Pollution: Overview of emissions, pollutant standard index, toxic air pollutants, vehicle emissions, indoor air quality, principles of air pollution control.

Solid and Hazardous Waste: Characteristics of Solid and Hazardous Waste, Collection and transfer system, recycling, composting, waste to energy conversion, landfills.

Environmental Management: Sustainable development, Environmental Impact Assessment (EIA), Environmental Ethics, Legal aspects.

Reading:

1. J.G. Henry and G.W. Heinke, Environmental Science and Engineering, Pearson Education, 2004
2. G.B. Masters, Introduction to Environmental Engineering and Science, Pearson Education, 2004.

ME101	BASIC MECHANICAL ENGINEERING	ESC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand basics of thermodynamics and components of a thermal power plant
CO2	Identify engineering materials, their properties, manufacturing methods encountered in engineering practice
CO3	Understand basics of heat transfer, refrigeration and internal combustion engines
CO4	Understand mechanism of power transfer through belt, rope, chain and gear drives
CO5	Understand functions and operations of machine tools including milling, shaping, grinding and lathe machines

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	2	-	-	-	-	1	-	-	-
CO2	3	-	-	2	-	-	-	-	1	-	-	-
CO3	3	-	-	2	-	-	-	-	1	-	-	-
CO4	3	-	-	2	-	-	-	-	1	-	-	-
CO5	3	-	-	2	-	-	-	-	1	-	-	-

Detailed Syllabus:

Introduction: Introduction to Thermodynamics - Concept of a System – Types of Systems, Thermodynamic Equilibrium, Properties, State, Process and Cycle, Zeroth Law, Energy Interactions - Heat and Work, Types of Work, Work interactions in a closed System for various processes

First and Second Laws of Thermodynamics: First Law: Cycle and Process, Specific Heats (c_p and c_v), Heat interactions in a Closed System for various processes, Limitations of First Law, Concept of Heat Engine (H.E.) and Reversed H.E. (Heat Pump and Refrigerator), Efficiency/COP, Second Law: Kelvin-Planck and Clausius Statements, Carnot Cycle, Carnot Efficiency, Statement of Clausius Inequality, Property of Entropy, T-S and P-V Diagrams

Thermal Power Plant: Thermal Power Plant Layout – Four Circuits, Rankine Cycle, Boilers: Fire Tube vs Water Tube; Babcock & Wilcox, Cochran Boilers, Steam Turbines : Impulse vs Reaction Turbines, Compounding of Turbines: Pressure Compounding, Velocity Compounding, Pressure-Velocity Compounding, Condensers: Types – Jet & Surface Condensers, Cooling Towers

Manufacturing Processes: Engineering Materials: Classification, Properties of Materials, Manufacturing Processes: Metal Casting, Moulding, Patterns, Metal Working: Hot Working and Cold Working, Metal Forming: Extrusion, Forging, Rolling, Drawing

Internal Combustion Engines and Refrigeration: IC Engines: 2 - Stroke and 4 - Stroke Engines, S.I. Engine and C.I. Engine: Differences, P-V and T-S Diagrams

Refrigeration System and Refrigerants: Principle and working of standard vapor compression refrigeration system and Brief description of Refrigerants

Heat Transfer: Heat Transfer: Modes; Thermal Resistance Concept, Conduction: Composite Walls and Cylinders, Combined Conduction and Convection: Overall Heat Transfer Co-efficient, Simple Numerical Problems: Heat Transfer

Welding: Welding: Gas Welding and Arc Welding, Soldering, Brazing

Power Transmission: Transmission of Mechanical Power: Belt Drives – Simple Numerical Problems, Gear Drives – Simple Numerical Problems

Basics of Automotive Vehicle: Layout of Automobile Transmission; Brakes – Types, Clutch, Differential

Machine Tools and Machining Processes: Machine Tools Machine Tools: Lathe Machine, Lathe Operations, Milling Machine-Types, Milling Operations, Shaper and Planer Machines: Differences, Quick-Return Motion Mechanism, Drilling Machine: Operations, Grinding Machine: Operations

Reading:

1. Mathur, M.L., Mehta, F.S., and Tiwari, R.P., Elements of Mechanical Engineering, Jain Brothers, New Delhi, 2011.
2. Roy, K.P., and HazraChowdary, S.K.., Elements of Mechanical Engineering, Media Promoters and Publishers Pvt. Ltd., 2002.
3. Rudramoorthy, R.., Thermal Engineering, Tata McGraw Hill Book Company, New Delhi, 2003.
4. HazraChowdary., S.K. and Bose, Workshop Technology, Vol. I and II, Media Promoters and Publishers Pvt. Ltd., 2002.

ME102	ENGINEERING GRAPHICS	ESC	2 – 0 – 3	4 Credits

Pre-requisites: None

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

CO1	Draw Orthographic projections of Lines, Planes, and Solids
CO2	Construct Isometric Scale, Isometric Projections and Views
CO3	Draw Sections of various Solids including Cylinders, cones, prisms and pyramids
CO4	Draw projections of lines, planes, solids, isometric projections and sections of solids including Cylinders, cones, prisms and pyramids using AutoCAD

Mapping of course outcomes with program outcomes

course outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	3	-	-	-	-	1	-	2	-
CO2	-	-	-	3	-	-	-	-	1	-	2	-
CO3	-	-	-	3	-	-	-	-	1	-	2	-
CO4	-	-	-	3	-	-	-	-	1	-	2	-

Detailed Syllabus:

Introduction: Overview of the course, Examination and Evaluation patterns.
Lines Lettering and Dimensioning: Types of lines, Lettering, Dimensioning, Geometrical Constructions, Polygons, Scales.
Orthographic projection of points: Principles of Orthographic projection, Projections of points.
Projections of Lines: Projections of a line parallel to one of the reference planes and inclined to the other, line inclined to both the reference planes, Traces
Projections of Planes: Projections of a plane perpendicular to one of the reference planes and inclined to the other, Oblique planes.
Projections of Solids: Projections of solids whose axis is parallel to one of the reference planes and inclined to the other, axis inclined to both the planes.
Section of Solids: Sectional planes, Sectional views - Prism, pyramid, cylinder and cone, true shape of the section.
Isometric views: Isometric axis, Isometric Planes, Isometric View, Isometric projection, Isometric views – simple objects.
Auto-CAD practice: Introduction to Auto-CAD, DRAW tools, MODIFY tools, TEXT, DIMENSION, PROPERTIES tool bar, Standard Tool bar, LAYERS

Reading:

1. N.D. Bhat and V.M. Panchal, Engineering Graphics, Charotar Publishers 2013
2. E. Finkelstein, “AutoCAD 2007 Bible”, Wiley Publishing Inc., 2007

CS101	PROBLEM SOLVING AND COMPUTER PROGRAMMING	ESC	4 – 0 – 0	4 Credits

Pre-requisites: None

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

CO1	Develop algorithms for mathematical and scientific problems
CO2	Explore alternate algorithmic approaches to problem solving
CO3	Understand the components of computing systems
CO4	Choose data types and structures to solve mathematical and scientific problem
CO5	Develop modular programs using control structures
CO6	Write programs to solve real world problems using object oriented features

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	-	-	2	-	-	1	-	-	-
CO2	3	-	-	-	-	2	-	-	1	-	-	-
CO3	3	-	-	-	-	2	-	-	1	-	-	-
CO4	3	-	-	-	-	2	-	-	1	-	-	-
CO5	3	-	-	-	-	2	-	-	1	-	-	-
CO6	3	-	-	-	-	2	-	-	1	-	-	-

Detailed Syllabus:

Problem solving techniques – algorithms.

Introduction to computers - Basics of C++ - Number representation, Basic data types - int, float, double, char, bool, void.

Flow of Control - Conditional statements - If-else, Switch-case constructs, Loops - while, do-while, for.

Functions - user defined functions, library functions, parameter passing - call by value, call by reference, return values, Recursion.

Arrays - Single, Multi-Dimensional Arrays, initialization, accessing individual elements, passing arrays as parameters to functions.

Pointers and Dynamic Arrays - Multidimensional Dynamic Arrays, creation and deletion of single and multi-dimensional arrays.

C Strings, Standard String Class

I/O Streams, stream flags, stream manipulators, formatted I/O, binary I/O, Character I/O, File I/O - Opening, closing and editing files.

Structures and Classes - Declaration, member variables, member functions, access modifiers, inheritance, function overloading, overriding, redefinition, virtual functions, operator overloading, polymorphism - compile time and runtime binding.

Reading:

1. Walter Savitch, Problem Solving with C++, Sixth Edition, Pearson, 2007.
2. Cay Horstmann, Timothy Budd, Big C++, Wiley, Indian Edition, 2006.

PH102	PHYSICS LABORATORY	BSC	0 – 0 – 3	2 Credits

Pre-requisites: None

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

CO1	Use CRO, signal generator, spectrometer, polarimeter and GM counter for making measurements
CO2	Test optical components using principles of interference and diffraction of light
CO3	Determine the selectivity parameters in electrical circuits
CO4	Determine the width of narrow slits, spacing between close rulings using lasers and appreciate the accuracy in measurements

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	-	-	2	-	-	2	-	-	-
CO2	3	-	-	-	-	2	-	-	2	-	-	-
CO3	3	-	-	-	-	2	-	-	2	-	-	-
CO4	3	-	-	-	-	2	-	-	2	-	-	-

Detailed Syllabus:

1. Determination of Wavelength of Sodium light using Newton's Rings.
2. Determination of Wavelength of He-Ne laser – Metal Scale.
3. Measurement of Width of a narrow slit using He- Ne Laser.
4. Determination of Specific rotation of Cane sugar by Laurent Half-shade Polarimeter.
5. Determination of capacitance by using R-C circuit.
6. Determination of resonating frequency and bandwidth by LCR circuit.
7. Measurement of half-life of radioactive source using GM Counter.
8. Diffraction grating by normal incidence method.

Reading:

1. Physics Laboratory Manual.

CY102	CHEMISTRY LABORATORY	BSC	0 – 0 – 3	2 Credits

Pre-requisites: None

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

CO1	Synthesize polymers
CO2	Analyze ores and bleaching powder
CO3	Estimate the Hardness of water in terms of Calcium and Magnesium ions
CO4	Determine salt content using chromatographic techniques
CO5	Standardize solutions using titration, conductivity meter, pH-meter, potentiometer and colorimeter
CO6	Verify the Freundlich adsorption isotherm

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	-	2	-	2	-	2	-	-	-
CO2	3	3	3	-	2	-	2	-	2	-	-	-
CO3	3	3	3	-	2	-	2	-	2	-	-	-
CO4	3	3	3	-	2	-	2	-	2	-	-	-
CO5	3	3	3	-	2	-	2	-	2	-	-	-
CO6	3	3	3	-	2	-	2	-	2	-	-	-

Detailed Syllabus:

Cycle 1

1. Standardization of potassium permanganate.
2. Determination of MnO2 in Pyrolusite.
3. Determination of Iron in Haematite.
4. Determination of available Chlorine in bleaching powder and of Iodine in Iodized salt.
5. Determination of hardness of water and of calcium in milk powder.
6. Chemistry of blue printing.
7. Preparation of phenol formaldehyde resin.

Cycle 2

1. Conductometric titration of an Acid vs Base.
2. pH-metric titration of an Acid vs Base.
3. Potentiometric titration of Fe^{2+} against $K_2Cr_2O_7$.
4. Colorimetric titration of potassium permanganate.
5. Determination of rate of corrosion of mild steel in acidic environment in the absence and presence of an inhibitor.
6. Determination of salt content by Ion-exchange.
7. Separation of Ions by paper chromatography.
8. Verification of Freundlich adsorption isotherm.

Reading:

1. Valentin, W. G. “A Course of Qualitative Chemical Analysis” Read Books Design, 2010; ISBN: 1446022730, 9781446022733.
2. G. Svehla: Vogel's Qualitative Inorganic Analysis. J. Mendham, R. C. Denny, J. D. Barnes, M. J. K. Thomas: Vogel’s Text Book of Quantitative Chemical Analysis.
3. G. N. Mukherjee: Semi-Micro Qualitative Inorganic Analysis (CU Publications) Vogel’s Text Book of Practical Organic Chemistry (5th Edition).
4. N. G. Mukherjee: Selected Experiments in Physical Chemistry.

CS102	PROBLEM SOLVING AND COMPUTER PROGRAMMING LABORATORY	ESC	0 – 0 – 3	2 Credits

Pre-requisites: None

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

CO1	Design and test programs to solve mathematical and scientific problems
CO2	Develop and test programs using control structures
CO3	Implement modular programs using functions
CO4	Develop programs using classes

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	-	-	2	-	-	1	-	-	-
CO2	3	-	-	-	-	2	-	-	1	-	-	-
CO3	3	-	-	-	-	2	-	-	1	-	-	-
CO4	3	-	-	-	-	2	-	-	1	-	-	-

Detailed Syllabus:

1. Programs on conditional control constructs.
2. Programs on loops (while, do-while, for).
3. Programs using user defined functions and library functions.
4. Programs on arrays, matrices (single and multi-dimensional arrays).
5. Programs using pointers (int pointers, char pointers).
6. Programs on structures.
7. Programs on classes and objects.
8. Programs on inheritance and polymorphism.

Reading:

1. Walter Savitch, Problem Solving with C++, 6th Edition, Pearson, 2008.
2. R.G. Dromey, How to solve it by Computer, Pearson, 2008.

ME103	WORKSHOP PRACTICE	ESC	0 – 0 – 3	2 Credits

Pre-requisites: None

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

CO1	Study and practice on machine tools and their operations
CO2	Practice on manufacturing of components using workshop trades including fitting, carpentry, foundry and welding
CO3	Identify and apply suitable tools for machining processes including turning, facing, thread cutting and tapping
CO4	Apply basic electrical engineering knowledge for house wiring practice

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	3	-	-	-	-	-	-	-	-
CO2	-	-	-	3	-	-	-	-	-	-	-	-
CO3	-	-	-	3	-	-	-	-	-	-	-	-
CO4	-	-	-	3	-	-	-	-	-	-	-	-

Detailed Syllabus:

Fitting Trade: Preparation of T-Shape Work piece as per the given specifications, Preparation of U-Shape Work piece which contains: Filing, Sawing, Drilling, Grinding, and Practice marking operations.

Plumbing: Practice of Internal threading, external threading, pipe bending, and pipe fitting, Pipes with coupling for same diameter and with reducer for different diameters and Practice of T-fitting, Y-fitting, Gate valves fitting.

Machine shop: Study of machine tools in particular Lathe machine (different parts, different operations, study of cutting tools), Demonstration of different operations on Lathe machine, Practice of Facing, Plane Turning, step turning, taper turning, knurling and parting and Study of Quick return mechanism of Shaper.

Power Tools: Study of different hand operated power tools, uses and their demonstration and Practice of all available Bosch Power tools.

Carpentry: Study of Carpentry Tools, Equipment and different joints, Practice of Cross Half lap joint, Half lap Dovetail joint and Mortise Tenon Joint

House Wiring: Introduction to House wiring, different types of cables. Types of power supply, types of motors, Starters, distribution of power supply, types of bulbs, parts of tube light, Electrical wiring symbols, Stair case wiring: Demo and Practice (2 switches with one lamp control) and Godown wiring

Foundry Trade: Introduction to foundry, Patterns, pattern allowances, ingredients of moulding sand and melting furnaces. Foundry tools and their purposes, Demo of mould preparation and Practice – Preparation of mould by using split pattern.

Welding: Introduction, Study of Tools and welding Equipment (Gas and Arc welding), Selection of welding electrode and current, Bead practice and Practice of Butt Joint, Lap Joint.

Reading:

1. Raghuwanshi B.S., Workshop Technology Vol. I & II, DhanpathRai& Sons.
2. Kannaiah P. and Narayana K.L., Workshop Manual, 2ndEdn, Scitech publishers.
3. John K.C., Mechanical Workshop Practice. 2ndEdn. PHI 2010.
4. JeyapoovanT.andPranitha S., Engineering Practices Lab Manual, 3rdEdn. Vikas Pub.2008.

MA151	MATHEMATICS – II	BSC	4 – 0 – 0	4 Credits

Prerequisites: Mathematics – I.

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

CO1	Solve linear differential equations using Laplace transforms
CO2	Evaluate multiple integrals and improper integrals
CO3	Convert line integrals to area integrals
CO4	Convert surface integrals to volume integrals
CO5	Determine potential functions for irrotational force fields

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	2	-	3	-	-	-	-	-	-
CO2	3	-	-	2	-	3	-	-	-	-	-	-
CO3	3	-	-	2	-	3	-	-	-	-	-	-
CO4	3	-	-	2	-	3	-	-	-	-	-	-
CO5	3	-	-	2	-	3	-	-	-	-	-	-

Detailed Syllabus:

Laplace Transformation: Laplace transform - Inverse Laplace transform - properties of Laplace transforms - Laplace transforms of unit step function, impulse function and periodic function - convolution theorem - Solution of ordinary differential equations with constant coefficients and system of linear differential equations with constant coefficients using Laplace transform.

Integral Calculus: Fundamental theorem of integral calculus and mean value theorems; Evaluation of plane areas, volume and surface area of a solid of revolution and lengths. Convergence of Improper integrals – Beta and Gamma integrals – Elementary properties – Differentiation under integral sign. Double and triple integrals – computation of surface areas and volumes – change of variables in double and triple integrals.

Vector Calculus : Scalar and Vector fields; Vector Differentiation; Level surfaces - directional derivative - Gradient of scalar field; Divergence and Curl of a vector field - Laplacian - Line and surface integrals; Green’s theorem in plane; Gauss Divergence theorem; Stokes’ theorem.

Reading:

1. R.K.Jain and S.R.K.Iyengar, Advanced Engineering Mathematics, Narosa Pub. House, 2008.
2. ErwynKreyszig, Advanced Engineering Mathematics, John Wiley and Sons, 8^{th} Edition, 2008.
3. B.S.Grewal, Higher Engineering Mathematics, Khanna Publications, 2009.

MA201	MATHEMATICS - III	BSC	4 – 0 – 0	4 Credits

Pre-requisites: MA151 Mathematics-II

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

CO1	Determine Fourier series expansion of functions
CO2	Evaluate improper integrals involving trigonometric functions
CO3	Solve finite difference equations using Z transforms
CO4	Solve PDEs using variables separable method.
CO5	Evaluate improper integrals using residue theorem.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	2	-	3	-	-	-	-	-	-
CO2	3	-	-	2	-	3	-	-	-	-	-	-
CO3	3	-	-	2	-	3	-	-	-	-	-	-
CO4	3	-	-	2	-	3	-	-	-	-	-	-
CO5	3	-	-	2	-	3	-	-	-	-	-	-

Detailed syllabus

Fourier Series: Expansion of a function in Fourier series for a given range - Half range sine and cosine expansions

Fourier Transforms: Complex form of Fourier series - Fourier transformation and inverse transforms - sine, cosine transformations and inverse transforms - simple illustrations.

Z-transforms: Inverse Z-transforms – Properties – Initial and final value theorems – convolution theorem - Difference equations – solution of difference equations using z-transforms

Partial Differential Equations: Solutions of Wave equation, Heat equation and Laplace's equation by the method of separation of variables and their use in problems of vibrating string, one dimensional unsteady heat flow and two dimensional steady state heat flow including polar form.

Complex Variables: Analytic function - Cauchy Riemann equations - Harmonic functions - Conjugate functions - complex integration - line integrals in complex plane - Cauchy's theorem (simple proof only), Cauchy's integral formula - Taylor's and Laurent's series expansions - zeros and singularities - Residues - residue theorem, evaluation of real integrals using residue theorem, Bilinear transformations, conformal mapping.

Reading:

1. R. K. Jain & S. R. K. Iyengar: Advanced Engineering Mathematics, Narosa Publishing House, 2008
2. ErwynKreyszig: Advanced Engineering Mathematics, John Wiley and Sons, 8th Edition.
3. B. S. Grewal: Higher Engineering Mathematics, Khanna Publications, 2009.

CY201	PHYSICAL AND ORGANIC CHEMISTRY	BSC	4 – 0 – 0	4 Credits

Pre-requisites: CY101 Chemistry

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

CO1	Apply the concepts of phase equilibria.
CO2	Apply the laws of thermodynamics to chemical systems and determine the kinetics and propose new mechanisms.
CO3	Apply and analyze the functioning and efficiency of fuel cells.
CO4	Design organic molecules to synthesize and discover drugs.
CO5	Apply resolution methods for the separation of chiral compounds
CO6	Identify organic compounds using spectroscopic techniques.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	-	2	-	2	-	2	-	-	-
CO2	3	3	3	-	2	-	2	-	2	-	-	-
CO3	3	3	3	-	2	-	2	-	2	-	-	-
CO4	3	3	3	-	2	-	2	-	2	-	-	-
CO5	3	3	3	-	2	-	2	-	2	-	-	-
CO6	3	3	3	-	2	-	2	-	2	-	-	-

Detailed syllabus

Physical Chemistry:

Phase Equilibria: Physical Equilibria, Nernst distribution law. Its validity and limitations.Applications of Nernst distribution law in the determination molecular nature, complex ions. Applications in solvent extraction. Introduction to Gibbs phase rule. Explanation of terms. One component systems- Water, Sulphur and Carbon dioxide systems.Two component systems. Solid –liquid equilibria. Construction of Temperature - Composition phase diagrams by cooling curves method. Ag-Pb system, Bi-Cd system.

Chemical Thermodynamics: First law of thermodynamics. Second law of thermodynamics.Concept of Entropy. Variation of entropy with temperature and pressure.Concept of free energy. Variation of free energy with temperature and pressure.Gibbs-

Helmholtz equations. Third law of thermodynamics: Determination of absolute entropy of substances.

Chemical Kinetics and Catalysis: Rate equations of zero, first, second, third and nth order reactions. Methods of determining order of reactions. Kinetics of complex reactions.Chain reactions.Explosive reactions.Reaction mechanisms from rate data.Enzyme catalysis and Inhibition. Kinetics of heterogeneous reactions.

Electrochemistry: Eelectrolytic conduction. DHO theory.Concepts of ionic strength, activity and activity coefficient. Debye-Huckel limiting law. Numerical calculations. Types of fuel cells- Proton exchange membrane fuel cells, High temperature fuel cells. Solid oxide fuel cells,Molten carbonate fuel cells

Organic Chemistry:

Reactivity of organic compounds:Review of electron displacement of covalent bond. Inductive effect, Mesomeric effect and Resonance.Reactive intermediates and their reactivity.Reactions of carbonium ion, carbanion.Reactions of carbenes and nitrenes.

Stereochemistry: Introduction to stereochemistry. Configuration of asymmetric and dissymmetric molecules.D, L and R, S-nomenclature.Conformational analysis of ethane.Conformational analysis of *n*-butane.Conformational analysis of cyclohexane.

Chemistry of heterocyclic compounds:Introduction to heterocycles. Synthesis and properties of π-excessive heterocycles (Furan).Synthesis and properties of Thiophene.Synthesis and properties of Pyrrole.Synthesis and properties of π-deficient heterocycles: Pyridine.

Classification and structure of drugs: Study of the following drugs with reference to structure and synthesis: Antipyretics-Paracetamol, Anti-inflammatory drugs-Ibuprofen, Antibiotics-Penicillin, Anti malarial drugs-Quinine, Anti cancer drugs, Anti hypertensive drugs.

Organic Spectroscopy:Review of basic principles of UV. Basic principles of IR.Basic principles of NMR.Basic principles of Mass spectrometry.

Applications of the above techniques for structural elucidation.

Reading:

1. Atkin's Physical Chemistry, Peter Atkins and Julio de Paula, W. H. Freeman & Co., 9th Edition, 2009.
2. A Text Book of Physical Chemistry, K. L. Kapoor, Volumes 2, 3 and 5, Macmillan India Ltd., 3rd Edition, 2004
3. Organic Chemistry by Francis A. Carey, 5th Edition, Tata McGraw Hill Publishing Company Limited, 2007.
4. Introduction to spectroscopy, Donald L. Pavia, Gary M Lanyman, 3rd Edition, Thompson publishers, 2008.
5. Chemical Kinetics, Keith J. Laidler, Pearson Education Inc., Third Edition, 2008
6. Thermodynamics for Chemists, S. Glasstone, Narahari Press, 2007
7. Stereochemistry of Carbon Compounds by E. Eliel, John Wiley & Sons, Inc., 2009.
8. Spectroscopy of Organic Compounds, P. S. Kalsi, New Age International, 6th Edition, 2006.
9. Heterocyclic Chemistry, Raj K. Bansal, 5th Edition, New Age International (Pvt.Ltd.), 2006

CH201	PRINCIPLES OF STOICHIOMETRY	PCC	3 – 1 – 0	4 Credits

Pre-requisites: MA101Mathematics-I

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

CO1	Understand the material and energy balances of chemical processes.
CO2	Perform material and energy balances on chemical processes/equipment without and with reactions.
CO3	Draw the flow diagram and solve the problems involving recycle, purge and bypass in a process or unit.
CO4	Understand the ideal and real behavior of gases, vapors and liquids.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	3	3	3	1	-	-	-	-	-
CO2	3	2	3	3	3	3	1	-	-	-	-	-
CO3	3	3	3	3	2	2	-	-	-	-	-	-
CO4	3	3	3	3	3	1	-	-	-	-	-	-

Detailed syllabus

Introduction to engineering calculations: Units and Dimensions - Conversion of Units, Fundamental concepts of stoichiometry.

Material Balances: Basic Material Balance Principles, Material balance problems without and with chemical reactions, Recycle, Bypass and Purge.

Gases, Vapours and Liquids: Ideal Gas Law, Real Gas relationships, Vapour pressure, Vapor-Liquid Equilibrium calculations, Partial saturation & Humidity, Humidity chart, Material balances involving condensation and vaporization.

Energy Balances: Heat Capacity, Calculation of enthalpy changes, Energy balances without chemical reactions, Enthalpy changes of phase changes, Heat of solution and mixing, Energy balances accounting for chemical reactions - Standard heat of reaction, formation and combustion, Hess Law, Effect of temperature, Adiabatic flame temperature.

Reading:

1. Himmelblau. D.H and James B. Riggs, Basic Principles and Calculations in Chemical Engineering, 8^{th} Edition, Prentice Hall, 2012.
2. Hougen. O.A., Watson. K.M. and Ragatz. R.A., Chemical Process Principles (Part-I): Material and Energy Balances, 2^{nd} Edition, CBS Publishers, 2004.
3. Bhatt, B.I. and Thakore S.M., Stoichiometry, 5^{th} Edition, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2010.

CH202	FLUID AND PARTICLE MECHANICS	PCC	3 – 1 – 0	4 Credits

Pre-requisites: MA151 Mathematics-II, CE101 Engineering Mechanics.

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

CO1	Derive dimensionless groups by dimensional analysis.
CO2	Solve problems related to manometers and decanters using the principles of fluid statics.
CO3	Determine the pipe size / flow rate / power requirements under laminar and turbulent flow conditions.
CO4	Solve problems involving motion of particles in fluid, fluid–solid operations in packed beds and fluidized beds.
CO5	Select machinery for fluid transportation.
CO6	Determine the flow rate of fluid passing through closed channels.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	1	1	-	-	-	-	-	-	-	-
CO2	3	2	2	2	-	-	-	-	-	-	-	-
CO3	3	1	3	3	1	2	-	-	-	-	-	-
CO4	3	3	3	3	1	2	-	-	-	-	-	-
CO5	2	3	2	3	1	-	-	-	-	-	-	-
CO6	2	3	2	2	1	-	-	-	-	-	-	-

Detailed syllabus

Unit Systems: Unit systems, Dimensional analysis.

Fluid Statics and Its Applications: Nature of Fluids, Hydrostatic Equilibrium, Applications of Fluid Statics.

Fluid Flow Phenomena: Laminar flow, Shear rate, Shear stress, Rheological properties of fluids, Turbulence, Boundary layers.

Basic Equations of Fluid Flow: Mass balance in a flowing fluid; Continuity, differential momentum balance; equations of motion, Macroscopic momentum balances, Mechanical energy equations.

Incompressible Flow in Pipes and Channels: shear stress and skin friction in pipes, laminar flow in pipes and channels, turbulent flow in pipes and channels, friction from changes in velocity or direction.

Flow of Compressible Fluids: Definitions and basic equations.

Flow Past Immersed Bodies: Friction in flow through beds of solids, Motion of particles through fluids, Fluidization.

Transportation and Metering of Fluids: Pipes, fittings and valves. Pumps - positive displacement pumps and centrifugal pumps, fans, blowers, and compressors, Measurement of flowing fluids - full bore meters, insertion meters.

Reading:

1. McCabe W. L., Jullian Smith C. and Peter Harriott - Unit operations of Chemical Engineering, 7th Edition, McGraw-Hill international edition, 2005.
2. Coulson J.M and Richardson. J.F, Chemical Engineering Volume I and II, 5th Edition, Elsevier India, 2006.
3. De Nevers NH - Fluid Mechanics for Chemical Engineers, 3rd edition, McGraw Hill, NY, 2004.

CH203	MECHANICAL OPERATIONS	PCC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand mechanical unit operations and their role in chemical engineering industries.
CO2	Understand the nature of solids, their characterization, handling, and the processes involving solids.
CO3	Analyze the performance of size reduction equipment and calculate the power requirement.
CO4	Design solid-fluid separation equipment.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	1	2	1	-	-	-	-	-	-	-
CO2	3	3	2	3	1	-	-	-	-	-	-	-
CO3	3	3	2	2	1	-	1	-	-	-	-	-
CO4	3	3	3	3	1	-	-	-	-	-	-	-

Detailed syllabus

Introduction: Unit operations and their role in chemical industries; Types of mechanical operations;

Properties and handling of particulate solids: Characterization of solid particles, Properties of masses of particles, Mixing of solids, Size reduction, Ultrafine grinders.

Screening: Screening equipment, Screen capacity.

Cake filters: Centrifugal filters, Filter media, Principles of cake filtration, Washing filter cakes.

Clarifying filters: Liquid clarification, Gas cleaning, Principles of clarification.

Cross flow filtration: Types of membranes, Permeate flux for ultrafiltration, Concentration polarization, Applications of ultrafiltration, Diafiltration, Microfiltration.

Sedimentation: Gravity sedimentation processes, Centrifugal sedimentation processes.

Agitation and mixing of liquids: Agitated vessels, Blending and mixing, Suspension of solid particles, Dispersion operations, Agitator selection and scaleup, Power Number, Mixing Index.

Reading:

1. McCabe W. L., Jullian Smith C. and Peter Harriott - Unit operations of Chemical Engineering, 7th Edition, McGraw-Hill international edition, 2005.
2. Coulson J.M., Richardson J.F, Chemical Engineering, Vol. II, 4th Edition, Elsevier India, 2006.

CH204	ENERGY TECHNOLOGY AND CONSERVATION	PCC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand energy conversion processes for solid fuels.
CO2	Design energy utilization systems for heat recovery.
CO3	Estimate the properties of fuel samples
CO4	Perform energy audit.

Mapping of course outcomes with program outcomes

Course outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	1	2	1	-	3	-	-	-	-	-
CO2	3	3	2	2	1	-	3	-	-	-	-	-
CO3	1	1	1	1	-	-	1	-	-	-	-	-
CO4	2	2	2	2	-	-	3	-	-	-	-	-

Detailed syllabus

Energy scenario: Introduction and classification of energy, renewable and non-renewable energy, Indian energy scenario, energy pricing in India, energy and environment.

Solid fuels: Introduction, Biomass, Peat, Light and brown coal, Black Lignite, Bituminous coal, Semi anthracite , Anthracite, Natural coke/SLV fuel, Origin of coal, composition of coal, classification of coal, Sampling and analysis of solid fuels, oxidation of coal, Hydrogenation of coal, storage of coal.

Carbonization and gasification processes: Introduction, carbonization of coal, the gasification of solid fuels, the gasification of oil and hydrocarbon gas reforming, carbureted water gas

Energy conversion with combustion: Introduction, Combustion, Burner design, Combustion plant, direct conversion of energy.

Fuel testing: Introduction, Calorific value, tests on liquid fuels, Fuel and flue gas analysis.

Energy auditing: Introduction, Energy conservation schemes Industrial energy use, energy conversion, energy index, energy costs.

Energy sources: Energy consumption, world energy reserves, energy prices, fuel production and processing, energy policies, choice of fuels, cycle efficiency.

Heat transfer media: Water, Steam, Thermal fluids, Air-water vapor mixtures

Heat transfer equipment: Heat exchangers, Combustion and thermal efficiency, Steam plant, pressure hot water and thermal fluids plant, thermal fluids plant.

Energy utilisation and conversion systems: Furnaces, Hydraulic power systems, Compressed air, steam turbines, combined power and heating systems, Energy conversion, District heating

Heat recovery: Sources of waste heat and its applications, Heat recovery systems, Incinerators, Regenerators and recuperators, waste heat boilers.

Reading:

1. Samir Sarkar, Fuels and Combustion, Universities Press, 2009.
2. Murphy W.R and Mckay G., Energy Management, Elsevier, 2007.
3. HarkerJ.H. and J.R. Backhurst, Fuel and Energy, Academic Press, London, 1981.

CH205	FLUID AND PARTICLE MECHANICS LABORATORY	PCC	0 – 0 – 3	2 Credits

Pre-requisites: None

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

CO1	Determine viscosity using Cannon Fenske viscometer and terminal velocity experiment.
CO2	Distinguish laminar and turbulent flows.
CO3	Select manometric fluid for experiment.
CO4	Determine the characteristics of packed & fluidized beds and centrifugal pumps.
CO5	Identify ball, gate, globe, check valves, elbow, bend and T-joint.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1	1	-	-	-	-	-	-	-	-
CO2	1	1	1	1	-	-	-	-	-	-	-	-
CO3	1	1	2	1	-	-	-	-	-	-	-	-
CO4	2	2	2	2	2	-	-	-	-	-	-	-
CO5	2	2	2	2	2	-	-	-	-	-	-	-

Detailed syllabus

1. Determination of viscosity using Cannon Fenske Viscometer.
2. Reynolds Experiment.
3. Verification of Bernoulli’s Principle.
4. Friction in flow through pipes - Friction in pipe fittings and valves.
5. Terminal settling velocity.
6. Characteristics of a packed bed with air flow.
7. Characteristics of a packed bed with water flow.
8. Characteristics of fluidized bed.
9. Orifice and Venturi meters.
10. Characteristics of a centrifugal pump.
11. Flow through helical coil.
12. Demonstration of rheometer.
13. Efflux time.

Reading: Lab Manuals

EE235	BASIC ELECTRICAL ENGINEERING LABORATORY	ESC	0 – 0 – 3	2 Credits

Pre-requisites: EE101 Basic Electrical Engineering

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

CO1	Evaluate the performance of various electrical machines
CO2	Handle electrical apparatus safely and confidently
CO3	Exploit the characteristics of electrical machines for a given application

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	-	-	-	-	-	1	-	-	-
CO2	3	-	-	-	-	-	-	-	1	-	-	-
CO3	3	-	-	-	-	-	-	-	1	-	-	-

Detailed syllabus

1. a) Verification of Kirchhoff's Voltage and Current Laws.
   b) Verification of Superposition Theorem.
2. Calculation of the Power factor and Power in a Single Phase Series R-L circuit.
3. Measurement of Self and Mutual inductance of Coils.
4. No load test on a DC Machine.
5. Load test on a DC Shunt Generator.
6. Speed Control of a DC Shunt Motor
7. a) Determination of Equivalent Circuit Parameters of a Single Phase Transformer.
   b) Predetermination of Efficiency and Regulation of a Single Phase Transformer.
   c) Direct Load test on a Single Phase Transformer.
8. Separation of No-load Losses of a Single phase Transformer.
9. Direct Load test on a Three Phase Induction Motor.

Reading: Lab Manuals

MA251	MATHEMATICS - IV	BSC	4 – 0 – 0	4 Credits

Pre-requisites: MA201 Mathematics-III

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

CO1	Estimate chance of occurrence of events using probability distributions.
CO2	Analyze the null hypothesis for large and small number of samples.
CO3	Construct a curve for the data using least squares
CO4	Estimate value of functions using Forward and Backward interpolations.
CO5	Solve initial values problems.
CO6	Determine series solution of Bessel and Legendre equations.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	2	-	3	-	-	-	-	-	-
CO2	3	-	-	2	-	3	-	-	-	-	-	-
CO3	3	-	-	2	-	3	-	-	-	-	-	-
CO4	3	-	-	2	-	3	-	-	-	-	-	-
CO5	3	-	-	2	-	3	-	-	-	-	-	-
CO6	3	-	-	2	-	3	-	-	-	-	-	-

Detailed syllabus

Statistics and Probability: Probability laws – Addition and Multiplication theorems on probability - Baye's theorem –Expectation, Moments and Moment generating function of Discrete and continuous distributions, Binomial, Poisson and Normal distributions, fitting these distributions to the given data, Testing of Hypothesis - Z-test for single mean and difference of means, single proportion and difference of proportions - t-test for single mean and difference of means, F-test for comparison of variances,. Chi-square test for goodness of fit. – Correlation, regression.

Numerical Analysis: Curve fitting by the method of least squares. Fitting of (i) Straight line (ii) Second degree parabola (iii) Exponential curves. Calculation of dominant eigen value by iteration, Gauss Seidal iteration method to solve a system of equations and convergence (without proof). Numerical solution of algebraic and transcendental equations by Regula-Falsi method Newton-Raphson's method.

Lagrange interpolation, Newton's divided differences, Forward, backward and central differences, Newton's forward and backward interpolation formulae, Gauss's forward and backward interpolation formulae, Numerical differentiation at the tabulated points with forward backward and central differences. Numerical Integration with Trapezoidal rule, Simpson's 1/3 rule, Simpson's 3/8 rule and Romberg integration. Taylor series method, Euler's method, modified Euler's method, Runge-Kutta method of 2^{nd}& 4^{th} orders for solving first order ordinary differential equations.

Series Solution: Series solution of Bessel and Legendre's differential equations. Bessel function of first kind Recurrence formulae Generating function Orthogonality of Bessel functions Legendre polynomial Rodrigue's formula Generating function Recurrence formula Orthogonality of Legendre polynomials.

Reading:

1. S.C.Gupta and V.K.Kapoor, Fundamentals of Mathematical Statistics, S.Chand& Co, 2006.
2. Jain, Iyengar and Jain, Numerical methods for Scientific and Engineering Computation, New Age International Publications, 2008.
3. ErwynKreyszig, Advanced Engineering Mathematics, John Wiley and Sons, 8^{th} Edition, 2008.
4. B.S.Grewal, Higher Engineering Mathematics, Khanna Publications, 2009.

CH251	CHEMICAL TECHNOLOGY	PCC	4 – 0 – 0	4 Credits

Pre-requisites: None

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

CO1	Understand inorganic and organic chemical technologies.
CO2	Draw process flow diagrams.
CO3	Identify the effect of chemical technologies on the health, safety and environment.
CO4	Understand engineering problems in chemical processes and equipments.
CO5	List chemical reactions and their mechanism involved.

Mapping of course outcomes with program outcomes

Course outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	3	2	1	-	-	-	-	-	-	-
CO2	2	2	2	2	2	-	-	-	-	-	-	-
CO3	1	1	1	-	-	-	3	-	-	-	-	-
CO4	3	3	2	1	2	-	-	-	-	-	-	-
CO5	2	2	2	2	-	-	-	-	-	-	-	-

Detailed syllabus

Introduction: Chemical industries-facts and figures, Unit operation and unit process concepts, Chemical processing and role of chemical engineers.

Chloro-Alkali Industries: Soda ash, Solvay process, dual process, Natural soda ash from deposits, Electrolytic process, Caustic soda.

Phosphorus Industries: Phosphoric acid, Wet process, Electric furnace process, Calcium phosphate, Ammonium phosphates, Nitrophosphates, Sodium phosphate.

Potassium Industries: Potassium recovery from sea water.

Nitrogen Industries: Ammonia, Nitric acid, Urea from ammonium carbonate, Ammonium nitrate.

Sulfur and Sulfuric Acid Industries: Elemental sulfur mining by Frasch process, Sulfur production by oxidation-reduction of H_2S, Sulfur and sulfur dioxide from pyrites, Sulfuric acid. Contact process, Chamber process.

Soap and Detergents: Batch saponification production, Continuous hydrolysis and saponification process, Sulfated fatty alcohols, Alkyl-aryl sulfonates.

Sugar and Starch Industries: Sucrose, Extraction of sugar cane to produce crystalline white sugar, Extraction of sugar cane to produce sugar, Starch production from maize, Production of dextrin by starch hydrolysis in a fluidized bed.

Fermentation Industries: Ethyl alcohol by fermentation, Fermentation products from petroleum.

Pulp and Paper Industries: Sulfate pulp process, Chemical recovery from sulfate pulp digestion liquor, Types of paper products, Raw materials, Methods of production.

Plastic Industries: Polymerization fundamentals, Polymer manufacturing processes, Ethenic polymer processes, Polycondensation processes, Polyurethanes.

Petroleum Processing: Production of crude petroleum, Petroleum refinery products, Types of refineries, Design of refinery, Choice of crude petroleum, Refinery processes, Pyrolysis and cracking, Reforming, Polymerization, Isomerization, Alkylation.

Rubber: Elastomer polymerization processes, Rubber polymers, Butadiene-Styrene copolymer, Polymer oils and rubbers based on silicon.

Reading:

1. Austin G.T., Shreve's Chemical Process Industries - International Student Edition, 5th Edition, McGraw Hill Inc., 1998.
2. Sittig M. and GopalaRao M., Dryden's Outlines of Chemical Technology for the 21st Century, 3rd Edition, WEP East West Press, 2010.

CH252	CHEMICAL ENGINEERING THERMODYNAMICS-I	PCC	3 – 1 – 0	4 Credits

Pre-requisites: ME101 Basic Mechanical Engineering

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

CO1	Apply the first and second laws of thermodynamics to chemical processes.
CO2	Compute the properties of ideal and real mixtures.
CO3	Analyze the behavior of flow and non-flow processes using mass and energy balances.
CO4	Estimate heat and work requirements for industrial processes.
CO5	Determine the efficiency of processes involving heat into work, refrigeration and liquefaction.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	2	-	-	-	-	-	-	-
CO2	3	2	2	2	-	-	2	-	-	-	-	-
CO3	3	3	3	3	1	-	-	-	-	-	-	-
CO4	3	3	3	3	2	-	3	-	-	-	-	-
CO5	1	2	2	2	-	-	3	-	-	-	-	-

Detailed syllabus

Introduction and First Law of Thermodynamics: Scope of Thermodynamics, Thermodynamic Systems: Basic Concepts, Joule's Experiments, Concept of Internal Energy, First Law of Thermodynamics, Energy Balance for Closed Systems, Thermodynamic State and State Functions, Equilibrium, The Phase Rule, The Reversible Process, Constant-V and Constant-P Processes, Enthalpy, Heat Capacity, Mass and Energy balances for Open Systems

Volumetric Properties of Pure Fluids: General P-V-T Behavior of Pure Substances, Virial Equations of State, The Ideal Gas, Application of the Virial Equations, Cubic Equations of State, Generalized Correlations for Gases, Generalized Correlations for Liquids.

The Second Law of Thermodynamics: Statements of the Second Law, Heat Engines, Thermodynamic Temperature Scales, Entropy, Entropy Changes of an Ideal Gas, Mathematical

Statement of the Second Law, Entropy Balance for Open Systems, Calculation of Ideal Work, Lost Work, The Third Law of Thermodynamics, Entropy from the Microscopic Viewpoint.

Thermodynamic Properties of Fluids: Thermodynamic Property Relations for Single Phase Systems, Residual Property Relations, Residual Property Calculation by Equations of State, Two-Phase Systems, Thermodynamic Diagrams, Tables of Thermodynamic Properties, Generalized Property Correlations for Gases.

Applications of Thermodynamics to Flow Processes: Duct Flow of Compressible Fluids, Turbines (Expanders), Compression Processes.

Conversion of Heat into Work by Power Cycles: The Steam Power Plant, Internal-Combustion Engines, Jet Engines; Rocket Engines

Refrigeration and Liquefaction: Carnot Refrigerator, Vapor-Compression Cycle, Choice of Refrigerant, Absorption Refrigeration, Heat Pump, Liquefaction Processes.

Reading:

1. Smith J. M, H. C. Van Ness and M. M. Abbott, Introduction to Chemical Engineering Thermodynamics, 7th ed., McGraw-Hill, 2004.
2. K. V. Narayanan, Chemical Engineering Thermodynamics, Prentice Hall of India Pvt. Ltd., 2009.

CH253	HEAT TRANSFER	PCC	3 – 1 – 0	4 Credits

Pre-requisites: CH201 Principles of Stoichiometry, CH202 Fluid and Particle Mechanics.

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

CO1	Understand the modes of heat transfer.
CO2	Determine heat transfer coefficients for forced and natural convection.
CO3	Understand heat transfer involving phase change.
CO4	Analyze the heat exchanger performance for co-current and counter-current flows.
CO5	Design double pipe and shell & tube heat exchangers.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	2	1	-	2	-	-	-	-	-
CO2	3	2	3	3	-	-	2	-	-	-	-	-
CO3	3	2	2	2	-	-	2	-	-	-	-	-
CO4	3	2	2	2	-	-	1	-	-	-	-	-
CO5	2	2	2	2	-	-	-	-	-	-	-	-

Detailed syllabus

Introduction: Modes of heat transfer, material properties of importance in heat transfer.

Heat Transfer by Conduction in Solids & Principles of heat flow in fluids: Steady state heat conduction, Conduction through bodies in series, Unsteady state heat conduction, Concept of heat transfer coefficient, Individual and overall heat transfer coefficient, Concept of fins, Critical insulation thickness.

Heat Transfer to fluids without & with phase change: Concept of Boundary layers, Heat transfer by forced convection in laminar flow, Turbulent flow and transition region, Heat transfer to liquid metals, Forced convection on outside tubes, Natural convection, Momentum and heat transfer analogies; Condensation and Boiling.

Radiation Heat Transfer: Concepts of radiation, Laws of radiation, Radiation between black surfaces, Interchange factor, Exchange of energy between parallel planes.

Heat Exchange equipment: Heat Exchangers, Condensers and Boilers, Shell and Tube Heat Exchangers, Other types of Heat Exchangers, Effectiveness-NTU Method.

Evaporation: Basics of evaporation, Performance of tubular evaporators, Capacity & Economy, Multiple effect evaporator; Principles of Crystallization, Crystallization equipment.

Reading:

1. W.L. McCabe, J.C. Smith and P. Harriott - Unit Operations of Chemical Engineering, 7th Edition, McGraw Hill, 2005.
2. J.P. Holman - Heat Transfer, 8th Edition, McGraw Hill, NewYork, 1997.
3. Incropera, DeWitt, Bergmann, Lavine - Fundamentals of Heat and Mass Transfer, 6th Edition, Wiley Publications, 2010.
4. NecatiOzisik, Heat Transfer: A Basic Approach, Vol 1, McGraw Hill, 1985.
5. Donald Q. Kern, Process Heat Transfer, Tata McGraw Hill Education Pvt. Ltd., 2001.
6. Robert W. Serth, Process Heat Transfer: Principles and Applications, Academic Press, 2007.

CH254	PROCESS INSTRUMENTATION	PCC	3 – 0 – 0	3 Credits

Pre-requisites: CH202 Fluid and Particle Mechanics.

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

CO1	Understand the measurement techniques for Pressure and Temperature
CO2	Understand the measurement techniques for Flow and Level
CO3	Understand recording, indicating and signaling instruments
CO4	Analyze repeatability, precision and accuracy of instruments

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	-	1	2	2	-	-	-	-	-	-	-
CO2	2	-	-	2	2	-	-	-	-	-	-	-
CO3	3	-	-	2	2	-	-	-	-	-	-	-
CO4	3	-	-	2	2	-	-	-	-	-	-	-

Detailed syllabus

Characteristics of Measurement System -Elements of instruments, static and dynamic characteristics, basic concepts of response of first order type instruments, mercury in glass thermometer, bimetallic thermometer, pressure spring thermometer, static accuracy and response of thermometers.

Pressure Measurement- Pressure, vacuum and head manometers, measuring elements for gage pressure and vacuum, measuring pressure in corrosive liquids, measuring of absolute pressure, static accuracy and response of pressure gages.

Temperature Measurement–Industrial thermocouples, thermocouple wires, thermo couple wells and response of thermocouples.

Flow Measurement- head flow meters, open channel meters, area flow meters, flow of dry materials, viscosity measurement. Level Measurement- direct measurement of liquid level, level measurement in pressure vessels, measurement of interface level, level of dry materials. Instruments for Analysis - recording instruments, indicating and signaling instruments, instrumentation diagram.

Reading:

1. Patranabis D, Principles of Industrial Instrumentation, 2nd Edition, Tata McGraw Hill Publishing Company, New Delhi, 1999.
2. EckmanDonald P., Industrial Instrumentation, Wiley Eastern Ltd., 2004.
3. William C. Dunn, Fundamentals of Industrial Instrumentation and Process Control, 1st Edition, Tata McGraw-Hill Education Private Limited, 2009.

CH255	PETROLEUM REFINING AND PETROCHEMICALS	PCC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	State the composition of petroleum.
CO2	Understand the unit operations and processes in petroleum refining.
CO3	Understand the technologies for conversion of petroleum refining products to chemical products.
CO4	Select feed stock for conversion to products.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	1	1	-	-	-	-	-	-	-	-
CO2	2	3	1	1	-	-	-	-	-	-	-	-
CO3	2	3	2	1	-	-	-	-	-	-	-	-
CO4	1	3	1	1	-	-	-	-	-	-	-	-

Detailed syllabus

Origin, formation and composition of petroleum: Origin and formation of petroleum, Reserves and deposits of world, Petro Glimpses and petroleum industry in India, Composition of petroleum

Petroleum processing data: Evaluation of Petroleum, Thermal properties of petroleum fractions, Important products-properties and test methods

Fractionation of petroleum: Dehydration and desalting of crudes, Heating of crudes, Distillation of petroleum, Blending of gasoline.

Treatment techniques: Fractions-Impurities, Gasoline treatment, Treatment of kerosene, Treatment of lubes, Wax and purification.

Thermal and catalytic processes: Cracking, Catalytic cracking, Catalytic reforming-introduction and theory, Naptha cracking, Coking, Hydrogen processes, Alkylation, Isomerisation processes, Polymer gasoline.

Petrochemical industry-Feed stocks: Feed stocks for petrochemicals.

Chemicals from methane: Oxidation of Methane, Halides of methane, Methyl amines, Carbon disulphide, Hydrogen Cynide, Liquid fuels from methane.

Reading:

I. B.K. BhaskaraRao, *Modern Petroleum Refining Processes*, 4th Edition, Oxford&IBH Publishing Co. Pvt. Ltd., 2008.
II. B.K. BhaskaraRao, *A Text Book of Petrochemicals,* 2ndedition, Khanna Publications, 2002.
III. W.L. Nelson, *Petroleum Refinery Engineering,* McGraw Hill Book Company, 1969.

CH256	CHEMICAL TECHNOLOGY LABORATORY	PCC	0 – 0 – 3	2 Credits

Pre-requisites: None

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

CO1	Prepare aspirin, soap, dyes and pigments
CO2	Extraction of oil using solvents
CO3	Determine the composition of common salt; Water; Lime; Urea; Soda ash; Vegetable oils and Sugar
CO4	Determine Reid's vapor pressure, Smoke point, Aniline point and Abel's Flash point of given fuel.
CO5	Determine gas composition using Orsat Analysis.
CO6	Determine the properties using Redwood viscometer; Photo-colorimeter, Bomb calorimeter.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	2	-	-	-	1	-	-	-	-	-	-
CO2	-	2	-	-	-	1	-	-	-	-	-	-
CO3	1	2	1	-	-	-	-	-	-	-	-	-
CO4	2	2	2	2	2	-	-	-	-	-	-	-
CO5	-	2	-	-	-	-	-	-	-	-	-	-
CO6	-	2	-	-	-	-	-	-	-	-	-	-

Detailed syllabus

List of experiments: Analysis of raw materials, intermediates and products such as: Common salt; Water; Lime; Urea; Soda ash; Vegetable oils; Sugar etc.Testing of fuels: Orsat Analysis; Reid's vapor pressure; Redwood viscometer; Smoke point; Aniline point; Photo-colorimeter; Abel's Flash point; infrared moisture balance; ASTM Distillation; Bomb calorimeter.

Reading: Lab manuals

CH257	HEAT TRANSFER LABORATORY	PCC	0 – 0 – 3	2 Credits

Pre-requisites: None

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

CO1	Understand the Electrical analogy in relation to heat conduction
CO2	Determine Emissivity of a given body.
CO3	Determine heat flow for resistances in series
CO4	Determine heat losses from cylindrical furnace
CO5	Determine temperature profiles in rod-double pipe heat exchanger, helical coil, heat pipe demonstration experiment.
CO6	Understand boiling Phenomena in liquids

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	2	2	-	-	-	-	-	-	-	-
CO2	-	1	-	-	-	-	-	-	-	-	-	-
CO3	1	2	2	2	-	-	-	-	-	-	-	-
CO4	1	2	2	2	-	-	-	-	-	-	-	-
CO5	1	2	2	2	-	-	-	-	-	-	-	-
CO6	2	2	2	2	-	-	-	-	-	-	-	-

Detailed syllabus

List of experiments:

1. Electrical Analogue of Heat Conduction.
2. Heat Conduction through Slabs in Series.
3. Heat Conduction in Thin Rod.
4. Thermal Conductivity Measurement of Metal Rod.
5. Natural Convection from a Heated Vertical Cylinder.
6. Pin – Fin Apparatus.
7. Double Pipe Heat Exchanger.
8. Shell and Tube Heat Exchanger.
9. Emissivity Measurement Apparatus.

10. Stefan Boltzmann Apparatus.
11. Boiling of liquids
12. Condensation of vapors.

Reading: Lab manuals

CH301	CHEMICAL REACTION ENGINEERING - I	PCC	3 – 1 – 0	4 Credits

Pre-requisites: CY201 Physical & Organic Chemistry**,** CH202 Fluid and Particle Mechanics.

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

CO1	Derive the rate law for non-elementary chemical reactions and gas-phase reactions catalyzed by solids.
CO2	Determine kinetics of chemical reaction from the data using integral, differential and method of fractional lives.
CO3	Design reactors for conducting homogenous reactions under isothermal conditions.
CO4	Compare the performance of ideal reactors.
CO5	Select optimal sequence in multiple reactor systems
CO6	Design adiabatic plug flow reactor and fixed bed reactor in the absence of mass transfer effects.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	1	-	-	-	-	-	-	-
CO2	3	3	3	3	-	-	-	-	-	-	-	-
CO3	3	3	3	3	-	-	-	-	-	-	-	-
CO4	3	3	3	3	-	-	-	-	-	-	-	-
CO5	3	3	3	3	-	-	-	-	-	-	-	-
CO6	3	3	3	3	1	-	3	-	-	-	-	-

Detailed syllabus

Kinetics of Homogeneous Reactions**:** Concentration-Dependent Term of a Rate Equation, Temperature-Dependent Term of a Rate Equation, Searching for a Mechanism, Predictability of Reaction Rate from Theory.

Conversion and Reactor Sizing**:** Definition of Conversion, Batch Reactor Design Equations, Design Equations for Flow Reactors, Applications of the Design Equations for Continuous-Flow Reactors, Reactors in Series, Some Further Definitions.

Analysis of Rate Data: The Algorithm for Data Analysis, Batch Reactor Data, Method of Initial Rates, Method of Half-Lives, Differential Reactors, Experimental Planning, Evaluation of Laboratory Reactors.

Isothermal Reactor Design: Mole Balances in Terms of Conversion- Design Structure for Isothermal Reactors, Scale-Up of Liquid-Phase Batch Reactor Data to the Design of a CSTR, Design of Continuous Stirred Tank Reactors (CSTRs), Tubular Reactors, Pressure Drop in Reactors, Synthesizing the Design of a Chemical Plant. Mole Balances Written in Terms of Concentration and Molar Flow Rate- Mole Balances on CSTRs, PFRs, PBRs, and Batch Reactors.

Catalysis and Catalytic Reactors: Catalysts, Steps in a Catalytic Reaction, Synthesizing a Rate Law, Mechanism, and Rate-Limiting Step, Heterogeneous Data Analysis for Reactor Design.

Adiabatic tubular reactor design.

Reading:

1. H. Scott Fogler - Elements of Chemical Reaction Engineering – 2nd Edition, Prentice Hall of India Pvt. Ltd.
2. O. Levenspiel – Chemical Reaction Engineering – 3rdEdition – Wiley India, 2006.
3. Ronald W. Missen, Charles A. Mims, Bradley A. Saville, Introduction to Chemical Reaction Engineering & Kinetics, Wiley, 1998.
4. E. Bruce Nauman, Chemical Reactor Design, Optimization and Scaleup, 2nd Edition, Wiley, 2008.
5. Mark E. Davis & Robert J. Davis, Fundamentals of Chemical Reaction Engineering, McGraw Hill, 2002.

CH302	CHEMICAL ENGINEERING THERMODYNAMICS – II	PCC	3 – 1 – 0	4 Credits

Pre-requisites: CH252 Chemical Engineering Thermodynamics – I

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

CO1	Calculate heat effects involved in industrial chemical processes
CO2	Determine thermodynamic properties of gaseous mixtures / solutions
CO3	Calculate Bubble-P & T, Dew-P & T for binary and multi-component systems
CO4	Calculate vapor-liquid equilibrium (VLE) composition for ideal and non-ideal systems
CO5	Determine equilibrium constant and composition of product mixture at given temperature and pressure

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	-	-	3	-	-	-	-	-
CO2	3	3	3	3	-	-	3	-	-	-	-	-
CO3	3	3	3	3	-	-	3	-	-	-	-	-
CO4	3	3	3	3	-	-	1	1	-	-	-	-
CO5	3	3	3	3	-	-	-	-	-	-	-	-

Detailed syllabus

Heat Effects: Sensible heat effects, Temperature dependency of heat capacity, Latent Heat of pure substance, Standard heats of reaction, formation and combustion, Heat effects of industrial reactions.

Solution Thermodynamics: Fundamental property relation, Chemical potential, Partial properties, The ideal gas mixture model, Fugacity and fugacity coefficient, The ideal solution model, Excess properties.

Applications of Solution Thermodynamics: Liquid phase properties from VLE data, Activity coefficient, Excess Gibbs Energy, Models for the excess Gibbs energy, Property changes of mixing, Heat effects of mixing process.

VLE at low to moderate pressures: The nature of equilibrium, Criteria of equilibrium, The phase rule, Duhem's theorem, Raoult's law, Henry's law, Modified Raoults's law, Dew point and bubble point calculations, Relative volatility, Flash calculations.

Thermodynamic properties and VLE from equations of state.

Chemical Reaction Equilibria: The reaction coordinate, Equilibrium criteria to chemical reactions, Gibbs free energy change, Equilibrium constant, Effect of temperature on equilibrium constant, Evaluation of equilibrium constants, Relation of equilibrium constant to composition, Equilibrium conversions for single reactions, Phase rule and Duhem's theorem for reacting systems, Multi-reaction equilibria.

Reading:

1. Smith J.M, Van Ness H.C and Abbott M.M., Introduction to Chemical Engineering Thermodynamics, 7th Edition, McGraw Hill International, 2004.
2. Hougen O. A, Watson. K. M and Ragatz R. A, Chemical Process Principles (Part-II), 2nd Edition, CBS Publishers, 2004.
3. Narayanan, K.V, Chemical Engineering Thermodynamics, Prentice Hall of India Pvt. Ltd., 2009.

CH303	INDUSTRIAL SAFETY AND HAZARD MITIGATION	PCC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Analyze the effects of release of toxic substances.
CO2	Select the methods of prevention of fires and explosions.
CO3	Understand the methods of hazard identification and preventive measures.
CO4	Assess the risks using fault tree diagram.

Mapping of course outcomes with program outcomes

Course Outcomes	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	2	3	2	2	2	-	3	-	-	-	-	-
CO2	2	3	1	1	1	-	3	-	-	-	-	-
CO3	3	3	3	1	2	-	3	-	-	-	-	-
CO4	2	2	3	2	2	-	3	-	-	-	-	-

Detailed syllabus

Introduction: Safety Programs, Engineering Ethics, Accident and Loss Statistics, Acceptable Risk, Public Perceptions, Nature of the Accident Process, Inherent Safety.

Industrial Hygiene: Anticipation and Identification, Hygiene Evaluation, Hygiene Control.

Fires and Explosions: Fire Triangle, Distinction between Fires and Explosions, Flammability Characteristics of Liquids and Vapors, Limiting Oxygen Concentration and Inerting, Flammability Diagram

Concepts to Prevent Fires and Explosions: Inerting, Controlling Static Electricity, Explosion-Proof Equipment and Instruments, Ventilation, Sprinkler Systems.

Introduction to Reliefs: Relief Concepts, Location of Reliefs, Relief Types, Relief Scenarios, Data for Sizing Reliefs, Relief Systems.

Relief Sizing- Conventional Spring: Operated Reliefs in Liquid Service, Conventional Spring-Operated Reliefs in Vapor or Gas Service, Rupture Disc Reliefs in Liquid Service, Rupture Disc Reliefs in Vapor or Gas Service.

Hazards Identification: Process Hazards Checklists, Hazards Surveys, Hazards and Operability Studies, Safety Reviews.

Safety Procedures and Designs: Process Safety Hierarchy, Managing Safety, Best Practices, Procedures—Operating, Procedures—Permits, Procedures—Safety Reviews and Accident Investigations, Designs for Process Safety.

Reading:

1. D.A. Crowl and J.F. Louvar, Chemical Process Safety (Fundamentals with Applications), Prentice Hall,2011.
2. R.K. Sinnott, Coulson & Richardson's Chemical Engineering, Vol. 6, Elsevier India, 2006.

CH304	MASS TRANSFER-I	PCC	3 – 1 – 0	4 Credits

Pre-requisites: CH253 Heat Transfer

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

CO1	Understand Fick's law of diffusion.
CO2	Determine diffusivity coefficient in gases and liquids.
CO3	Determine mass transfer coefficients.
CO4	Calculate rate of mass transfer in humidification.
CO5	Select equipment for gas-liquid operations.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	2	2	-	-	-	-	-	-	-	-
CO2	2	-	1	1	-	-	-	-	-	-	--	-
CO3	3	2	3	3	-	-	-	-	-	-	-	-
CO4	3	1	3	3	-	-	-	-	-	-	-	-
CO5	3	2	2	3	-	-	-	-	-	-	-	-

Detailed syllabus

Introduction: Types of mass transfer operations in chemical industries.

Molecular Diffusion: Stefan tube experiment to determine diffusion coefficient in gases, Fick's law of diffusion, Determination of diffusion coefficient in liquids, Diffusion of naphthalene into air – example, Two bulb method to determine diffusion coefficient in gases, Correlations for diffusion coefficient in gases and liquids, Dependence on temperature and pressure, Correlation for diffusion coefficient in multi-component gaseous mixture, Formulation of flux with a reaction occurring on surface, Diffusion in solids.

Inter-Phase Mass Transfer: Pure liquid (stationary) to gas mixture (gently mixed), Concept of mass transfer coefficient and driving force, Pure gas (stationary) to liquid mixture (gently mixed), Pure gas to liquid (laminar falling film), Concept of Sherwood number, Sherwood number correlations for various geometries and flow regimes, Theories of mass transfer coefficient for gas to turbulent liquid flow, Analogies between heat, mass and momentum transfer, Two film resistance theory.

Equipment for Gas-Liquid Operations: Components of equipment in packed towers, Bubble column, Tray towers, etc. Material balance for packed tower– Distributed parameter model, Equilibrium curve & Operating line, Concept of H_{tOG} and N_{tOG} - height of transfer unit and number of transfer units, Stage efficiency.

Humidification Operations: Psychrometric charts, Adiabatic operation, Equipment & components, Non-adiabatic operation, Design of cooling tower.

Reading:

1. Treybal R.E., Mass Transfer Operations, 3rd Ed., McGrawHill, 1981.
2. Geankoplis C.J., Transport processes and Separation Process Principles, 4th Ed., Prentice-Hall India, 2003.
3. Binay K. Dutta, Principles of Mass Transfer and Separation Processes, 2nd Ed., Prentice-Hall India, 2007.

CH305	COMPUTATIONAL METHODS IN CHEMICAL ENGINEERING LABORATORY	PCC	0 – 0 – 3	2 Credits

Pre-requisites: CH202 Fluid and Particle Mechanics, CH253 Heat Transfer, CH252 Chemical Engineering Thermodynamics-I

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

CO1	Apply numerical methods to solve problems involving material and energy balances, fluid flow operations, heat and mass transfer, evaporation, thermodynamics and mechanical operations.
CO2	Determine roots of algebraic equations, solution of simultaneous equations and ordinary differential equations.
CO3	Solve problems using regression analysis, interpolation, extrapolation and numerical differentiation and numerical integration
CO4	Solve problems using MATLAB.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	3	-	3	-	-	-	-	-	-
CO2	-	-	-	2	-	3	-	-	-	-	-	-
CO3	-	-	-	1	-	3	-	-	-	-	-	-
CO4	-	-	-	-	-	3	-	-	-	-	-	-

Detailed syllabus

Applications of Numerical Methods to Chemical Engineering Problems: Roots of algebraic equation and solution of simultaneous equations, Regression analysis, Interpolation and Extrapolation, Differentiation and Numerical Integration, Solution of ordinary differential equations.

Chemical Engineering Problems: Material and Energy balance, Fluid flow operations, Heat transfer and evaporation, Mass Transfer operations, Thermodynamics, Mechanical operations, Prediction of properties.

Reading: Lab manuals

CH306	CHEMICAL REACTION ENGINEERING LABORATORY	PCC	0 – 0 – 3	2 Credits

Pre-requisites: None

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

CO1	Determine the kinetics of chemical reaction in Batch reactor, CSTR, PFR
CO2	Determine the kinetics using Dilatometer
CO3	Determine the temperature dependency of reaction rate constant
CO4	Analyze the performance of reactors through RTD studies
CO5	Compare the performance of CSTR-PFR with PFR-CSTR reactor systems
CO6	Compare the performance of single CSTR with series of CSTRs

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	3	3	2	2	1	-	1	-	1	-
CO2	3	3	3	2	1	2	1	-	1	-	1	-
CO3	3	3	3	3	2	2	1	-	1	-	1	-
CO4	3	2	3	3	3	3	1	-	1	-	1	-
CO5	3	2	3	3	3	2	1	-	1	-	1	-
CO6	3	2	3	3	3	2	1	-	1	-	1	-

Detailed syllabus

List of experiments:

1) Saponification of ethyl acetate in batch reactor.
2) Saponification of ethyl acetate in a tubular flow reactor.
3) Kinetic studies to establish rate constant using continuous stirred tank reactor.
4) Determination of rate constant in a combined reactor (PFR followed by CSTR).
5) Kinetic studies in CSTRs in series.
6) Determination of dispersion number in a packed bed reactor.
7) Determination of rate constant and activation energy for esterification reaction.

8) Studies on gas-liquid-solid reaction using hydrodynamic cavitation- carbonization process.
9) Polymerization of acrylic acid in a batch reactor.
10) Demonstration of nitration reaction in Microreactors
11) Demonstration of Microwave Reactor
12) Demonstration of Ultrasound Probe Reactor
13) Kinetic studies using Dilatometer.

Reading:

1. Laboratory Manuals
2. Octave Levenspiel, *Chemical Reaction Engineering*, 2nd Edition, Wiley India, 2006.

CH311	NUCLEAR PROCESS ENGINEERING	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand radioactivity, nuclear fission and fusion.
CO2	Understand the interaction of alpha, beta particles and neutrons with matter.
CO3	Understand neutron cycle, critical mass, reactor period and transient conditions.
CO4	Understand engineering aspects of nuclear power production and environmental effects.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	1	-	3	-	-	-	-	-
CO2	1	2	-	-	-	-	3	-	-	-	-	-
CO3	1	2	-	-	-	-	2	-	-	-	-	-
CO4	2	3	3	3	-	-	3	-	-	-	-	-

Detailed syllabus

Nuclear Energy Fundamentals: Atomic structure and Radio isotopes, Nuclear fission and fusion, types and classification of nuclear reactors, nuclear fuels, other reactor materials, fuel processing flow sheet, chemical processes for nuclear power industries, separation of reactor products, nuclides.

Nuclear Reactions and radiations: Radioactivity, interaction of alpha and beta particles with matter, decay chains, neutron reactions, fission process, growth and decay of fission products in a reactor with neutron burnout and continuous processing. Make up of reactor, reactor fuel process flow sheet, irradiation schemes, neutron balance, feed requirements and fuel burn up for completely mixed fuels with no recycle.

Nuclear Reactor theory: The neutron cycle, critical mass, neutron diffusion, the diffusion equation, slowing down of neutrons, reactor period, transient conditions and reflectors.

Engineering Consideration of nuclear Power-Environmental effects: Introduction to nuclear power systems, Thermal-hydraulics: Thermal parameters: definitions and uses. Sources and distribution of thermal loads in nuclear power reactors. Conservation equations and their applications to nuclear power systems: power conversion cycles, containment analysis.

Thermal analysis of nuclear fuel, Single-phase flow and heat transfer, Two-phase flow and heat transfer.

Reading:

1. Glasstone S and Alexender Seasonske, *Nuclear Reactor Engineering, 3rd Edition*, CBS publisher, USA, 1994.
2. K. Sriram, *Basic Nuclear Engineering*, Wiley Eastern Ltd., 1990.
3. W Marshall, *Nuclear Power Technology*, Vol I, II, and III, Oxford University Press, New York 1983.

CH312	RENEWABLE ENERGY SOURCES	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Describe the challenges and problems associated with the use of energy sources.
CO2	List renewable energy resources and technologies.
CO3	Design conversion technologies for solar, wind, biomass and hydrogen energies.
CO4	Evaluate the performance of energy conversion technologies.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	1	1	1	-	3	-	-	-	-	-
CO2	1	2	-	-	-		3	-	-	-	-	-
CO3	2	1	3	3	-	-	-	-	-	-	-	-
CO4	2	2	2	2	-	-	3	-	-	-	-	-

Detailed syllabus

Sources of energy: Energy sources and their availability, renewable energy sources.

Energy from Biomass: Introduction, Biomass as a source of energy, Biomass conversion technologies, Biogas generation, classification of biogas plants, Biomass gasification.

Solar Energy: Sun and solar energy, solar radiation and its measurement, solar energy collectors, solar energy storage, Photovoltaic systems, Application of solar energy

Wind Energy: Wind as an Energy source, Basic principles of wind energy conversion, Types of Wind machines, Components of wind energy conversion system, Performance of wind machines, application of wind energy.

Geothermal Energy: Introduction, Origin and distribution of geothermal energy, types of geothermal resources, Hybrid geothermal power plant, Application of geothermal energy

Hydrogen energy: Introduction, Hydrogen production, Hydrogen storage, Hydrogen transportation

Energy from the Oceans: Introduction, Ocean Thermal Electric Conversion (OTEC), Energy from Tides, Ocean Waves

Chemical Energy Sources: Introduction, Fuel cells, Batteries.

Reading:

1. Rai, G.D, Non-Conventional Energy Sources, Khanna Publishers, New Delhi, 2010.
2. Rajesh Kumar Prasad, T.P. Ojha, Non-Conventional Energy Sources, Jain Brothers, 2012.
3. Sukhatme S.P and J. Nayak, Solar energy – Thermal Collection and storage, 3rd Edition, Tata McGraw Hill Education Pvt Ltd., 2008.
4. MM. El – Wakil, Power Plant Technology, Tata McGraw Hill, NewYork, 1999.

CH313	FUEL CELL ENGINEERING	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand fuel cell fundamentals.
CO2	Analyze the performance of fuel cell systems.
CO3	Understand construction and operation of fuel cell stack and fuel cell system.
CO4	Apply the modeling techniques for fuel cell systems.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	1	1	-	-	3	-	-	-	-	-
CO2	2	1	1	1	-	-	-	-	-	-	-	-
CO3	2	2	-	-	2	-	3	-	-	-	-	-
CO4	2	3	3	3	-	3	3	-	-	-	-	-

Detailed syllabus

Overview of Fuel Cells: What is a fuel cell, brief history, classification, how does it work, why do we need fuel cells, Fuel cell basic chemistry and thermodynamics, heat of reaction, theoretical electrical work and potential, theoretical fuel cell efficiency.

Fuels for Fuel Cells: Hydrogen, Hydrocarbon fuels, effect of impurities such as CO, S and others.

Fuel cell electrochemistry: electrode kinetics, types of voltage losses, polarization curve, fuel cell efficiency, Tafel equation, exchange currents.

Fuel cell process design: Main PEM fuel cell components, materials, properties and processes: membrane, electrode, gas diffusion layer, bi-polar plates, Fuel cell operating conditions: pressure, temperature, flow rates, humidity.

Main components of solid-oxide fuel cells, Cell stack and designs, Electrode polarization, testing of electrodes, cells and short stacks, Cell, stack and system modeling

Fuel processing: Direct and in-direct internal reforming, Reformation of hydrocarbons by steam, CO_2 and partial oxidation, Direct electro-catalytic oxidation of hydrocarbons, carbon decomposition, Sulphur tolerance and removal, Using renewable fuels for SOFCs

Reading:

1. Hoogers G., Fuel Cell Technology Hand Book, CRC Press, 2003.
2. Karl Kordesch& Gunter Simader, Fuel Cells and Their Applications, VCH Publishers, NY, 2001.
3. F. Barbir, PEM Fuel Cells: Theory and Practice, 2nd Ed., Elsevier/Academic Press, 2013.
4. Subhash C. Singal and Kevin Kendall, High Temperature Fuel Cells: Fundamentals, Design and Applications, 2003.
5. O'Hayre, R. P., S. Cha, W. Colella, F. B. Prinz, Fuel Cell Fundamentals, Wiley, NY 2006.

CH314	PIPING ENGINEERING	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand the key steps in a pipeline's lifecycle: design, construction, installation and maintenance.
CO2	Draw piping and instrumentation diagrams (P&ID).
CO3	Understand codes, standards and statutory regulations.
CO4	Select pipe and pipe fittings.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	1	1	1	-	-	-	-	-	-	-
CO2	1	1	1	1	-	2	-	-	-	-	-	-
CO3	2	2	-	-	2	-	-	-	-	-	-	-
CO4	1	1	3	3	1	1	-	-	-	-	-	-

Detailed syllabus

Piping: Pipeline Pigging, Pipe Laying, Pipe Lowering, Ditching, Pipeline Welding.

Pipe Design: Steel pipe design, Properties, Length and calculation of pipe in bends, American standard taper pipe threads, Floodlighting Concepts.

Hydrostatic Testing: Benefits and limitations, charts; for estimating the amount of pressure change for a change in test water temperature, chart development.

Pipeline Drying: Pipeline Dewatering, Cleaning and Drying, Brush pig run with gas, Brush pig run with liquid, Internal sand blasting. Chemical cleaning, Pipeline drying, Moisture content of air, Vacuum drying, Corrosion/Coatings, Advances in Pipeline Protection.

Gas—Hydraulics: Gas pipeline hydraulics calculations.

Liquids—Hydraulics: Marine Hose Data, CALM system, SALM system, Tandem system, Multi-point mooring system, Pressure Loss through Valves and Fittings.

Measurement: Multiphase flow meter, Pipeline flow measurement—the new influences, Liquid measurement orifice plate flange taps, Gas Measurement.

Instrumentation: Developments in Pipeline Instrumentation; Flow measurements Proving devices, Valves Acoustic line break detectors, ‘‘Smart’’ pressure sensors, Densitometers, Pipeline samplers, Pipeline monitoring systems, Computer systems, SCADA systems, Cathodic protection.

Leak Detection: Pipeline leak detection techniques.

Reading:

1. McAllister E.W., Pipeline Rules of Thumb Handbook, 7th Edition, Gulf Publication, 2009.
2. Kellogg, Design of Piping System, 2nd Edition, M.W. Kellogg Co. 2009.
3. Weaver R., Process Piping Design Vol .1 and 2, Gulf Publication, 1989.

CH315	CORROSION ENGINEERING	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand the principles of corrosion
CO2	Determine corrosion rates for industrial equipment and metallic structures.
CO3	Calculate corrosion rates using electrochemical work station.
CO4	Understand corrosion resistant coatings, oxide layers.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	-	-	2	-	-	-	-	-	-	-
CO2	1	2	1	-	-	-	-	-	-	-	-	-
CO3	1	1	1	1	-	2	-	-	-	-	-	-
CO4	1	2	1	1	-	-	-	-	-	-	-	-

Detailed syllabus

Introduction & Corrosion Principles: Definition of corrosion, impact on economy, Electrochemical reactions, Corrosion rate expressions, Polarization, Passivity, Metallurgical aspects.
Eight Forms of Corrosion: Galvanic corrosion, crevice corrosion, pitting, intergranular corrosion, erosion corrosion, stress corrosion, hydrogen damage.

Corrosion testing: Specimen preparation, exposure tests, open corrosion potential, linear polarization, Tafel slopes, corrosion current, stress corrosion, slow-strain-rate tests AC impedance.

Corrosion Prevention: Cathodic protection, sacrificial anode methods of corrosion prevention, Anti-corrosion coatings.

Modern Theory-Principles & Applications: Alloy evaluation, Nobel metal alloying, velocity effects, galvanic coupling.

Reading:

1. Fontana M, Corrosion Engineering, 3rd edition, Tata McGraw Hill Education Pvt. Ltd., 2010.
2. Pierre Roberge, Corrosion Engineering: Principles and Practice, 1st Edition, McGraw Hill, 2008.
3. Denny A. Jones, Principles and Prevention of Corrosion, 2nd Edition, Pearson-Prentice Hall, 2005.

CH316	NANOTECHNOLOGY	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand the properties of nano-materials and their applications
CO2	Apply chemical engineering principles to nano-particles production and scale-up
CO3	Solve the quantum confinement equations.
CO4	Characterize nano-materials.
CO5	State the applications of nanotechnology in electronics and chemical industries.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	2	-	-	3	-	-	-	-	-	-
CO2	3	2	2	3	1	1	1	-	-	-	-	-
CO3	1	-	-	-	-	-	3	-	-	-	-	-
CO4	1	1	1	1	-	1	1	-	-	-	-	-
CO5	2	2	3	3	3	3	1	1	1	1	1	-

Detailed syllabus

Introduction to Nanotechnology: Introduction to nanotechnology and materials, Nanomaterials, Introduction to nano sizes and properties comparison with the bulk materials, different shapes and sizes and morphology.

Fabrication of Nanomaterials: Top Down Approach, Grinding, Planetary milling and Comparison of particles, Bottom Up Approach, Wet Chemical Synthesis Methods, Micro emulsion Approach, Colloidal Nanoparticles Production, Sol Gel Methods, Sonochemical Approach, Microwave and Atomization, Gas phase Production Methods : Chemical Vapour Depositions.

Kinetics at Nanoscale: Nucleation and growth of particles, Issues of Aggregation of Particles, Oswald Ripening, Stearic hindrance, Layers of surface Charges, Zeta Potential and pH.

Carbon Nanomaterials: Synthesis of carbon buckyballs, List of stable carbon allotropes extended fullerenes, metallofullerenes solid C60, bucky onions nanotubes, nanocones Difference between Chemical Engineering processes and nanosynthesis processes.

Quantum mechanics: Quantum mechanics Quantum dots and its Importance, Pauli exclusion principle Schrödinger's equation, Application of quantum Dots: quantum well, wire, dot, characteristics of quantum dots, Synthesis of quantum dots, Semiconductor quantum dots, Introduction - Nanoclay Synthesis method, Applications of nanoclay.

Nanomaterials characterization: Instrumentation Fractionation principles of Particle size measurements, Particle size and its distribution, XRD, Zeta potential Microscopies SEM, TEM, Atomic Forced Microscopy, Scanning and Tunneling Microscopy

Applications in Chemical Engineering: Self-assembly and molecular manufacturing : Surfactant based system Colloidal system applications, ZnO,TiO_2, Silver Nanoparticles Functional materials Applications, Production Techniques of Nanotubes, Carbon arc, bulk synthesis, commercial processes of synthesis of nanomaterials, Nanoclay, Commercial case study of nano synthesis - applications in chemical engineering, Nano inroganic materials - $CaCO_3$ synthesis, Hybrid wastewater treatment systems, Electronic Nanodevices, sensor applications,

Nanobiology: biological methods of synthesis.Applications in drug delivery, Nanocontainers and Responsive Release of active agents, Layer by Layer assembly for nanospheres, Safety and health Issues of nanomaterials, Environmental Impacts, Case Study for Environmental and Societal Impacts.

Reading:

1. Kulkarni Sulabha K., Nanotechnology: Principles and Practices, Capital Publishing Company, 2007.
2. Gabor L. Hornyak., H.F. Tibbals, Joydeep Dutta, John J. Moore, Introduction to Nanoscience and Nanotechnology, CRC Press.
3. Robert Kelsall, Ian Hamley, Mark Geoghegan, Nanoscale Science and Technology, John Wiley & Sons, 2005.
4. Stuart M. Lindsay, Introduction to Nanoscience, Oxford University Press, 2009.
5. Davies, J.H. 'The Physics of Low Dimensional Semiconductors: An Introduction', Cambridge University Press, 1998.

SM335	ENGINEERING ECONOMICS AND ACCOUNTANCY	HSC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Prepare accounting records and summarize and interpret the accounting data for managerial decisions
CO2	Understand the macro-economic environment of the business and its impact on enterprise
CO3	Understand cost elements of the product and its effect on decision making
CO4	Understand the concepts of financial management and smart investment

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	-	-	3	2	2	2	-
CO2	-	-	-	-	-	-	-	3	2	2	-	-
CO3	-	-	-	-	-	-	-	3	2	2	-	-
CO4	-	-	-	-	-	-	-	3	2	3	-	-

Detailed syllabus

Engineering Economics: Introduction to Engineering Economics – Fundamental concepts – Time value of money – Cash flow and Time Diagrams – Choosing between alternative investment proposals – Methods of Economic analysis. The effect of borrowing on investment- Various concepts of National Income – Significance of National Income estimation and its limitations, Inflation –Definition – Process and Theories of Inflation and measures to control, New Economic Policy 1991 – Impact on industry.

Accountancy: Accounting Principles, Procedure – Double entry system – Journal – Ledger, Trail Balance – Cash Book – Preparation of Trading, Profit and Loss Account – Balance sheet.

Cost Accounting – Introduction – Classification of costs – Methods of costing – Techniques of costing – Cost sheet and preparation of cost sheet- Breakeven Analysis – Meaning and its application, Limitations.

Reading:

1. Henry MalcomStenar, Engineering Economic Principles, McGraw Hill, 2005.
2. K KDewett, Modern Economic Theory, Siltan Chand & Co., 2005.
3. Agrawal AN, Indian Economy, Wiley Eastern Ltd, New Delhi, 2012.
4. Jain and Narang, Accounting Part-I, Kalyani Publishers, 2012.
5. Arora, M.N., Cost Accounting, Vikas Publications, 2013.

CH351	MASS TRANSFER-II	PCC	3 – 1 – 0	4 Credits

Pre-requisites: CH302 Chemical Engineering Thermodynamics-II, CH304 Mass Transfer-I.

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

CO1	Select solvent for absorption and extraction operations
CO2	Determine number of stages in distillation, absorption and extraction operations
CO3	Determine the height of packed column in absorption, distillation and extraction operations
CO4	Calculate drying rates and moisture content for batch and continuous drying operations

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	3	3	-	-	-	-	-	-	-	-
CO2	3	3	3	3	-	-	-	-	-	-	-	-
CO3	2	2	2	2	-	-	-	-	-	-	-	-
CO4	2	2	2	2	-	-	-	-	-	-	-	-

Detailed syllabus

Gas Absorption: Equilibrium solubility of gases in liquids, one component transferred - material balances, one component transferred counter-current multistage operation, continuous contact equipment, multicomponent systems and absorption with chemical reaction.

Distillation: Vapor-Liquid Equilibria, single stage operation - flash vaporization, differential or simple distillation, continuous rectification - binary systems, multistage tray towers-McCabe-Thiele method. Continuous contact equipment (packed towers), multicomponent systems, Extractive distillation, Azeotropic distillation, low pressure distillation (molecular distillation)

Liquid-Liquid Extraction: Liquid equilibria, equipment and flow sheets, stage-wise contact, stage type extractors and differential (continuous contact) extractors.

Drying: Equilibrium, drying operations - batch drying, the mechanism of batch drying and continuous drying, drying equipment.

Reading:

1. Treybal R.E., Mass Transfer Operations, 3rd Edition, International Student Edition, McGraw Hill International, 1981.
2. C.J. Geankoplis, Transport Processes and Separation Process Principles, 4th Edition, Prentice Hall Inc., 2009.
3. Warren L. McCabe, Jullian Smith C. and Peter Harriott - Unit operations of Chemical Engineering, 7th Edition, McGraw-Hill international edition, 2005.
4. Seader J.D. and Henley E.J., Separation Process Principles, 2nd edition, John Wiley & Sons, 2006.

CH352	CHEMICAL REACTION ENGINEERING – II	PCC	3 – 0 – 0	3 Credits

Pre-requisites: CH301 Chemical Reaction Engineering-I, CH304 Mass Transfer-I.

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

CO1	Compare the performance of ideal and non-ideal reactors using E- and F-curves.
CO2	Determine the mean residence time and standard deviation using residence time distribution (RTD) data.
CO3	Analyze the performance of non-ideal reactors using segregation model, tanks-in series model and dispersion model.
CO4	Understand the effect of velocity, particle size and fluid properties on rate of reactions controlled by mass transfer.
CO5	Design fixed bed reactors involving chemical reactions with mass transfer.
CO6	Determine internal and overall effectiveness factors.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	1	-	-	-	-	-	-	-
CO2	3	3	3	3	-	-	-	-	-	-	-	-
CO3	3	3	3	3	-	-	-	-	-	-	-	-
CO4	3	3	3	3	-	-	-	--	-	-	-	-
CO5	3	3	3	3	1	-	3	-	-	-	-	-
CO6	3	3	3	3	-	-	-	-	-	-	-	-

Detailed syllabus

RTD for Chemical Reactors: General Characteristics, Measurement of the RTD, Characteristics of the RTD, RTD in Ideal Reactors, Diagnostics and Troubleshooting, Reactor Modelling Using the RTD, Zero-Parameter Models, RTD and Multiple Reactions.

Analysis of non-ideal reactors**:** One- parameter models, two-parameter models, Tanks-in-Series (T-I-S) Model, Dispersion Model, Tanks-in-Series Model Versus Dispersion Model, Two-Parameter Models-Modelling Real Reactors with Combinations of Ideal Reactors, Other Models of Non-ideal Reactors Using CSTRs and PFRs.

External Diffusion Effects on Heterogeneous Reactions: Diffusion Fundamentals, Binary Diffusion, External Resistance to Mass Transfer, Parameter Sensitivity, the Shrinking Core Model. Rate equation for fluid solid reactions. Design of heterogeneous catalytic reactors.

Diffusion and Reaction: Diffusion and Reaction in Spherical Catalyst Pellets, Internal Effectiveness Factor, Falsified Kinetics, Overall Effectiveness Factor, Estimation of Diffusion- and Reaction-Limited Regimes, Mass Transfer and Reaction in a Packed Bed, Determination of Limiting Situations from Reaction Data, Multiphase Reactors, Fluidized Bed Reactors, Chemical Vapor Deposition (CVD).

Reading:

1. Fogler H. S., Elements of Chemical Reaction Engineering, 4th Edition, Prentice Hall of India Pvt. Ltd., 2005.
2. J. M. Smith, Chemical Engineering Kinetics, 3rd Edition, McGraw Hill, 1981.
3. T. J. Carberry, Chemical and Catalytic Reaction Engineering, McGraw Hill, 1976.
4. O. Levenspiel, Chemical Reaction Engineering, 3rd Edition, Wiley India, 2006.

CH353	PROCESS EQUIPMENT DESIGN & DRAWING	PCC	0 – 2 – 3	4 Credits

Pre-requisites: ME102 Engineering Graphics, CH301 Chemical Reaction Engineering-I, CH304 Mass Transfer-I, CH203 Mechanical Operations, CH251 Chemical Technology.

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

CO1	Identify equipment and instruments based on symbols
CO2	Draw process flow diagrams using symbols
CO3	Apply mechanical design aspects to process equipment.
CO4	Design heat exchangers, evaporators, absorbers, distillation columns, reactors and filters.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	2	-	-	1	-	-	-	-	-	2	3
CO2	-	2	-	-	1	-	-	-	-	-	-	-
CO3	2	-	3	3	2	2	-	-	-	-	-	-
CO4	2	-	3	3	2	3	-	-	-	-	-	-

Detailed Syllabus:

Mechanical Design of Process Equipment: Introduction to mechanical aspects of chemical equipment design, Design Preliminaries, Design of cylindrical and spherical vessels under internal pressure, Design of heads and closers, Design of tall vessels.

Drawing: Drawing of process equipment symbols for fluid handling, heat transfer, mass transfer, Drawing of process equipment symbols for vessels, conveyers and feeders etc. Drawing of process equipment symbols for, separators, mixing & comminution etc. Drawing of process equipment symbols for distillation, driers, evaporators, scrubbers etc. Drawing of process equipment symbols for crystallizer, grinding, jigging, elutriation, magnetic separation, compressor etc. Drawing of basic instrumentation symbols for flow, temperature, level, pressure and combined instruments, Drawing of miscellaneous instrumentation symbols, Detailed drawing of equipment, Drawing of flow sheet.

Process Equipment Design: Design of a heat exchanger, Design of an absorber, Design of a distillation column, Design of evaporator, Design of condenser, Design of a chemical reactor.

Reading:

1. Brownell L.E, Process Equipment Design - Vessel Design, Wiley Eastern Ltd., 1986.
2. Bhattacharya B.C., Introduction to Chemical Equipment Design - Mechanical Aspects, CBS Publishers and Distributors, 2003.
3. Towler, G. P. and R. K. Sinnott, Chemical Engineering Design, Principles, Practice and Economics of Plant and Process Design, 2nd Edition, Butterworth Heinemann, 2012.
4. Donald Kern, Process Heat Transfer, 1st Edition, Tata McGraw-Hill Education, 1950
5. Robert E. Treybal, Mass-Transfer Operations, 3rd Edition, McGraw-Hill Book Company, 1981.

CH354	**MASS TRANSFER LABORATORY**	**PCC**	**0 – 0 – 3**	**2 Credits**

Pre-requisites: CH304 Mass Transfer-I

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

CO1	Determine efficiency of steam distillation
CO2	Plot mutual solubility curve for acetone-methyl-iso-butyl-ketone and water
CO3	Determine the overall plate efficiency of sieve plate distillation
CO4	Verify Rayleigh's equation for batch distillation.
CO5	Determine HETP and HTU for given packing for distillation of benzene-acetone mixture under total reflux.
CO6	Determine the critical moisture content in drying

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	3	2	-	-	-	-	3	-	3	-
CO2	2	-	3	-	-	3	-	-	3	-	3	-
CO3	2	-	3	-	-	-	-		3	-	3	-
CO4	2	-	3	-	-	-	-	-	3	-	3	-
CO5	2	-	3	-	-	-	-	-	3	-	3	-
CO6	2	-	3	-	-	-	-	-	3	-	3	-

Detailed Syllabus:

Steam distillation, batch distillation, packed tower distillation, sieve plate distillation, determination of diffusivity coefficient, mutual solubility data, tie-line data, distribution co-efficient, batch drying, and V.L.E data.

Reading: Lab Manuals

CH361	PHARMACEUTICALS AND FINE CHEMICALS	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand the grades of chemicals.
CO2	State properties, uses and testing of pharmaceuticals and fine chemicals
CO3	Draw flow sheets for manufacture of pharmaceuticals and fine chemicals
CO4	Understand tablet making and coating, preparation of capsules and extraction of crude drugs.
CO5	Understand sterilization.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	-	-	-	-	-	-	-	-	-	-
CO2	1	3	-	1	-	-	-	-	-	-	-	-
CO3	-	3	-	1	-	2	-	-	-	-	-	-
CO4	2	1	1	-	-	-	3	-	-	-	-	-
CO5	1	-	-	-	-	-	2	-	-	-	-	-

Detailed Syllabus:

A brief outline of different grades of chemicals – Reagent grade and Laboratory grade.

Outlines of preparation – Different methods of preparation of Reagent grade and Laboratory grade Chemicals.

Uses and testing of the pharmaceuticals and fine chemicals – Applications of medicinal value Chemicals and their quality testing procedures.

Properties, assays and manufacture of Pharmaceuticals and fine chemicals with flow sheets- Physical and Chemical properties, methods of assessing the quality and industrial methods of formulating the drugs and fine chemicals that have no medicinal value but are used as the intermediates.

Compressed Tablet making and coating – Types of tablets and Methods of compressed tablet making and coating.

Preparation of capsules and extraction of crude drugs – Industrial procedures of capsule formulation and methods of recovering the drugs formulated from the reaction mixture.

Sterilization – Need for sterilization, Sterilization methods, batch and continuous sterilization.

Reading:

1. Remington, Pharmaceutical Sciences, Mak. Publishing Co., 16th Edition, 1980.
2. William Lawrence Faith, Donald B. Keyes and Ronald L. Clark, Industrial Chemicals, 4th Edition, John Wiley & Sons, 1975.
3. Gurdeep R. Chatwal, Synthetic Drugs, Himalaya Publishing House, 2002.

CH362	POLLUTION CONTROL IN PROCESS INDUSTRIES	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Analyze the effects of pollutants on the environment.
CO2	Understand meteorological aspects of air pollution
CO3	Understand air pollution control methods
CO4	Select treatment technologies for water/wastewater/solid waste.
CO5	Design unit operations for pollution control.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	-	-	-	-	3	-	-	-	-	-
CO2	1	3	-	-	-	-	3		-	-	-	-
CO3	1	3	-	-	-	-	3	-	-	-	-	-
CO4	1	3	-	1	-	-	3	-	-	-	-	-
CO5	1	3	3	3	-	-	3	-	-	-	-	-

Detailed Syllabus:

Introduction: Biosphere, Hydrological cycle, Nutrient cycle, Consequences of population growth, Pollution of air, Water and soil.

Air pollution sources & effects: Classification and properties of air pollutants, Emission sources, Behavior and fate of air pollutants, Effect of air pollution.

Meteorological aspects of air pollutant dispersion: Temperature lapse rates and stability, Wind velocity and turbulence, Plume behavior, Dispersion of air pollutants, Estimation of plume rise.

Air pollution sampling and measurement: Types of pollutant sampling and measurement, Ambient air sampling, Stack sampling, Analysis of air pollutants.

Air pollution control methods & equipment: Control methods, Source correction methods, Cleaning of gaseous effluents, Particulate emission control, Selection of a particulate collector, Control of gaseous emissions, Design methods for control equipment.

Control of specific gaseous pollutants: Control of sulphur dioxide emissions, Control of nitrogen oxides, Carbon monoxide control, Control of hydrocarbons and mobile sources.

Water pollution: Water resources, Origin of wastewater, types of water pollutants and there effects.

Waste water sampling, analysis and treatment: Sampling, Methods of analysis, Determination of organic matter, Determination of inorganic substances, Physical characteristics, Bacteriological measurement, Basic processes of water treatment, Primary treatment, Secondary treatment, Advanced wastewater treatment, Recovery of materials from process effluents.

Solid waste management: Sources and classification, Public health aspects, Methods of collection, Disposal Methods, Potential methods of disposal.

Hazardous waste management: Definition and sources, Hazardous waste classification, Treatment methods, Disposal methods.

Reading:

1. Rao C.S., Environmental Pollution Control Engineering, Wiley Eastern Limited, India, 1993.
2. Noel de Nevers, Air Pollution and Control Engineering, McGraw Hill, 2000.
3. Glynn Henry J. and Gary W. Heinke, Environmental Science and Engineering, 2nd Edition, Prentice Hall of India, 2004.
4. Rao M.N. and Rao H.V.N - Air Pollution, Tata – McGraw Hill Publishing Ltd., 1993.
5. De A.K - Environmental Chemistry, Tata – McGraw Hill Publishing Ltd., 1999.

CH363	FERTILIZER TECHNOLOGY	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Classify fertilizers
CO2	Explain manufacturing processes involved in production of fertilizers.
CO3	Identify the effect of technologies on the health, safety and environment.
CO4	State the chemical reactions and their mechanism involved.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	3	-	-	-	-	3	-	-	-	-	-
CO2	1	3	-	-	-	-	3		-	-	-	-
CO3	1	3	-	-	-	-	3	-	-	-	-	-
CO4	1	3	-	-	-	-	3	-	-	-	-	-

Detailed Syllabus:

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

Nitrogenous Fertilizers: Manufacturing Processes for Ammonia, Manufacture of ammoniumsulphate, ammonium chloride, Ammonium phosphate, Ammonium nitrate, nitric acid, Urea etc. Economics and other strategies, Material of construction and corrosion problem.

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

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

Reading:

1. Sittig Mand GopalaRao M., Dryden's Outlines of Chemical Technology for the 21st Century, 3rd Edition, WEP East West Press, 2010.
2. Austin G T., Shreve's Chemical Process Industries, McGraw Hill Book Company, New Delhi, 5th Edition, 1986.
3. Shukla S D and Pandey G N, A Text Book of Chemical Technology, Vol I & II, Vikas Publishing House Pvt. Ltd., New Delhi, 2000.

CH364	FOOD TECHNOLOGY	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Explain techniques in food processing
CO2	Design process equipment to achieve the desired quality of food.
CO3	Develop novel food processes that have a minimal effect on food quality
CO4	Design efficient controllers to maintain food quality.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	-	-	-	-	3	-	-	-	-	-
CO2	1	3	2	3	-	-	3		-	-	-	-
CO3	1	3	2	2	-	-	3	-	-	-	-	-
CO4	1	3	-	3	-	1	3	-	-	-	-	-

Detailed Syllabus:

Introduction: General aspects of food industry, World food demand and Indian scenario, Constituents of food, Quality and nutritive aspects, Product and Process development, engineering challenges in the Food Processing Industry.

Basic principles: Properties of foods and processing theory, Heat transfer, Effect of heat on micro-organisms, Basic Food Biochemistry and Microbiology: Food Constituents; Food fortification, Water activity, Effects of processing on sensory characteristics of foods, Effects of processing on nutritional properties, Food safety, good manufacturing practice and quality Process Control in Food Processing.

Ambient Temperature Processing: Raw material preparation, Size reduction, Mixing and forming, Separation and concentration of food components, Centrifugation, Membrane concentration, Fermentation and enzyme technology, Irradiation, Effect on micro-organisms, Processing using electric fields, high hydrostatic pressure, light or ultrasound.

Heat processing using steam, water and air: Blanching, Pasteurisation, Heat sterilization, Evaporation and distillation, Extrusion, Dehydration, Baking and roasting.

Heat processing by direct and radiated energy: Dielectric heating, Ohmic heating, Infrared heating.

Post Processing Applications Packaging: Coating or enrobing, Theory and Types of packaging materials, Printing, Interactions between packaging and foods, Environmental considerations.

Reading:

1. Fellows P., Food Processing Technology: Principles and Practice, 2nd Edition, Woodhead Publishing, 2000.
2. Toledo R, Fundamentals of Food Process Engineering, 3rd Edition, Springer, 2010.
3. Singh, R.P. &Heldman, D.R., Introduction to Food Engineering, 3rd Edition, Academic Press, UK, 2001.
4. Smith J.M., Chemical Engineering Kinetics, 3^{rd} Edition, McGraw Hill, 1981.

CH365	GREEN TECHNOLOGY	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand principles and concepts of green chemistry
CO2	Develop manufacturing processes to reduce wastage and energy consumption.
CO3	Design the technologies to reduce the level of emissions from buildings and core infrastructure
CO4	Analyze the effects of pollutants on the environment

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	-	-	-	-	3	-	-	-	-	-
CO2	1	3	3	-	-	-	3		-	-	-	-
CO3	1	3	3	3	2	-	3	-	-	-	-	-
CO4	1	3	-	-	-	-	3	-	-	-	-	-

Detailed Syllabus:

Principles and concepts of Green Chemistry: Introduction, Sustainable Development and Green Chemistry, Atom Economy, Atom Economic Reactions, Rearrangement Reactions, Addition Reactions, Atom Un-economic Reactions, Substitution Reactions, Elimination Reactions, Wittig Reactions, Reducing Toxicity, Measuring Toxicity.

Waste- Production, Problems and Prevention: Introduction, Some Problems Caused by Waste, Sources of Waste from the Chemical Industry, The Cost of Waste, Waste Minimization Techniques, The Team Approach to Waste Minimization, Process Design for Waste Minimization, Minimizing Waste from Existing Processes, On-site Waste Treatment, Physical Treatment, Chemical Treatment, Biotreatment Plants, Design for Degradation, Degradation and Surfactants, DDT, Polymers, Some Rules for Degradation, Polymer Recycling, Separation and Sorting, Incineration, Mechanical Recycling, Chemical Recycling to Monomers.

Measuring and controlling environmental performance: The Importance of Measurement, Lactic Acid Production, Safer Gasoline, Introduction to Life Cycle Assessment, Green Process Metrics, Environmental Management Systems, The European Eco-management and Audit Scheme, Eco-labels, Legislation, Integrated Pollution Prevention and Control.
Catalysis and green chemistry: Introduction to Catalysis, Comparison of Catalyst Types, Heterogeneous Catalysts, Basics of Heterogeneous Catalysis, Zeolites and the Bulk Chemical

Industry, Heterogeneous Catalysis in the Fine Chemical and Pharmaceutical Industries, Catalytic Converters, Homogeneous Catalysis, Transition Metal Catalysts with Phosphine Ligands, Greener Lewis Acids, Asymmetric Catalysis, Phase Transfer Catalysis, Hazard Reduction, C–C Bond Formation, Oxidation Using Hydrogen Peroxide, Biocatalysis, Photocatalysis.

Organic solvents, Environmentally benign solutions: Organic Solvents and Volatile Organic Compounds, Solvent-free Systems, Supercritical Fluids, Supercritical Carbon Dioxide, Supercritical Water, Water as a Reaction Solvent, Water-based Coatings, Ionic Liquids, Ionic Liquids as Catalysts, Ionic Liquids as Solvents, Fluorous Biphase Solvents.

Renewable resources: Biomass as a Renewable Resource, Energy, Fossil Fuels, Energy from Biomass, Solar Power, Other Forms of Renewable Energy, Fuel Cells, Chemicals from Renewable Feedstocks, Chemicals from Fatty Acids, Polymers from Renewable Resources, Some Other Chemicals from Natural Resources, Alternative Economies, The Syngas Economy, The Biorefinery, Chemicals from renewable feed stocks.

Emerging Greener technologies and Alternative energy solutions: Design for Energy Efficiency, Photochemical Reactions, Advantages of and Challenges Faced by Photochemical, Processes, Examples of Photochemical Reactions, Chemistry Using Microwaves, Microwave Heating, Microwave-assisted Reactions, Sonochemistry, Sonochemistry and Green Chemistry, Electrochemical Synthesis, Examples of Electrochemical Synthesis.

Designing greener processes: Conventional Reactors, Batch Reactors, Continuous Reactors, Inherently Safer Design, Minimization, Simplification, Substitution, Moderation, Limitation, Process Intensification, Some PI Equipment, Examples of Intensified Processes, In-process Monitoring, Near-infrared Spectroscopy.

Industrial case studies: A Brighter Shade of Green, Greening of Acetic Acid Manufacture, EPDM Rubbers, Vitamin C, Leather Manufacture, Tanning, Fatliquoring, Dyeing to be Green, Some Manufacturing and Products Improvements, Dye Application, Polyethene, Radical Process, Ziegler–Natta Catalysis, Metallocene Catalysis, Eco-friendly Pesticides, Insecticides.

An integrated approach to a greener chemical industry: Society and Sustainability, Barriers and Drivers, The Role of Legislation, EU White Paper on Chemicals Policy, Green Chemical Supply Strategies.

Reading:

1. Mike Lancaster, Green Chemistry, Royal Society of Chemistry, 2010.
2. Paul T. Anastas John C. Warner, Green Chemistry: Theory and Practice, Oxford University Press, 2000.
3. Jay Warmke, Annie Warmke, Green Technology, Educational Technologies Group, 2009.

CH366	PULP AND PAPER TECHNOLOGY	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Explain process for manufacturing paper.
CO2	Understand harmful impacts of paper and pulp industries on environment.
CO3	Understand mechanical pulping, Chemi-thermo-mechanical processes, chemical pulping.
CO4	Understand methods for pulp treatment.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	-	-	-	-	3	-	-	-	-	-
CO2	1	3	-	-	2	-	3		-	-	-	-
CO3	1	3	-	-	-	-	3	-	-	-	-	-
CO4	1	3	-	-	2	-	3	-	-	-	-	-

Detailed Syllabus:

Introduction: History of Paper Making, Technological Advancements, Global and Indian Market Situation.

Paper making raw materials: Wood anatomy and chemistry, Wood chip preparation and handling at the pulp mill, Solid wood measurement, Properties of selected wood species.

Pulping processes: Introduction to pulping, Mechanical pulping, Chemical pulping, Semi-chemical pulping, Soda pulping, Kraft pulping, Sulfite pulping, Other pulping methods.

Pulp treatment: Bleaching mechanical pulps, Measurement of lignin content, Bleaching chemical pulps, Chemical recovery, Refining, Pulp characterization.

Paper making equipment and process: Fiber preparation and approach, Raw materials, Functional additives, Control additives, Wet end chemistry, Paper manufacture, Paper machine, headbox, fourdrinier wet end, Twin wire formers, cylinder machine, press section, dryer section, Post drying operations, Coating.

Environmental protection: Water pollution, Water quality tests, Aqueous effluent treatments, Air pollution, Air quality tests and control, Solid waste disposal.

Properties of paper: General grades of paper, Structure, Mechanical and chemical properties, Basic optical tests of paper.

Reading:

1. J.P. Casey, Pulp and Paper: Chemistry and Chemical Technology, 3rd Edition, Volumes 1 & 2., Wiley Interscience, 1980
2. G.A. Smook, Handbook for Pulp and Paper Technologists, 3rd Edition, Angus Wilde Publ, Inc, 2002.
3. Christopher J. Biermann, Handbook of Pulping and Paper Making, Academic Press, 1996.

ME435	INDUSTRIAL MANAGEMENT	ESC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand the basic principles, approaches and functions of management and identify concepts to specific situations.
CO2	Understand marketing management process to discuss marketing mix in formulation of marketing strategies during the life cycle of product.
CO3	Outline various techniques for improving productivity using work study.
CO4	Understand concepts of quality management and use process control charts, concepts and tools of quality engineering in the design of products and process controls.
CO5	Use and distinguish basic methods/tools of inventory classification and control.
CO6	Identify activities with their interdependency and use scheduling techniques of project management PERT/CPM.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	-	-	3	3	3	-	-
CO2	-	-	-	-	-	-	-	3	3	3	-	-
CO3	-	-	-	-	-	-	-	3	3	3	-	-
CO4	-	-	-	-	-	-	-	3	3	3	-	-
CO5	-	-	-	-	-	-	-	3	3	3	-	-
CO6	-	-	-	-	-	-	-	3	3	3	-	-

Introduction: Overview of the course, Examination and Evaluation patterns; Nature, significance and role of management in organizations.

Evolution of Industry and Principles of management: Evolution of industry and professional management; Functions of management; Organization structures; Hawthorne Experiments and informal organizational structures; Motivational theories and leadership styles.

Marketing Management: Marketing management process; 4P’s of marketing mix; Target marketing; Product life cycle and marketing strategies.

Work Study: Productivity and its role in the economy; Techniques for improving productivity; Method study; Principles of motion economy; Stop watch time study; Work sampling.

Quality Management: Dimensions of quality; Process control charts; Acceptance sampling; Taguchi's Quality Philosophy; Quality function deployment; Introduction to TQM.

Inventory Management: Purpose of inventories; Inventory costs; ABC classification; Economic Order Quantity (EOQ); P and Q systems of inventory control.

Project Scheduling- PERT/CPM: Project activities; Network diagrams; Critical path method (CPM); Programme Evaluation and Review Technique (PERT).

Reading

1. Koontz H and Weihrich H, Essentials of Management, 7th Ed., McGraw-Hill , New York 2007.
2. Kotler P, Marketing Management, 13th Ed., Prentice Hall of India/Pearson, New Delhi 2009.
3. Chase, Shankar, Jacobs and Aquilano, Operations and Supply Management, 12th Ed., Tata McGraw Hill, New Delhi 2010.

CH401	PROCESS DYNAMICS AND CONTROL	PCC	3 – 1 – 0	4 Credits

Pre-requisites: MA201 Mathematics-III, CH254 Process Instrumentation, CH351 Mass Transfer – II, CH352 Chemical Reaction Engineering – II.

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

CO1	Understand the dynamic behaviour of different processes
CO2	Analyze different components of a control loop
CO3	Analyze stability of feedback control system
CO4	Design controllers for first and second order processes
CO5	Analyze frequency response for controllers and processes

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	-	-	-	-	-	-	-	-
CO2	3	1	3	3	-	-	-	-	-	-	-	-
CO3	3	1	3	3	-	-	-	-	-	-	-	-
CO4	3	1	3	3	1	-	-	-	-	-	-	-
CO5	3	1	3	3	-	-	-	-	-	-	-	-

Detailed Syllabus:

Response of First order systems: Transfer Function, Transient Response, Forcing Functions and Responses. Physical examples of First and Second order systems: Examples of First order systems, Linearization, Transportation Lag.

Components of a Control System, Block Diagram, Development of Block Diagram, Controllers and Final Control Elements. Closed loop Transfer functions: Standard Block-Diagram Symbols, Transfer Functions for Single-Loop Systems and Multi-loop Systems.

Transient response of simple control systems: Servo Problem, Regulatory Problem, Controllers: Proportional, Proportional-Integral, PID Controllers. Ziegler-Nichols Controller Settings. Stability: Routh Test for Stability, Root Locus.

Introduction to frequency Response: Substitution Rule, Bode Diagrams. Control system design based on frequency response: Bode and Nyquist Stability Criterion, Gain and Phase Margins.

Advanced Control Strategies: Cascade Control, Feed-forward Control, Ratio Control, Dead-Time Compensation (Smith Predictor), Internal Model Control. Controller tuning and process identification. Control Valves: Control Valve Construction, Valve Sizing, Valve Characteristics, Valve Positioner.

Reading:

1. Coughanowr D.R., Process System analysis and Control, 2nd Edition, McGraw Hill International Edition, 2011.
2. Seborg D.E., Edgar T. E and Millichamp D.A, Process Dynamics and Control, John Wiley & Sons, 2004.
3. Stephanopolis G., Chemical Process Control, Prentice Hall India, 2008.
4. Bequette, B.W., Process Control: Modeling, Design and Simulation, 2007.

CH402	CAD AND SIMULATION LABORATORY	PCC	0 – 1 – 3	3 Credits

Pre-requisites: CH351 Mass Transfer-II, CH352 Chemical Reaction Engineering-II.

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

CO1	Simulate and design mixer, splitter, pump, flash column, heat exchanger, reactor and distillation column.
CO2	Apply Aspen software to simulate a chemical process
CO3	Apply sensitivity, design and optimization tools in Aspen software.
CO4	Estimate physical properties

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	3	-	3	-	-	-	-	-	-
CO2	3	2	2	2	-	3	-	-	-	-	-	-
CO3	3	2	2	1	-	3	-	-	-	-	-	-
CO4	2	2	-	-	-	3	-	-	-	-	-	-

Detailed Syllabus:

Design, Rating and Simulation of Chemical Engineering Equipment Using Aspen Plus / Chemcad Software: Mixer, Flow splitter; Flash column; pipe line and pipe pressure drop; Pump; Single and multistage compressors; Heat Exchangers; Distillation Columns; Reactors etc.

Simulation Exercises Using Aspen Plus /Chemcad: Physical property estimations; Simulation of a flow sheet: Mass and Energy balances; Handling user specifications on output streams.

Reading: Lab manuals

CH403	INSTRUMENTATION AND PROCESS CONTROL LABORATORY	PCC	0 – 0 – 3	2 Credits

Pre-requisites: CH254 Process Instrumentation, CH401 Process Dynamics and Control.

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

CO1	Calculate the characteristics of control valves
CO2	Determine the dynamics of level and temperature measurement process
CO3	Determine the dynamics of two capacity liquid level process without interaction and with interaction, U-tube manometer.
CO4	Determine the performance of controllers for a flow process, pressure process, level process, temperature process.
CO5	Evaluate the performance of cascade control

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	-	-	3	-	3	-	-	3	-	3	-
CO2	2	-	-	2	-	3	-	-	3	-	3	-
CO3	2	-	-	1	-	3	-	-	3	-	3	-
CO4	2	-	-	2	-	3	-	-	3	-	3	-
CO5	3	-	-	-	-	3	-	-	3	-	3	-

Detailed Syllabus:

List of experiments:

1. Control valve characteristics
2. Dynamics of Interacting process
3. Dynamics of Non-interacting process
4. Dynamics of Temperature measurement process
5. Flapper nozzle system
6. Dynamics of Cascade control system
7. Characteristics of I&P converters
8. Dynamics of Level measurement system
9. Dynamics of First and second order process
10. Design of controllers and simulation using MATLAB

Reading: Lab manuals

CH449	PROJECT WORK - PART A	PRC	0 – 0 – 3	2 Credits

Pre-requisites: CH353 Process Equipment Design & Drawing.

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

CO1	Carry out literature and market survey.
CO2	Select a process for manufacture of a chemical product
CO3	Draw flow sheet of the selected process
CO4	Perform mass balance calculations for each unit operation and process.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	2	2	-	2	3	2	2	3	3
CO2	3	3	3	3	2	2	1	1	2	2	3	3
CO3	3	3	3	3	1	1	1	-	-	1	3	-
CO4	3	3	3	3	2	3	1	-	-	1	3	3

Detailed Syllabus:

Feasibility study for production of any chemical product on industrial scale:

Introduction, market survey, different processes for production, selection of process, process description and material balance.

Reading: Chemical Industry Periodicals, Professional core books.

CH411	BIOCHEMICAL ENGINEERING	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand cell and enzyme kinetics
CO2	State methods of immobilization.
CO3	Calculate volume of a bioreactor
CO4	State sterilization methods
CO5	Select downstream process to separate the products

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	1	3	-	-	-	-	-	-	-	-
CO2	1	1	3	3	-	-	-	-	-	-	-	-
CO3	1	1	3	3	-	-	-	-	-	-	-	-
CO4	1	1	3	3	1	-	-	-	-	-	-	-
CO5	3	2	3	3	-	-	-	-	-	-	-	-

Detailed Syllabus:

Introduction: Biotechnology, Biochemical Engineering, Biological Process, Definition of Fermentation.

Enzyme Kinetics: Introduction, Simple Enzyme Kinetics, Enzyme Reactor with Simple Kinetics, Inhibition of Enzyme Reactions, and Other Influences on Enzyme Activity.

Immobilized Enzyme: Immobilization techniques and effect of mass transfer resistance.

Industrial application of enzymes: Carbohydrates, starch conversion and cellulose conversion.
Cell Cultivation: Microbial cell cultivation, animal cell cultivation, plant cell cultivation, cell growth measurement and cell immobilization.

Cell Kinetics and Fermentor Design: Introduction, growth cycle for batch cultivation, stirred tank fermenters, multiple fermenters connected series, cell recycling, alternate fermenters and structured model.

Sterilization: Sterilization methods, thermal death kinetics, design criterion, batch sterilization, continuous sterilization and air sterilization.

Agitation and Aeration: Introduction, basic mass transfer concepts, correlation for mass transfer co-efficient, measurement of interfacial area, correlations for ‘a’ and D_{32}, gas-holdup, power consumption, determination of oxygen absorption rate, correlation for k_{La}, scale-up and shear sensitivity.

Downstream Processing: introduction, solid-liquid separation, cell rupture, recovery and purification.

Reading:

1. Lee J.M., Biochemical Engineering, Ebook, version 2.32, 2009.
2. James E. Bailey & David F. Ollis, Biochemical Engineering Fundamentals, 2nd edition, McGraw Hill International, 1986.
3. Michael L. Shuler & Fikret Kargi, Bioprocess Engineering – Basic Concepts, 2nd edition, Prentice Hall of India, New Delhi, 2002.

CH412	INTERFACIAL SCIENCE	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Identify the interfacial phenomena occurring in a larger process and quantify its effect.
CO2	Analyze ab-initio calculations for inter-colloidal forces.
CO3	Design instruments, equipment and sensors for interfacial science.
CO4	Evaluate the suitability of characterizing methods for colloids or emulsions.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	-	-	-	-	-	-	-	-
CO2	3	3	3	3	-	-	-	3	-	-	-	-
CO3	3	3	3	3	-	-	-	-	-	-	-	-
CO4	3	3	3	3		-	-	-	-	-	-	-

Detailed Syllabus:

Introduction to types of interfaces: The importance of interfaces, Surfaces and interfaces, Stable interfaces.

Capillarity and surface tension: Surface tension and work, Measurement of surface tension, The Laplace equation, The Kelvin equation, The surface tension of pure liquids.

Adsorption and thermodynamics of surfaces: Introduction, Models of the interface, Adsorption, Thermodynamic properties of interfaces, Surface excess quantities, Measurement of Adsorption, Adsorption form solution, Kinetics of Adsorption.

Surfactants & Micelles, Films and foams: Introduction, Measurement of equilibrium adsorption, Adsorption kinetics, Adsorption of non-ionized solutes, Application of surfactants, Adsorption of surfactants, Micelles, films and foams, Aerosols.

Monolayers formation: Introduction, Formation of floating monolayers, Surface pressure-area relationships, Deposition of Langmuir Blodgett (LB) films, The study of film structure, the structure and properties of floating monolayers, Interactions in monolayers, the structures of LB films, characterization and application.

The liquid-liquid interface: Emulsions, Colloids, Membranes: Introduction, Emulsions, Emulsion stability and selection of the emulsion, Micro-emulsion, Emulsion polymerization, Liquid-liquid extraction, Membranes.

The liquid-solid interface: Introduction, Colloidal dispersions, The properties of colloidal dispersions, Coagulation of lyophobic colloids by electrolytes, solvent effects in colloidal interactions, Nanoparticles.

Reading:

1. Geoffrey Barnes and Ian Gentle, Interfacial Science: An Introduction, 2nd Edition, Oxford University Press, 2011.
2. Jacob N. Israelachvili, Intermolecular and Surface Forces, 3rd Edition, Academic Press, London, 2011.
3. John B. Hudson, Surface Science: An Introduction, John Wiley & Sons, 1998.

CH413	STATISTICAL THERMODYNAMICS	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Identify the molecular level properties influencing the macroscopic properties.
CO2	Develop models for simulating real gases, liquids and solids using ensemble methods to estimate thermodynamic properties
CO3	Design molecular level architecture to enhance macroscopic properties.
CO4	Estimate macroscopic properties based on molecular level interactions.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	-	-	-	-	-	-	-	-
CO2	3	3	3	3	-	-	-	3	-	-	-	-
CO3	3	3	3	3	-	-	-	-	-	-	-	-
CO4	3	3	3	3		-	-	-	-	-	-	-

Detailed Syllabus:

Basics of Statistical Thermodynamics: The Statistical Foundation of Classical Thermodynamics, Classification Scheme for Statistical Thermodynamics, Importance of Statistical Thermodynamics.

Ensembles: Ensembles and Postulates, Canonical Ensemble, Canonical Ensemble and Thermodynamics, Grand Canonical Ensemble, Micro Canonical Ensemble, Thermodynamic Equivalence of Ensembles.

Evaluation of Probabilities: Probability- Definitions and Basic Concepts, Permutations and Combinations, Distribution Functions: Discrete and Continuous, Binomial Distribution, Poisson Distribution, Gaussian Distribution, Combinatorial Analysis for Statistical Thermodynamics.

Criteriafor Equilibrium: Equilibrium Principles, States of Equilibrium: Neutral, Metastable, and Unstable equilibrium, Maximizing Multiplicity.

Modelfor Mono-atomic Ideal Gas and Polyatomic Ideal Gases: Energy Levels and Canonical Ensemble, Partition Function, Thermodynamic Functions for Mono-atomic Ideal Gases, Grand Ensemble, Internal Degrees of Freedom, Independence of Degrees of Freedom, Potential Energy Surface, Vibration, Rotation,Thermodynamic Functions for Poly-atomic Ideal Gases, Hindered Internal Rotation in Ethane, Hindered Translation on a Surface.

Einstein's and Debye's Model of the Solid, Simple Liquids, Phase Equilibrium, Models for Multi-Component Systems: Ideal Lattice Gas, Lattice Gas with Interactions, Solutions (Bragg-William Model and Regular Solutions, Quasi-Chemical Model), Chemical Equilibrium.

Reading:

1. Leonard K. Nash, Elements of Statistical Thermodynamics, 2nd Edition, Dover Publications, 2006.
2. Normand M. Laurendeau, Statistical Thermodynamics: Fundamentals and Applications, Cambridge University Press, 2005.
3. Stanley I. Sandler, An Introduction to Applied Statistical Thermodynamics, John Wiley &Sons, 2010.

CH414	NON-NEWTONIAN FLOW AND RHEOLOGY	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Identify the types of non-Newtonian fluids.
CO2	Understand the macroscopic behavior of the complex fluids.
CO3	Analyze the flow of non-Newtonian fluids through circular and non-circular cross sectional conduits.
CO4	Develop heat and mass transfer characteristics of non-Newtonian fluids.
CO5	Develop models of non-Newtonian fluid flow.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	2	2	-	-	-	-	-	-	-
CO2	2	2	2	2	2	-	-	-	-	-	-	-
CO3	2	2	2	2	2	-	-	-	-	-	-	-
CO4	2	2	2	2	2	-	-	-	-	-	-	-
CO5	1	2	2	2	2	-	-	-	-	-	-	-

Detailed Syllabus:

Non-Newtonian fluid behaviour - Introduction, Classification of fluid behaviour, Time-independent fluid behaviour, Time-dependent fluid behaviour, Visco-elastic fluid behaviour, Dimensional considerations for visco-elastic fluids.

Rheometry for non-Newtonian fluids - Introduction, Capillary viscometers, Rotational viscometers, The controlled stress Rheometer, Yield stress measurements, Normal stress measurements, Oscillatory shear measurements, High frequency techniques, The relaxation time spectrum, Extensional flow measurements.

Flow in pipes and in conduits of non-circular cross-sections - Introduction, Laminar flow in circular tubes, Criteria for transition from laminar to turbulent flow, Friction factors for transitional and turbulent conditions, Laminar flow between two infinite parallel plates, Laminar flow in a concentric annulus, Laminar flow of inelastic fluids in non-circular ducts

Flow of multi-phase mixtures in pipes - Introduction, Two-phase gas-non-Newtonian liquid flow, Two-phase liquid-solid flow (hydraulic transport).

Particulate systems - Introduction, Drag force on a sphere, Effect of particle shape on terminal falling velocity and drag force, Motion of bubbles and drops, Flow of a liquid through beds of particles, Flow through packed beds of particles (porous media), Liquid-solid fluidization.

Heat transfer characteristics of non-Newtonian fluids in pipes - Introduction, Thermo-physical properties, Laminar flow in circular tubes, Fully-developed heat transfer to power-law fluids in laminar flow, Isothermal tube wall, Constant heat flux at tube wall, Effect of temperature-dependent physical properties on heat transfer.

Momentum transfer in boundary layers - Introduction, Integral momentum equation, Laminar boundary layer flow of power-law liquids over a plate, Laminar boundary layer flow of Bingham plastic fluids over a plate, Transition criterion and turbulent boundary layer flow, Heat transfer in boundary layers, Mass transfer in laminar boundary layer flow of power-law fluids, Boundary layers for visco-elastic fluids.

Liquid mixing - Introduction, Liquid mixing, Gas-liquid mixing, Heat transfer, Mixing equipment and its selection, Mixing in continuous systems.

Reading:

1. Chhabra R.P., J.F. Richardson, Non-Newtonian Flow and Applied Rheology: Engineering Applications, 2nd Edition, Butterworth-Heinemann, 2008.
2. Christopher W. Macosko, RHEOLOGY: Principles, Measurements and Applications, WILEY-VCH, 1994.
3. Alexander Ya. Malkin, Rheology Fundamentals, ChemTech Publishing, 1994.

CH451	ELEMENTS OF TRANSPORT PHENOMENA	PCC	3 – 1 – 0	4 Credits

Pre-requisites: MA251 Mathematics-IV, CH304 Mass transfer-I.

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

CO1	Understand the analogy among momentum, heat and mass transport.
CO2	Formulate a mathematical representation of a flow/heat/mass transfer phenomena.
CO3	Solve flow/heat/mass transfer problems either individually or coupled for simple geometries analytically.
CO4	Identify the similarities among the correlations for flow, heat and mass transfer at interfaces.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	2	2	-	2	1	-	-	-	-	-
CO2	3	1	3	3	-	3	-	-	-	-	-	-
CO3	3	-	3	3	-	3	-	-	-	-	-	-
CO4	2	-	3	3	-	3	-	-	-	-	-	-

Detailed Syllabus:

Introduction

Momentum Transfer: Newton's law of viscosity & mechanism of momentum transport, Continuity equation, Equation of motion, Navier-Stokes Equation, Laminar velocity profiles in simple geometries such as flow between parallel plates, flow in a circular pipe, flow down an inclined plane, Time dependent velocity profile, Turbulent flow correlations, Flow in packed beds, Flow past objects,

Heat Transfer: Fourier's law of heat conduction & mechanism of heat transport, Heat conduction-convection equation, Temperature profile for simple geometries with/without heat generation, Temperature profile in laminar flowing fluids with/without heat generation, Time dependent Temperature profile, Natural convection, Inter-phase heat transport.

Mass Transfer: Fick's law of diffusion & mechanism of mass transport, Species balance equation with convection-diffusion and reaction, Diffusion in solids, Dispersion model for laminar flow in tubes, Stefan tube experiment – determination of diffusion constant, Interphase mass transport - Mass transfer for flow past spheres.

Analogies: Analogies between momentum, heat & mass transfer correlations for friction factor/Nusselt Number/Sherwood Number.

Reading:

1. Bird R.B., Stewart W.E. and Light Foot E.N. Transport Phenomena, 2nd Edition, John Wiley &Sons., 2007.
2. Geankoplis C.J., Transport Processes and Separation Process Principles, 4th Edition, Prentice Hall Inc., 2009.

CH452	PLANT DESIGN AND PROCESS ECONOMICS	PCC	3 – 1 – 0	4 Credits

Pre-requisites: CH351 Mass Transfer-II, CH352 Chemical Reaction Engineering-II, SM335 Engineering Economics and Accountancy.

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

CO1	Analyze alternative processes and equipment for manufacturing a product.
CO2	Design plant layout and engineering flow diagrams.
CO3	Perform economic analysis related to process design.
CO4	Evaluate project profitability.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	-	-	-	-	-	-	-	-	-	
CO2	2	2	3	3	3	-	2	-	1	-	2	-
CO3	-	-	2	2	2	-	-	3	1	-	-	-
CO4	-	-	1	1	1	-	-	3	-	-	-	-

Detailed Syllabus:

Introduction: Chemical Engineering plant design, Overall design consideration, Practical considerations in design, engineering ethics in design.

General Design Considerations: Health and Safety hazards, Loss prevention, Environmental Protection, Plant Location, Plant Layout, Plant Operation and Control.

Process Design Development: Development of design database, Process creation, Process design criteria, Process flow diagram (PFD), Piping and instrumentation diagram (P&ID), Vessel and piping layout isometrics, Equipment design and specifications.

Flow sheet synthesis and development: General procedure, Process information, Functions diagram, Process flow sheet, Software use in process design.

Cost and asset accounting: General accounting procedure, Balance sheet and Income statements.

Analysis of Cost Estimation: Cash flow for industrial operations, Factors affecting investment and production costs, Capital investments, Fixed capital and working capital, Estimation of capital investment, Cost indices, Estimation of total cost, Gross profit, Net profit and cash flow, Cost scaling factors, Net present value analysis.

Interest and Insurance: Interest, Simple interest, Compound interest, Nominal and effective interest rates, Continuous interest, Costs of capital, Time value of money, Annuity, Cash flow patterns, Income taxes, Present worth, Future worth, Taxes and Insurance.

Depreciation: Depreciable investments, Methods for calculating Depreciation.

Profitability Analysis: Profitability standards, Costs of capital, Minimum acceptable rate of return, Methods of calculating profitability, Rate of return on investment, Payback period, Net return, Discounted cash flow rate of return, Net present worth, Payout period, Alternative investments, Replacements.

Optimum design and design strategy: Defining the optimization problem, Selecting an objective function, Structural optimization, Parametric optimization, Variable screening and selection, Optimization Applications.

Reading:

1. Peters M.S., K.D. Timmerhaus and R.E. West. "Plant Design and Economics for Chemical Engineers", McGraw Hill, 5th Edition, 2011.
2. Turton R., R.C. Baile, W.B. Whiting, J. A. Shaeiwitz. "Analysis, Synthesis and Design of Chemical Processes", PHI, New Delhi, 3rd Edition, 2011.
3. Seider W.D., J.D. Seader, D.R. Lewin, "Product and Process Design Principles: Synthesis, Analysis, and Evaluation, Wiley, 2nd Edition, 2004.

CH491	SEMINAR	PCC	0 – 0 – 3	1 Credits

Pre-requisites: None

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

CO1	Acquire knowledge on topics outside the scope of curriculum.
CO2	Communicate with group of people on different topics.
CO3	Collect and consolidate required information on a topic.
CO4	Prepare a seminar report.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	1	1	-	-	-	-	-	3
CO2	1	1	-	-	1	1	-	-	3	2	3	3
CO3	-	1	-	-	1	-	1	-	-	-	3	3
CO4	-	-	-	-	-	-	-	-	1	-	3	1

Detailed Syllabus: Any topic of relevance to Engineering / Science.

Reading: Journals, Magazines, etc.

CH499	PROJECT WORK- PART B	PRC	0 – 0 – 6	4 Credits

Pre-requisites: CH204 Energy Technology & Conservation, CH303 Industrial Safety and Hazard Mitigation, CH351 Mass Transfer-II, CH352 Chemical Reaction Engineering-II, ME435 Industrial Management, CH449 Project Work A.

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

CO1	Perform energy balance
CO2	Design critical equipment involved in the process
CO3	Perform cost estimation and profitability study
CO4	Select location for plant based on societal, economical, environmental, availability of raw materials, human resources, power.
CO5	Design pollution control and safety systems to meet environmental standards.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	3	2	3	2	-	3	-	3	3
CO2	3	1	3	3	1	3	-	-	3	-	3	3
CO3	3	-	2	2	3	1	2	3	3	2	3	-
CO4	-	3	-	-	3	-	3	3	3	3	3	2
CO5	2	2	3	3	1	-	3	1	3	-	3	2

Detailed Syllabus:

Feasibility study for production of any product on industrial scale, Energy balance, design of equipment, cost estimation, profitability analysis, plant layout, site selection, environmental considerations and safety.

Reading: Chemical Industry Periodicals, Professional core books

CH461	MICROSCALE UNIT OPERATIONS	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Identify the micro-scale processes.
CO2	Solve fluid flow phenomena for single and immiscible liquids in micro-channels.
CO3	Design architectures of micro-fluidic devices for chemical & medical applications
CO4	Integrate theoretically components for assembly of Lab-on-a-chip devices.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	-	-	-	-	-	-	-	-	-	-
CO2	3	-	-	2	3	-	-	-	-	-	-	--
CO3	-	-	-	3	-	2		-	-		-	-
CO4	-	-	-	3	-	-	-	-	-	-	-	-

Detailed Syllabus:

Physics and Chemistry at microscale: Introduction, Ranges of forces of microscopic origin, Microscopic length scales intervening in liquids and gases, Micromanipulation of molecules and cells in Microsystems, The physics of miniaturization, miniaturization of electrostatic systems, miniaturization of electromagnetic systems, miniaturization of mechanical systems, miniaturization of thermal systems, miniaturization of systems for chemical analysis.

Fluid dynamics in micro channels: Introduction, hypotheses of hydrodynamics, Hydrodynamics of gases in Microchannels, Flow of liquids with slip at the surface, Microhydrodynamics, Microfluidics involving inertial effects.

Interfacial phenomena: a few ideas about capillarity, Microfluidics of drops and bubbles, two-phase flows, emulsion in Microsystems.

Reaction, Mixing and separation in micro chambers: Introduction, The microscopic origin of diffusion process, Advection-diffusion equation and its properties, Analysis of dispersion phenomena, chaotic mixing, mixing in Microsystems, Adsorption phenomena, Dispersion with chemical kinetics, Chromatography.

Instruments for micro devices: Introduction, Examples of microfluidic structures, connectors, Examples of micro-fabricated valves and pumps.

Fabrication of micro devices, Applications of micro devices: Introduction, Current situation of micro-technologies, The environment of micro-fabrication, Photolithography, Micro-fabrication methods for silicon and glass MEMS, Methods of Fabrication for plastic MEMS.

Reading:

1. Tabeling P, Introduction to Microfluidics, Oxford University Press, 2010.
2. N.T. Nguyen, Steven Wereley, Fundamentals and Applications of Microfluidics, 2nd Edition, Artech Housenc., 2002.
3. Ronald F. Probstein, Physicochemical Hydrodynamics: An Introduction, 2nd Edition, Wiley-Interscience,2003.

CH462	PROCESS DESIGN PRINCIPLES	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Identify steps in product and process design
CO2	Understand principles of steady-state flow sheet simulation
CO3	Understand heuristics for process synthesis
CO4	Design reactors for complex configurations.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	-	3	3	-	3	-	-	-	-	-	-
CO2	2	1	3	3	-	3	-	-	-	-	-	-
CO3	2	1	3	3	-	3	-	-	-	-	-	-
CO4	2	-	3	3	-	3	-	-	-	-	-	-

Detailed Syllabus:

Design Process: Design opportunities, steps in product and Process design, Environmental protection, Safety considerations, Engineering ethics, Role of computers.

Molecular Structure Design: Introduction, Property estimation methods, Optimization to Locate molecular structure.

Process Creation: Introduction, preliminary Database Creation, Experiments, preliminary Process Synthesis, Development of Base-Case Design.

Process Synthesis: Introduction, Principles of Steady-state Flowsheet simulation, Synthesis of the Toluene Hydrodealkylation process, Steady state Simulation of the Monochlorobenzene Separation Process, Principles of Batch flowsheet Simulation.

Heuristics for Process Synthesis: Introduction, Raw materials and Chemical Reactions, Distribution of Chemicals, Separations, Heat removal from and Addition to Reactors, Heat Exchangers and Furnaces, Pumping, Compression, Pressure Reduction, Vacuum, and Conveying of Solids, Changing the Particle Size of Solids and Size Separation of particles, Removal of Particles from Gases and Liquids.

Reactor Design and Reactor Network Synthesis: Reactor models, Reactor Design for Complex Configurations, Reactor Network Design Using the Attainable region.

Reading:

1. Sieder, W.D.,Seader J.D. and Lewin D.R., Process Design Principles: Synthesis Analysis and Evaluation, John Wiley & Sons, 3rd Edition, 2008.
2. J.M., Douglas, Conceptual Design of Chemical Processes, McGraw Hill International Editions, 1988.
3. Loren T Biegler, Grossman E.I., Westerberg, Systematic Methods of Chemical Process Design, A.W. Prentice Hall Intl ed,1997.

CH463	PLANT UTILITIES	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	List utilities in a plant.
CO2	Understand properties of steam and operation of boilers for steam generation.
CO3	Understand refrigeration methods used in industry.
CO4	Compare power generation methods.
CO5	Classify and describe the types of water, water treatment methods, storage and distribution techniques.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	-	3	-	-	-	-	-	-
CO2	2	2	3	3	-	3	-	-	-	-	-	-
CO3	2	2	3	3	-	3	-	-	-	-	-	-
CO4	2	-	3	3	-	3	-	-	-	-	-	-
CO5	2	-	3	3	-	3	3	-	-	-	-	-

Detailed Syllabus:

Importance of Process utilities in Chemical Plant: Different utilities - water, steam, compressed air, vacuum, refrigerants, their properties and requirements, selection and application of different utilities.

Compressed air and Vacuum: Use of Compressed air, process air and instrument air, Process of getting instrument air, Vacuum.

Steam: Properties of steam, types of steam generator / Boiler, steam handling and distribution, steam traps, steam nozzles, Scaling, trouble shooting, preparing boiler for inspection, Boiler Act.

Refrigeration: Refrigeration cycles, Different methods of refrigeration used in industry, different refrigerants, Simple calculation of C.O.P. Refrigerating effects.

Liquefaction processes: Liquefaction process, liquefaction of air, liquefaction of natural gas.

Power Generation: Internal Combustion engines, Gas turbines, steam power plants.

Water: Hard and soft water, water treatment, Water Resources, storage and distribution of water resources and conservation of water.

Reading:

1. Jorgenson R., Fan Engineering, Buffalo Rorge Co., 8th Edition, 1983.
2. Lyle, O., Efficient Use of Steam, HMSO, London, 1974.
3. Stoecker, W.F., Refrigeration and Air Conditioning, Mc-Graw Hill, 2nd Edition, 1983.
4. Chattopadhyay, P., Boiler operations engineering, Tata McGraw Hill, 1998.
5. Perry R.H., Green D.W., Perry's chemical Engineer's Handbook, McGraw Hill, NewYork, 8th Edition, 2007.

CH464	POLYMER TECHNOLOGY	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand thermodynamics of polymer structures
CO2	Select polymerization reactor for a polymer product.
CO3	Characterize polymers.
CO4	State polymer additives, blends and composites.
CO5	Understand polymer rheology.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	1	1	-	2	1	-	-	-	-	-
CO2	3	3	3	3	3	3	2	-	-	-	-	-
CO3	3	2	1	1	-	-	-	-	-	-	-	-
CO4	3	3	3	3	3	-	1	-	-	-	-	-
CO5	3	3	3	3	2	-	2	-	-	-	-	-

Detailed Syllabus:

Introduction and Classification of Polymers. Thermosets, Factors influencing the polymer properties, Monomers used for polymer synthesis, synthesis procedure for monomers Styrene, ethylene, Vinyl monomers etc., Thermoplastics, Linear Branch, Cross Linked Polymers, Ewart Kinetics for emulsion polymerization.

Addition polymers – kinetics, synthesis and reactions, Condensation polymers, Kinetics reaction and processes, Polymerization Techniques - Emulsion polymerization and Suspension polymerization, Interfacial Polymerization with their merits

Molecular Weights, Polydispersity Index, Different Methods of determination of Molecular weight, Effect of Molecular weight on Engineering Properties of Polymers, Smith Ewart Kinetics for emulsion polymerization, Kinetics of free radical polymerization, Chain transfer agents, Kinetics of Step growth polymerization, Ziegler Natta polymerization Processes, Differentiation based on kinetics of Anionic and cationic polymers.

Polymerization reactors types and mode of operation, Polymerization reactor design, control of polymerization, Post polymerization unit operations and unit processes

High Performance and Specialty Polymers, Polymer additives, compounding. Fillers plastisizers lubricants colourants UV stabilizers, fire retardants, antioxidants, Different moulding methods of polymers.

Impact flexural tensile testing methods of polymers, Mechanical Properties of Polymers, Thermodynamics of Polymer Mixtures, ASTM and ISO methods for testing of polymers.

Manufacturing of typical polymers with flow-sheet diagrams properties &application: PE, PP, PS, Polyesters, Nylons, ABS, PC.

Reading:

1. Fried J R, Polymer Science and Technology, Prentice Hall of India Pvt. Ltd., New Delhi, Eastern Economy Edition, 2000.
2. Premamoy Ghosh, Polymer Science and Technology, 3rd Edition, Tata Mc. Graw-Hill Publishing Company, New Delhi, 2010.
3. R. Sinha, Outlines of Polymer Technology: Manufacture of Polymers, Prentice Hall of India Pvt. Ltd., New Delhi, 2002.

CH465	BIOTECHNOLOGY	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand microbial, plant and animal cells.
CO2	Select methods of cell culture and tissue culture.
CO3	Design fermentation technology for industrial microbiology.
CO4	Apply biotechnology in food, agriculture, environment and energy sectors.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	3	1	-	-	-	-	-	-	-	-	-
CO2	2	1	-	-	-	2	-	-	-	-	-	-
CO3	2	3	1	3	-	-	1	2	-	-	-	-
CO4	3	2	1	1	-	-	-	-	-	-	-	-

Detailed Syllabus:

Introduction: Basics, applications of biotechnology.

Plant cell and Tissue Culture: Introduction to gene structure, expression and regulation; Implication for plant transformation; Protein targeting; Heterologous promoters; Genome size and organization; Plant tissue culture – plasticity and tot potency; culture environment; Growth regulators, media regulators; Culture types.

Biotechnology of Animals: Animal breeds; Embryo transfer and transgenic animals; Animal cell culture; Recombinant vaccines for animal health; Biotechnology in animal production.

Fermentation Technology and Industrial Microbiology: The range of fermentation processes; microbial biomass; microbial enzymes; microbial metabolites; recombinant products; transformation processes; Media for industrial fermentations – Typical medium formulation, energy sources, carbon sources, nitrogen sources, minerals, growth factors, nutrient recycle; Sterilization – Medium sterilization, sterilization of the fermentor and feeds.

Food and Agriculture Biotechnology: Food Biotechnology – Preservation technology; Food production Technology; Food quality and control Agriculture Biotechnology – Plant breeding, Crop science and production, Pest management.

Environmental and Energy Biotechnology: Waste water treatment – Physical, chemical, biological methods, aerobic and anaerobic methods; Bioremediation – types of bioremediation, bioremediation of hydrocarbons; Bio energy – Energy and Biomass Production from wastes, biofuels, bio hydrogen and biomass.

Reading:

1. H.D. Kumar, A Text Book on Biotechnology, Affiliated East West Press Private Ltd., 2000.
2. James E. Bailey and David F. Ollis, Biochemical Engineering Fundamentals, 2nd Edition, Tata McGraw Hill Education Pvt. Ltd., 2010.

CH466	MATHEMATICAL METHODS IN CHEMICAL ENGINEERING	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Formulate lumped and distributed parameter mathematical models for chemical processes
CO2	Calculate degrees of freedom for the developed mathematical models
CO3	Solve the model equations describing chemical processes and equipment
CO4	Analyze the results of the solution methods.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	3	3	-	3	-	-	-	-	-	-
CO2	3	2	3	3	-	-	-	-	-	-	-	-
CO3	3	3	3	3	-	-	-	-	-	-	-	-
CO4	3	3	3	3	-	-	-	-	-	-	-	-

Detailed Syllabus:

Mathematical Formulation of the Physical Problems- Introduction, Representation of the problem, blending process, continuous stirred tank reactor, Unsteady state operation, heat exchangers, distillation columns, biochemical reactors.

Analytical (explicit) Solution of Ordinary Differential Equations encountered in Chemical Engineering Problems-Introduction, Order and degree, first order differential equations, second order differential equations, Linear differential equations, Simultaneous differential equations, .

Formulation of partial differential equations- Introduction, Interpretation of partial derivatives, Formulation partial differential equations, particular solutions of partial differential equations, Orthogonal functions, Method of separation of variables, The Laplace Transform method, Other transforms.

Unsteady state heat conduction in one dimension - Mass transfer with axial symmetry - Continuity equations; Boundary conditions - Iterative solution of algebraic equations- The difference operator - Properties of the difference operator- Linear finite difference equations- Non-linear finite difference equations- Simultaneous linear differential equations - analytical solutions - Application of Statistical Methods.

Reading:

1. Rice R. G. and D. Do Duong, ‘Applied mathematics and modeling for chemical engineers’ John Wiley & Sons, 1995.
2. Jenson J F and G. V. Jeffereys, 'Mathematical Methods in Chemical Engineering', Academic Press, 1977.
3. B. A. Finlayson, 'Introduction to Chemical Engineering Computing', Wiley India Edition, 2010
4. Singaresu S. Rao, 'Applied Numerical Methods for Engineers and Scientists', Prentice Hall, 2002.
5. Amiya K. Jana, Chemical Process Modelling and Computer Simulation, Prentice Hall India, 2^{nd} Edition, 2011.

CH467	MEMBRANE TECHNOLOGY	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand the technologies of membrane synthesis
CO2	Classify the membranes
CO3	Select membrane according to the application.
CO4	Understand the mathematical models of membrane processes.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	2	2	-	2	-	-	-	-	-
CO2	-	1	1	2	-	-	-	-	-	-	-	-
CO3	-	2	1	2	2	-	2	-	-	-	-	-
CO4	2	2	2	2	2	2	-	-	-	-	-	-

Detailed Syllabus:

Introduction: Membrane separation process, Definition of Membrane, Membrane types, Advantages and limitations of membrane technology compared to other separation processes, Membrane materials.

Preparation of synthetic membranes: Phase inversion membranes, Preparation techniques for immersion precipitation, Synthesis of asymmetric and composite membranes, and Synthesis of inorganic membranes.

Transport in membranes: Introduction, Driving forces, Transport through porous membranes, transport through non-porous membranes, Transport through ion-exchange membranes.

Membrane processes: Pressure driven membrane processes, Concentration as driving force, Electrically driven membrane processes

Polarisation phenomena and fouling: Concentration polarization, Membrane fouling

Modules: Introduction, membrane modules, Comparison of the module configuration

Reading:

1. Mulder M, Basic Principles of Membrane Technology, Kluwer Academic Publishers, London, 1996.
2. Richard W. Baker, Membrane Technology and Research, Inc. (MTR), Newark, California, USA, 2004.
3. Kaushik Nath, Membrane Separation Processes, Prentice-Hall Publications, New Delhi, 2008.

CH468	CHEMICAL PROCESS OPTIMIZATION	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Translate a verbal description of the chemical engineering problem into mathematical description.
CO2	Formulate unconstrained or constrained objective functions of chemical engineering problems
CO3	Understand how the problem formulation influences its solvability
CO4	Solve the optimization problem.
CO5	Interpret the results of optimization and present the insights.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	3	3	-	3	-	-	-	-	-	-
CO2	2	2	3	3	-	3	-	-	-	-	-	-
CO3	1	3	3	3	-	-	-	-	-	-	-	-
CO4	2	1	3	3	-	-	-	-	-	-	-	-
CO5	2	2	3	3	-	-	-	-	-	-	-	-

Detailed Syllabus:

Thenature and organization of optimization problems: Scope and Hierarchy, General procedure for solving optimization problems, Formulation of the objective function, Basic concepts of optimization - Continuity, Convexity and applications, Necessary and sufficient conditions for an extremum.

Optimization of unconstrained functions: Functions of single variable, scanning and bracketing procedures, Newton and Quasi-Newton methods, Evaluation of one-dimensional search methods.

Unconstrained multivariable optimization: Methods using function values only, Methods using first derivatives, Newton's method and Quasi-Newton's method.

Linear programming and applications: Graphical methods, Simplex algorithm, Barrier methods, Linear mixed integer programs. Non-linear programming with constraints - Direct substitution, Quadratic programming, Penalty, Barrier and Augmented Lagrangian methods.

Optimization of stage and discrete processes, Applications of optimization: Heat transfer and energy conservation, separation processes, chemical reactor design and operation.

Reading:

1. Edgar T.F. and D. M. Himmelblau, 'Optimization of Chemical Processes', 2nd Edition, McGraw Hill, 2001
2. Singiresu S Rao, 'Engineering Optimization: Theory and Practice', 4th Edition, John Wiley & Sons Ltd., 2009
3. Mohan C. Joshi and Kannan M. Moudgalya, 'Optimization: Theory and Practice', Alpha Science International Limited, 2004
4. K. Urbanier and C. McDermott, 'Optimal Design of Process Equipment', John Wiley & Sons, 1986.

CH469	SCALE-UP METHODS	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand scale up in chemical engineering plants.
CO2	Apply dimensional analysis technique for scale up problems.
CO3	Scale up of chemical reactors.
CO4	Scale up mixers and heat exchangers, distillation columns and packed towers.

Mapping of course outcomes with program outcomes

Course outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	2	-	-	-	-	-	-	-	-
CO2	1	2	1	2	-	-	-	-	-	-	-	-
CO3	3	3	3	3	-	-	-	-	-	-	-	-
CO4	3	3	3	3	-	-	-	-	-	-	-	-

Detailed Syllabus:

Principals of Similarity, Pilot Plants & Models: Introduction to scale-up methods, pilot plants, models and principles of similarity, Industrial applications.

Dimensional Analysis and Scale-Up Criterion: Dimensional analysis, regime concept, similarity criterion and scale up methods used in chemical engineering, experimental techniques for scale-up.

Scale-Up of Mixing and Heat Transfer Equipment: Typical problems in scale up of mixing equipment and heat transfer equipment.

Scale-Up of Chemical Reactors: Kinetics, reactor development & scale-up techniques for chemical reactors.

Scale-Up of Distillation Column & Packed Towers: Scale-up of distillation columns and packed towers for continuous and batch processes.

Reading:

1. Johnstone and Thring, Pilot Plants Models and Scale-up methods in Chemical Engg., McGraw Hill, New York, 1962.
2. W. Hoyle, Pilot Plants and Scale-Up, Royal Society of Chemistry, 1st Edition, 1999.
3. Marko Zlokarnik, Dimensional Analysis and Scale-up in Chemical Engineering, Springer Verlag, Berlin, Germany,1991.
4. E. Bruce Nauman, Chemical Reactor Design, Optimization and Scale-up, McGraw Hill, New York, 2002.

OPEN ELECTIVES

CE390	ENVIRONMENTAL IMPACT ANALYSIS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Identify the environmental attributes to be considered for the EIA study.
CO2	Formulate objectives of the EIA studies.
CO3	Identify the suitable methodology and prepare Rapid EIA.
CO4	Prepare EIA reports and environmental management plans.
CO5	Plan the methodology to monitor and review the relief and rehabilitation works.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	3	-	3	-	3	-	-	3
CO2	-	-	-	-	3	-	3	-	3	-	-	3
CO3	-	-	-	-	3	-	3	-	3	-	-	3
CO4	-	-	-	-	3	-	3	-	3	-	-	3
CO5	-	-	-	-	3	-	3	-	3	-	-	3

Detailed Syllabus:

Introduction: The Need for EIA, Indian Policies Requiring EIA , The EIA Cycle and Procedures, Screening, Scoping, Baseline Data, Impact Prediction, Assessment of Alternatives, Delineation of Mitigation Measure and EIA Report, Public Hearing, Decision Making, Monitoring the Clearance Conditions, Components of EIA, Roles in the EIA Process. Government of India Ministry of Environment and Forest Notification (2000), List of projects requiring Environmental clearance, Application form, Composition of Expert Committee, Ecological sensitive places, International agreements.

Identifying the Key Issues: Key Elements of an Initial Project Description and Scoping, Project Location(s), Land Use Impacts, Consideration of Alternatives, Process selection: Construction Phase, Input Requirements, Wastes and Emissions, Air Emissions, Liquid Effluents, Solid Wastes, Risks to Environment and Human, Health, Socio-Economic Impacts, Ecological Impacts, Global Environmental Issues.

EIA Methodologies**:** Criteria for the selection of EIA methodology, impact identification, impact measurement, impact interpretation & Evaluation, impact communication, Methods-Adhoc methods, Checklists methods, Matrices methods, Networks methods, Overlays methods, Environmental index using factor analysis, Cost/benefit analysis, Predictive or Simulation methods. Rapid assessment of Pollution sources method, predictive models for impact assessment, Applications for RS and GIS.

Reviewing the EIA Report: Scope, Baseline Conditions, Site and Process alternatives, Public hearing. Construction Stage Impacts, Project Resource Requirements and Related Impacts, Prediction of Environmental Media Quality, Socio-economic Impacts, Ecological Impacts, Occupational Health Impact, Major Hazard/ Risk Assessment, Impact on Transport System,Integrated Impact Assessment.

Review of EMP and Monitoring: Environmental Management Plan, Identification of Significant or Unacceptable Impacts Requiring Mitigation, Mitigation Plans and Relief & Rehabilitation, Stipulating the Conditions, What should be monitored? Monitoring Methods, Who should monitor? Pre-Appraisal and Appraisal.

Case Studies: Preparation of EIA for developmental projects- Factors to be considered in making assessment decisions, Water Resources Project, Pharmaceutical industry, thermal plant, Nuclear fuel complex, Highway project, Sewage treatment plant, Municipal Solid waste processing plant, Tannery industry.

Reading:

1. Jain, R.K., Urban, L.V., Stracy, G.S., *Environmental Impact Analysis*, Van Nostrand Reinhold Co., New York, 1991.
2. Barthwal, R. R., *Environmental Impact Assessment*, New Age International Publishers, 2002
3. Rau, J.G. and Wooten, D.C., *Environmental Impact Assessment,* McGraw Hill Pub. Co., New York, 1996.
4. Anjaneyulu.Y., and Manickam. V., Environmental Imapact Assessment Methodologies, B.S. Publications, Hyderabad, 2007.
5. Wathern.P., Environmental Impact Assessment- Theory and Practice, Routledge Publishers, London, 2004.

EE390	LINEAR CONTROL SYSTEMS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Analyze electromechanical systems using mathematical modelling
CO2	Determine Transient and Steady State behavior of systems using standard test signals
CO3	Analyze linear and non-linear systems for steady state errors, absolute stability and relative stability
CO4	Design a stable control system satisfying requirements of stability and reduced steady state error

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	3	-	3	-	-	3	-	-	-
CO2	-	-	-	3	-	3	-	-	3	-	-	-
CO3	-	-	-	3	-	3	-	-	3	-	-	-
CO4	-	-	-	3	-	3	-	-	3	-	-	-

Detailed syllabus:

Introduction - control system, types, feedback and its effects-linearization

Mathematical Modelling of Physical Systems. Block diagram Concept and use of Transfer function. Signal Flow Graphs- signal flow graph, Mason's gain formula.

Time Domain Analysis of Control Systems - BIBO stability, absolute stability, Routh-Hurwitz Criterion.

P, PI and PID controllers. Root Locus Techniques - Root loci theory, Application to system stability studies.

Frequency Domain Analysis of Control Systems - polar plots, Nyquist stability criterion, Bode plots, application of Bode plots.

Reading:

1. B.C. Kuo, Automatic Control Systems, 7th Edition, Prentice Hall of India, 2009.
2. I.J. Nagarath and M. Gopal: Control Systems Engineering, 2nd Edition, New Age Pub. Co. 2008.

ME390	AUTOMOTIVE MECHANICS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Analyze operation and performance indicators of transmission systems, internal combustion engines and after treatment devices.
CO2	Understand operation of engine cooling system, lubrication system, electrical system and ignition system.
CO3	Understand fuel supply systems in an diesel and petrol vehicles
CO4	Analyze current and projected future environmental legislation and its impact on design, operation and performance of automotive power train systems.
CO5	Understand operation and performance of suspension, steering and braking system.
CO6	Understand layout of automotive electrical and electronics systems.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	-	-	-	3	-	-	-
CO2	-	-	-	-	-	-	-	-	3	-	-	-
CO3	-	-	-	-	-	-	-	-	3	-	-	-
CO4	-	-	-	-	-	-	-	-	3	-	-	-
CO5	-	-	-	-	-	-	-	-	3	-	-	-
CO6	-	-	-	-	-	-	-	-	3	-	-	-

Detailed syllabus

Introduction: Layout of an automotive chassis, engine classification.

Cooling Systems: Air cooling, air cleaners, Water cooling: Thermosyphon and pump circulation systems, Components of water cooling systems- Radiator, thermostat etc.

Engine Lubrication: Petroils system, Splash system, Pressure lubrication and dry sump system

Ignition System: Battery, Magneto and Electronic, Engine Starting drives

Fuel supply system: Components in fuel supply system, types of feed pumps, air cleaners, fuel and oil filters, pressure and dry sump systems.

Engine testing and Performance: Performance parameters, constant and variable speed test, heat balance test, performance characteristics. Engine Emissions: SI and CI engine emissions, emission control methods

Automotive electrical and electronics: Electrical layout of an automobile, ECU, sensors, windscreen wiper, Electric horn.

Transmission: Clutch- Single and multiplate clutch, semi & centrifugal clutch and fluid flywheel, Gear box: Sliding mesh, constant mesh and synchromesh gear box, selector mechanism, over drive, Propeller shaft and Differential.

Suspension System: Front and rear suspension, shock absorbers, Rear Axles mountings, Front Axle. Steering Mechanism: Manual and power steering systems, Braking System: Mechanical, Hydraulic and Air braking systems.

Engine service: Engine service procedure.

Reading:

1. S. Srinivasan, Automotive Mechanics, Tata McGraw-Hill, 2004.
2. K.M.Gupta, Automobile Engineering, Vol.1 and Vol.2, Umesh Publications, 2002
3. Kirpal Singh, Automobile Engineering, Vol.1 and Vol.2, Standard Publishers, 2003.
4. William H.Crouse and Donald L. Anglin, Automotive Mechanics, Tata McGraw-Hill, 2004
5. Joseph Heitner, Automotive Mechanics, East-West Press, 2000.

ME391	ROBUST DESIGN	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand stages in engineering design and concept of robust design.
CO2	Develop quality loss functions and S/N ratios for S, N and L type objective functions.
CO3	Identify control and noise factors for a given product or process.
CO4	Conduct experiments using DOE concepts to decide the optimal setting of parameters
CO5	Apply quality loss function approach for fixing the component tolerances.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	-	-	-	2	-	-	-
CO2	-	-	-	-	-	-	-	-	2	-	-	-
CO3	-	-	-	-	-	-	-	-	2	-	-	-
CO4	-	-	-	-	-	-	-	-	2	-	-	-
CO5	-	-	-	-	-	-	-	-	2	-	-	-

Detailed syllabus

Introduction: Taguchi's quality philosophy, causes of performance variation, concept of robust design, stages in product/process design, need for experimentation, QFD, process flow analysis, cause and effect diagram.

Design of Experiments**:** Principles of experimentation, Basic concepts of probability and statistics, Comparison of two means and two variances, Comparison of multiple (more than two) means & ANOVA, Factorial designs, fractional factorial designs, orthogonal arrays, standard orthogonal arrays & interaction tables, modifying the orthogonal arrays, selection of suitable orthogonal array design, analysis of experimental data.

Parameter Design**:** Loss function, average quality loss, S/N ratios, objective functions, selection of control & noise factors and their levels, strategy for systematic sampling of noise, classification of control factors, inner-array and outer-array design, data analysis, selection of optimum levels/values for parameters.

Tolerance Design: Experiments, selection of tolerances to be tightened, fixing the final tolerances.

Reading:

1. Taguchi G, Chowdhury S and Taguchi S, Robust Engineering, TMH, 2000.
2. Ross PJ, Taguchi Techniques for Quality Engineering, TMH, 2005.

ME392	ENTREPRENEURSHIP DEVELOPMENT	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand entrepreneurship and entrepreneurial process and its significance in economic development.
CO2	Develop an idea of the support structure and promotional agencies assisting ethical entrepreneurship.
CO3	Identify entrepreneurial opportunities, support and resource requirements to launch a new venture within legal and formal frame work.
CO4	Develop a framework for technical, economic and financial feasibility.
CO5	Evaluate an opportunity and prepare a written business plan to communicate business ideas effectively.
CO6	Understand the stages of establishment, growth, barriers, and causes of sickness in industry to initiate appropriate strategies for operation, stabilization and growth.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	-	-	-	2	3	3	-
CO2	-	-	-	-	-	-	-	-	2	3	3	-
CO3	-	-	-	-	-	-	-	-	2	3	3	-
CO4	-	-	-	-	-	-	-	-	2	3	3	-
CO5	-	-	-	-	-	-	-	-	2	3	3	-
CO6	-	-	-	-	-	-	-	-	2	3	3	-

Detailed syllabus

Entrepreneur and Entrepreneurship: Introduction; Entrepreneur and Entrepreneurship; Role of entrepreneurship in economic development; Entrepreneurial competencies and motivation; Institutional Interface for Small Scale Industry/Enterprises.

Establishing Small Scale Enterprise: Opportunity Scanning and Identification; Creativity and product development process; Market survey and assessment; choice of technology and selection of site.

Planning a Small Scale Enterprises: Financing new/small enterprises; Techno Economic Feasibility Assessment; Preparation of Business Plan; Forms of business organization/ownership.

Operational Issues in SSE: Financial management issues; Operational/project management issues in SSE; Marketing management issues in SSE; Relevant business and industrial Laws.

Performance appraisal and growth strategies: Management performance assessment and control; Causes of Sickness in SSI, Strategies for Stabilization and Growth.

Reading:

1. G.G. Meredith, R.E.Nelson and P.A. Neek, The Practice of Entrepreneurship, ILO, 1982.
2. Dr. Vasant Desai, Management of Small Scale Enterprises, Himalaya Publishing House, 2004.
3. A Handbook for New Entrepreneurs, Entrepreneurship Development Institute of India, Ahmedabad, 1988.
4. Bruce R Barringer and R Duane Ireland, Entrepreneurship: Successfully Launching New Ventures, 3rd ed., Pearson Edu., 2013.

EC390	COMMUNICATION SYSTEMS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand different modulation and demodulation schemes for analog communications.
CO2	Design analog communication systems to meet desired application requirements
CO3	Evaluate fundamental communication system parameters, such as bandwidth, power, signal to quantization noise ratio etc.
CO4	Elucidate design tradeoffs and performance of communications systems.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	-	-	-	3	-	-	-
CO2	-	-	-	-	-	-	-	-	3	-	-	-
CO3	-	-	-	-	-	-	-	-	3	-	-	-
CO4	-	-	-	-	-	-	-	-	3	-	-	-

Detailed syllabus

Signal Analysis**:** Communication Process, Sources of Information, Communication Channels, Modulation Process, Types of Communication, Random Process, Gaussian Process, Correlation Function, Power Spectral Density, Transmission of Random Process through an LTI Filter.

Noise Analysis: External Noise, Internal Noise, White Noise, Narrow Band Noise, Representation of Narrow Band noise In phase and Quadrature Components, Noise Figure, Noise Bandwidth, Noise Temperature.

Amplitude (Linear) Modulation: Linear Modulation Schemes, Generation of AM, Envelope Detector, DSB-SC Product Modulator, Switching Modulator, Ring Modulator, Coherent Detection, Costas receiver, SSB Signal Representation, Filtering Method, Phase Shift Method, Coherent Demodulation, VSB Modulator and Demodulator, Carrier Acquisition using Squaring Loop and Costas Loop, Receiver Model, SNR, Noise in SSB and DSB receivers using coherent detection, Noise in AM Receiver using Envelope detection, Threshold Effect.

Angle (Exponential) Modulation: Types of Angle Modulation, Relation between FM and PM, Narrow Band FM, Wideband FM, Transmission Bandwidth of FM Signals, Generation of FM using Direct and Indirect methods, FM Demodulation using Slope Circuit, Frequency Discriminator, Interference in Angle Modulation, Noise in FM Receiver, FM Threshold Effect, Pre-emphasis and De-emphasis in FM, Model of PLL for FM Demodulation.

Pulse Modulation: Sampling Process, PAM, PWM, PPM, Quantization, PCM, TDM, Digital Multiplexer Hierarchy, DM, DSM, Linear Prediction, DPCM, ADPCM, Noise in PCM System, Companding, Comparison of the Noise Performance of AM,FM,PCM and DM.

Information Theory: Uncertainty, Information, Entropy, Source Coding Theorem, Data Compaction, Mutual information, Channel Capacity, BSC Channel, Information Capacity Theorem, Bandwidth - Power Tradeoff, Huffman Coding.

Reading:

1. S. Haykin, Communication Systems, 4^{th} Edn, John Wiley & Sons, Singapore, 2001.
2. B.P. Lathi, Modern Digital & Analog Communication Systems, 3^{rd}Edn, Oxford University Press, Chennai, 1998.
3. Leon W. Couch II., Digital and Analog Communication Systems, 6^{th}Edn, Pearson Education inc., New Delhi, 2001.
4. A Bruce Carlson, PB Crilly, JC Rutledge, Communication Systems, 4^{th}Edn, MGH, New York, 2002.

EC391	MICROPROCESSOR SYSTEMS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Develop basic understanding of microprocessor architecture.
CO2	Design Microprocessor and Microcontroller based systems.
CO3	Understand C, C++ and assembly language programming
CO4	Understand concept of interfacing of peripheral devices and their applications

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	-	-	-	3	-	-	-
CO2	-	-	-	-	-	-	-	-	3	-	-	-
CO3	-	-	-	-	-	-	-	-	3	-	-	-
CO4	-	-	-	-	-	-	-	-	3	-	-	-

Detailed syllabus

Microcomputer Organization: CPU, Memory, I/O, Operating System, Multiprogramming, Multithreading, MS Windows

80386 Micro Processors : Review of 8086,salient features of 80386, Architecture and Signal Description of 80386, Register Organization of 80386, Addressing Modes, 80386 Memory management, Protected mode, Segmentation, Paging, Virtual 8086 Mode, Enhanced Instruction set of 80386, the Co- Processor 80387

Pentium & Pentium-pro Microprocessor: Salient features of Pentium microprocessor, Pentium architecture, Special Pentium registers, Instruction Translation look aside buffer and branch Prediction, Rapid Execution module, Memory management, hyper-threading technology, Extended Instruction set in advanced Pentium Processors

Microcontrollers: Overview of micro controllers-8051 family microcontrollers, 80196 microcontrollers family architecture, instruction set, pin out, memory interfacing.

ARM Processor Fundamentals: Registers, current Program Status Registers, Pipeline Exceptions, Interrupts and Vector Table, Architecture Revisions, ARM Processor families, ARM instruction set, Thumb Instruction set-Exceptions Handing, Interrupts, Interrupt Handling schemes, firmware, Embedded operating systems, Caches-cache architecture, Cache policy, Introduction to DSP on the ARM, DSP on the ARM7TDMI,ARM9TDMI.

Case study-Industry Application of Microcontrollers

Reading:

1. Barry B. Brey: Intel Microprocessor Architecture, Programming and Interfacing-8086/8088, 80186, 80286, 80386 and 80486, PHI,1995.
2. Muhammad Ali Mazidi and Mazidi:The 8051 Microcontrollers and Embedded systems, PHI, 2008
3. Intel and ARM Data Books on Microcontrollers.

MM390	METALLURGY FOR NON-METALLURGISTS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand the characteristics and usefulness of metals and alloys.
CO2	Differentiate metals and alloys and their fabrication techniques.
CO3	Correlate the microstructure, properties, processing and performance of materials.
CO4	Select metal/alloy for engineering applications.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	3	2	-	-	-	-	3	-	-	-
CO2	-	-	3	2	-	-	-	-	3	-	-	-
CO3	-	-	3	2	-	-	-	-	3	-	-	-
CO4	-	-	3	2	-	-	-	-	3	-	-	-

Detailed Syllabus:

Introduction to Metallurgy:

Structure of Metals and Alloys: Nature of Metallic Bonding, Crystal Structures of Metals, Structure of Alloys, Imperfections in Crystals

Mechanical Properties: Plastic Deformation Mechanisms, Tensile, Creep, Fatigue, Fracture

Strengthening Mechanisms: Strain Hardening, Grain Size Refinement, Solid Solution Strengthening, Precipitation Hardening

Discovering Metals: Overview of Metals, Modern Alloy Production

Fabrication and Finishing of metal products: Metal Working and Machining

Testing of Metals: Both Destructive and Non-Destructive, Inspection and Quality Control of Metals

Engineering Alloys: Steel Products and Properties, Cast Irons, Tool Steels and High Speed Steels, Stainless Steels, Nonferrous Metals

Heat Treatment: Annealing, Normalizing, Hardening, Tempering

Corrosion and its Prevention: Electro chemical considerations, Corrosion Rates, Passivity, Environmental Effects, Forms of Corrosion, Corrosion Environments, Oxidation; Durability of Metals and Alloys

The material selection processes: Case studies

Reading:

1. M. F. Ashby: Engineering Metals, 4th Edition, Elsevier, 2005.
2. R. Balasubramaniam (Adapted): Calister's Materials Science and Engineering, 7th Edition, Wiley India (P) Ltd, 2007.
3. Reza Abbaschian, Lara Abbaschian, R E Reed-Hill: Physical Metallurgy Principles, Affiliated East-West Press, 2009.
4. V Raghavan: Elements of Materials Science and Engineering- A First Course, 5th Edition, PHI, 2006

CH390	NANOTECHNOLOGY AND APPLICATIONS	OPC	3 – 0 – 0	3 Credits

(Not offered to Chemical Engineering Students)

Prerequisites: None

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

CO1	Understand the properties of Nano-materials and applications
CO2	Apply chemical engineering principles to Nano-particle production
CO3	Solve the quantum confinement equations.
CO4	Characterize Nano-materials.
CO5	Scale up the production Nanoparticles for Electronics and Chemical industries.

Detailed Syllabus:

Introduction to Nanotechnology: Introduction to nanotechnology and materials, Nanomaterials, Introduction to nano-sizes and properties comparison with the bulk materials, Different shapes and sizes and morphology.

Fabrication of Nanomaterials: Top Down Approach Grinding, Planetory milling and Comparison of particles, Bottom Up Approach, Wet Chemical Synthesis Methods, Microemulsion Approach, Colloidal Nanoparticles Production, Sol Gel Methods, Sonochemical Approach, Microwave and Atomization, Gas phase Production Methods : Chemical Vapour Depositions.

Kinetics at Nanoscale: Nucleation and growth of particles, Issues of Aggregation of Particles, Oswald Ripening, Stearic hindrance, Layers of surface charges, Zeta Potential and pH.

Carbon Nanomaterials: Synthesis of carbon bucky-balls, List of stable carbon allotropes extended, fullerenes, metallofullerenes, solid C_{60}, bucky onions, nanotubes, nanocones

Quantum mechanics: Quantum dots and its Importance, Pauli exclusion principle, Schrödinger's equation, Application of quantum Dots: quantum well, wire, dot, characteristics of quantum dots, Synthesis of quantum dots Semi-conductor quantum dots

Nanomaterials characterization: Fractionation principles of Particle size measurements, Particle size and its distribution, XRD, Zeta potential, Electronic band structure Electron statistics Application: Optical transitions in solids, photonic crystals, Microscopies SEM, TEM, Atomic Forced Microscopy, Scanning and Tunneling Microscopy.

Applications: Self-assembly and molecular manufacturing, Surfactant based system Colloidal system applications, Functional materials Applications, commercial processes of synthesis of nanomaterials.

Nano inroganic materials of $CaCO_3$ synthesis, Hybrid Waste Water Treatments systems, Electronic Nanodevices,

Nanobiology: Biological synthesis of nanoparticles and applications in drug delivery, Nanocontainers and Responsive Release of active agents, Layer by Layer assembly for nanospheres, Safety and health Issues of nano materials, Environmental Impacts, Case Study for Environmental and Societal Impacts

Reading:

1. KulkarniSulabha K, Nanotechnology: Principles and Practices, Capital Publishing Company, 2007
2. Stuart M. Lindsay, Introduction to Nanoscience, Oxford University Press, 2009.
3. Robert Kelsall, Ian Hamley, Mark Geoghegan, Nanoscale Science and Technology, John Wiley & Sons, 2005.
4. Gabor L. Hornyak , H.F. Tibbals , JoydeepDutta , John J. Moore Introduction to Nanoscience and Nanotechnology, CRC Press, 2008.
5. Davies, J.H. 'The Physics of Low Dimensional Semiconductors: An Introduction', Cambridge University Press, 1998.

CH391	INDUSTRIAL SAFETY AND HAZARDS	OPC	3 – 0 – 0	3 Credits

(Not offered to Chemical Engineering Students)

Prerequisites: None.

Course Outcomes: At the end of the course the student will be able to:

CO1	Analyze the effects of release of toxic substances.
CO2	Select the methods of prevention of fires and explosions.
CO3	Understand the methods of hazard identification and preventive measures.
CO4	Assess the risks using fault tree diagram.

Detailed syllabus:

Introduction-Safety Programs, Engineering Ethics, Accident and Loss Statistics, Acceptable Risk, Public Perceptions, The Nature of the Accident Process, Inherent Safety.

Industrial Hygiene-Anticipation and Identification, Hygiene Evaluation, Hygiene Control.

Toxic Release and Dispersion Models-Parameters Affecting Dispersion, Neutrally Buoyant Dispersion Models, Dense Gas Dispersion, Toxic Effect Criteria, Effect of Release Momentum and Buoyancy, Release Mitigation.

Fires and Explosions-The Fire Triangle, Distinction between Fires and Explosions, Flammability Characteristics of Liquids and Vapors, Limiting Oxygen Concentration and Inerting, Flammability Diagram

Hazards Identification- Process Hazards Checklists, Hazards Surveys, Hazards and Operability Studies, Safety Reviews.

Risk Assessment- Review of Probability Theory, Event Trees, Fault Trees.

Safety Procedures: Process Safety Hierarchy, Managing Safety, Best Practices, Procedures-Operating, Procedures-Permits, Procedures-Safety Reviews and Accident Investigations.

Reading:

1. D. A. Crowl and J.F. Louvar, Chemical Process Safety (Fundamentals with Applications), Prentice Hall, 2011.
2. R.K. Sinnott, Coulson & Richardson's Chemical Engineering, Vol. 6, Elsevier India, 2006.

CS390	OBJECT ORIENTED PROGRAMMING	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand fundamental concepts in object oriented approach.
CO2	Analyze design issues in developing OOP applications.
CO3	Write computer programs to solve real world problems in Java.
CO4	Analyze source code API documentations.
CO5	Create GUI based applications.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	3	2	-	-	-	-	3	-	-	-
CO2	-	-	3	2	-	-	-	-	3	-	-	-
CO3	-	-	3	2	-	-	-	-	3	-	-	-
CO4	-	-	3	2	-	-	-	-	3	-	-	-
CO5	-	-	3	2	-	-	-	-	3	-	-	-

Detailed Syllabus:

Object- oriented thinking, History of object-oriented programming, overview of java, Object-oriented design, Structure of java program. Types and modifiers, Classes, declaring objects in classes, Methods, constructors, garbage collection, Method overloading, passing objects as parameters, Inheritance, various forms and types of inheritance, Multilevel hierarchy, use of super, method overriding, Applications of method overriding, abstract classes, Packages with examples

Interfaces and implementation, Exception handling, types, throwing, creating own exceptions, Multithreading and concepts, its usage and examples, Input/output streams, String operations and examples, Collection classes-array, stack collection, bitset collection, Utility classes-string tokenizer, bitset, date, Applets- methods, creation, designing and examples, Event handling-event classes, Event listener interfaces, AWT classes, working with frames, AWT controls-layout manager, user interface components, Graphics programming

Reading:

1. Timothy Budd, “Understanding object-oriented programming with Java”, Pearson,
2. Herbert Schildt, “ The complete reference Java 2”, TMH,

BT390	GREEN TECHNOLOGY	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Address smart energy and green infrastructure
CO2	Build models that simulate sustainable and renewable green technology systems
CO3	Understand the history, global, environmental and economical impacts of green technology
CO4	Address non-renewable energy challenges

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	2	-	-	-	3	-	-	-	-	2
CO2	-	-	2	-	-	-	3	-	-	-	-	2
CO3	-	-	2	-	-	-	3	-	-	-	-	2
CO4	-	-	2	-	-	-	3	-	-	-	-	2

Detailed Syllabus:

Biomass Energy, basic concepts, sources of biomass energy, uses of biomass energy, science and engineering aspects of biomass energy, production of biomass electricity, transmission of biomass electricity, storage of biomass electricity.

Energy transformation from source to services; Energy sources, sun as the source of energy; biological processes; photosynthesis; food chains, classification of energy sources, quality and concentration of energy sources; fossil fuel reserves - estimates, duration; theory of renewability, renewable resources; overview of global/ India's energy scenario.

Environmental effects of energy extraction, conversion and use; sources of pollution from energy technologies, Criteria for choosing appropriate green energy technologies, life cycle cost; the emerging trends-process/product innovation-, technological/ environmental leap-frogging; Eco/green technologies for addressing the problems of Water, Energy, Health, Agriculture and Biodiversity.

First and second laws of thermodynamics and their applications – Thermodynamic processes - Irreversibility of energy – Entropy. Properties of steam and classification of steam engines. Carnot cycle - Rankine cycle, Current energy requirements, growth in future energy requirements, Review of conventional energy resources- Coal, gas and oil reserves and resources, Tar sands and Oil, Shale, Nuclear energy Option.

Biomass fuels, market barriers of biomass fuels, biomass fuel standardization, biomass fuel life cycle, Sustainability of biomass fuels, economics of biomass fuels, Fuel stoichiometry and analysis: Fuel stoichiometry relations; Estimation of air required for complete combustion; Estimation of minimum amount of air required for a fuel of known composition; Estimation of dry flue gases for known fuel composition; Calculation of the composition of fuel & excess air supplied, from exhaust gas analysis; Dew point of products; Flue gas analysis (O_2, CO_2, CO, NOx, SOx).

Biomass as a major source of energy in India: Fuel-wood use in rural households. Consequences for ecosystems. Future energy scenario in rural areas. Utilization of biomass in industrial and semi-industrial settings. Future utilization of biomass in India. Future of landscape management: optimal management.

Reading:

1. Ayhan Demirbas, Green Energy and Technology, Biofuels, Securing the Planet’s Future Energy Needs, 1st Edition, Springer, 2009.
2. Jay Cheng, Biomass to Renewable Energy Processes, 1st Edition, CRC press, 2009.
3. Samir K. Khanal, Rao Y. Surampally, 1st edition, American Society of Civil Engineers, 2010.

SM390	MARKETING MANAGEMENT	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand concepts and scope of marketing and market oriented strategic planning
CO2	Analyze macro level environment
CO3	Identify factors influencing consumer behavior in competitive global business environment
CO4	Identify tools and techniques for marketing management through integrated marketing communication systems.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	-	-	3	3	-	-	-
CO2	-	-	-	-	-	-	-	3	3	-	-	-
CO3	-	-	-	-	-	-	-	3	3	-	-	-
CO4	-	-	-	-	-	-	-	3	3	-	-	-

Detailed Syllabus:

Importance of Marketing, Scope of Marketing, Core Marketing concepts company orientation towards market place-production concept, Product concept, selling concept and Marketing concept.

Market oriented Strategic planning – Defining corporate Mission and Vision Statement at Corporate level and at Business unit level. Assigning resources to Strategic Business units through B.C.G Matrix and G.E Model.

Analyzing Macro environment-Demographic environment. Economic Environment, Technical Environment, Social-Cultural Environment and political – Legal Environment.

Components of Marketing information systems- Internal Records, Marketing intelligence, Marketing research and Marketing Decision support system.

Consumer Behavior- Buying Decision process and the factors influencing consumer Behavior-Psychological factors, social factors, cultural factors and personal factors.

Importance of Market segmentation, Target market selection and positioning.

Importance of new product development process and the various stages involved.

The concept of product lifecycle and the various strategies used by the marketer in each stage.

Product characteristics and classification, Product mix and product line decisions Branding Decisions, Building Brand Equity.

Importance of Pricing, Factors influencing pricing decisions. Various pricing methods-cost based and demand based methods.

Role of Marketing channels-Channel functions and channel levels channel Design and channel Management Decisions, Managing Retailing. Wholesaling and logistics. Importance of Electronic channels.

Importance of integrated Marketing communication. Advantages and Disadvantages of Various promotional tools- Advertising, Sales promotion, personal selling, publicity and public Relations and Direct marketing.

Reading:

1. Philip Kotler, Marketing Management, PHI, 14th Edition, 2013.
2. William Stonton & Etzel, Marketing Management, TMH, 13thEdition, 2013.
3. Rama Swamy & Namakumari, Marketing Management, McMillan, 2013.

MA390	NUMERICAL SOLUTION OF DIFFERENTIAL EQUATIONS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Solve nonlinear differential equations by numerical methods.
CO2	Determine the convergence region for a finite difference method.
CO3	Solve elliptic PDE by finite difference method
CO4	Solve a parabolic PDE by finite difference method
CO5	Solve a hyperbolic PDE by finite difference method

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	-	-	3	-	-	3	-	-	-
CO2	3	-	-	-	-	3	-	-	3	-	-	-
CO3	3	-	-	-	-	3	-	-	3	-	-	-
CO4	3	-	-	-	-	3	-	-	3	-	-	-
CO5	3	-	-	-	-	3	-	-	3	-	-	-

Detailed Syllabus:

Ordinary Differential Equations: Multistep (explicit and implicit) methods for initial value problems, Stability and Convergence analysis, Linear and nonlinear boundary value problems, Quasi-linearization, Shooting methods

Finite difference methods: Finite difference approximations for derivatives, boundary value problems with explicit boundary conditions, implicit boundary conditions, error analysis, stability analysis, convergence analysis.

Partial Differential Equations: Classification of partial differential equations, finite difference approximations for partial derivatives and finite difference schemes for Parabolic equations, Schmidt's two level, multilevel explicit methods, Crank-Nicolson's two level, multilevel implicit methods, Dirichlet's problem, Neumann problem, mixed boundary value problem, stability analysis.

Hyperbolic Equations: Explicit methods, implicit methods, one space dimension, two space dimensions, ADI methods.

Elliptic equations: Laplace equation, Poisson equation, iterative schemes, Dirichlet's problem, Neumann problem, mixed boundary value problem, ADI methods.

Reading:

1. M.K. Jain, Numerical Solution of Differential Equations, Wiley Eastern, 1984.
2. G.D. Smith, Numerical Solution of Partial Differential Equations, Oxford Univ. Press, 2004.
3. M.K. Jain, S.R.K. Iyengar and R.K. Jain, Computational Methods for Partial Differential Equations, Wiley Eastern, 2005.

MA391	**FUZZY MATHEMATICS AND APPLICATIONS**	**OPC**	**3 – 0 – 0**	**3 Credits**

Pre-requisites: None

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

CO1	Apply operations on Fuzzy sets
CO2	Solve problems related to Propositional Logic.
CO3	Apply Fuzzy relations to cylindric extensions.
CO4	Apply logic of Boolean Algebra to switching circuits.
CO5	Develop Fuzzy logic controllers

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	-	-	-	-	3	-	-	3	-	-	-
CO2	2	-	-	-	-	3	-	-	3	-	-	-
CO3	2	-	-	-	-	3	-	-	3	-	-	-
CO4	2	-	-	-	-	3	-	-	3	-	-	-
CO5	2	-	-	-	-	3	-	-	3	-	-	-

Detailed Syllabus:

Crisp set theory (CST): Introduction, Relations between sets, Operations on sets, Characteristic functions, Cartesian products of crisp sets, crisp relations on sets.

Fuzzy set theory (FST): Introduction, concept of fuzzy set (FS), Relation between FS, operations on FS, properties of standard operations, certain numbers associated with a FS, certain crisp sets associated with FS, Certain FS associated with given FS, Extension principle.

Propositional Logic (PL1): Introduction, Syntax of PL1, Semantics of PL1, certain properties satisfied by connectives, inference rules, Derivation, Resolution.

Predicate Logic (PL2): Introduction, Syntax of PL2, Semantics of PL2, certain properties satisfied by connectives and quantifiers, inference rules, Derivation, Resolution

Fuzzy Relations (FR): Introduction, Operations on FR, α-cuts of FR, Composition of FR, Projections of FR, Cylindric extensions, Cylindric closure, FR on a domain.

Fuzzy Logic (FL): Introduction, Three-valued logics, N-valued logics and infinite valued logics, Fuzzy logics, Fuzzy propositions and their interpretations in terms of fuzzy sets, Fuzzy rules and their interpretations in terms of FR, fuzzy inference, More on fuzzy inference, Generalizations of FL.

Switching functions (SF) and Switching circuits (SC): Introduction, SF, Disjunctive normal form, SC, Relation between SF and SC, Equivalence and simplification of circuits, Introduction of Boolean Algebra BA, Identification, Complete Disjunctive normal form.

Applications: Introduction to fuzzy logic controller (FLC), Fuzzy expert systems, classical control theory versus fuzzy control, examples, working of FLC through examples, Details of FLC, Mathematical formulation of FLC, Introduction of fuzzy methods in decision making.

Reading:

1. M. Ganesh, Introduction to Fuzzy Sets and Fuzzy Logic, PHI, 2001.
2. G.J. Klir and B.Yuan, Fuzzy sets and Fuzzy Logic–Theory and Applications, PHI, 1997.
3. T. J. Ross, Fuzzy Logic with Engineering Applications, McGraw-Hill, 1995.

PH390	MEDICAL INSTRUMENTATION	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand the origin of bio-potentials and their physical significance.
CO2	Understand anatomy and functioning of human heart and its common problems.
CO3	Analyze ECG, ENG and EMG signals and instrumentation.
CO4	Compare different techniques of measuring blood pressure, blood flow and volume.
CO5	Interpret the principle and operation of therapeutic and prosthetic devices.
CO6	Differentiate between the various techniques for measurement of parameters.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	-	3	-	3	-	-	-
CO2	-	-	-	-	-	-	3	-	3	-	-	-
CO3	-	-	-	-	-	-	3	-	3	-	-	-
CO4	-	-	-	-	-	-	3	-	3	-	-	-
CO5	-	-	-	-	-	-	3	-	3	-	-	-
CO6	-	-	-	-	-	-	3	-	3	-	-	-

Detailed Syllabus:

General Introduction: The cell, body fluids, Musculoskeletal system, respiratory system, gastrointestinal system, Nervous system, endocrine system and circulatory system.

Origin of Bio potentials: electrical activity of Excitable cells: the resting state, The active state, Volume conductor fields, Functional organization of the peripheral nervous system: Reflex are & Junctional transmission.

The Electroneurogram (ENG): The H-Reflex, The Electromyogram (EMG), The Electrocardiogram (ECG), heart and the circulatory system, Electro conduction system of the heart and heart problems, ECG waveform and Physical significance of its wave features, Electrical behavior of cardiac cells, The standard lead system, The ECG preamplifier, DC ECG Amplier, Defibrillator protection circuit, Electro surgery Unit filtering, Functional blocks of ECG system, Multichannel physiological monitoring system, Common problems encountered and remedial techniques.

Blood Pressure: indirect measurement of blood pressure, korotkoff sounds, auscultatory method using sphygmo manometer, Oscillometric and ultrasonic non invasive pressure measurement, Direct measurement of blood pressure H2O manometers, electronic manometry, Pressure transducers,. Pressure amplifier designs, Systolic, diastolic mean detector circuits

Blood flow and Volume Measurement: indicator dilution methods, Transit time flow meter, DC flow meter, Electromagnetic flow meter AC electromagnetic flow meter, Quadrature suppression flow meter, Ultrasonic flow meter, Continuous-wave Doppler flow meter, Electric impedance plethysmography, chamber plethysmography, Photo plethysmography.

Pulse Oximetr: Principles of Operation, Absorption Spectrum, Sensor design, Pulse oximeter, Therapeutic and Prosthetic Devices.

Cardiac Pacemakers: Lead wires and electrodes, Synchronous Pacemakers, rate responsive pacemaking, Defibrillators, cardioverters, Electrosurgical unit, Therapeutic applications of laser, Lithotripsy Haemodialysis.

Reading:

1. John G Webster, Medical Instrumentation: Application and Design , John Wiley,3rd Ed. 2012.
2. Joseph J. Carr & John M. Brown , Introduction to biomedical Equipment Technology, 4th Ed., Prentice Hall India, 2001

PH391	ADVANCED MATERIALS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand the synthesis and properties of nanomaterials
CO2	Evaluate the usefulness of nanomaterials in medicine, biology and sensing
CO3	Understand modeling of composite materials by finite element analysis
CO4	Differentiate superconducting materials
CO5	Understand the characteristics and uses of functional materials

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	2	-	3	-	-	2	-	3	-	-	-
CO2	-	2	-	3	-	-	2	-	3	-	-	-
CO3	-	2	-	3	-	-	2	-	3	-	-	-
CO4	-	2	-	3	-	-	2	-	3	-	-	-
CO5	-	2	-	3	-	-	2	-	3	-	-	-

Detailed Syllabus:

Nano Materials: Origin of nano technology, Classification of nano materials, Physical, chemical, electrical, mechanical properties of nano materials. Preparation of nano materials by plasma arcing, physical vapour deposition, chemical vapour deposition (CVD), Sol-Gel, electro deposition, ball milling, carbon nano tubes (CNT). Synthesis, preparation of nanotubes, nano sensors, Quantum dots, nano wires, nano biology, nano medicines.

Biomaterials: Overview of biomaterials. Biomaterials, bioceramics, biopolymers, tissue grafts, soft tissue applications, cardiovascular implants, biomaterials in ophthalmology, orthopedicim plants, dental materials.

Composites: General characteristics of composites, composites classes, PMCs, MMCs, CMCs, CCCs, IMCs, hybrid composites, fibers and matrices, different types of fibers, whiskers, different matrices materials, polymers, metal, ceramic matrices, toughening mechanism, interfaces, blending and adhesion, composite modeling, finite element analysis and design.

Optical materials: Mechanisms of optical absorption in metals, semiconductors and insulators. Nonlinear optical materials, optical modulators, optical fibers. Display devices and materials photo-emissive, photovoltaic cells, charge coupled devices (CCD), laser materials.

Super conducting materials: Types of super conductors, an account of mechanism of superconductors, effects of magnetic field currents, thermal energy, energy gap, acoustic attenuation, penetration depth, BCS theory, DC and AC Josephson effects, high Tc superconductors, potential applications of superconductivity, electrical switching element, superconductor power transmission and transformers, magnetic mirror, bearings, superconductor motors, generators, SQUIDS etc.

Smart materials: An introduction, principles of smart materials, input – output decision ability, devices based on conductivity changes, devices based on changes in optical response, biological systems smart materials. Devices based on magnetization, artificial structures, surfaces, hetero structures, polycrystalline, amorphous, liquid crystalline materials.

Surface Acoustic Wave (SAW) Materials and Electrets: Delay lines, frequency filters, resonators, Pressure and temperature sensors, Sonar transducers. Comparison of electrets with permanent magnets, Preparation of electrets, Application of electrets..

Reading:

1. T. Pradeep, Nano: The Essentials; TATA McGraw-Hill, 2008.
2. B.S. Murthy et al., Textbook of Nano science and Nanotechnology, University press
3. Krishan K Chawla, Composite Materials; 2nd Ed., Springer 2006.

CY390	INSTRUMENTAL METHODS IN CHEMICAL ANALYSIS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Characterize materials using ultraviolet and visible absorption and fluorescence techniques
CO2	Analyze materials, minerals and trace samples using atomic absorption, emission and X-ray fluorescence techniques
CO3	Analyze environmental, industrial, production-line materials by liquid, gas and size-exclusion chromatographic techniques.
CO4	Characterize interfaces and traces of surface adsorbed materials using electro-analytical techniques
CO5	Understand principles of thermogravimetry and differential thermal analyses.
CO6	Characterize chemical, inorganic and engineering materials using analytical techniques

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	1	-	-	-	-	-	3	-	-	-
CO2	-	-	1	-	-	-	-	-	3	-	-	-
CO3	-	-	1	-	-	-	-	-	3	-	-	-
CO4	-	-	1	-	-	-	-	-	3	-	-	-
CO5	-	-	1	-	-	-	-	-	3	-	-	-
CO6	-	-	1	-	-	-	-	-	3	-	-	-

Detailed Syllabus:

UV-Visible Spectrophotometry and Fluorescence Beer-Lambert's law, limitations, Molecular fluorescence, influencing factors, basic instruments, standardization, quantitative methods, applications.

Atomic spectrometry, atomic absorption, X-ray fluorescence methods Flame atomic emission and absorption, flame emission photometer, flame absorption spectrometer, spectral interferences, quantitative aspects, X-ray fluorescence principle, Instrumentation, quantitative analysis.

Separation techniques Solvent extraction, Principle, Extraction of solutes, Soxhlet extraction

Chromatography methods Gas chromatography, High performance liquid chromatography, Size exclusion chromatography, Principle, Basic instrumentation, Capillary Electrophoresis: Principle and application.

Thermoanalytical methods Thermogravimetry, Differential thermal analysis, differential scanning calorimetry, Principle, Block diagram, Applications, Quantitative determinations.

Electroanalytical methods Coulometric methods, Polarography, Pulse voltammetric methods, Amperometry, Principles, Applications, Electrochemical sensors, Ion selective, Potentiometric and amperometric sensors, Applications.

Spectroscopic methods Molecular absorption, Woodward rules, applications, Infra red absorption, functional group analysis, qualitative analysis, 1H- and 13C-NMR spectroscopy, Principle, Basic instrumentation, terminology, Interpretation of data, Quantitative applications.

Mass spectrometry Principles, Instrumentation, Ionization techniques, Characterization and applications.

Reading:

1. Mendham, Denny, Barnesand Thomas, Vogel: Text book of Quantitative Chemical Analysis, Pearson Education, 6th Edition, 2007.
2. Skoog, Holler and Kouch, Thomson, Instrumental methods of chemical analysis, 2007.
3. Willard, Meritt and Dean, Instrumental methods of chemical analysis, PHI, 2005.

CY391	CHEMICAL ASPECTS OF ENERGY SYSTEMS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course the student will be able to:

CO1	Understand traditional and alternative forms of energy
CO2	Understand energy production, storage, distribution and utilization.
CO3	Model environmental impacts of energy generation and conservation
CO4	Apply concepts of engineering design to energy challenges

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	-	3	-	3	-	-	-
CO2	-	-	-	-	-	-	3	-	3	-	-	-
CO3	-	-	-	-	-	-	3	-	3	-	-	-
CO4	-	-	-	-	-	-	3	-	3	-	-	-

Detailed Syllabus:

Thermochemistry and Chemical Kinetics of Energy Sources: Chemistry of Fuels and Characteristics of a Good Fuel; Heats of Combustion of Fuels; Determination of Heats of Combustion by Bomb Calorimetry and Differential Scanning Calorimetry; Thermodynamics of Electrochemical Cells; Determination of Various Thermochemical Functions of Energy Materials by Electroanalytical Methods (Potentiometry, Coulometry and Voltammetry)

Rates of Combustion Processes; Determination of Ignition Point, Flash Point and Other Kinetic Parameters of Chemical Energy Sources

Chemistry of Conventional and Non-Conventional Energy Materials: Chemical Composition of Finite Energy materials (Petroleum Products, Petroleum Refinery, Fractional Distillation and Petroleum Cracking; Natural Gas, Water Gas, Biomass and Goober Gas; Hydrogen as a Fuel and Its Controlled Combustion; Coal Carbonization and Gasification; Pulverization of Cellulose and Firewood

Electrochemical Energy Systems: Primary and Secondary batteries, Reserve batteries, Solid state and molten solvent batteries, Recent technological trends, Lithium ion batteries, Nanostructured electrode materials, Lithium and carbon based nanomaterials and nanocomposites, Solid-state Lithium ion batteries, Energy storage and backup. Fuel cells, Scientific prospects of fuel cells, Electrochemistry, In-situ and ex-situ electrochemical characterizations, Current-Voltage measurement, Current Interrupt measurements, Porosity, BET surface area analysis, Gas permeability, Hydrogen as future fuel, Alkaline-, acid- and molten carbonate-fuel cells, Solid oxide fuel cells.

Solar Energy Harnessing: Fundamentals, Conversion into electrical energy, Photovoltaic and Photogalvanic energy storage, Semiconductor photoelectrochemical cells, Photoelectrochemical reactions, Regenerative photoelectrochemical cells, Basic problems, Photocorrosion and protection of semiconductor electrodes, Protective coatings, Coatings of metals and electrically conductive polymers, Electrodes with chemically modified surfaces.

Photochemical and Photoelectrochemical Cleavage of Water: Photochemistry and Photocatalysis of Splitting of Water Molecule; Chemically Modified Electrodes for Water Cleavage; Coordination Chemistry of Water Cleavage

Environmental Concerns and Green Methods of Energy Sources: Quality of Chemical Energy Sources; Pollution Control and Monitoring of Energy Extraction from Materials; Nanochemical Methods in Energy Extraction; Modeling of Combustion and Other Energy Tapping from Materials

Reading:

1. Energy systems Engineering – Evaluation and Implementation, Francis Vanek, Louis Albright, LargusArgenent, McGraw-Hill, 2012.
2. Energy Systems and Sustainability: Power for a Sustainable Future, Bob Everett, Godfrey Boyle, Stephen Peake and Janet Ramage, Oxford Uni Press, 2012.
3. Lithium ion batteries – Advances and applications, Gianfranco Pistoria, Elsevier, 2014.
4. Tomorrow’s Energy: Hydrogen, Fuel cells, and the prospects for a cleaner planet, Peter Hoffmann, Byron Dorgan, MIT Press, 2012.
5. solar energy conversion Yuri V Pleskov, Springer-Verlag, 1990.
6. Solar energy conversion – Dynamics of interfacidal electron and excitation transfer, Piotrowiak, Laurie Peter, Heinz Frei and Tim Zhao, RSC, 2013.

HS390	SOFT SKILLS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand corporate communication culture
CO2	Prepare business reports and proposals expected of a corporate professional
CO3	Employ appropriate speech in formal business situations
CO4	Exhibit corporate social responsibility and ethics
CO5	Acquire corporate email, mobile and telephone etiquette

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	-	-	-	3	-	3	-
CO2	-	-	-	-	-	-	-	-	3	-	3	-
CO3	-	-	-	-	-	-	-	-	3	-	3	-
CO4	-	-	-	-	-	-	-	-	3	-	3	-
CO5	-	-	-	-	-	-	-	-	3	-	3	-

Detailed Syllabus:

English Language Enhancement: Verbs and tenses, Phrasal verbs, Synonyms, Antonyms, Homonyms - Descriptive Words, Combining Sentences, Business Idioms, Indianisms in English.

Art of Communication, Communication process- Non-verbal Communication- Effective Listening.

Interpersonal and Intra Personal Communication Skills- Self-Awareness- Self-Esteem and Confidence- Assertiveness and Confidence- Dealing with Emotions-Team Concept- Elements of Teamwork- Stages of Team Formation- Effective Team-Team Player Styles-Leadership.

Campus to Company- Dressing and Grooming- The Corporate Fit- Business Etiquette- Communication; media etiquette- Group Discussions, Interviews, and Presentation Skills.

Interview Handling skills- Effective Resume-- Common Interview Mistakes- Body-language- Content Aid, Visual Aids- Entrepreneurial Skills Development.

Reading:

1. Robert M.Sherfield, Developing Soft Skills, Montgomery and Moody 4th Ed. Pearson, 2009.
2. K. Alex, Soft Skills: Know Yourself & Know The world, S. Chand; 2009.
3. Robert Bramson, Coping with Difficult People, Dell, 2009

CE440	BUILDING TECHNOLOGY	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course the student will be able to:

CO1	Apply basic principles to develop stable, sustainable and cost-effective building plans.
CO2	Identify effective measures for fire proofing, damp proofing, and thermal insulation.
CO3	Adopt standard building provisions for natural ventilation and lighting.
CO4	Identify different materials, quality and methods of fabrication &construction.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	-	-	-	3	-	-	-
CO2	-	-	-	-	-	-	-	-	3	-	-	-
CO3	-	-	-	-	-	-	-	-	3	-	-	-
CO4	-	-	-	-	-	-	-	-	3	-	-	-

Detailed Syllabus:

Overview of the course, basic definitions, Buildings – Types, components, economy and design, Principles of planning of buildings and their importance.

Definitions and importance of Grouping and circulation; Lighting and ventilation; How to consider these aspects during planning of building

Termite proofing: Inspection, control measures and precautions, Lighting protection of buildings: General principles of design of openings, Various types of fire protection measures to be considered while planning a building.

General requirements and extra requirements for safety against fire, special precautions, Vertical transportation in building – types of vertical transportation, Stairs, different forms of stairs, planning of stair cases, Other modes of vertical transportation – lifts, ramps, escalators.

Prefabrication systems in residential buildings – walls, openings, cupboards, shelves etc., planning and modules and sizes of components in prefabrication.

Planning and designing of residential buildings against the earthquake forces, Principles, Seismic forces and their effect on buildings.

Air conditioning – process and classification of air conditioning, Dehumidification. Systems of air-conditioning, ventilation, functional requirements of ventilation.

Acoustics, effect of noise, properties of noise and its measurements, Principles of acoustics of building. Sound insulation – importance and measures.

Plumbing services – water supply system, maintenance of building pipe line, Sanitary fittings, principles governing design of building drainage.

Reading:

1. Building Construction - Varghese, PHI Learning Private Limited, 2008
2. Building Construction - Punmia, B C, Jain, A J and Jain A J, Laxmi Publications, 2005.
3. Building Construction by S.P. Arora and S.P. Bindra – Dhanpatrai and Sons, New Delhi, 1996.
4. Building Construction – Technical Teachers Training Institute, Madras, Tata McGraw Hill, 1992.
5. National Building code of India, Bureau of Indian Standards, 2005.

EE440	NEW VENTURE CREATION	OPC	3–0– 0	3 Credits

Pre-requisites: None

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

CO1	Understand the process and practice of entrepreneurship and new venture creation
CO2	Understand conceptual frameworks for identifying entrepreneurial opportunities and for preparation of business plan
CO3	Explore opportunities for launching a new venture
CO4	Identify functional management issues of running a new venture

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	-	-	-	3	3	3	-
CO2	-	-	-	-	-	-	-	-	3	3	3	-
CO3	-	-	-	-	3	-	2	-	-	3	-	-
CO4	-	-	-	-	-	-	-	-	3	3	3	-

Detailed syllabus:

Entrepreneur and Entrepreneurship: Entrepreneurship and Small Scale Enterprises (SSE) – Role in Economic Development, Entrepreneurial Competencies, Institution Interface for SSE.

Establishing the Small Scale Enterprise: Opportunity Scanning and Identification, Market Assessment for SSE, Choice of Technology and Selection of Site, Financing the New/Small Enterprises, Preparation of the Business Plan, Ownership Structures and Organizational Framework.

Operating the Small Scale Enterprises: Financial Management Issues in SSE, Operational Management Issues in SSE, Marketing Management Issues in SSE, Organizational Relations in SSE.

Reading:

1. Kuratko: New Venture Management: The Entrepreneur's Roadmap, Pearson Education India, 2008.
2. Holt, "Entrepreneurship: New Venture Creation", PHI(P), Ltd., 2001.
3. Lisa K. Gundry, Jill R. Kickul: Entrepreneurship Strategy: Changing Patterns in New Venture Creation, Growth, and Reinvention, Sage Publications, 2007.

ME440	ALTERNATIVE SOURCES OF ENERGY	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Identify renewable energy sources and their utilization.
CO2	Understand basic concepts of solar radiation and analyze solar thermal systems for its utilization.
CO3	Understand working of solar cells and its modern manufacturing technologies.
CO4	Understand concepts of Fuel cells and their applications
CO5	Identify methods of energy storage.
CO6	Compare energy utilization from wind energy, geothermal energy, biomass, biogas and hydrogen.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	1	1	-	-	-	3	-	3	-	-	-
CO2	-	1	1	-	-	-	3	-	3	-	-	-
CO3	-	1	1	-	-	-	3	-	3	-	-	-
CO4	-	1	1	-	-	-	3	-	3	-	-	-
CO5	-	1	1	-	-	-	3	-	3	-	-	-
CO6	-	1	1	-	-	-	3	-	3	-	-	-

Detailed Syllabus:

Introduction: Overview of the course; Examination and Evaluation patterns; Global warming; Introduction to Renewable Energy Technologies

Energy Storage: Introduction; Necessity of Energy Storage; Energy Storage Methods

Solar Energy: Fundamentals; Solar Radiation; Estimation of solar radiation on horizontal and inclined surfaces; Measurement of solar radiation data

Solar Thermal systems: Introduction; Basics of thermodynamics and heat transfer; Flat plate collector; Evacuated Tubular Collector; Solar air collector; Solar concentrator; Solar distillation; Solar cooker; Solar refrigeration and air conditioning; Thermal energy storage systems

Solar Photovoltaic systems: Introduction; Solar cell Fundamentals; Characteristics and classification; Solar cell: Module, panel and Array construction; Photovoltaic thermal systems.

Wind Energy: Introduction; Origin and nature of winds; Wind turbine siting; Basics of fluid mechanics; Wind turbine aerodynamics; wind turbine types and their construction; Wind energy conversion systems

Fuel cells: Overview; Classification of fuel cells; operating principles; Fuel cell thermodynamics

Biomass Energy: Introduction; Photosynthesis Process; Biofuels; Biomass Resources; Biomass conversion technologies; Urban waste to energy conversion; Biomass gasification.

Other forms of Energy: Introduction: Nuclear, ocean and geothermal energy applications; Origin and their types; Working principles

Reading:

1. Sukhatme S.P. and J.K. Nayak, Solar Energy - Principles of Thermal Collection and Storage, Tata McGraw Hill, New Delhi, 2008.
2. Khan B.H., Non-Conventional Energy Resources, Tata McGraw Hill, New Delhi, 2006.
3. J.A. Duffie and W.A. Beckman, Solar Energy - Thermal Processes, John Wiley, 2001.

EC440	ELECTRONIC MEASUREMENTS AND INSTRUMENTATION	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Apply knowledge of instruments for effective use
CO2	Select suitable instruments for typical measurements.
CO3	Identify various transducers to measure strain, temperature and displacement.
CO4	Understand data acquisition system and general purpose interfacing bus.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	-	-	-	3	-	-	-
CO2	-	-	-	-	-	-	-	-	3	-	-	-
CO3	-	-	-	-	-	-	-	-	3	-	-	-
CO4	-	-	-	-	-	-	-	-	3	-	-	-

Detailed syllabus

Measurement And Error: Sensitivity, Resolution, Accuracy and precision, Absolute and Relative types of errors, Statistical analysis, Probability of and Limiting errors, Linearity.

Instruments: D'Arsonval movement and basic principles of Measurement of Voltage, Current and Resistance in instruments. Analog and Digital Multimeters, Measurement of time and Frequency – Digital Frequency Meter and applications.

Impedance Measurement:Kelvin Bridge; Megger; Maxwell, Hay and Shering Bridges. Q-meter; Noise and Interference reduction techniques in Measurement Systems.

Oscilloscopes: Block diagram, probes, Deflection amplifier and delay line, Trigger Generator, Coupling, Automatic Time Base and Dual Trace Oscilloscopes, Pulse Measurements, Delayed Time Base, Analog Storage, Sampling and Digital Storage Oscilloscopes.

Special instruments: Wave Analyzer, Harmonic Distortion Analyzer, Spectrum Analyzer, FFT Analyzer.

Transducers (Qualitative Treatment Only): Classification and selection of Transducers, Introduction to strain, Load, force, Displacement, Velocity, Acceleration, Pressure and Temperature Measurements.

Introduction to Data Acquisition Systems (DAS): Block Diagram, Specifications and various components of DAS.

General purpose Instrumentation Bus (GP-IB): Protocol, SCPI Commands and Applications to DSO and DMM.

Reading:

1. Oliver and Cage, Electronic Measurements and Instrumentation, McGraw Hill, 2009
2. Helfrick Albert D. and Cooper William D., Electronic Instrumentation & Measurement Techniques, PHI, 2008.
3. D.A. Bell, Electronic Instrumentation and Measurements, 3/e, Oxford, 2013.

MM440	MATERIALS FOR ENGINEERING APPLICATIONS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Correlate processing, microstructure and properties of materials.
CO2	Understand behaviour of materials under various conditions.
CO3	Characterize modes of failure of engineering materials and design new materials with better properties and cost effective processes.
CO4	Identify suitable materials for engineering applications.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	1	-	-	1	-	3	-	3	-	-	-
CO2	-	1	-	-	1	-	3	-	3	-	-	-
CO3	-	1	-	-	1	-	3	-	3	-	-	-
CO4	-	1	-	-	1	-	3	-	3	-	-	-

Detailed Syllabus:

Materials Science and Engineering Materials, Classification of Materials and Properties: Mechanical, Dielectric, Magnetic and Thermal

Metallurgical Aspects of Materials: Structure of Metals and Alloys, Nature of Metallic Bonding, Crystal Structures of Metals, Structure of Alloys, Imperfections in Crystals, Significance of microstructural features

Heat Treatment: effect of cooling and heating rates and ageing materials for mechanical load bearing applications; Corrosion Resistant Materials: Some important Metals, Alloys, Ceramics and Polymers

Materials for Electrical Applications: Conductors, Dielectrics, insulators; Materials for Civil Engineering Applications

Materials for Biomedical applications: Steels, Ti and its alloys, Ni-Ti alloys, bioceramics, porous ceramics, bioactive glasses, calcium phosphates, collagen, thin films, grafts and coatings, biological functional materials Latex products

Reading:

1. M.F. Ashby: Engineering Materials, 4th Edition, Elsevier, 2005.
2. M.F. Ashby: Materials Selection in Mechanical Design, B H, 2005.
3. ASM Publication Vol. 20, Materials Selection and Design, ASM, 1997
4. Pat L. Mangonon: The Principles of Materials Selection and Design, PHI, 1999.

CH440	INDUSTRIAL POLLUTION CONTROL	OPC	3 – 0 – 0	3 Credits

(Not offered to Chemical Engineering Students)

Pre-requisites: None

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

CO1	Analyze the effects of pollutants on the environment.
CO2	Understand meteorological aspects of air pollution
CO3	Understand air pollution control methods
CO4	Select treatment technologies for water/wastewater/solid waste.
CO5	Design unit operations for pollution control.

Detailed Syllabus:

Introduction: Biosphere, hydrological cycle, nutrient cycle, consequences of population growth, pollution of air, water and soil.

Air pollution sources & effects: Classification and properties of air pollutants, emission sources, behavior and fate of air pollutants, effect of air pollution.

Meteorological aspects of air pollutant dispersion: Temperature lapse rates and stability, wind velocity and turbulence, plume behavior, dispersion of air pollutants, estimation of plume rise.

Air pollution sampling and measurement: Types of pollutant sampling and measurement, ambient air sampling, stack sampling, analysis of air pollutants.

Air pollution control methods & equipment: Control methods, source correction methods, cleaning of gaseous effluents, particulate emission control, selection of a particulate collector, control of gaseous emissions, design methods for control equipment.

Water pollution: Water resources, origin of wastewater, types of water pollutants and there effects.

Waste water sampling, Analysis and Treatment: Sampling, methods of analysis, determination of organic matter, determination of inorganic substances, physical characteristics, bacteriological measurement, basic processes of water treatment, primary treatment, secondary treatment, advanced wastewater treatment, recovery of materials from process effluents.

Solid Waste Management: Sources and classification, public health aspects, methods of collection, disposal Methods, potential methods of disposal.

Hazardous Waste Management: Definition and sources, hazardous waste classification, treatment methods, disposal methods.

Reading:

1. Rao C.S. – Environmental Pollution Control Engineering- Wiley Eastern Limited, India, 1993.
2. Noel de Nevers- Air Pollution and Control Engineering- McGraw Hill, 2000.
3. Glynn Henry J. and Gary W. Heinke - Environmental Science and Engineering, 2^{nd} Edition, Prentice Hall of India, 2004.
4. Rao M.N. and Rao H.V.N - Air Pollution, Tata – McGraw Hill Publishing Ltd., 1993.
5. De A.K - Environmental Chemistry, Tata – McGraw Hill Publishing Ltd., 1999.

CH441	FUEL CELL TECHNOLOGY	OPC	3 – 0 – 0	3 Credits

(Not offered to Chemical Engineering Students)

Pre-requisites: None.

Course Outcomes: At the end of the course the student will be able to:

CO1	Understand fuel cell fundamentals.
CO2	Analyze the performance of fuel cell systems.
CO3	Understand construction and operation of fuel cell stack and fuel cell system.
CO4	Apply the modeling techniques for fuel cell systems

Detailed syllabus

Overview of Fuel Cells: What is a fuel cell, brief history, classification, how does it work, why do we need fuel cells, Fuel cell basic chemistry and thermodynamics, heat of reaction, theoretical electrical work and potential, theoretical fuel cell efficiency.

Fuels for Fuel Cells: Hydrogen, Hydrocarbon fuels, effect of impurities such as CO, S and others.

Fuel cell electrochemistry: electrode kinetics, types of voltage losses, polarization curve, fuel cell efficiency, Tafel equation, exchange currents.

Fuel cell process design: Main PEM fuel cell components, materials, properties and processes: membrane, electrode, gas diffusion layer, bi-polar plates, Fuel cell operating conditions: pressure, temperature, flow rates, humidity.

Main components of solid-oxide fuel cells, Cell stack and designs, Electrode polarization, testing of electrodes, cells and short stacks, Cell, stack and system modeling

Fuel processing: Direct and in-direct internal reforming, Reformation of hydrocarbons by steam, CO_2 and partial oxidation, Direct electro-catalytic oxidation of hydrocarbons, carbon decomposition, Sulphur tolerance and removal , Using renewable fuels for SOFCs

Reading:

1. GregorHoogers, Fuel Cell Technology Hand Book, CRC Press, 2003.
2. Karl Kordesch& Gunter Simader, Fuel Cells and Their Applications, VCH Publishers, NY, 2001.
3. F. Barbir, PEM Fuel Cells: Theory and Practice (2nd Ed.) Elsevier/Academic Press, 2013.
4. Subhash C. Singal and Kevin Kendall, High Temperature Fuel Cells: Fundamentals, Design and Applications

CS440	MANAGEMENT INFORMATION SYSTEMS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course the student will be able to:

CO1	Determine key terminologies and concepts including IT, marketing, management, economics, accounting, finance in the major areas of business.
CO2	Design, develop and implement Information Technology solutions for business problems.
CO3	Analysis of computing systems and telecommunication networks for business information systems.
CO4	Understand ethical issues that occur in business, evaluate alternative courses of actions and evaluate the implications of those actions.
CO5	Plan projects, work in team settings and deliver project outcomes in time.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	-	-	-	3	3	-	-
CO2	-	-	-	-	-	-	-	-	3	3	-	-
CO3	-	-	-	-	-	-	-	-	3	3	-	-
CO4	-	-	-	-	-	-	-	-	3	3	-	-
CO5	-	-	-	-	-	-	-	-	3	3	-	-

Detailed syllabus

Organization and Information Systems, Foundation Concepts, Information Systems in Business, The Components of Information Systems, Competing with Information Technology, Fundamentals of Strategic Advantage, Using Information Technology for Strategic Advantage.

Changing Environment and its impact on Business, Kinds of Information Systems.

Computer Fundamentals, Computer Hardware, Computer Systems: End User and Enterprise Computing, Computer Peripherals: Input, Output, and Storage Technologies, Computer Software, Application Software, System Software, Computer System Management, Data Resource Management, Technical Foundations of Database Management, Managing Data Resources

Telecommunication and Networks, Telecommunications and Networks, The Networked Enterprise, Telecommunications Network Alternatives

System Analysis and Development and Models, Developing Business/IT Strategies, Planning Fundamentals, Implementation Challenges, Developing Business/IT Solutions, Developing Business Systems, Implementing Business Systems

Manufacturing and Service Systems Information systems for Accounting, Finance, Production and Manufacturing, Marketing and HRM functions, Enterprise Resources Planning (ERP), Choice of IT, Nature of IT decision, Managing Information Technology, Managing Global IT,

Security and Ethical Challenges, Security and Ethical Challenges, Security and Ethical, and Societal Challenges of IT, Security Management of Information Technology, Enterprise and Global Management of Information Technology

Reading:

1. Kenneth J Laudon, Jane P. Laudon, *Management Information Systems*, 10th Edition, Pearson/PHI, 2007.
2. W. S. Jawadekar, *Management Information Systems*, 3rd Edition, TMH, 2004.

BT440	BIOSENSORS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand biosensing and transducing techniques
CO2	Understand principles of linking cell components and biological pathways with energy transduction, sensing and detection
CO3	Demonstrate appreciation for the technical limits of performance of biosensor
CO4	Apply principles of engineering to develop bioanalytical devices and design of biosensors

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	1	-	-	-	-	-	-	3	-	-	-
CO2	-	1	-	-	-	-	-	-	3	-	-	-
CO3	-	1	-	-	-	-	-	-	3	-	-	-
CO4	-	1	-	-	-	-	-	-	3	-	-	-

Detailed Syllabus:

General principles: A historical perspective; Signal transduction; Physico-chemical and biological transducers; Sensor types and technologies, Definitions and Concepts Terminology and working vocabulary; Main technical definitions: calibration, selectivity, sensitivity, reproducibility, detection limits, response time.

Physico-chemical transducers: Electrochemical transducers (amperometric, potentiometric, conductimetric); optical transducers (absorption, fluorescence, SPR); Thermal transducers; Piezoelectric transducers.

Biorecognition systems: Enzymes; Oligonucleotides and Nucleic Acids; Lipids (Langmuir-Blodgett bilayers, Phospholipids, Liposomes); Membrane receptors and transporters; Tissue and organelles (animal and plant tissue); Cell culture; Immunoreceptors; Chemoreceptors; Limitations & problems. Immobilization of biomolecules.

Biosensor Engineering: Methods for biosensors fabrication: self-assembled monolayers, screen printing, photolithography, micro-contact printing, MEMS. Engineering concepts for mass production.

Application of modern sensor technologies: Clinical chemistry; Test-strips for glucose monitoring; Urea determination; Implantable sensors for long-term monitoring; Environmental monitoring; Technological process control; Food quality control; Forensic science benefits; Problems & limitations.

Reading:

1. Donald G. Buerk, Biosensors: Theory and Applications, 1st Edition, CRC Press, 2009.
2. Alice Cunningham, Introduction to Bioanalytical Sensors, John Wiley& Sons, 1998.
3. Brian R. Eggins, Chemical Sensors and Biosensors, John Wiley& Sons, 2003.

SM440	HUMAN RESOURCE MANAGEMENT	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand principles, processes and practices of human resource management.
CO2	Apply HR concepts and techniques in strategic planning to improve organizational performance.
CO3	Understand tools to manage HR systems and procedures.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	-	-	1	3	3	3	-
CO2	-	-	-	-	-	-	-	1	3	3	3	-
CO3	-	-	-	-	-	-	-	1	3	3	3	-

Detailed Syllabus:

Introduction to Human Resource Management, Objectives, Scope and Significance of HRM, Functions of HRM, Problems and Prospects in HRM, Environmental scanning.

Human Resource Planning, Demand Forecasting Techniques, Supply Forecasting Techniques, Analyzing work and designing jobs, Recruitment and Selection, Interviewing Candidates.

Human Resource Development, Orientation, Training and Development, Management, Development, Performance Appraisal and Employee Compensation, Factors Influencing, Employee Remuneration and Challenges of Remuneration.

Industrial Relations, Industrial Disputes and Discipline, Managing Ethical Issues in Human Resource Management, Workers Participation in Management, Employee safety and health, Managing Global Human Resources and Trade Unions

International HRM, Future of HRM and Human Resource Information Systems

Reading:

1. Aswathappa, Human Resource Management — TMH., 2010.
2. Garry Dessler and BijuVarkkey, Human Resource Management, PEA., 2011.
3. Noe&Raymond , HRM: Gaining a Competitive Advantage, TMH, 2008.
4. Bohlander George W, Snell Scott A, Human Resource Management, Cengage Learning, 2009.

MA440	OPTIMIZATION TECHNIQUES	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Formulate and solve linear Programming Problems
CO2	Determine the optimum solution to constrained and unconstrained
CO3	Apply dynamic programming principle to Linear programming problems.
CO4	Determine the integer solutions to Linear Programming Problems.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	1	3	-	-	3	-	-	-
CO2	-	-	-	-	1	3	-	-	3	-	-	-
CO3	-	-	-	-	1	3	-	-	3	-	-	-
CO4	-	-	-	-	1	3	-	-	3	-	-	-

Detailed Syllabus:

Linear Programming: Introduction and formulation of models, Convexity, Simplex method, Big-M method, Two-phase method, Degeneracy, non-existent and unbounded solutions, revised simplex method, duality in LPP, dual simplex method, sensitivity analysis, transportation and assignment problems, traveling salesman problem .

Nonlinear Programming: Introduction and formulation of models, Classical optimization methods, equality and inequality constraints, Lagrange multipliers and Kuhn-Tucker conditions, quadratic forms, quadratic programming problem, Wolfe's method.

Dynamic Programming: Principle of optimality, recursive relations, solution of LPP.

Integer Linear Programming: Gomory's cutting plane method, Branch and bound algorithm, Knapsack problem, linear 0-1 problem.

Reading:

1. KantiSwarup, Man Mohan and P.K.Gupta, Introduction to Operations Research, S.Chand& Co., 2006
2. J.C.Pant, Introduction to Operations Research, Jain Brothers, New Delhi, 2008.
3. N.S.Kambo, Mathematical Programming Techniques, East-West Pub., Delhi, 1991.

MA441	OPERATIONS RESEARCH	OPC	3 – 0 – 0	3 Credits

Prerequisites: None

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

CO1	Formulate and solve linear programming problems
CO2	Determine optimum solution to transportation problem
CO3	Determine average queue length and waiting times of queuing models.
CO4	Determine optimum inventory and cost in inventory models.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	3	-	-	3	-	-	-
CO2	-	-	-	-	-	3	-	-	3	-	-	-
CO3	-	-	-	-	-	3	-	-	3	-	-	-
CO4	-	-	-	-	-	3	-	-	3	-	-	-

Detailed Syllabus:

Linear Programming: Formulation and graphical solution of LPP's. The general LPP, slack, surplus and artificial variables. Reduction of a LPP to the standard form. Simplex computational procedure, Big-M method, Two-phase method. Solution in case of unrestricted variables. Dual linear programming problem. Solution of the primal problem from the solution of the dual problems.

Transportation Problems: Balanced and unbalanced Transportation problems. Initial basic feasible solution using N-W corner rule, row minimum method, column minimum, least cost entry method and Vogel's approximation method. Optimal solutions. Degenracy in Transportation problems. Queueing Theory: Poisson process and exponential distribution. Poisson queues - Model (M/M/1):(∞/FIFO) and its characteristics.

Elements of Inventory Control: Economic lot size problems - Fundamental problems of EOQ. The problem of EOQ with finite rate of replenishment. Problems of EOQ with shortages - production instantaneous, replenishment of the inventory with finite rate. Stochastic problems with uniform demand (discrete case only).

Reading:

1. K. Swarup, ManMohan & P.K.Gupta, Introduction to Operations Research, S.Chand & Co., 2006
2. J.C. Pant, Introduction to Operations Research, Jain Brothers, New Delhi, 2008.
3. N.S.Kambo: Mathematical Programming Techniques, East-West Pub., Delhi, 1991.

PH440	NANOMATERIALS AND TECHNOLOGY	OPC	3 – 0 – 0	3 Credits

Prerequisites: None

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

CO1	Understand synthesis and properties of nanostructured materials.
CO2	Analyze magnetic and electronic properties of quantum dots
CO3	Understand structure, properties and applications of Fullerenes and Carbon nanotubes.
CO4	Understand applications of nanoparticles in nanobiology and nanomedicine

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	2	-	-	3	-	-	-	-	-	-
CO2	3	2	2	3	1	1	1	-	-	-	-	-
CO3	1	-	-	-	-	-	3	-	-	-	-	-
CO4	1	1	1	1	-	1	1	-	-	-	-	-

Detailed Syllabus:

General properties of Nano materials: Origin of nanotechnology. Classification of nanomaterials. Fullerene, carbon, Nanotubes (CNT's), Nanoparticles. Physical, Chemical, Electrical, Optical, Magnetic and mechanical properties of nanomaterials.

Fullerenes and Carbon Nanotubes (CNT's): Introduction: Synthesis and purification. Preparation of fullerenes in the condensed phase, Transport, mechanical, physical properties of CNT's.

Investigation and manipulating materials in the Nanoscale: Electron microscope, scanning probe microscopes, optical microscopes for Nanoscience and Technology, X-Ray Diffraction.

SAMs and clusters: Growth process. Patterning monolayers. Types of clusters. Bonding and properties of clusters.

Semi conducting Quantum Dots: Introduction: Synthesis of Quantum Dots. Electronic structure of Nanocrystals, properties.

Nanobiology: Interaction between Biomolecules and Nanoparticle surgaces. Different types of Inorganic materials used for the synthesis of Hybrid Nano-bio assemblies. Nanoprobes for Analytical Applications.

Nanosensors: Nanosensors based on optical properties. Nanosensors based on quantum size effects. Nanobiosensors.

Nanomedicines: Developments of nanomedicines. Nanotechnology in Diagnostic Applications, materials for use in Diagnostic and therapeutic Applications.

Reading:

1. T. Pradeep, Nano: The Essentials; Tata McGraw-Hill, 2008.
2. W.R. Fahrner, Nanotechnology and Nanoelectronics; Springer,2006.
3. Rechard Booker and Earl Boysen, Nanotechnology, Willey, 2006.

PH441	BIOMATERIALS AND TECHNOLOGY	OPC	3 – 0 – 0	3 Credits

Prerequisites: None

Course Outcomes: At the end of the course the student will be able to:

CO1	Understand the structure and properties of biomaterials
CO2	Classify implant biomaterials
CO3	Evaluate biocompatibility of implants
CO4	Identify appropriate biomaterials for specific medical applications

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	2	-	-	-	-	2	-	3	-	-	2
CO2	-	2	-	-	-	-	2	-	3	-	-	2
CO3	-	2	-	-	-	-	2	-	3	-	-	2
CO4	-	2	-	-	-	-	2	-	3	-	-	2

Detailed Syllabus:

Overview of biomaterials: Historical developments, impact of biomaterials, interfacial phenomena, tissue responses to implants.

Structure and properties of biomaterials: Crystal structure of solids, phase changes, imperfections in solids, non-crystalline solids, surface properties of solids, mechanical properties, surface improvements.

Types of biomaterials: Metallic implant materials, ceramic implant materials, polymeric implant materials composites as biomaterials.

Characterization of materials: Electric properties, optical properties, X-ray absorption, acoustic and ultrasonic properties.

Bio implantation materials: Materials in ophthalmology, orthopedic implants, dental materials and cardiovascular implant materials.

Tissue response to implants: Normal wound healing processes, body response to implants, blood compatibility, structure – property relationship of tissues.

Reading:

1. JoonPark, R.S. Lakes, Biomaterials an introduction; 3rd Ed., Springer, 2007
2. Sujatha V Bhat, Biomaterials; 2nd Ed., Narosa Publishing House, 2006.

CY440	CORROSION SCIENCE	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand the electrochemical Principles of Corrosion.
CO2	Apply eight forms of corrosion to industrial problems.
CO3	Evaluate corrosion rates for industrial problems
CO4	Evaluate the corrosion rates of steel in RCC under corrosive environments.
CO5	Perform case studies using microbially induced corrosion of metals.
CO6	Perform case studies using appropriate methods of corrosion control of metals and alloys

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	1	-	2	-	-	2	-	2	-	-	2
CO2	-	1	-	2	-	-	2	-	2	-	-	2
CO3	-	1	-	2	-	-	2	-	2	-	-	2
CO4	-	1	-	2	-	-	2	-	2	-	-	2
CO5	-	1	-	2	-	-	2	-	2	-	-	2
CO6	-	1	-	2	-	-	2	-	2	-	-	2

Detailed Syllabus:

Understanding Corrosion: Types of corrosion: uniform corrosion, Galvanic corrosion, pitting corrosion, stress corrosion cracking, corrosion fatigue, stray current corrosion, selective leaching, microbial corrosion, Pourbaix potential-pH diagrams for iron, for aluminium, limitations of Pourbaix diagram Passivity- characteristics of passivation and the Flade potential, Theories of passivity, passive-active cells, critical pitting potential, Anodic protection and transpassivity.

Methods of corrosion monitoring: Polarisation and corrosion rates, polarisation diagrams of corroding metals, calculation of corrosion rates from polarization data. Electrochemical impedance spectroscopy: Nyquist plots, Bode plots, simple equivalent circuits for fitting the impedance data, calculation of corrosion parameters from impedance measurements. Electrochemical cell assembly for polarization and impedance studies. Gravimetric method of determination of corrosion rates.

Measurement of corrosion rates of carbon steel in reinforced cement concrete, Corrosion rates of metals due to micriobially induced corrosion.

Methods of corrosion prevention and control: Cathodic protection; By impressed current, By the use of sacrificial anodes, combined use with coatings, Advances in cathodic protection.

Metallic coatings: Methods of application, Electroplating, Electroless plating, specific metal platings like Cu, Ni and Cr.

Inhibitors and passivators: Picking inhibitors, vapour phase inhibitors, Inhibitors for cooling water systems, understanding of action of inhibitors through polarization and impedance.

Corrosion prevention and control strategies in different industries – case studies

Reading:

1. R. Winston Revie, Herbert H. Uhlig, Corrosion and Corrosion control, 4th edition, Wiley-Interscience, 2007
2. McCafferty and Edward, Introduction to Corrosion Science, 1st Edition, Springer, 2010.
3. Mars G. Fontana, Corrosion Engineering, 3rd edition, Tata McGraw- Hill, New Delhi, 2008.

CY441	CHEMISTRY OF NANOMATERIALS	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand the state of art synthesis of nano materials
CO2	Characterize nano materials using ion beam, scanning probe methodologies, position sensitive atom probe and spectroscopic ellipsometry.
CO3	Analyze nanoscale structure in metals, polymers and ceramics
CO4	Analyze structure-property relationship in coarser scale structures
CO5	Understand structures of carbon nano tubes.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	1	-	-	-	-	-	2	-	-	2
CO2	-	-	1	-	-	-	-	-	2	-	-	2
CO3	-	-	1	-	-	-	-	-	2	-	-	2
CO4	-	-	1	-	-	-	-	-	2	-	-	2
CO5	-	-	1	-	-	-	-	-	2	-	-	2

Detailed Syllabus:

Introduction: Scope of Nano science and nanotechnology, Nano science in nature, classification of nanostructured materials, importance of nano materials.

Synthetic Methods: Chemical Routes (Bottom-Up approach):- Sol-gel synthesis, micro emulsions or reverse micelles, solvothermal synthesis, microwave heating synthesis and sonochemical synthesis. Physical methods (Top-Down approach):- Inert gas condensation, plasma arc technique, ion sputtering, Laser ablation, laser pyrolysis, and chemical vapour deposition method.

Techniques for characterization:

Diffraction Technique: Powder X-ray diffraction for particle size analysis.

Spectroscopy Techniques: Operational principle and applications of spectroscopy techniques for the analysis of nanomaterials, UV-VIS spectrophotometers and its application for band gap measurement.

Electron Microscopy Techniques: Scanning electron microscopy (SEM) and EDAX analysis, transmission electron microscopy (TEM), scanning probe microscopy (SPM).

BET method for surface area determination.

Dynamic light scattering technique for particle size analysis.

Reading:

1. T. Pradeep, NANO: The Essentials: McGraw-Hill, 2007.
2. B.S. Murty, P. Shankar, BaldevRai, B.B. Rath and James Murday, Textbook of Nanoscience and nanotechnology: Univ. Press, 2012.
3. Guozhong Cao, Nanostructures & Nanomaterials; Synthesis, Properties & Applications: Imperial College Press, 2007.
4. M.A. Shah and Tokeer Ahmad, Principles of Nanoscience and Nanotechnology: Narosa Pub., 2010.
5. ManasiKarkare, Nanotechnology: Fundamentals and Applications: IK International, 2008.
6. C. N. R. Rao, Achim Muller, K. Cheetham, Nanomaterials Chemistry, Wiley-VCH, 2007

HS440	CORPORATE COMMUNICATION	OPC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Understand corporate communication culture
CO2	Prepare business letters, memos and reports
CO3	Communicate effectively in formal business situations
CO4	Exhibit corporate social responsibility and ethics
CO5	Practice corporate email, mobile and telephone etiquette
CO6	Develop good listening skills and leadership qualities

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	-	-	-	3	2	3	-
CO2	-	-	-	-	-	-	-	-	3	2	3	-
CO3	-	-	-	-	-	-	-	-	3	2	3	-
CO4	-	-	-	-	-	-	-	-	3	2	3	-
CO5	-	-	-	-	-	-	-	-	3	2	3	-
CO6	-	-	-	-	-	-	-	-	3	2	3	-

Detailed Syllabus:

Importance of Corporate communication: Introduction to and definition of corporates – Communication, process, patterns and channels of communication- Barriers to communication and strategies to overcome them- Evolution of corporate culture- Role and contribution of individual group and organization - Role of psychology in communication.

Oral Communication: Techniques for improving oral fluency-Speech mechanics-Group Dynamics and Group Discussion – Debate and oral presentations.

Written Communication: Types and purposes- Writing business reports, and business proposals- Memos, minutes of meetings- Circulars, persuasive letters- Letters of complaint- ; language and formats used for drafting different forms of communication. Internal and external communication.

Corporate responsibility: Circulating to employees vision and mission statements- ethical practices- Human rights -Labour rights-Environment- governance- Moral and ethical debates surrounding -Public Relations - Building trust with stakeholders.

Corporate Ethics and Business Etiquette: Integrity in communication-Harmful practices and communication breakdown- Teaching how to deal with tough clients through soft skills. Body language- Grooming- Introducing oneself- Use of polite language- Avoiding grapevine and card pushing – Etiquette in e-mail, mobile and telephone.

Listening Skills: Listening- for information and content- Kinds of listening- Factors affecting listening and techniques to overcome them- retention of facts, data and figures- Role of speaker in listening.

Leadership Communication Styles: Business leadership -Aspects of leadership-qualities of leader- training for leadership-delegation of powers and ways to do it-humour-commitment.

Reading:

1. Raymond V. Lesikar, John D. Pettit, Marie E. Flatley Lesikar's Basic Business Communication - 7th Edition: Irwin, 1993
2. Krishna Mohan and Meera Banerji, Developing Communication Skills: Macmillan Publishers India, 2000
3. R.C. Sharma & Krishna Mohan Business Correspondence and Report Writing: – 3rd Edition Tata McGraw-Hill, 2008
4. Antony Jay & Ross Jay, Effective Presentation, University Press, 1999.
5. Shirley Taylor, Communication for Business, Longman, 1999