Department of Chemical Engineering
Proposed New Course Structure (B. Tech. in Chemical Engineering)

II year B.Tech Ist Semester (3rd semester)

Sr. No.	Course Code	Course Title	L	T	P	Credits
1	MA 301	Engineering Mathematics - III	3	1	-	4
2	CH 302	Chemical Process Calculations	3	1	-	4
3	CH 303	Fluid Flow Operations	3	-	-	3
4	CH 304	Mechanical Operations	3	-	-	3
5	CH 305	Strength of Materials	3	-	-	3
6	CH 306	Numerical Methods	3	-	-	3
7	CH 307	Elective - I	3	-	-	3
8	CH 308	Fluid Flow Operations Lab	-	-	2	1
9	CH 309	Mechanical Operations Lab	-	-	2	1
10	IX 310	NCC/NSS/Sports/Arts	-	-	-	-
		Total	21	2	4	25

II year B.Tech IInd Semester (4th semester)

Sr. No.	Course Code	Course Title	L	T	P	Credits
1	CH 401	Chemical Engineering Thermodynamics - I	3	1	-	4
2	CH 402	Heat Transfer Operations	3	1	-	4
3	CH 403	Elective - II	3	-	-	3
4	CH 404	Elective - III	3	-	-	3
5	CH 405	Chemical Technology	3	-	-	3
6	CH 406	Basic Human Rights	2	-	-	2
7	CH 407	Chemical Technology Lab	-	-	2	1
8	CH 408	Heat Transfer Operations Lab	-	-	3	2
9	CH 409	Programming Languages Lab	-	-	2	1
10	IX 410	NCC/NSS/Sports/Arts	-	-	-	-
		Total	17	2	7	23

Electives:

Elective – I:

1. Advanced Engineering Chemistry
2. Energy Technology and Conservation
3. NSS-I

Elective – II:

1. Introduction to Bio-process Engineering
2. Renewable Energy Sources
3. Development Engineering

Elective –III:

1. Nanotechnology
2. NSS-II
3. Materials for Engineering Applications

Semester III: Core Courses

1. MA 301 Engineering Mathematics – III

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

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	-	-	✓		✓	-	-	-	-	-	-
CO2	✓	-	-	✓		✓	-	-	-	-	-	-
CO3	✓	-	-	✓		✓	-	-	-	-	-	-
CO4	✓	-	-	✓		✓	-	-	-	-	-	-
CO5	✓			✓		✓						

Detailed syllabus

Unit I: Power series methods for solution of ordinary differential equation legendre equations and legendre polynomials, Bessel equations Bessel functions of first and second kind; orthogonality, Strum Llouville problems.

Unit II: Laplace transforms, Inverse transforms shifting on the S axis, Convolutions, Partial fractions.

Unit III: Fourier series, half – range expansions, approximation by trigonometeric polynomials fourier integrals.

Unit IV: Partial differential equations: First and second order linear partial.differential. equations. with variable coefficients, wave equation and heat equation in one and two dimensions, Laplace equation in two and three dimensions (cartesian coordinates only) Transforms, techniques in o. d. e and p.d.e.

Unit V: Infinite sequences and series of numbers, improper integrals

Unit VI: Cauchy criterion, test of convergence, absolute and conditional convergence series of function, uniform convergence, power series, Badlus of convergence.

Text/Reference Books:

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, 8th Edition, 2008.
3. B.S.Grewal, Higher Engineering Mathematics, Khanna Publications, 2009

2. CH 302 Chemical Process Calculations

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
CO3	Draw the flow diagram and solve the problems involving recycle, purge and
CO4	Understand the ideal and real behavior of gases, vapors and liquids.

Mapping of course outcomes with program outcomes

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

Detailed syllabus

Unit I: Introduction to Chemical Engineering: Historical evolution of Chemical Engineering and Chemical Process Industries, Chemistry to Chemical Engineering, Revision of Units and Dimensions., Mathematical techniques, Introduction to use of calculators.

Unit II: Mole concept, composition relationship and stoichiometry.

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

Unit IV: 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.

Unit V: 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.

Unit VI: Un-steady state mass balances.

Texts / References:

1. D.M. Himmelblau, "Basic Principles and Calculations in Chemical Engineering", 6th Edition, Prentice Hall of India, 1997.
2. B. I. Bhat and S. M. Vora, "Stoichiometry" Tata McGraw-Hill, New Delhi
3. V. Venkataramani, N. Anantharaman and K.M. MeeraSheriffa Begum, "Process Calculations" 2nd edition, Prentice Hall of India, 2015.

3. CH 303 Fluid Flow Operations

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 / turbulent conditions
CO4	Solve problems involving motion of fluid, fluid – solid operations in packed 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

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

Detailed syllabus

Unit I: Continuity equation for compressible and incompressible fluids.Bernoulli equation, Euler equation.Equation of motion.

Unit II: Types of flow, steady and unsteady, laminar and turbulent flows, relationship between shear stress and pressure gradient, Hagen Poiseuille equation.Prandtl mixing length theory and eddy diffusivity, losses in pipes and fittings.

Unit III: Darcy-Weisbach equation for frictional head loss, friction factor, Moody diagram. Velocity profile and boundary layer calculations for turbulent flow. Flow through packed and fluidized beds.

Unit IV: Pumps and compressors for handling different fluids, valves, pipe fittings and their standards, power requirement for flow.Piping layout and economical pipe diameter.

Unit VI: Flow measuring devices: orificemeter, venturimeter, rotameter, pitot tube, anemometer etc. Flow through constrictions such as notches, weirs, nozzles.

Unit I: Mixing and agitation, calculation of power numbers and mixing indices.Liquid-liquid and liquid solid mixing.
Vacuum producing devices. Introduction to non Newtonian flow and two phase flow.

Texts / References:

W. L. McCabe and J. C. Smith, P. Harriot, Unit Operations of Chemical Engineering 4th ed. McGraw Hill 1985.
S. K. Gupta, Moment Transfer Operations, Tata McGraw Hill, 1979.
J. M. Coulson and J. F. Richardson, Chemical Engineering Vol.I Pergamon Press, 1970.
A. S. Foust, L. A. Wenzel, C. W. Clump, L. B. Andersen. Principles of Unit Operations, 2nd ed. John Wiley, New York, 1980.

4. CH 304 Mechanical Operations

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
CO2	Understand the nature of solids, their characterization, handling, and the processes invoving solids.
CO3	Analyze the performance of size reduction equipment and calculate the power requirements.
CO4	Design solid-fluid separation equipment.

Mapping of course outcomes with program outcomes

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

Detailed syllabus

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

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

Unit III: Screening: Screening equipment, Screen capacity.

Unit IV: Cake filters: Centrifugal filters, Filter media, Principles of cake filtration, Washing filter cakes. Clarifying filters: Liquid clarification, Gas cleaning, Principles of clarification.

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

Unit VI: 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.

Text / Reference:

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.

5. CH 305 Strength of Materials

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

CO1	Analyze and design structural members subjected to tension, compression, torsion, bending and combined stresses using the fundamental concepts of stress, strain
CO2	Utilize appropriate materials in design considering engineering properties, sustainability, cost and weight.
CO3	Perform engineering work in accordance with ethical and economic constraints related to the design of structures and machine parts.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	-	-	✓	-	-	-	-	-	-	-
CO2	✓	✓	-	-	✓	-	-	-	-	-	-	-
CO3	✓	✓	-	-	✓	-	✓	-	-	-	-	-

Detailed syllabus

Unit I: **Stress and Strain**: Load and its effect, Types of stresses, Types of strain, Support and free body diagram, Types of structures, Equilibrium considerations, Thermal stresses and strains

Unit II: **Trusses**: Stability of trusses on application of load, redundancy, Unstable trusses, Use of different methods for analysis of trusses, Condition for perfect trusses

Unit III: **Shear Force and Bending Moment**: S. F. and B. M. diagram, Cantilever, Simply Supported Beams, Concentrated and Uniformly Distributed Loads

Unit IV: **Torsion**: Concept of torsion, Basic Torsion equation, Slope and Deflection of Beams, Cantilevers etc.Macaulay's Method.

Unit V: **Short and Long Columns (Struts):** Basic Theory, Crippling loads and conditions thereof, Euler's and Rankine's Approach for the same.

Unit VI: **Thick and Thin Cylinders**: Radial and Longitudinal Stresses, Behavior of thin Cylinders, Problems on thin cylinders and Spherical shells, Behavior of thick cylinders

Texts and References:

1. Timoshenko & Young, "Strength of Materials."
2. V.N. Vazirani&Ratwani, "Analysis of Structures", Vol.I Khanna Publishers.
3. R.L. Bansal, "Strength of Materials", Luxmi Publishers.
4. Popov, "Strength of Materials", Prentice Hall of India.
5. Ramamrutham, Strength of materials

6. CH 306 Numericl Methods

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

CO1	Demonstrate understanding of common numerical methods and how they are used to obtain approximate solutions.
CO2	Apply numerical methods to obtain approximate solutions to mathematical problems
CO3	Derive numerical methods for various mathematical operations like interpolation, differentiation etc.
CO4	Analyse and evaluate the accuracy of common numerical methods.

Mapping of course outcomes with program outcomes

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

Detailed syudllabus

Unit I: Solutions of Linear Algebraic Equations - Gauss elimination and LU decomposition, Gauss-Jordan Elimination, Guass-Seidel and relaxation methods.

Unit II: Eigen values and Eigen Vectors of Matrices - Faddeev-Leverrier method, Power method, Householder's and Given's method

Unit III: Nonlinear Algebraic Equations - Fixed point method, Multivariable successive substitutions, Single variable Newton-Raphson Technique, Multivariable Newton-Raphson Technique

Unit IV: Function Evaluation - Least-squares curve fit, Newton's Interpolation formulae, Newton's divided difference interpolation polynomial, Langrangian interpolation, Pade approximations, Cubic spline approximations

Unit V: **Ordinary Differential Equations (Initial value problems) –** RungeKutta Methods, Semi-implicit RungeKutta Techniques, Step size control and estimates of error **Ordinary Differential Equations (Boundary value problems) -** Finite difference technique, Orthogonal collocation technique, Orthogonal collocation on finite elements

Unit VI: **Partial Differential Equations –** Introduction to finite difference technique

Texts / References:
S.K. Gupta, "Numerical Methods for Engineers", Wiley Eastern, 1995.
M.E. Davis, "Numerical Methods & Modeling for Chemical Engineers", Wiley, 1984.

Semester III: Elective Courses

CH 307: Elective – I

A. Advanced Engineering Chemistry

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

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

Detailed syllabus

Unit I: Corrosion and its Control: Introduction, Fundamental reason, Electrochemical Corrosion, Direct Chemical Corrosion, Factors affecting the rate of corrosion, types of corrosion- Galvanic, Pitting Corrosion, Microbiological corrosion, Stress corrosion, methods to minimise the corrosion- Proper design, Cathodic and Anodic protection. Study of Composite materials.

Unit II: Spectroscopy: Brief introduction to spectroscopy, UV – Visible Spectroscopy: Laws of absorption, types of transitions, instrumentation and application. FT- IR spectroscopy: introduction, theory, instrumentation and application. Brief discussion on NMR Spectroscopy and its Applications. Brief introduction of AAS (Atomic Absorption Spectroscopy)

Unit III: Instrumental Methods of Chemical Analysis: Introduction to Chromatography, Types of Chromatography (Adsorption and partition chromatography), Paper and Thin Layer Chromatography, Gas Chromatography – introduction, theory, instrumentation. Brief discussion of Thermo gravimetric analysis (TGA), Differential Scanning Colorimetry .

Unit IV: Organic reaction Mechanisms: Introduction, Electronic displacement effects in organic molecule, reactive intermediates (carbocation, carbanion and carbine), Brief introduction of Addition, Substitution and Elimination reaction with suitable examples. **Rearrangement :**introduction, Pinacole – Pinacolone rearrangement.

Unit V: Polymers and its Characterisation: Introduction, Nomenclature of Polymers, types of Polymerization, Molecular weight determination by Osmotic pressure and Viscosity method, polymers in medicines and surgery, Inorganic polymers: Silicones. Brief discussion on Bio- polymer.

Unit VI: Drugs and Dyes;

Drugs: Introduction, Study of the following drugs with reference to structure, occurrence, medicinal uses and side effects: Antipyretic :Paracetamol (synthesis), Anti Inflammatory drug: Ibuprofen, Antibiotic drugs, Anti malarial drug: Quinine(Synthesis), Anti- Cancer drugs, Anti-hypertensive drugs.

Dyes: Introduction, Synthesis and uses of Synthetic dyes: Congo- red, Eriochrome black - T

Text books:

1. Bhal and Bhal Advance Organic Chemistry, S. Chand & Company, New Delhi, 1995.
2. Jain P.C & Jain Monica, Engineering Chemistry, DhanpatRai& Sons, Delhi, 1992.
3. Bhal&Tuli, Text book of Physical Chemistry (1995), S. Chand & Company, New Delhi.
4. Handbook of Drugs and Dyes, Himalaya Publications.

Reference books:

1. Finar I.L., Organic Chemistry (Vol. I & II), Longman Gr. Ltd & English Language Book Society, London.
2. Barrow G.M., Physical Chemistry, McGraw-Hill Publication, New Delhi.
3. ShikhaAgarwal, Engineering Chemistry- Fundamentals and applications, Cambridge Publishers - 2015.
4. O. G. Palanna , Engineering Chemistry, Tata McGraw-Hill Publication, New Delhi.
5. WILEY, Engineering Chemistry, Wiley India, New Delhi 2014.
6. Books on Drugs and Dyes, McGraw-Hill Publication, New Delhi.

B. Energy Technology and Conservation

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

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	✓	✓	✓	✓	✓	-	✓	-	-	-	-	-
CO2	✓	✓	✓	✓	✓	-	✓	-	-	-	-	-
CO3	✓	✓	✓	✓	-	-	✓	-	-	-	-	-
CO4	✓	✓	✓	✓	-	-	✓	-	-	-	-	-

Detailed syllabus

Unit I: 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.

Unit II: 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.

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

Unit IV: 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.

Unit V: 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.

Unit VI: Energy utilization 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.

Text / Reference:

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.

C. NSS-I

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

CO1	Understand features of Indian constitution, fundamental rights and duties of citizens
CO2	Explain importance of Health, Hygiene & Sanitation
CO3	Summarize yoga a tool for healthy lifestyle
CO4	Conclude environmental issues and organize its management
CO5	Classify the disasters and youth role in its management

Mapping of course outcomes with program outcomes

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

Detailed Syllabus

Unit I: Introduction and Basic Concepts of NSS: History, Philosophy, Aims & objectives of NSS Organizational structure, Concept of regular activities, Special camping, Day Camps. Basis of adoption village/slums, Methodology of conducting Survey

Unit II: Youth and Community Mobilization: Definition, Profile of youth, Categories of youth, Issues, Challenges and opportunities for youth, Youth as an agent of social change, Youth-adult partnership, Mapping of community stakeholders, Identifying methods of mobilization, Needs & importance of volunteerism

Unit III: Importance and Role of Youth Leadership: Meaning and types of leadership, Qualities of good leaders; Traits of leadership, Importance and role of youth leadership

Unit IV: Life Competencies and Skill; Definition and importance of life competencies, Communication, Inter Personal, Problem solving and decision making, Positive thinking, Self-confidence and self-esteem, Life goals, Stress and time management

Unit I: Social Harmony and National Integration: Indian history and culture, Role of youth in peace-building and conflict resolution, Role of youth in Nation building

Unit VI: Youth Development Programs in India

National Youth Policy, Youth development programs at the National Level, State Level and voluntary sector, Youth-focused and Youth-led organizations

Semester III: Labs

CH 308: Fluid Flow Operations Lab

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

CO1	Determine viscosity using Fenske or other viscometer and terminal velocity
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	✓	✓	✓	✓	-	-	-	-	-	-	-	-
CO2	✓	✓	✓	✓	-	-	-	-	-	-	-	-
CO3	✓	✓	✓	✓	-	-	-	-	-	-	-	-
CO4	✓	✓	✓	✓	✓	-	-	-	-	-	-	-
CO5	✓	✓	✓	✓	✓	-	-	-	-	-	-	-

List of Experiments:

1. Determination of flow regimes -Reynolds' apparatus
2. Verification of Bernoulli's equation
3. Determination of Fanning friction factor for smooth and rough pipes
4. Determination of equivalent length of pipe fittings
5. Determination of viscosity with capillary tube viscometer.
6. Determination of friction factor for flow through packed bed.
7. Determination of discharge coefficient for venturi meter
8. Determination of discharge coefficient for orifice meter
9. Centrifugal pump characteristics
10. Study of Rota meter

CH 309: Mechanical Operations Lab

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

CO1	Understand screen effectiveness
CO2	Understand dry screen analysis
CO3	Understand wet screen analysis
CO4	Understand cyclone separator and froth flotation

Mapping of course outcomes with program outcomes

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

List of Experiments:

1. Determination of screen effectiveness
2. Dry screen analysis
3. Wet screen analysis
4. Study of sedimentation
5. Study of air elutriation
6. Study of cyclone separator
7. Study of froth flotation

Semester IV: Core Courses

1. CH 401: Chemical Engineering Thermodynamics - I

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

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓	-	✓	-	-	-	-	-	-
CO2	✓	✓	✓	✓	-	-	✓	-	-	-	-	-
CO3	✓	✓	✓	✓	-	✓	-	-	-	-	-	-
CO4	✓	✓	✓	✓	-	✓	✓	-	-	-	-	-
CO5	✓	✓	✓	✓	-	-	✓	-	-	-	-	-

Detailed syllabus

Unit I: INTRODUCTION : The Scope of thermodynamics; Dimensions and units; Measures of Amount or size; Force; Temperature; Pressure; Work; Energy; Heat. **THE FIRST LAW OF THERMODYNAMICS:** Joule's Experiments; Internal Energy; The 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.

Unit II: VOLUMETRIC PROPERTIES OF PURE FLUIDS : PVT Behaviour of pure substances; the Virial Equation; The Ideal Gas; Application of the Virial Equation; Cubic Equations of State; Generalised Correlation's for gases; Generalised correlation's for Liquids

Unit III: HEAT EFFECTS: Sensible Heat Effects, Heat Effects Accompanying Phase Changes of Pure Substances,The Standard Heat of Reaction, The Standard Heat of Formation, The Standard Heat of Combustion, Effect of Temperature on the standard Heat of Reaction.

Unit IV: THE SECOND LAW OF THERMODYNAMICS : Statement of the Second law : The Heat Engine; 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 view point.

Unit V: THERMODYNAMIC PROPERTIES OF FLUIDS: Property Relations for Homogeneous phase; Residual Properties; Residual properties by equations of state; Two phase systems, Thermodynamic diagrams; Tables of Thermodynamic properties; Generalised property correlations for gases.

Unit VI: APPLICATIONS OF THERMODYNAMICS TO FLOW PROCESSES: Duct flow of compressible fluids; Turbines (expanders); Compression processes. **REFRIGERATION AND LIQUEFACTION :** The Carnot Refrigerator; the vapour-compression cycle; The Choice of refrigerant; Absorption Refrigeration; The heat pump; Liquefaction Processes.

TEXT BOOK :

1. Smith J.M, Van Ness H.C and Abbott M.M. - Introduction to Chemical Engineering Thermodynamics - 6th Edition, McGraw Hill International (2001).

REFERENCE BOOK :

1. Rao, Y.V.C. - Chemical Engineering Thermodynamics - Universities Press (India) Ltd., 1997.
2. Narayanan, K.V. - Chemical Engineering Thermodynamics - Prentice Hall of India Pvt. Ltd. – 2001
3. Hougen O.A, Watson. K.M and Ragatz R.A - Chemical Process Principles (Part - II) - 2nd edn., Asia Publishing House.

2. CH 402: Heat Transfer operations

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

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓	✓	✓	✓	-	-	-	-	-
CO2	✓	✓	✓	✓	-	-	✓	-	-	-	-	-
CO3	✓	✓	✓	✓	-	✓	✓	-	-	-	-	-
CO4	✓	✓	✓	✓	-	✓	✓	-	-	-	-	-
CO5	✓	✓	✓	✓	-	-	-	-	-	-	-	-

Detailed syllabus

Unit I: **Conduction** through a single homogeneous solid, thermal conductivity of solids, liquids and gases.Conduction through several bodies in series. Contact resistances. Unsteady state heat conduction, lumped heat capacity system, transient heat flow in a semi-infinite solid.

Unit II: **Heat transfer by Convection**: Forced convection, Laminar heat transfer on a flat plate Laminar and turbulent flow heat transfer inside and outside tubes. Film and overall heat transfer coefficients. Resistance concept, Coefficients for scale deposits, L.M.T.D. in heat exchangers with co and counter current flow. Heat exchanger design, Effectiveness – N T U method in finned tube heat exchangers. **Natural convection**: Heat transfer from plates and cylinders in verticals and horizontal configuration, natural convection to spheres.
Heat transfer with phase change, i. e. heat transfer in Boiling and condensation, Single and multiple effect evaporators.

Unit III: **Heat Transfer by Radiation:** Black and gray body radiations, view factor, luminous and non-luminous gases. Combined heat transfer, i.e. conduction, convection and radiation together.
Concept of critical insulation thickness.

Unit IV: **Combined natural and forced convection:** Fluid flow and heat transfer across cylinders and spheres. Combined natural and forced convection heat transfer in horizontal circular conduits. Heat transfer in extended surfaces such as fins, conduction convection heat transfer, forced convection heat transfer in circular conduits with longitudinal fins.
Heat transfer in non Newtonian fluids.

Unit V: **Heat exchanger design:** Design of single and multi pass shell and tube type exchangers using LMTD and effectiveness – NTU methods.
Spiral coil and plate type heat exchangers.
Single and multi phase condenser. Design of Reboilersvapourisers.
Kettle type and Thermosiphonreboilers, forced circulation vaporizers.
Heat transfer in agitated vessels both, jacketed and with coil, Determination of overall heat transfer coefficient, transient heating or cooling,

Unit VI: Heat transfer in packed and fluidized beds.

Texts / References:

J. M. Coulson and J. F. Richardson, "Chemical Engineering", Vol. 1 ELBS, Pergamon press, 1970

J. M. Coulson and J. F. Richardson, "Chemical Engineering" Vol. 2 ELBS, Pergamon press, 1970

W. L. McCabe J. C. Smith and P. Harriot, "Unit Operations of Chemical Engineering", 4th ed. McGraw Hill 1985.

D. Q. Kern, "Process Heat Transfer", McGraw Hill, 1950.

3. CH 405: Chemical Technology

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

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓	✓	-	-	-	-	-	-	-
CO2	✓	✓	✓	✓	✓	-	-	-	-	-	-	-
CO3	✓	✓	✓	-	-	-	-	-	-	-	-	-
CO4	✓	✓	✓	✓	✓	-	-	-	-	-	-	-
CO5	✓	✓	✓	✓	-	-	-	-	-	-	-	-

Detailed syllabus

Unit I: 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.

Unit II: Phosphorus Industries: Phosphoric acid, Wet process, Electric furnace process, Calcium phosphate, Ammonium phosphates, Nitrophosphates, Sodium phosphate. Potassium Industries: Potassium recovery from sea water.

Unit III: 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 H2S, Sulfur and sulfur dioxide from pyrites, Sulfuric acid. Contact process, Chamber process.

Unit IV: 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.

Unit V: 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.

Unit VI: 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.

Text / Reference:

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

4. CH 406: Basic Human Rights

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

CO1	Understand the history of human rights.
CO2	Learn to respect others caste, religion, region and culture.
CO3	Be aware of their rights as Indian citizen.
CO4	Understand the importance of groups and communities in the society.
CO5	Realize the philosophical and cultural basis and historical perspectives of human rights.
CO6	Make them aware of their responsibilities towards the nation.

Mapping of course outcomes with program outcomes

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

Unit I: The Basic Concepts: Individual, group, civil society, state, equality, justice.Human Values, Human rights and Human Duties: Origin, Contribution of American bill of rights, French revolution. Declaration of independence, Rights of citizen, Rights of working and exploited people

Unit II: Fundamental rights and economic program: Society, religion, culture, and their inter-relationship. Impact of social structure on human behavior, Social Structure and Social Problems: Social and communal conflicts and social harmony, rural poverty, unemployment, bonded labour.

Unit III: Workers and Human Rights: Migrant workers and human rights violations, human rights of mentally and physically challenged. State, Individual liberty, Freedom and democracy.

Unit IV: NGOs and human rights in India: Land, Water, Forest issues.

Unit V: `Human rights in Indian constitution and law

i) The constitution of India: Preamble
ii) Fundamental rights.
iii) Directive principles of state policy.
iv) Fundamental duties.
v) Some other provisions.

Unit VI: Universal declaration of human rights and provisions of India. Constitution and law.National human rights commission and state human rights commission.

References:

1. Shastry, T. S. N., "India and Human rights: Reflections", Concept Publishing Company India (P Ltd.), 2005.
2. C.J. Nirmal, "Human Rights in India: Historical, Social and Political Perspectives(Law in India)", Oxford India.

Semester IV: Elective Courses

CH 403: Elective – II

A. Introduction to Bio-process Engineering

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

CO1	Understand cell and enzyme kinetics
CO2	Understand basics of biology, structure
CO3	Understand material and energy balances in bioprocesses
CO4	Understand kinetics and manufacture and application of enzyme-catalyzed reactions,
CO5	Study design of bioreactor

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓	-	-	-	-	-	-	-	-
CO2	✓	✓	✓	✓	-	-	-	-	-	-	-	-
CO3	✓	✓	✓	✓	-	-	-	-	-	-	-	-
CO4	✓	✓	✓	✓	-	✓	-	-	-	-	-	-
CO5	✓	✓	✓	✓	-	-	-	-	-	-	-	-

Detailed Syllabus:

Unit I: Bioprocess engineering and related fields, basics of biology, structure and function of microbial, plant and animal cells, introduction to chemicals of life such as lipids, carbohydrates, nucleic acids and proteins

Unit II: Metabolism and central metabolic pathways, central dogma, transcription and translation processes, material and energy balances in bioprocesses with examples.

Unit III: Unstructured and structured growth models of bioprocesses, growth kinetics, estimation of process parameters, logistic equation, effect of substrate and product inhibition

Unit IV: Enzymes, kinetics of enzyme-catalyzed reactions, inhibited enzyme kinetics, immobilized enzymes, manufacture and application of enzymes

Unit V: Design of biological reactors, continuous, batch and fedbatch processes and their comparison, multistage chemostat systems, introduction to transport phenomena in bioprocesses.Non-ideal effects. Scale-up and scale-down criteria.

Unit VI: Recovery and purification of bioprocesses, recent advances and applications of bioprocess engineering, genetic engineering and recombinant DNA technology, mixed cultures, application to biological wastewater treatment. Introduction to control strategies in bioprocesses.

References:

1. Shuler and Kargi, "Bioprocess Engineering : Basic Concepts" Prentice Hall of India,2002
2. J.E. Bailey & D.F. Ollis (eds) : `Biochemical Engineering Fundamentals', McGraw Hill Inc., 1986.

B. Renewable Energy Sources

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

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

Mapping of course outcomes with program outcomes

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

Detailed syllabus

Unit I: Sources of energy: Energy sources and their availability, renewable energy sources. Energy from Biomass: Introduction, Biomass as a source of energy, Biomass conversion technologies, Biogas generation, classification of biogas plants, Biomass gasification.

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

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

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

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

Unit VI: Hydrogen energy: Introduction, Hydrogen production, Hydrogen storage, Hydrogen transportation. Chemical Energy Sources: Introduction, Fuel cells, Batteries.

Text / Reference:

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

C. Development Engineering

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

CO1	
CO2	
CO3	
CO4	

Mapping of course outcomes with program outcomes

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

Unit I: Introduction to Development Engineering: Introduction to development engineering; need of development engineering; core disciplines and concept; major issues in development; urban development; rural development; socioeconomic development; scientific social research, formulation of research problem, field work and data collection, report drafting.

Unit II: Design of Sustainable Communities: Concept and development of sustainable communities; Sustainable design principles, building regulations, codes and standards – ANSI, ASTM, ASHRAE, approval process; green buildings – green building techniques-energy solutions, site solutions, site solutions, exterior and interior solutions, Certification – BREEAM, GRIHA, NAHB, LEED, IGBC.

Unit III: Town/City Planning: Town Planning, history of town planning in India, characteristics of city/town, town planning at national, regional and local levels, planning standards, master plan, site layout and development, zoning and density control, green belt, slum redevelopment; Smart city planning introduction to city planning, infrastructure elements of smart city planning, d imensions of smart cities global standards and performance benchmark; smart solutions e-governance, waste management, water management, energy management, urban mobility, citizen services, other services such as telemedication and education, trade facilitation, skill development; GIS for Planning.

Unit IV: Planning and Development of Rural Areas: District administration, District Planning, introduction to various sectors of rural areas such as drinking water, Waste water treatment, electricity, public transport, irrigation, sanitation and cooking energy; issues and challenges associated with these sectors; People's participation and role in development of rural areas; various schemes and policies floated by state and central government – phases in the schemes; life cycle costing of these schemes.

Unit V: Geoinformatics for Planning and Development: Introduction to Geoinformatics; Advantages, benefits and limitations; Interdisciplinary applications; Data extraction; use of Geoinformatics for planning, mapping and preparation of layouts.

Unit VI: Development aspects: Urban and Rural: Planning and designing of a model town / city and using Auto-CAD and/or GIS, Visit to a village or small town – The project will be carried out in groups. Problem faced by the villagers pertaining to various sectors or existing schemes; define the need, method, tools and techniques for development; deliver technology based solution.

Text Books:

1. Chand M. and Purr U.K. (1983), 'Regional Planning in India', Allied Publisher, New

Delhi.
2. Kaiser E.J., et.at., 'Urbun Landuse Planning', 4th edition Urbana, University of Illinois Press.
3. Sundaram K.V., 'Geography Planning', Concept Publishing Co., New Delhi.
4. Ayyar C.P.V., 'Town Planning in Early South India', Mittal Publications, Delhi.
5. Reeder, Hoboken, 'Guide to green building rating systems', John Wiley & sons, Inc.
6. Longley, et.al, 'Geographic Information Systems and Science', John Wiley & Sons, New York.
7. Desai V., 'Rural Development of India', Himalaya publishing house, Mumbai.
8. Rau S.K., 'Global Search for Rural Development', NIRD, Hyderabad.

Reference Books:

1. Institute of Town Planners, India, Ministry of Urban Affairs & Employment, Government of India, New Delhi, UDPFI Guidelines, 1996.
2. Miles R. Simon, 1970, 'Metropolitan Problems', Methuen Publications, Canada.
3. B.I.S., 1980, "National Building Code of India', ISI, New Delhi.
4. ANSI/ASHRAE/USGBC/IES Standard 189.1, Standard for the Design of High-Performance Green Buildings Except Low-Rise Residential Buildings.
5. ASHRAE Standard 90.1, Energy Standard for Buildings Except Low-Rise Residential Buildings.

CH 404: Elective – III

A. Nanotechnolgy

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

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

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	-	-	-	-	-	-	-	-	-
CO2	✓	✓	✓	✓	✓	✓	✓	-	-	-	-	-
CO3	✓	-	-	-	-	-	✓	-	-	-	-	-
CO4	✓	✓	✓	✓	-	✓	-	-	-	-	-	-
CO5	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-

Detailed Syllabus:

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

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

Unit III: Kinetics at Nanoscale: Nucleation and growth of particles, Issues of Aggregation of Particles, Oswald Ripening, Stearic hindrance, Layers of surface Charges, Zeta Potential and pH. Carbon Nanomaterials: Synthesis of carbon buckyballs, List of stable carbon allotropes extended fullerenes, metallofullerenes solid C60, bucky onions nanotubes, nanocones Difference between Chemical Engineering processes and nanosynthesis processes.

Unit IV: Characteristics of quantum dots, Synthesis of quantum dots, Semiconductor quantum dots, Introduction - Nanoclay Synthesis method, Applications of nanoclay. Nanomaterials characterization: Instrumentation Fractionation principles of Particle size measurements, Particle size and its distribution, XRD, Zeta potential Microscopy's SEM, TEM, Atomic Forced Microscopy, Scanning and Tunneling Microscopy

Unit V: Applications in Chemical Engineering: Self-assembly and molecular manufacturing : Surfactant based system Colloidal system applications, ZnO,TiO2, Silver Nanoparticles Functional materials Applications, Production Techniques of Nanotubes, Carbon arc, bulk synthesis, commercial processes of synthesis of nanomaterials, Nanoclay, Commercial case study of nano synthesis - applications in chemical engineering, Nano inroganic materials - CaCO3 synthesis, Hybrid wastewater treatment systems, Electronic Nanodevices, sensor applications,

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

Text / Reference:

1. Kulkarni Sulabha K., Nanotechnology: Principles and Practices, Capital Publishing Company, 2007.
2. Gabor L. Hornyak., H.F. Tibbals, JoydeepDutta, John J. Moore, Introduction to Nanoscience and Nanotechnology, CRC Press.
3. Robert Kelsall, Ian Hamley, Mark Geoghegan, Nanoscale Science and Technology, John Wiley & Sons, 2005.
4. Stuart M. Lindsay, Introduction to Nanoscience, Oxford University Press, 2009.

5. Davies, J.H. 'The Physics of Low Dimensional Semiconductors: An Introduction', Cambridge University Press, 1998.

B. NSS – II

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

CO1	
CO2	
CO3	
CO4	
CO5	
CO6	

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Unit I: Citizenship: Basic Features of Constitution of India, Fundamental Rights and Duties, Human Rights, Consumer awareness and the legal rights of the consumer, RTI.

Unit II: Health, Hygiene & Sanitation: Definition, Needs and scope of health education , Food and Nutrition , Safe drinking water, Water borne diseases and sanitation, National Health Programme, Reproductive health , Healthy Lifestyles ,HIV AIDS, Drugs and Substance abuse, Home Nursing , First Aid.

Unit III: Youth and Yoga: History, Philosophy and concept of Yoga , Myths and misconceptions about yoga , Different Yoga traditions and their Impacts, Yoga as a preventive, promotive and curative method, Yoga as a tool for healthy lifestyle.

Unit IV: **Environment Issues:** Environment conservation, Enrichment and Sustainability, Climate change, Waste management, Natural resource management, Rain water harvesting, Energy conservation, Waste land development, Soil conservations and forestation.

Unit V: **Disaster a Management:** Introduction to Disaster Management, Classification disaster, Role of youth in Disaster Management

Unit VI: **Youth and crime:** Sociological and psychological factors influencing youth crime, Peer mentoring in preventing crime, Awareness about anti-ragging, Cybercrime and its prevention, Juvenile justice.

C. Materials for Engineering Applications

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

CO1	Correlate processing, microstructure and properties of materials.
CO2	Understand behaviour of materials under various conditions.
CO3	Characterize modes of failure of engineering materials and design new materials with better properties and cost effective processes.
CO4	Identify suitable materials for engineering applications.

Mapping of course outcomes with program outcomes

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

Detailed Syllabus:

Unit I: Materials Science and Engineering Materials, Classification of Materials and Properties: Mechanical, Dielectric, Magnetic and Thermal

Unit II: Metallurgical Aspects of Materials: Structure of Metals and Alloys, Nature of Metallic Bonding, Crystal Structures of Metals, Structure of Alloys, Imperfections in Crystals, Significance of micro structural features

Unit III and IV: Heat Treatment: effect of cooling and heating rates and ageing materials for mechanical load bearing applications; Corrosion Resistant Materials: Some important Metals, Alloys, Ceramics and Polymers

Unit IV: Materials for Electrical Applications: Conductors, Dielectrics, insulators; Materials for Civil Engineering Applications

Unit VI: Materials for Biomedical applications: Steels, Ti and its alloys, Ni-Ti alloys, bioceramics, porous ceramics, bioactive glasses, calcium phosphates, collagen, thin films, grafts and coatings, biological functional materials Latex products.

Text / Reference:

1. M.F. Ashby: Engineering Materials, 4th Edition, Elsevier, 2005.
2. M.F. Ashby: Materials Selection in Mechanical Design, B H, 2005.
3. ASM Publication Vol. 20, Materials Selection and Design, ASM, 1997
4. Pat L. Mangonon: The Principles of Materials Selection and Design, PHI, 1999.

Semester IV: Labs

1. CH 407: Chemical Technology Lab

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

CO1	Prepare aspirin, soap, dyes and pigments
CO2	Extraction of oil using solvents
CO3	Determine composition of common salt, water, lie, urea, soda ash, vegetable oil and sugar
CO4	Determine Reid's vapor pressure, Smoke point, Aniline point and Abel's Flash point f given fuel
CO5	Determine gas composition using Orsat Analysis.
CO6	Determine the properties using Redwood viscometer; Photo-colorimeter, Bomb caloriemeter

Mapping of course outcomes with program outcomes

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

List of Experiments

1. Analysis of raw materials, intermediates and products such as: Common salt; Water; Lime; Urea; Soda ash; Vegetable oils; Sugar etc.

2. 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.
3. Preparation of Na2CO3 and percentage purity of Na2CO3
3. Determination Cu in CuSO4 solution by electrolytic analyzer.
4. Determination of acid value of an oil
5. Determination of saponification value of an oil
6. Determination of iodine value of an oil
7. Preparation of soap and analysis of soap

2. CH 408: Heat Transfer Operations Lab

Course Outcomes: At the end of the course, students 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 demonstratio 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	✓	✓	✓	✓	-	-	-	-	-	-	-	-
CO2		✓	-	-	-	-	-	-	-	-	-	-
CO3	✓	✓	✓	✓	-	-	-	-	-	-	-	-
CO4	✓	✓	✓	✓	-	-	-	-	-	-	-	-
CO5	✓	✓	✓	✓	-	-	-	-	-	-	-	-
CO6	✓	✓	✓	✓	-	-	-	-	-	-	-	-

List of Experiments

1. To determine thermal conductivity of given metal rod
2. Study of Double Pipe Heat Exchanger
3. Study of Shell and Tube Heat Exchanger
4. Study of Study of emissivity of circular discs with and without black coating.
5. Study of Stefan-Boltzman’s constant
6. To determine the surface heat transfer coefficient for a vertical tube losing heat by natural convection.

3. CH 409: Programming Languages Lab

Course Outcomes: At the end of the course, students 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	✓	-	-	-	-	✓	-	-	✓	-	-	-
CO2	✓	-	-	-	-	✓	-	-	✓	-	-	-
CO3	✓	-	-	-	-	✓	-	-	✓	-	-	-
CO4	✓	-	-	-	-	✓	-	-	✓	-	-	-
CO5	✓	-	-	-	-	✓	-	-	✓	-	-	-
CO6	✓	-	-	-	-	✓	-	-	✓	-	-	-

Detailed Syllabus:

Unit I: Problem solving techniques – algorithms. Introduction to computers - Basics of C++ - Number representation, Basic data types - int, float, double, char, bool, void.

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

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

Unit IV: 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

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

Unit VI: 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.

Text / Reference:

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

Laboratory Practice:

1. Simple gauss elimination method
2. Partial pivoting
3. LU decomposition method
4. Newton Raphson method.
5. Bisection method
6. Successive substitution method
7. Least square method
8. Runge-Kutta method
9. Function approximation method