NATIONAL INSTITUTE OF TECHNOLOGY WARANGAL

SCHEME OF INSTRUCTION AND SYLLABI
FOR B.TECH PROGRAM

Effective from 2014-15

DEPARTMENT OF CHEMICAL ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY WARANGAL

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

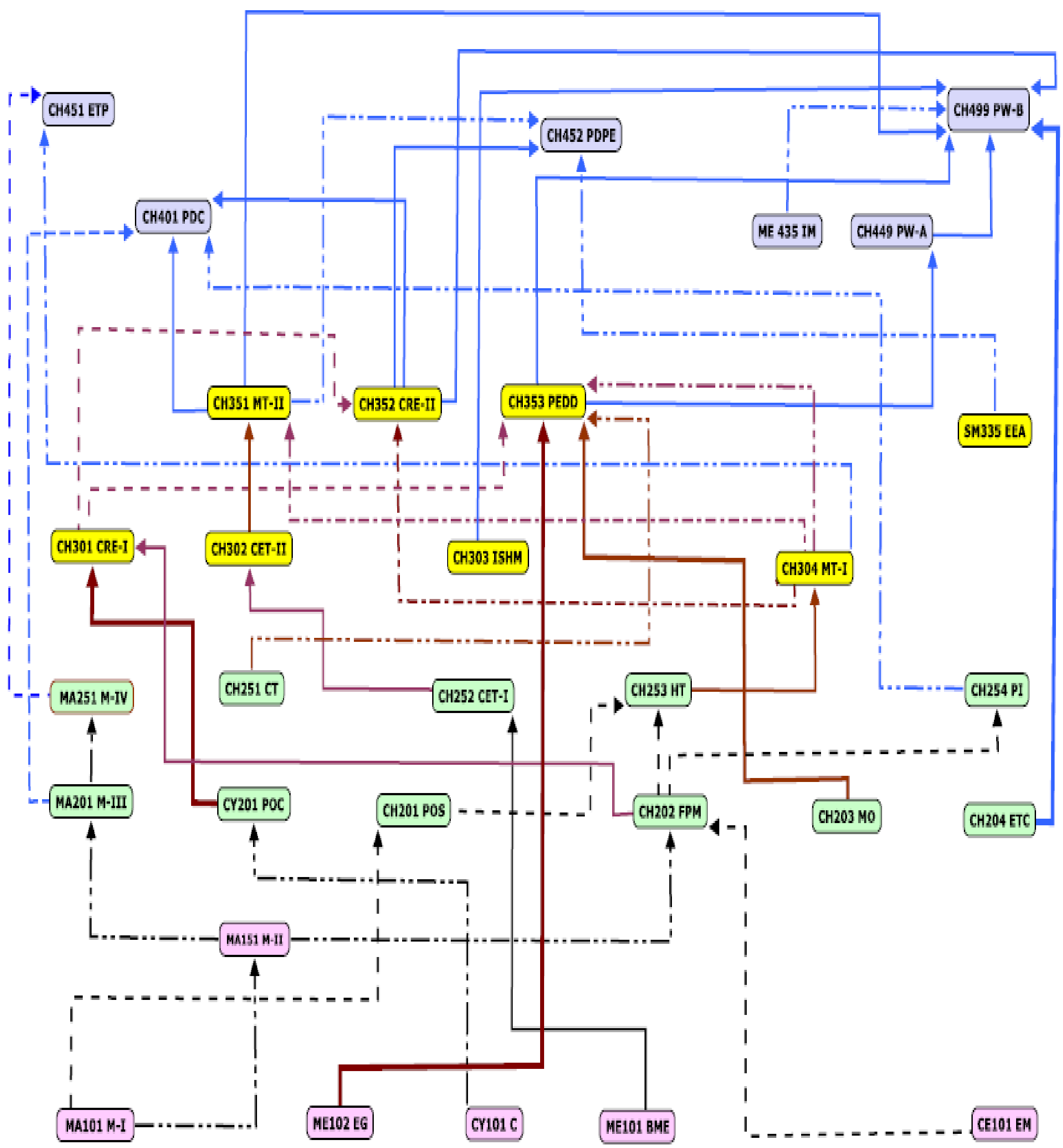
CH467 Membrane Technology

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 ^{1}H 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, 10th Edition, ELBS, 2010.
2. Vincent Del Toro, Electrical Engineering Fundamentals, 2nd 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, 8th Edition, Prentice Hall, 2012.
2. Hougen. O.A., Watson. K.M. and Ragatz. R.A., Chemical Process Principles (Part-I): Material and Energy Balances, 2nd Edition, CBS Publishers, 2004.
3. Bhatt, B.I. and Thakore S.M., Stoichiometry, 5th 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,* 2^{nd}edition, 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.