Bansilal Ramnath Agarwal Charitable Trust’s

Vishwakarma Institute of Technology

(An Autonomous Institute affiliated to University of Pune)

Structure & Syllabus of

B.E. (Chemical Engineering)

Pattern ‘A11’

Effective from Academic Year 2011-12

Prepared by: - Board of Studies in Chemical Engineering
Approved by: - Academic Board, Vishwakarma Institute of Technology, Pune

Signed by,

Chairman – BOS  Chairman – Academic Board
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- Please Refer to Academic Information
- Please Refer to F.E. Structure and Syllabi Booklet
- Please Refer GP-PD-OE Structure & Syllabi Booklet
**Program Educational Objectives**

**B.E. (Chemical Engineering)**

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<th>Description of the Objective</th>
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<td>To prepare the students for successful industrial careers and postgraduate education in a global environment.</td>
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<td>To provide the students with a solid foundation in chemistry, physics and mathematics, necessary to address a wide range of chemical engineering problems from conventional chemical engineering design to novel areas such as nanotechnology and biotechnology.</td>
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<tr>
<td>3</td>
<td>To train the students in the chemical engineering principles of equipment design, process design and plant design.</td>
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<td>4</td>
<td>To provide learning opportunity in a broad spectrum of multidisciplinary fields such as nanotechnology, biotechnology, advanced materials, energy engineering, environmental engineering, product design etc.</td>
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<td>5</td>
<td>To train the students in conducting and planning experiments on physical systems and computer simulation tools, analyzing data and preparing technical reports with the aid of computer tools.</td>
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<tr>
<td>6</td>
<td>To promote awareness of life-long learning and to prepare the students for teamwork, leadership and ethical conduct.</td>
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**Program Outcomes**

(a) The graduates will demonstrate ability to apply knowledge of mathematics, science and engineering.
(b) The graduates will demonstrate ability to formulate requirements for and design a chemical engineering system taking into account constraints such as economic, environmental, social, safety, manufacturability and sustainability.
(c) The graduates will demonstrate ability to design and conduct experiments, interpret and analyze data and prepare a technical report of the results.
(d) The graduates will be exposed to the state-of-the-art in one of more fields of their choice from amongst a broad spectrum of fields such as nanotechnology, biotechnology, advanced materials, energy engineering, environmental engineering, product design etc.
(e) The graduates will demonstrate ability to use modern software tools and equipments necessary for engineering practice.
(f) The graduates will possess necessary foundation to pursue higher education and careers in research and academics.
(g) The graduates will demonstrate ability to work in multi-disciplinary teams.
(h) The graduates will demonstrate an awareness of professional and ethical responsibilities.
(i) The graduates will demonstrate effective communication and leadership skills.
(j) The graduates will possess an attitude of life-long learning.
(k) The graduates will be exposed to opportunities to pursue recreational activities of their choice.
MODULE III
# Module III, S.E. Chemical Engineering

(FF 653, Issue No. 3, Rev 01 Dated 02/04/2011)

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<tr>
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<td>Process Calculations</td>
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<td>S3</td>
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<td>Physical and Inorganic Chemistry</td>
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Institute Elective: S.E. Semester I (Irrespective of Module)

| OE3         | CH26101      | Strength of Materials                  | 2 0 0                      | 2       |
# CH20101 :: PROCESS CALCULATIONS

<table>
<thead>
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<th>Credits: 03</th>
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**Prerequisites:** Nil

**Objectives:**
- To understand material balance over a unit with and without chemical reaction.
- To understand energy balance over a unit.
- To understand steady state, unsteady state, recycle, by-pass, purge adiabatic, isothermal, operations and material and energy balance for them.
- Mapping with PEOs : 3 (b)

## Unit I (8 Hrs)
**Basic Chemical Calculations**
A. Dimensions and Units, chemical calculations including mole, equivalent weight, solids, liquids, solutions and their properties, properties of gases.
B. Significance Unit conversions of mass, energy and pressure

## Unit II (8 Hrs)
**Material Balances Without Chemical Reactions**
A. Process flow sheet, Concept, Material balance calculations, recycling and bypassing operations, material balance of unsteady state processes.
B. Material balance of unit operations such as distillation, crystallization

## Unit III (8 Hrs)
**Material Balances Involving Chemical Reactions**
A. Mass balance with chemical reactions, single, multiple reactions, excess and limiting reactants, conversion, yield and selectivity. Material balance with recycle, bypass and purge operation. Material balance of unsteady state processes with chemical reaction.
B. Material balance of metallurgical applications.

## Unit IV (8 Hrs)
**Energy Balance**
A. Specific heat of gases, liquids solids, latent heat of phase change, heat of reaction, energy balance of unit process, combustion of fuels and combustion calculations.
B. Heat of solutions.

## Unit V (8 Hrs)
**Complex Chemical Calculations**
A. Psychometric calculations, Non ideal calculations for gaseous and liquid mixtures, calculations for n number of reactions, simultaneous material and energy balance, adiabatic flame temperature calculations.
B. Applications of spreadsheet software in process calculations.

Text Books

Reference Books
CH20103 :: FLUID FLOW OPERATIONS

Credits: 03  
Teaching Scheme: - Theory 3 Hrs/Week

Prerequisites: Nil

Objectives:
1. To understand the fundamental aspects of fluid motion, fluid properties, flow regimes, pressure variation, fluid kinematics and methods of flow description and analysis.
2. To study the conservation laws in their integral and differential forms, and their use in analyzing and solving the fluid flow problems.
3. Mapping with PEOs : 3 (a,b)

Unit I  (8 Hrs)
Fundamentals of Fluid Flow Operations
A. Fluids and properties of fluids, Newton’s law of viscosity pressure and temperature dependence, introduction to rheology of fluids, types of flow, lines to describe the flow, The basic equation of fluid statics, pressure-depth relationship, pressure forces on surfaces, pressure measurements.
B. Engineering applications of fluid flow operations, pressure measuring devices, rheological classification of fluids

Unit II  (8 Hrs)
Momentum and Energy Balance Equations
A. Mass and energy balance equations, Bernoulli’s equation; variable head and variable area meters.
B. Flow measuring devices

Unit III  (8 Hrs)
Dimensional Analysis and Boundary Layer Theory
A. Fundamental dimension of quantities, dimensional homogeneity, Reyleigh’s method and Buckingham’s π method, concept of hydrodynamic boundary layer, growth over a flat plate, change in nature of boundary layer, and different thicknesses of boundary layer, drag on flat plate, coefficient of drag and its variation
B. Physical significance of dimensionless numbers, hydrodynamic, thermal and concentration boundary layers

Unit IV  (8 Hrs)
Flow through Conduits
A. Shell balance based solutions for laminar flow through circular tube (Hagen Poiseuelle equation), on inclined plane, through annular space, Concept of Reynolds number; transition and turbulent flow in pipes, Darcy-Weisbach equation, friction factor chart.
B. Different pipe fittings and valves
Unit V  
Transportation of Fluids  
(8 Hrs)

A Minor losses and major losses in pipes, concept of equivalent pipe, series and parallel pipe systems, cavitation and water hammer, transportation of fluids, centrifugal pump.
B Compressors, fans and blowers

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<thead>
<tr>
<th>Text Books</th>
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<tr>
<th>Reference Books</th>
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</thead>
</table>
CH20105 :: PHYSICAL AND INORGANIC CHEMISTRY

Credits: 03
Teaching Scheme: - 3 Hrs/Week

Prerequisites: Nil

Objectives:
1. To create an acquaintance with inorganic compounds which are used in different chemical industries.
2. To impart the knowledge about catalytic activity of transition metal complexes which are used in heterogeneous and homogeneous catalysis in industries.
3. To get an insight into surface behavior of materials for the promotion of reactivity.
4. To get an understanding of atomic structure and geometry of organic and inorganic molecules
5. Mapping with PEOs : 2 (a)

Unit I
8 Hrs
Kinetics and Molecule in Motion
A. The kinetic model of gases, Molecular motion in gases & liquids, diffusion. The rates of chemical reactions- experimental techniques, the rates of reactions, integrated rate laws, the temperature dependence of reaction rates. Numerical on reaction rates.
B. Numerical on kinetics and diffusion

Unit II
8 Hrs
Surface Chemistry and Enzyme Catalysis
A. Adsorption and Chemisorptions, adsorption isotherms (Langmuir, Freundlich, B.E.T.), Chemisorptions and Catalysis, Surface Tension, Gibb's isotherm, Classification & properties of colloids, detergency and their industrial applications. Composition of enzymes, international classification of enzymes, cofactors and coenzymes, primary, secondary, tertiary and quaternary structure of enzymes, how it works as catalyst. Industrially important reactions catalyzed by enzymes. Three dimensional structure of enzymes, families of enzymes, structure of enzyme substrate complex and methods of examining them, basic equations of enzyme kinetics, enzyme inhibition.

Unit III
8 Hrs
Transition elements and their complexes
A. Transition elements, study of 1st transition series w.r.t. oxidation states, magnetic behavior, color, ability to form complexes and catalytic behavior. Coordination compounds-different terms-C.N., ligands, EAN, etc. Nature of metal ligand bonding-VBT and CFT- Formation and above properties of tetrahedral square planar and octahedral complexes of 1st transition series on the basis of VBT and CFT. Organometallic catalysis chemistry.

B. Calculation of CFSE, General principles of catalysis.

Unit IV 8 Hrs
Thermodynamics

B. Carnot cycle, entropy, mathematical statement of 2nd law of thermodynamics, application of second law, statement of 3rd law. Refrigeration cycle

Unit V 8 Hrs
Volumetric Properties of Pure Fluids
A. The PVT behavior of pure substance, the viral equation, Compressibility factor, the ideal gas, the constant volume, constant pressure, adiabatic, polytrophic processes, real gas, applications of Viral equation, critical properties, Vander Wall equation.

B. Benedict - Webb – Rubin equation, Redlich –Kwong equation, Peng Robinson Equation.

Text Books

Reference Books
CH21101 :: CHEMICAL ENGINEERING MATERIALS

Credits: 03  
Teaching Scheme: - Theory 3 Hrs/Week

Prerequisites: Nil

Objectives:
- To understand mechanical properties of materials
- To understand profile of methods used for testing and characterization of materials
- To understand the structure-property relationship in the materials and material selection criteria for suitable utility
- To understand phenomenon of corrosion and methods to combat it
- Mapping with PEOs : 3 (b)

Unit I (8 Hrs)
Introduction
A] Introduction to materials and their principle properties, Simple stresses and strains, Concept of stress, strain, shear stress, shear strain, Hooks law, Elastic limit, stress-strain curve for mild steel and elastomeric materials, factor of safety, Poisson’s ratio
B] Strain energy due to axial load and impact.

Unit II (8 Hrs)
Materials Testing
A] Testing of materials, destructive and nondestructive tests, structure of atom and chemical bonds, crystal structures and their influence on material properties
B] Deformation and slip processes.

Unit III (8 Hrs)
Alloys & Phase Equilibrium diagrams
A] Iron – carbon diagram, Ferrous and nonferrous alloys, mild steel, special steels, stainless steels, brasses, aluminum alloys and titanium alloys, high and low temperature material, insulation, refractories.

Physical transformation of pure substances -The stability of phases, phase boundaries, three typical phase diagrams. The thermodynamic criterion of equilibrium, the dependence of stability on the conditions, the location of phase boundaries, the physical liquid surfaces.
B] Phase diagrams , basic concept, phase rule, Methods for fabrication, rolling, bending, central punching, revetting, welding.

Unit IV (8 Hrs)
Corrosion its control
A. Different types of corrosion: chemical, biochemical, and electrochemical; Internal
and external factors affecting corrosion of chemical equipments, Methods to minimize corrosion, corrosion charts for process equipments.

B. Corrosion measurement – apparatus, monitoring, control

Unit V (8 Hrs)

Polymers & Ceramics

A. Selection of polymeric materials for chemical equipments, fiber reinforced plastic, applications of special polymers like Nylon 66, Teflon in engineering. Crystalline and non-crystalline ceramics, silicates, refractories, clays

B. Cements, cements, glass vitreous silica, and borosilicate, abrasives

Text Books


Reference Books

**CH20201 :: PROCESS CALCULATIONS (Tutorial)**

<table>
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<th>Credits: 01</th>
<th>Teaching Scheme: - Tutorial 1 Hr/Week</th>
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</table>

**Prerequisites:** Nil

**Objectives:**
- To practice problem solving in process calculations.
- Mapping with PEOs: 3 (b)

**List of Contents**

**TERM-WORK**

1. Solve problems based on units and conversions
2. Solve problems based on material balance without chemical reaction.
3. Solve problem of recycle without chemical reaction
4. Solve problem of bypass and purge
5. Solve problems based on material balance with chemical reaction
6. Solve problems based on energy balance
7. Solve problems based on unit operations

**Text Books**


**Reference Books**

## CH20203 :: FLUID FLOW OPERATIONS (Tutorial)

<table>
<thead>
<tr>
<th>Credits: 01</th>
<th>Teaching Scheme: - Tutorial 1Hr/Week</th>
</tr>
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</table>

### Prerequisites:
Nil

### Objectives:
- To work out examples on fluid flow operations
- Mapping with PEOs: 3 (a, b)

### List of Content
1. Assignment based on fluid properties and Newton’s law of viscosity, fluid statics and manometers
2. Assignment based on continuity equation and energy balance equation
3. Assignment on variable head meters
4. Assignment based on dimensional analysis
5. Assignment based on boundary layer, drag force and drag coefficient
6. Assignment based on laminar flow through pipes
7. Assignment based on major and minor losses in pipes, fluid flow in series and parallel pipe systems

### Text Books

### Reference Books
# CH20303 :: FLUID FLOW OPERATIONS LABORATORY

| Credits: 01 | Teaching Scheme: - Laboratory 2 Hrs/Week |

### Prerequisites:
Nil

### Objectives:
- To understand the basic principles of fluid flow and working of fluid flow devices
- Mapping with PEOs : 3 (b)

### List of Practical
Required to perform minimum 6-8 practical from the list given below:

1. Determination of viscosity of fluid by Redwood viscometer
2. Verification Bernoulli equation
3. Calibration of orificemeter
4. Calibration of venturimeter
5. Calibration of rotameter
6. Determination of frictional losses in pipes
7. Reynolds experiment
8. Determination of operating characteristics of centrifugal pump

### Text Books

### Reference Books
CH20305 :: CHEMISTRY AND MATERIALS LABORATORY

Credits: 01  Teaching Scheme: - Laboratory 2 Hrs/Week

Prerequisites: Nil

Objectives:
1. To create an acquaintance with inorganic compounds which are used in different chemical industries.
2. To develop the analytical ability among students and to develop skills in the Chemical Engineering material subject.
3. Mapping with PEOs: 2, 3, 5 (a, b, c, e)

List of Practical
Physical And Inorganic Chemistry Laboratory (Any four)-
1. Determination of surface tension of solution.
2. Estimation of copper from brass.
3. Experiments on pH meter and conductivity meter (any one).
4. Preparation of transition metal complex.
5. Estimation of Ba metal from the solution gravimetrically.
6. Study on adsorption isotherm.

Chemical Engineering Materials Laboratory (Any four)-
1. Brinell hardness test on different materials.
2. Poldt hardness test on different materials.
3. Izod and Charpy impact tests.
4. Study and drawing of microstructures of mild steel, medium carbon steel, eutectoid steel and hypereutectoid steel.

Text Books

Reference Books
CH26101 :: STRENGTH OF MATERIALS

Credits: 02 | Teaching Scheme: - Theory 2 Hrs/Week

Prerequisites: Nil

Objectives:
- To understand and predict physical phenomena to lay the foundation for engineering applications.
- To develop logical approach and reasoning for analysis and design of engineering applications / unfamiliar situations.
- To provide necessary background for deformable bodies and mechanics of fluids.
- Promotion of processes of : problem solving abilities , experimental, observational, manipulative, decision making and investigatory skills in the learners.
- Mapping with PEOs : 3 (a,b)

Unit I (5+1Hrs)

[A] Stress And Strain:
Types of Actions: (axial loading, bending moment, shear force, torsion, combined axial loading-bending and torsion), Types of Stresses (Normal, shearing, bearing, bending), Normal stress and strain under axial loading, Hooke’s law, modules of elasticity and rigidity, design considerations viz ultimate strength of material, allowable stress, factor of safety. Deformation of members under axial loading, axial force diagram, Poisson’s ratio, generalized Hooke’s law, bulk modules,

[B] Self Study:
Stress-strain diagram for ductile and brittle material, inter-reaction between elastic constants, selection of an appropriate factor of safety, axial deformation in indeterminate members.

Unit II (5+1Hrs)

[A] Shear Force and Bending Moment:
Shear force and bending moment diagram of determinate beams due to concentrated loads, uniformly distributed loads, uniformly varying loads and couples, concept of pure bending, relations among distributed load, shear force and bending moment,

[B] Self Study: Construction, of loading diagram from shear force diagram and/or bending moment diagram,

Unit III (5+1Hrs)

[A] Moment of Inertia of Areas:
Use of parallel and perpendicular axis theorem, polar moment of inertia, radius of
gyration moment of inertia of composite areas.

**Bending Stresses in Beams:**
Application of flexural formula Bending stress distribution diagrams.

**Shearing Stresses in Beams:**
Application of shear stress formula, shear stress distribution diagrams.

[B] Self Study:
Assumptions in pure bending, Derivation of flexural formula and shear stress distribution in beams.

**Unit IV**

(A)

**Slope and Deflection in Beams:**
Slope and deflection of determinate beams using Macaulay’s method

**Axially Loaded Columns:**
Buckling of column, concept of actual length and equivalent length for various end conditions. Applications of Euler’s and Rankine’s formula.

[B] Self Study:
Derivation of formulae for slope and deflection for standard cases of simply supported and cantilever beams.
Derivations of Euler’s formula for buckling load of column with hinged ends
Derivations of Rankine’s formula for column.

**Unit V**

(A)

**Transformation of Stress and Strain:**
Derivation of transformation of plane stress, principal stresses and maximum shearing stress and their locations of planes, Mohr’s circle for plane stress.

[B] Self Study:
Derivation of principal stresses, maximum shearing stress and their location of planes, derivation of Mohr’s circle of plane stress.

**Text Books**
Mechanics of materials by Gere and Timoshenko, C.B.S, Publishers and distributors, New Delhi

**Reference Books**
MODULE IV
## Module IV, S.E. Chemical Engineering
(FF 653, Issue No. 3, Rev 01 Dated 02/04/2011)

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CH21102 :: DIFFERENTIAL EQUATIONS

Credits: 03  |  Teaching Scheme: - Theory 3 Hrs/Week

Prerequisites: Engineering Mathematics I and Engineering Mathematics II

Objectives:
By the end of this module students are expected to demonstrate the knowledge of
- Linear differential equations for modeling of a linear systems and its solutions by classical and transform techniques.
- Cauchy-Riemann equations, Contour Integration.
- Complex Fourier series and frequency spectrum, Fourier transforms and its properties.
- Derivative of vector functions and integration of vector functions and their applications in science and engineering.
- Partial differential equations and transforms such as Fourier and Laplace Transforms.
- Chemical engineering applications of the theory portion covered will be emphasized.
- Mapping with PEOs : 2 (a)

Unit I  (8 Hrs)
Linear Differential equations of higher order

Unit II  (8 Hrs)
Complex Analysis
Derivative, Analytical function, Cauchy-Riemann equations, Complex Integration, Cauchy’s Integral Theorem and formula, Residue Theorem and applications to Engineering Problems.

Unit III  (8 Hrs)
Fourier and Laplace Transforms

Unit IV  (8 Hrs)
Vector Calculus

Vector and scalar functions & fields, Derivative, Gradient of a scalar field, Directional derivative, Divergence and curl of a vector field, vector identities, Irrotational and solenoidal vectors and potential functions, line and surface integrals, Green’s, Stoke’s and Gauss theorems and applications to Engineering Problems.

Unit V (8 Hrs)
Applications of Partial Differential equations


Unit VI (8 Hrs)
Self Study


Text Books

Reference Books

Additional Reading
CH20102 :: CHEMICAL ENGINEERING THERMODYNAMICS

Credits: 03  
Teaching Scheme: - Theory 3 Hrs/Week

Prerequisites: Nil

Objectives:
- To understand the fundamental concepts of chemical engineering
- To introduce students to thermodynamics for application to Chemical Engineering.
- To solve complex chemical engineering problems using thermodynamic concepts, data, and models.
- Mapping with PEOs : 3 (a,b)

Unit I
Thermodynamic Properties of Fluids

A. Maxwell relationships, homogeneous phases, residual properties, residual properties by equations of state, two-phase systems

B. Clausius-Clapeyron equation, tables and diagram of thermodynamic properties.

Unit II
Solution Thermodynamics

A. Fundamental property relations, chemical potential, criteria for phase equilibrium, partial properties, ideal gas mixtures, fugacity and fugacity coefficients for pure species, for species in solution, ideal solutions,

B. generalized correlations, van Laar equation,

Unit III
Solution Thermodynamics Applications

A. Excess properties, VLE data- fugacity, Activity coefficients, Excess Gibb’s energy, Margules equation, NRTL, UNIQUAC

B. Wilson, Property changes of mixing

Unit IV
Phase Equilibria

A. Vapour – liquid equilibrium: The nature of equilibrium, criteria of equilibrium, phase rule, Duham’s theorem, Raoult’s law, VLE by modified Raoult’s law, dew point and bubble point calculations, Flash calculations, Determine whether azeotrope exist, Equilibrium and stability

B. liquid -liquid equilibrium, solid liquid equilibrium, VLL equilibrium
Unit V

**Chemical Reaction Equilibria**

**(9 Hrs)**

A. Criteria for equilibrium to chemical reactions, the standard Gibbs free energy change and the equilibrium constant. Effect of temperature on equilibrium constant, evaluation of the equilibrium constant, relation of equilibrium constant to composition, calculation of equilibrium conversion for single reaction

B. The phase rule and Duhem’s theorem for reacting systems, multireaction Equilibria

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**CH20104 :: HEAT TRANSFER**

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<th>Credits: 03</th>
<th><strong>Teaching Scheme:</strong> - Theory 3 Hrs/Week</th>
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**Prerequisites:** Nil

**Objectives:**
1. To develop a good understanding of physical principles underlying heat transfer.
2. To understand the methodology and the quantitative approach of the process engineer and to be able to use this approach in problem solving.
3. Mapping with PEOs : 3 (b)

**Unit I**

**Conduction Heat Transfer**

A. Introduction to heat transfer, conduction heat transfer, convection heat transfer, radiation heat transfer Fourier’s law of heat conduction, thermal conductivity, general differential equation for conduction heat transfer, steady state heat conduction through a plane slab, composite slab, hollow cylinder, composite cylinder and hollow sphere, thermal insulation and critical thickness of insulation

B. Thermal conductivity of materials, insulators, engineering applications of heat transfer

**Unit II**

**Convection without Phase Change**

A. Newton’s law of cooling, individual and overall heat transfer coefficient, natural and forced convection systems. Heat transfer from extended surfaces with uniform cross section, thermal boundary layer, dimensional analysis in heat transfer, dimensional analysis by Rayleigh’s method and Buckingham’s method

B. Natural and forced convection systems, different types of fins

**Unit III**

**Convection with Phase Change and Radiation**

A. Condensation: Modes and features: Theory and derivation of Nusselt’s equation, Condensation on vertical plate and horizontal plate. Heat transfer in boiling liquids: Pool boiling of saturated liquid, Concept of maximum heat flux and critical temperature drop. Fundamental facts and definition of terms radiation heat transfer, basic equation of heat transfer by radiation, various cases of radiation between two surfaces, the shape factor, radiation shields

B. Condensers and boilers, radiation heat transfer systems

**Unit IV**

**Heat Exchangers**
A. Classification of heat exchangers, double pipe heat exchangers, Shell and tube heat exchangers, fouling factors, LMTD and NTU methods for heat exchanger calculation to estimate heat transfer area and overall heat transfer coefficient
B. Different types of heat exchangers, compact heat exchangers

Unit V

Evaporation

A. Evaporation, material and energy balance, calculations, performance, capacity and economy, single and multiple effect evaporators, effect of liquid head and boiling point elevation
B. Different types of evaporators

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CH20106 :: ORGANIC CHEMISTRY

<table>
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<tr>
<td>Objectives:</td>
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<tr>
<td>• To get acquainted with organic compounds which are used in different chemical industries.</td>
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<tr>
<td>• To develop different chemical synthesis processes.</td>
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<td>• Mapping with PEOs : 2 (a)</td>
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</tbody>
</table>

Unit I 8Hrs
Structural Effect and Reactivity
A. Benzene and aromaticity, concept of aromaticity (4n+2), conditions necessary for demoralization, breaking and formation of bonds (Reaction intermediate). Factors affecting electron availability – Inductive effect, Resonance effect (resonance structures of naphthalene, anthracene, aniline, phenoxide ion, benzaldehyde, nitrobenzene, etc.), hyperconjugation, steric effect, tautomerism. Effects of resonance, inductive effect, steric effect on pKa, and pHb value of simple acid and bases. Types of reactions, types of reagents.
B. Acidity and basicity of organic compounds, pKa and pHb terms.

Unit II 8Hrs
Equilibria, rates and mechanisms
A. Equilibrium constant variation with the reactant and product, product formation, entropy of reaction, Equilibrium constant variation with the temperature. Kinetics of reaction. Kinetia versus thermodynamic products, solvents effects in product formation. Determination of reaction mechanism- Hammet relationship, detection of intermediates.
B. Methods for investigation of mechanism.

Unit III 8Hrs
Reaction Mechanisms
A. Mechanism of reaction involving carbonium ion intermediates:
Nucleophilic substitution – Hydrolysis of alkyl halide (SN1 Mechanism). Also discuss SN2 mechanism and factors affecting SN reactions. Electrophilic substitution in benzene and mono-substituted benzene nitration, sulphonation, halogenation, Friedel Craft alkylation and acylation. Electrophilic addition to C=C, polar addition of hydrogen halides and water, alkylation, dimerisation, oxidation of alkene to form epoxide.
Elimination’s - E1 reaction s in acid catalyzed dehydration of alcohols, base catalyzed dehydro- halogenation of alkyl halides, comparison of elimination with substitution. Also
cover E2 mechanism. Rearrangement-Beckman rearrangement. Baeyer- villager reaction.

B. Carbanion, Breaking and making of bonds, Energetic of reaction.

Unit IV 8Hrs
Mechanism of reactions involving carbanion intermediates.


B. Classification of organic reactions, Carbanion and free radical generation and their stability order.

Unit V 8Hrs
Stereochemistry

A. Stereochemistry: Basic concepts of Stereochemistry, conformational isomerism of ethane, propane, butane, cyclohexane. Optical isomerism with one, two chiral centres (AA and AB types), erythro, threo , meso distereoisomers. Geometrical isomerism (compounds containing one double bond). Resolution and diastereoselectivity.

B. Conformational isomerism of monosubstituted cyclohexane, Problems on designation of organic compounds.

Text Books

Reference Books
**CH21202 :: DIFFERENTIAL EQUATIONS (Tutorial)**

**Credits:** 01  
**Teaching Scheme:** - - Tutorial 1 Hr/Week

**Prerequisites:** Nil

**Objectives:**
- This module is a full one semester course taken by all second year chemical engineering students. It starts with Linear Differential equations of higher order, complex analysis, Fourier, Laplace Transforms, Vector Calculus and Applications of Partial Differential equations. The Engineering Mathematics – III emphasizes both theoretical foundations of the above stated topics and it is intended to enable students to recognize mathematical structures in practical problems, to translate problems into mathematical language and apply engineering mathematics to solve them.
- Upon completion of this module students will be able to:
  - Recognize mathematical structures in practical problems.
  - Translate problems into mathematical language and analyze problems using methods from all the units.
- Mapping with PEOs : 2 (a)

**List of Contents**

In this module students will work on problems to practice and apply methods introduced in the lectures. Discussions of problems in small groups is always encouraged and facilitated and students are asked to submit weekly home work assignments and provide them immediate feedback and support materials.

**Tutorial No. 1:** Summary on higher order linear differential equations, solution of homogeneous and non homogeneous equations, complementary solution, particular solution by method of undetermined coefficients and problems solving.

**Tutorial No. 2:** Summary on method of variation by parameters, Euler – Cauchy Equation, system of ODE, application to chemical engineering problems and problems solving.

**Tutorial No. 3:** Summary on Functions of complex variables, Differentiation of functions of complex variables, Analytic functions, Harmonic functions, Harmonic conjugate, complex potential, orthogonal trajectories and problems solving.

**Tutorial No. 4:** Summary on Integration of functions of complex variables, integration along a path, Cauchy’s theorem, Cauchy’s integral formula, Cauchy’s residue theorem and problems solving.
Tutorial No. 5: Summary on Fourier series, Complex form of Fourier series, Fourier integral representation, Sine and Cosine representations, Fourier transform, Sine transform, Cosine transform and corresponding inverse and problems solving.

Tutorial No. 6: Summary on Laplace transform its properties and theorems on Laplace transform and problems solving. Summary on Unit step function, Dirac Delta function, Periodic functions and problems solving.

Tutorial No. 7: Summary on Inverse Laplace transform, properties of inverse Laplace transform, solution of differential equations by Laplace transform method and problems solving.

Tutorial No. 8: Summary and problem solving on Directional derivative, Divergence and curl of a vector field, vector identities.

Tutorial No. 9: Summary and problem solving on Irrotational and solenoidal vectors and potential functions, line and surface integrals.

Tutorial No. 10: Summary and problem solving on Greens, Stokes and Gauss theorems.


Tutorial No. 13: Summary and problem solving on solution of PDE involving Bessel functions.

Text Books

Reference Books

Additional Reading
CH20202 :: CHEMICAL ENGINEERING THERMODYNAMICS  
(Tutorial)

Credits: 01  
Teaching Scheme: - Tutorial 1 Hr/Week

Prerequisites: : Nil

Objectives:
- To solve complex chemical engineering problems using thermodynamic concepts, data, and models.
- Solve problems in Chemical Engineering Thermodynamics
- Mapping with PEOs : 3 (a,b)

List of Contents

Solution of Numerical based on Unit I to Unit V from Chemical Engineering Thermodynamics course.

Text Books

Reference Books
**CH20304 :: HEAT TRANSFER LABORATORY**

**Credits:** 01  
**Teaching Scheme:** - Laboratory 2 Hrs/Week

<table>
<thead>
<tr>
<th>Prerequisites: Nil</th>
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</table>

**Objectives:**
- To understand the basic principles heat transfer by conduction, convection and radiation
- Mapping with PEOs: 3,5 (b,c)

**List of Practical**
Required to perform minimum 6-8 practical from the list given below:

1. Determination of thermal conductivity of insulating powder
2. Determination of thermal conductivity of composite wall
3. Determination of thermal conductivity of a metal rod and to study effect of temperature on its thermal conductivity.
4. Determination of heat transfer coefficient for convection heat transfer
5. Determination of efficiency and effectiveness and efficiency of fin
6. Verification of Stefan-Boltzmann constant
7. Determination of emissivity of a non black surface
8. Determination critical heat flux in pool boiling
9. Study of heat exchangers

**Text Books**

**Reference Books**
CH20306 :: CHEMISTRY LABORATORY

Credits: 01  
Teaching Scheme: - Laboratory 2 Hrs/Week

Prerequisites: Nil

Objectives:
- To create an acquaintance with organic compounds which are used in different chemical industries.
- To develop different chemical synthesis processes.
- To make the students understand the mechanism underlying various reactions.
- Mapping with PEOs : 2,5 (a,c)

List of Practical

1. Purification of organic compound by recrystalization and sublimation and to find their physical constants (any two compounds).
2. Organic qualitative analysis - preliminary tests, type, elements, functional group and physical constants- atleast one function from each type.
3. Acids- benzoic acid, salicylic acid, phthalic acid, oxalic acid, acetic acid.
4. Phenols- α naphthol, β naphthol, resorcinol, O-nitrophenol, P-nitrophenol
5. Bases- Aniline, p-toludine, diphenylamine
6. Neutral- Benzaldehyde, glucose, acetone, ethylmethyl ketone, ethyl acetate, naphthalene, nitrobenzene, urea, thiourea, m- dinitrobenzene.
7. Preparation of m-nitroaniline from m-dinitrobenzene.
8. Alizarin - Theory explanation, and analysis of product.
10. Methyl orange- Theory explanation, and analysis of product.

Text Books

Reference Books:
MODULE IV
## Skill Development Courses (SD3/SD4), S.E. Chemical Engineering

<table>
<thead>
<tr>
<th>Subject Code</th>
<th>Subject Name</th>
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</thead>
<tbody>
<tr>
<td>CH24301</td>
<td>Computing in MS Excel</td>
</tr>
<tr>
<td>CH24302</td>
<td>Chemical Synthesis</td>
</tr>
<tr>
<td>CH24303</td>
<td>Pipe Stress Analysis Using CAESAR-II</td>
</tr>
<tr>
<td>CH24304</td>
<td>Water Treatment</td>
</tr>
<tr>
<td>CH24305</td>
<td>Heat Exchanger Simulation Using HTRI</td>
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<tr>
<td>CH24306</td>
<td>Industrial Visits</td>
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<tr>
<td>CH24307</td>
<td>Analytical Techniques</td>
</tr>
<tr>
<td>CH24308</td>
<td>Scilab</td>
</tr>
</tbody>
</table>
CH24301 :: COMPUTING IN MS EXCEL

Credits: 01  
Teaching Scheme: - Laboratory 2 Hrs/Week

Prerequisites: Nil

Objectives:

- To expose the students to the use of a spreadsheet for technical computations
- Mapping with PEOs: 4,5 (c, d, e)

List of Practical (any 8)

1. Introduction to Ms Excel & basic commands.
2. Introduction to higher level commands.
4. To study material balance problems with excel.
5. To study energy balance problems with excel.
6. Import & Export of data.
7. Solving Heat transfer problem with excel.
9. Different operation on Matrix with excel.
10. Solving different numerical methods.
11. To study preparation of mass balance.
12. Interfacing of excel with Mat lab.

Text Books


Reference Books

<table>
<thead>
<tr>
<th>Prerequisites: Nil</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objectives:</strong></td>
</tr>
<tr>
<td>• The focus of the course is on understanding strategies and methods used in chemical synthesis for a wider range of applications.</td>
</tr>
<tr>
<td>• The course intends to train students in the use of research methods and techniques involved in the discovery and development of chemical species.</td>
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<tr>
<td>• Mapping with PEOs: 4, 5 (c, d, e)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>List of Practical</th>
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</thead>
<tbody>
<tr>
<td>1. Synthesis of Aspirin—different route of synthesis, explanation, and analysis of product.</td>
</tr>
<tr>
<td>2. Halogenation of cyclo alkanes—Theory explanation, and analysis of product.</td>
</tr>
<tr>
<td>3. Disintegration of hazardous organic dyes using catalyst—preparation of catalyst, Theory explanation, and analysis of product.</td>
</tr>
<tr>
<td>5. Alizarin—Theory explanation, and analysis of product.</td>
</tr>
<tr>
<td>6. Isatin from indigo—Theory explanation, and analysis of product.</td>
</tr>
<tr>
<td>7. Methyl orange—Theory explanation, and analysis of product.</td>
</tr>
<tr>
<td>8. Cinnamic acid (Perkin's reaction)—Theory explanation, and analysis of product.</td>
</tr>
<tr>
<td>9. Benzoylaceton (Claisen's reaction)—Theory explanation, and analysis of product.</td>
</tr>
</tbody>
</table>

<table>
<thead>
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<th>Text Books</th>
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<tr>
<th>Reference Books</th>
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</table>
CH24303 :: PIPE STRESS ANALYSIS USING CAESAR-II

Credits: 01

Teaching Scheme: - Laboratory 2 Hrs/Week

Prerequisites: Nil

Objectives:
1. To use various software to solve problems in chemical engineering.
2. To learn the details of applications problems and how any technical report can be prepared.
3. Mapping with PEOs : 4,5 (c, d, e)

List of Practical
Around Two Practical per unit on the topic mentioned below:
1. Given a line sketch isometric - Input pipe run data into CAESAR-II select pipe supports as given and Entering vendor data into CAESAR-II and learn stress calculation; changes for various nations.
2. Static pipe stress analysis. Use XYZ coordinates and pipe connection basics as given data and re-do layout and stress analysis simulation. Learn to save costs.
3. Static pipe stress analysis. Solve Tutorial. Linear dynamic analysis. Given pipe network flow simulation data and design constraints that cavitation can occur under certain constraints add static and linear dynamic stress analysis to clear the design to lie much below the maximum allowable stress.
4. Linear dynamic analysis. A Tutorial. Changes in pressure and temperature rating for header (main) and branch pipes modular design (simulation results) and safe piping system design.
5. Pipe network simulation and safety rules as per codes. Re-design piping system to include static and linear dynamic stress analysis. Piping class components and static and linear dynamic stress analysis.
6. Preparation of specification sheets as per ASME Codes and industry job skill specifications.

Text Books

Reference Books
CH24304 :: WATER TREATMENT

Credits: 01  
Teaching Scheme: - Laboratory 2 Hrs/Week

Prerequisites: Process calculations; basic chemistry and instrumentation used in analytical chemistry.

Objectives:
- To learn how to design water treatment plant for various types of industrial and other system applications.
- To learn to analyze the water/thick slurry and form design philosophy which begins with collection of design data to start plant design activities.
- Mapping with PEOs: 4, 5 (c, d, e)

List of PracticalS
Around Two Practical per unit on the topic mentioned below:
1. Types of Unit processes used in design of water treatment plant; and design & synthesis of water treatment trains. Given various surrogate measures and data, and system requirements, prepare a process flow sheet and design the water treatment plant.
2. How to treat a thick slurry coming as waste from a chemical plant? (Any two water treatment plant design applications.) How to collect data on organic contaminants and bacterial/viral microbial content, and, design a drinking water purifier (Use industrial specifications.)
4. Water treatment plant design for re-use of process water for boiler feed to produce steam. Design and synthesis of membrane modules available as industry products to design industrial water processing systems (also study relative cost benefits.).
5. Equilibrium stage designs as treatment steps which use membrane modules to be included in process plants & utilities. Life cycle analysis and synthesis of a water treatment plant. Example of an industrial chemical plant and that basic data is available by SimaPRO 7.3 provider.

Text Books
1. “Water Treatment Unit Processes: Physical and Chemical (Civil and Environmental Engineering)” by David W. Hendricks.
Reference Books

2. Coulson & Richardson's Chemical Engineering, vol 2.
CH24305 :: HEAT EXCHANGER SIMULATION USING HTRI

| Credits: 01 | Teaching Scheme: - Laboratory 2 Hrs/Week |

**Prerequisites:** Nil

**Objectives:**
- To use HTRI software to design heat exchangers.
- To learn to use TEMA codes for design of heat exchangers.
- Mapping with PEOs : 4,5 (c, d, e)

**List of Practical**
Around Two Practical per unit on the topic mentioned below:
2. TEMA codes and applications in heat exchanger design, various types of industrial specification for design; correlation equation used in heat exchanger design.
3. Shell and tube heat Exchanger; double pipe heat exchanger; exchanger internals and design of heat exchangers; engineering drawings used in industrial practice.
4. Condenser, types of condenser and design; use of TEMA codes.
5. Evaporators, multi-effect evaporator; use of design; specifications used in design.
6. Air cooled heat exchanger; industrial applications and design; chiller design.

**Text Books**

**Reference Books**
2. Coulson & Richardson's Chemical Engineering, vol 2.
CH24306 :: INDUSTRIAL VISITS

Credits: 1 | Teaching Scheme: - Laboratory 2 Hrs/Week

Prerequisites: NIL

Objectives:
- To introduce the students study of industrial chemical processes by visiting various chemical process industries.
- Mapping with PEOs : 4,5 (c, d, e)

List of Practical
Students will visit minimum three of the below mentioned chemical process industries in and around Pune along with the concerned faculty member. They will study the whole process before visiting the industry. Also they will make detailed report of the visit immediately after visiting an industry.
1 Inorganic chemical industries.
2 Natural product industries.
3 Synthetic organic chemical industries.
4 Polymerization industries.
4 Metallurgical industries
5 Pollution control & toxic chemicals industries

Text Books

Reference Books
### CH24307 :: ANALYTICAL TECHNIQUES

**Credits:** 01  
**Teaching Scheme:** Laboratory 2 Hrs/Week

<table>
<thead>
<tr>
<th>Prerequisites: Nil</th>
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</thead>
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**Objectives:**
- To get acquainted with the sophisticated instruments used in Analytical Chemistry.
- To learn to carry out qualitative and quantitative analysis of samples from various industrial / research areas.
- Mapping with PEOs: 4, 5 (c, d, e)

**List of Practical**
Minimum 6 practicals out of the following:
1) Preparation of a spreadsheet using sample data and Statistical tools.
2) Determination of unknown concentration from the given solution using UV-Vis Spectroscopy
3) Separation of one component sample using HPLC
4) Separation of multi component sample using HPLC
5) Separation of one component sample using GC
6) Separation of multi component sample using GC
7) Separation of a sample using Ion Chromatography
8) Volumetric exercise using pH metry.
9) Volumetric exercise using Conductometry.
10) Determination of structural features using refractometry.

**Text Books**

**Reference Books**
# CH24308 :: SCILAB

**Credits:** 01  
**Teaching Scheme:** - Laboratory 2 Hrs/Week

## Prerequisites:
Nil

## Objectives:
- Scilab is an open source scientific software package for numerical computations providing a powerful open computing environment for engineering and scientific applications. The objective of the course is to solve Example problems and laboratory projects drawn from the Chemical engineering field.
- Mapping with PEOs: 4,5 (c, d, e)

## List of Practical (any 6 to 8)
1. Scilab Basics, Scilab Environment  
2. The Workspace and Working Directory  
3. Matrix Operations  
5. Plotting graph  
6. Functions in Scilab.  
7. Miscellaneous Commands.  
8. Fluid flow problems  
9. Problems will be taken from the areas of material and energy balances, kinetics, data fitting and analysis of experimental data.

## Text Books

## Reference Books
Module V, T.E. Chemical Engineering

Module V, T.E. Chemical Engineering

FF No. : 654
<table>
<thead>
<tr>
<th>Subject No.</th>
<th>Subject Code</th>
<th>Subject Name</th>
<th>Teaching Scheme (Hrs/ week)</th>
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<tbody>
<tr>
<td></td>
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<td>Lect.</td>
<td>Tutorial</td>
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<tr>
<td>S1</td>
<td>CH30101</td>
<td>Chemical Engineering Mathematics</td>
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<tr>
<td>S2</td>
<td>CH31101</td>
<td>Mechanical Design of Equipment</td>
<td>3</td>
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<tr>
<td>S3</td>
<td>CH30103</td>
<td>Mechanical Operations</td>
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<tr>
<td>S4</td>
<td>CH30105</td>
<td>Mass Transfer Operations</td>
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<td>T1</td>
<td>CH30201</td>
<td>Chemical Engineering Mathematics (Tutorial)</td>
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<tr>
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<td>P2</td>
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<td>Mass Transfer Operations Laboratory</td>
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<td>MP5</td>
<td>CH37301</td>
<td>Mini Project</td>
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<td>PD1</td>
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<td>CVV3</td>
<td>CH30405</td>
<td>Comprehensive Viva Voce</td>
<td>Based on courses S2,S4</td>
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</table>
CH30101 :: CHEMICAL ENGINEERING MATHEMATICS

Credits: 03  |  Teaching Scheme: - Theory 3 Hrs/Week

Prerequisites: Nil

Objectives:
- To introduce several computational techniques that are important in the solution of a variety of Mathematical problems that cannot be solved analytically. The sample problems will, for the most part of the course be taken from Chemical Engineering, though occasionally we will consider problems also from other related engineering areas. The methods and skills taught in this course will be valuable for future Chemical Engineering courses.
- Mapping with PEOs : 2 (a, b)

Unit I
(8 Hrs)
System of Linear Equation and Statistical Data Analysis

A. Systems of linear equation using Eigen values and Eigen vector, multiple ODE, Sylvester formulae
Least square method, curve fitting and Regression (linear, multiple linear, polynomial and nonlinear)
B. Gauss Siedel method, Interpolation

Unit II
(8 Hrs)
Numerical Analysis I

A. Root finding methods for algebraic equations (False position method, Newton-Raphson method), Euler’s method, 2nd and 4th order Runge Kutta Method, Trapezoidal rule, Simpson’s 1/3 rule, integration with unequal segments
B. Bisection method, modified Euler’s method, Simpson’s 3/8 rule

Unit III
(8 Hrs)
Numerical Analysis II

A. Properties of finite methods (stability, convergence etc.) Finite difference method, elliptical and parabolic equations, Laplace equation, solution techniques, boundary conditions, explicit and implicit method, Finite Volume method
B. Crank-Nicholson method, Introduction to Finite Element Methods

Unit IV
(9 Hrs)
Optimization
A. Basic concept of optimization and formulation, Nature of optimization problem (constraints and unconstraint), Linear programming by simplex method. 
Unconstraint Optimization problem: Global and local optimization, Region of convex or concave, Indirect methods (Newton’s Method), Direct Methods (Region elimination method, Golden section method) 
B. Hessian Matrix, Quasi-Newton’s Method, Secant Method, Polynomial approximation (Quadratic and Cubic) 

Unit V (7 Hrs)
Tensor Analysis

A. Curvilinear orthogonal system e.g. Expression in these co-ordinate systems for second order tensor such as velocity gradient 
B. Newton’s law of viscosity in tensorial form in Cartesian coordinates 

Text Books

Reference Books
CH31101 :: MECHANICAL DESIGN OF EQUIPMENTS

Credits: 03 | Teaching Scheme: Theory 3 Hrs/Week

Prerequisites: NIL

Objectives:
- To introduce the students the basic considerations in equipment design, materials of construction different types of stresses involved, design of machine elements, design of various types of equipments like pressure vessel, storage vessel, vessel supports and mixers & reaction vessels
- Mapping with PEOs : 3 (b)

Unit I (8 Hrs)
Introduction to Design

A. Nature of design, design factors, degrees of freedom, design variables, optimization, nature of process equipments, general design procedure, basic considerations in design, standards, codes, and their significance, fabrication techniques, equipment classification and their significance, power for rotational motion, drives for process equipments.

Materials of construction. Design considerations- stresses due to static & dynamic loads, design pressure, design temperature, design stress, elastic instability, combined stresses and theories of failure, fatigue, brittle fracture, creep, temperature effect, effects of fabrication methods, economic considerations. Design of machine elements- shafts, keys & pins, couplings, packing & gaskets, stuffing box & gland

B. Joints, bearings, packing & gaskets, stuffing box & gland

Unit II (9 Hrs)
Pressure Vessels

A. Basics, thin & thick wall vessel, main component of vessels, proportioning of pressure vessels, selection of L/D ratio, optimum proportions of vessels.

Design of unfired pressure vessels: Types of pressure vessels, codes and standards for pressure vessels (ASME Sec VIII Div-1, 2), material of construction, selection of material, selection of corrosion allowance and weld joint efficiency, purging of vessels.

Pressure vessels subjected to internal pressure:
Complete design as per ASME Sec VIII Div-1,2 involving Shells: cylindrical, spherical and conical,

Study, selection and design of various heads such as flat, hemispherical, torispherical, elliptical and conical,

Opening/ nozzles, oblique, nozzles and manholes, nozzle sizing, nozzle opening reinforcement calculations etc.

Flanged joints:
Gasket: Types, selection, and design.

Bolt design and selection.

Flange dimensions and optimization for bolt spacing.

Flange rating calculation as per ASME B16.5 and B16.47

Vessel internals like demister pads, spargers, vortex breaker, baffles. Inspection and
testing of pressure vessels.

B. Design of pressure vessels subjected to external pressure as per ASME Sec VIII Div-1, 2, constructional features, materials for high pressure vessels, solid walled vessels, multi shell construction, vessel closures, and jacket for vessels.

Unit III (7 Hrs)
Design of Vessel Supports

A. Types of loads on pressure vessels in addition to internal & external pressure, stresses due to weight, test loads, wind & seismic loads, attached piping, weight directly attached to vessel. Introduction and classification of supports, design of bracket or lug supports-thickness of base plate, gusset plates, column supports for brackets. Design of leg supports- base plate for channel leg support. Design of skirt supports- skirt design, skirt bearing plate, anchor bolt design, design of bolting chair.

B. Design of saddle supports- longitudinal bending moments, stress in shell at the saddle, stresses in the shell at mid-span, wear plates and stiffeners, design of saddles.

Unit IV (8 Hrs)
Storage Vessels

A. Various types of storage vessels and applications, losses in storage vessels, storage of fluids- storage of volatile & non-volatile liquids- fixed roof and variable volume tanks, Various types of roofs used for storage vessels, accessories of floating roof tank. Storage of gases- spherical vessels or hortonspheres. Design of cylindrical storage vessels as per API-650- materials, bottom design, shell design, wind girders for open-top tanks, roof curb angles, self supporting roof design, column supported roof, nozzles and mountings.

B. Design of rectangular tanks as per IS: 804- design without stiffener, design with top-edged stiffener, horizontal and vertical stiffeners, bottom plate.

Unit V (8 Hrs)
Mixers and Reaction Vessels

A. Mixers- Various types of mechanical mixers- propeller, turbines & paddles their selection, flow patterns in agitated tanks, baffling, design practices, standard geometry tank, power dissipation and discharge flow correlation, mechanical agitator design.

B. Reaction vessels- Introduction, classification, heating systems, design of vessels, study and design of various types of jackets like plain, half coil, channel, limpet oil. Study and design of internal coil reaction vessels, Heat transfer coefficients in coils.

Textbooks:
# Reference Books

CH30103 :: MECHANICAL OPERATIONS

Credits: 03  
Teaching Scheme: - Theory 3 Hrs/Week

Prerequisites: nil

Objectives:
- To understand the solid-fluid operations
- To understand working, principles of various mechanical operations.
- Mapping with PEOs : 3 (b)

Unit I  
Particle Technology and size reduction  ( 8 Hrs )
A. Particle size and shape, Mixtures of particles, Determination of particle size, Standard screen series, screen analysis, Screen effectiveness and capacity, Industrial screening equipments. Crushing efficiency, energy requirement calculations by using different crushing laws, Open circuit & Closed circuit grinding.
B. Size reduction equipments.

Unit II  
Storage & Different Operations of Solids  ( 8 Hrs )
A. Storage of solids, characteristics of Bulk solids. Different operations:-Froth flotation, magnetic separator, fiber and fabric filter, electrostatic precipitators, cyclone separator, hydro cyclone.
B. Mineral jig, scrubbers, centrifuges, centrifugal clarifier.

Unit III  
Mixing and Transport of Solids  ( 8 Hrs )
A. Necessity of mixing & agitation in chemical industries, Calculation of power requirement of mixing equipment, Solid – Solid Mixing, Agitator selection. Conveyors: design, calculation of Screw conveyors, Belt Conveyors, Chain & Flight conveyors, Bucket elevators, Pneumatic conveyors
B. Mixing equipment of pastes & viscous material, Mixing equipment of free flowing solids.

Unit IV  
Filtration:  ( 8 Hrs )
A. Filter media and filter aids, classification of filtration, pressure drop through filter cake, filter medium resistance, specific cake resistance, Continuous Filtration, Washing and dewatering of filter cakes, Centrifugal filtration.
B. Filtration Equipments.

Unit V  
Fluid – Solid systems  ( 8 Hrs )
A. Motion of particles in liquid, drag force, drag coefficients, Gravity settling method:
Terminal velocity, Stoke’s law, free settling, sink and float method, differential settling, Sedimentation and thickening: Batch sedimentation, equipments for sedimentation, Kynch theory of sedimentation, calculation of area and depth of continuous thickeners, Fluidization: flow through packed beds, characteristics of fluidized systems, minimum fluidization velocity, types of fluidization.

B. Batch thickeners, and continuous thickeners, applications of fluidization technique, spouted beds and fixed bed.

Text Books

Reference Books
CH30105 :: MASS TRANSFER OPERATIONS

Credits: 03
Teaching Scheme: - Theory 3 Hrs/Week

Prerequisites: Nil

Objectives:
- Apply mass transfer fundamentals to calculate rates of mass transfer for practical situations and to identify rate-limiting processes. Students will understand the importance of diffusion in Mass transfer Operations, Mass transfer without Chemical reaction. Develop familiarity with major chemical process separations units.
- Mapping with PEOs : 3 (b)

Unit I
(8 Hrs)
Introduction to Mass Transfer and Molecular Diffusion

B. Equation of continuity, Study of Raoult’s law, Henrys law, Dimensional analysis for mass transfer and its applications, Simultaneous mass and heat transfer.

Unit II
(8 Hrs)
Equipment for gas liquid operation And Mass Transfer Coefficient

A. Gas dispersal equipments – bubble columns, Liquid dispersal equipments – Venturi scrubbers, wetted wall columns.
Gas dispersed Sparged vessels – flow of gas velocity problems based on aeration tank as a time for sparging Gas hold up.. Liquid hold up – determination of interfacial area based on hold up and MTC. End effects and axial mixing. Determination of mass transfer coefficient through contacting equipment.
B. Tray tower Verses packed tower. Dimensional analysis for mass transfer and its applications, Simultaneous mass and heat transfer.

Unit III
(8 Hrs)
Gas Absorption
A. Mechanism of gas absorption, equilibrium in gas absorption, Two film theory – concept of individual and overall mass transfer coefficient, application of mass transfer theories to absorption, absorption in wetted wall columns, values of transfer coefficient, absorption in packed tower and spray tower, calculation of HETP, HTU, NTU, calculation of height of packed and spray tower. Absorption in tray towers, absorption and stripping factors, calculation of number of trays for absorption
B. Tray efficiencies, absorption with chemical reaction.

Unit IV (8 Hrs)
Humidification, Dehumidification and Drying

B. Psychrometric chart, methods of humidification and dehumidification, equipment like cooling tower, spray dryer, fluidized bed and spouted bed dryer, pneumatic dryer and vacuum dryer.

Unit V (8 Hrs)
Crystallization and Membrane Separation

B. Batch and continuous crystallizers, Numerical based on material and enthalpy balance
Textbooks:

Reference Books
CH30201 :: CHEMICAL ENGINEERING MATHEMATICS (Tutorial)

Credits: 01  Teaching Scheme: - Tutorial 1 Hr/Week

Prerequisites: : Nil

Objectives:
- To solve complex chemical engineering problems using numerical techniques.
- Solve problems in Chemical Engineering Mathematics
- Mapping with PEOs : 2 (a,b)

List of Contents
Solution of Numerical based on Unit I to Unit V from Chemical Engineering Mathematics course.

Text Books

Reference Books
CH31201 :: MECHANICAL DESIGN OF EQUIPMENTS (Tutorial)

Credits: 01
Teaching Scheme: - Tutorial 1 Hr/Week

Prerequisites: NIL

Objectives:
- To introduce the students the basic considerations in equipment design, materials of construction different types of stresses involved, design of machine elements, design of various types of equipments like pressure vessel, storage vessel, vessel supports and mixers & reaction vessels.
- Mapping with PEOs : 3 (b)

List of Contents
A TERM-WORK containing the record of the following:

1. Assignments (Any three of the following)
   a. Problems on introduction to design
   b. Problems on pressure vessel design.
   c. Problems on vessel support design.
   d. Problems on design of storage tanks.

2. Half Imperial Size Drawing Sheets (Any two of the following)
   a. Design of pressure vessels.
   b. Design of skirt support.
   c. Design of storage tanks
   d. Design of mixer.

Textbooks:

Reference Books
**CH30303 :: MECHANICAL OPERATIONS LABORATORY**

| Credits: 01 | Teaching Scheme: - Laboratory 2 Hrs/Week |

**Prerequisites:** Nil

**Objectives:**
- To get hands on experience of different unit operations and should be able to handle them efficiently and independently.
- Mapping with PEOs: 3, 5 (b, c)

**List of Practical (ANY 8)**

1. Properties of solids: To determine Avg. Particle size, Specific surface of mixture and No. of particles in the mixture.
2. Screening: To determine the effectiveness of screen.
3. Sedimentation: To determine area of thickener by conducting batch sedimentation test.
4. Ball mill: To determine crushing law constant (by using Rittingers law, Bonds law and Kicks law).
5. Jaw Crusher: To determine crushing law constant (by using Rittingers law, Bonds law and Kicks law).
6. Vacuum Leaf Filter: To determine filter medium resistance and cake resistance by using vacuum leaf filter.
7. Cyclone Separator: To determine efficiency of cyclone separator.
8. Froth Flotation: To determine separation efficiency using froth flotation.
9. Fluidization: To determine minimum fluidization velocity and verify with Ergun Equation.
10. Drag Coefficient: To determine terminal settling velocity and compare with theoretical settling velocity.

**Text Books**


**Reference Books**

CH30305 :: MASS TRANSFER OPERATIONS

Credits: 01  Teaching Scheme: - Laboratory 2 Hrs/Week

Prerequisites: Nil

Objectives:
1. To provide hands-on experience in performance of mass transfer, separations related processes and equipment.
2. To familiarize students with various methods of data gathering, analysis and reduction.
3. Mapping with PEOs: 3,5 (b,c)

List of Practical(any 6 to 8)
1. To calculate rate of Drying using Tray Dryer and Rotary Dryer.
2. Process of Crystallization and its Characteristics and Batch Crystallization
3. Liquid Diffusion – To calculate the Diffusion Coefficient for a liquid –liquid system
4. Winkelman’s method – To find the diffusion Coefficient of vapour in still air
5. Enhancement Factor – To find the enhancement factor for absorption with and without chemical reaction
6. Mass transfer Coefficient – To determine the Mass Transfer Coefficient for Absorption in a Packed Tower
7. Cooling Tower– To study the characteristics
8. Humidifier and Dehumidifier – To study the Characteristics
9. Interphase Mass Transfer Coefficient – To calculate the individual and overall Mass Transfer Coefficient
10. Wetted Wall Column – To find the mass transfer coefficient in a wetted wall Column
11. Assignment using ASPEN software.

Text Books

Reference Books
CH37301 :: SEMINAR

Credits: 01  
Teaching Scheme: - Laboratory 2 Hrs/Week

Prerequisites: Nil

Objectives:
- To work on a chosen topic, create a technical report and present it.
- Mapping with PEOs : 1,4,5,6 (a-e,g,i,j)

Contents:
Seminar should be based on any latest engineering topic allotted to a group of students. The topic may be defined by the guide in discussion with the group.

Students may undertake studies in research survey, literature review and analysis, synthesis, design and development, generation of new ideas and concept, modification in the existing process/system, development of computer programs, solutions, modeling and simulation related to the subject. Topics of interdisciplinary nature may also be taken up. A detailed literature survey is expected to be carried out as a part of the work. The group of students is required to choose the topic in consultation with the Guide.

A technical report is required to be submitted at the end of the term and a presentation made based on the same. Modern audio-visual techniques may be used at the time of presentation.

Text Books
1. “Project Writing Manual” B.A. Bhanvase, Chemical Engineering Department, VIT, Pune

Reference Books: Nil
Module VI, T.E. Chemical Engineering
(FF 653, Issue No. 3, Rev 01 Dated 02/04/2011)
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### CH30102 :: PROCESS EQUIPMENT DESIGN

| Credits: 03 | Teaching Scheme: - Theory 3 Hrs/Week |

**Prerequisites:** NIL

**Objectives:**
- To introduce the students to design of various types of equipments like heat exchangers, plate and packed towers, filtrations equipments and auxiliary equipments, etc.
- Mapping with PEOs : 3 (b)

#### Unit I (8 Hrs)
**Heat Exchangers**
Introduction, process heat transfer, types of heat exchangers, codes and standards for heat exchangers, materials of construction, API scale, forced convection equation, mean metal temperature, LMTD, caloric temperatures, countercurrent & concurrent exchangers, temperature approach & cross, counter-flow: double pipe exchangers, baffles and tie rods, tube joining methods, design of shell and tube heat exchangers as per IS: 4503 and TEMA standards i.e. shell, tube sheets, channel, channel cover, flanged joints. Condensers & reboilers. Awareness on commercial software for thermal design.

#### Unit II (6 Hrs)
**Evaporators & Crystallizers**
Classification of vaporizing equipment, evaporators (including different types such as kettle, thermosiphon, vertical, horizontal etc.) Chemical evaporators, natural circulation & forced circulation evaporators, the calculation of chemical evaporators, crystallizers, types of crystallizers, design considerations.

#### Unit III (7 Hrs)
**Tray Column Design**
Design of plate column- distillation columns, design variables in distillation, design methods for binary systems, plate efficiency, approximate column sizing, plate contactors, plate hydraulic design.

#### Unit IV (7 Hrs)
**Packed Column Design**
Choices of packing, types of packing, packed bed height (distillation and absorption), HETP, HTU, NTU, Cornell’s method, Onda’s method, column diameter, column internals, column auxiliaries.

#### Unit V (7 Hrs)
**Filters & Dryers**
Study of various types of filters like vacuum filters, pressure filters, centrifuges and rotary drum filters, design of rotary drum filters including design of drum, shaft, bearing and drive system. Types of dryers, batch type dryers, continuous dryers.

**Unit VI**

**Self Study- Auxiliary Process Vessels**

Study of auxiliary process vessels such as reflux drum, knockout drum, liquid-liquid and gas-liquid separators, entrainment separators, oil water separator, Decanter, gravity separator. Safety devices used in process industries, Introduction to design and engineering software.

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CH30104 :: CHEMICAL REACTION KINETICS

Credits: 03
Teaching Scheme: - Theory 3 Hrs/Week

Prerequisite: Nil

Objectives:
- Demonstrate the ability to quantitatively predict the performance of common chemical reactors using simplified engineering models
- Demonstrate the ability to design a set of experiments from which they determine the kinetic model of a multi-reaction system and use this information to design a commercial reactor
- Write a rate law and define reaction order and activation energy
- Mapping with PEOs : 3 (b)

Unit I (8 Hrs)

Unit 1: Kinetics of homogeneous reactions
A. Irreversible and reversible reactions, Equilibrium; Order and molecularity of reaction. Elementary and non elementary reactions; Stoichiometry, Fractional conversion. Rate of reaction based on all components of the reaction and their interrelation. Law of mass action, Rate Constant-Based on thermodynamic activity, partial pressure, mole fraction and concentration of the reaction components and their interrelation,

B. Temperature dependency of rate Constant -Arrhenious law, Transition state theory and collision theory. Temperature and conversion profiles for exothermic and endothermic reactions, Stable operating condition in reactors

Unit II (8 Hrs)

Unit 2: Interpretation of batch reactor data
A. Batch reactor concept, Constant volume Batch reactor system; Design equation for zero, first, Second irreversible and reversible reactions, graphical interpretation of these equations and their limitations, Variable volume Batch reactors. Design equation for first and second order irreversible and reversible reactions, Graphical interpretation of their limitations, Multiple reactions-stoichiometry and Rate equations for series and parallel reactions

B. Multiple reactions-stoichiometry and Rate equations for series and parallel reactions; Non elementary single reactions Development of rate expression; Chain reactions development of rate expressions

Unit III Ideal flow reactors (8 Hrs)
A. Concept of ideality, Types of flow reactors and their differences, Space-time and Space velocity, Design equation for plug flow reactor and CSTR; Design equations for first and second order reversible and irreversible constant volume and variable volume reactor

B. Graphical interpretation of these equations; Mean holding time; Development of rate expression for mean holding time for a plug flow reactor.

Unit IV  
Single and multiple reactor system

A. Size comparison of single reactors; Optimum size determination; Staging of reactors, Reactors in series and parallel; Performance of infinite number of back mix reactors in series, Back mix and plug flow reactors of different sizes in series and their optimum way of staging; Recycle reactors, Optimum recycle ratio for auto-catalytic (recycle) reactors 
Yield and selectivity, Parallel reactions Requirements for high yield, best operating condition for mixed and plug flow reactors, Series reactions

B. Multiple reactions in CSTR and PFR reactors. Maximization of desired product rate in a plug flow reactor and back mixed reactor, product distribution in multiple reactions.

Unit V  
Temperature and Pressure Effects

A. Equilibrium Conversion, Optimum temperature progression, Adiabatic and non adiabatic operations, Temperature and conversion profiles for exothermic and endothermic reactions. 

B Solving problems based on POLYMATHS, ODE, Interpretation of Batch Reactor data, Series and Parallel Reactions, Sizing of Reactor Finding Tau Optimum Etc

Text Books

Reference Books
### CH30106 :: CHEMICAL TECHNOLOGY

<table>
<thead>
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<th>Credits: 03</th>
<th>Teaching Scheme: - Theory 3 Hrs/Week</th>
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#### Prerequisites:
NIL

#### Objectives:
1. To understand how to prepare process flow sheet for a given reaction chemistry.
2. To learn to study scope and basic principles of various unit operations used in chemical process industry and used in plants.
3. To learn about unit process, yield and process economics to study a chemical process technology.
4. Mapping with PEOs: 3 (b)

#### Unit I
(8 Hrs)
**Basic Concepts**

A. Theory of Unit operations and industrial equipment and systems used in large scale plants; Unit processes, Development of flow diagram, schematic representation and application for unit operations and unit processes.
B. Study the selection and process specific applications knowing available industrial equipment and plant accessories.

#### Unit II
(8 Hrs)
**Chlor-Alkali Industry**

A. Chlor-alkali chart and importance of chlor-alkali industry, manufacturing processes process economics, and plants in India and a few examples of latest technology used in other nations; Manufacturing of soda ash, caustic soda, chlorine and engineering problems.
B. Membrane cell, mercury cell diaphragm cell processes and electrolytic cell processes and flowsheets

#### Unit III
(8 Hrs)
**Nitrogen industry**

A. Role of nitrogen in fertilizers, manufacturing of ammonia, nitric acid, urea, the above study must involves different routes adopted, limitations, advantages and disadvantages of the process; steam-reforming process technology.
B. Coal gasification technologies (Fixed bed (Lurgi Process) Fluidised bed (Winkler Process))
Sulfur and Sugar Industry

A. Importance, manufacturing of sulfur by Frasch process, technology for the manufacturing of sulfuric acid.
Sugar Industry: Manufacture of sugar and engineering problems associated, Dextrin and starch derivatives.
B. Detailed study and comparison between chamber and DCDA processes; process economics.

Unit V (8 Hrs)
Phosphorus and Paper Pulp Industry

A. Importance, manufacturing of super phosphate, triple super phosphate, phosphoric acid, electro thermal processes and NPK fertilizers, production of pulp, engineering problems involved, paper manufacturing from pulp, and comparison of methods of manufacturing.
B. Flow sheet and process for manufacture of sulfuric acid and 'phosphate rock'

Textbooks:

Reference Books:
CH30108 :: SEPARATION TECHNIQUES

Credits: 03  
Teaching Scheme: - Theory 3 Hrs/Week

Prerequisites: Nil

Objectives:
1. To present the principles of mass transfer and their application to separation and purification processes.
2. To cover graphical methods of design of Distillation columns, liquid-liquid and solid-liquid extraction.
3. Mapping with PEOs : 3 (b)

Unit I                                                                  (8+1 Hrs)
Distillation -I
B. Packed towers for distillation, NTU, HTU, HETP concept and calculations, distillation column internals.

Unit II                                                                  (8 Hrs)
Distillation-II
A. Ponchon Savarit method for multistage operations, tray efficiencies, concept of multi component distillation. Numerical problems on multi component distillation, steam distillation, positive and negative deviations from ideality, Non ideal distillation-extractive and azeotropic distillation.
B. Numerical problems based on multi component distillation and Ponchon Savarit method.

Unit III                                                                  (8 Hrs)
Liquid – Liquid Extraction
A: Ternary liquid equilibria, single stage extraction, multistage crosscurrent, countercurrent and cocurrent extraction, calculations based on triangular diagrams, x – y co – ordinates and solvent free basis. Continuous countercurrent extraction with reflux, total reflux, stage efficiency

B., Continuous contact extraction in packed towers, HTU and NTU concept

Unit IV

Solid – Liquid Extraction (Leaching)

A. continuous counter current leaching, ideal stage equilibrium, operating time, constant and variable underflow, number of ideal stages, stage efficiencies. Problem based on Calculation of single stage and multistage leaching processes.

B: Leaching equipments,

Unit V

Adsorption and Ion Exchange


B. Equipments: Continuous Contact steady state –moving bed adsorber. Techniques and applications, equipments.

Textbooks
Reference Books

CH30202 :: PROCESS EQUIPMENT DESIGN (Tutorial)

Credits: 01
Teaching Scheme: - Tutorial 1 Hr/Week

Prerequisites: NIL

Objectives:
• To introduce the students to design of various types of equipments like heat exchangers, plate and packed towers, filtrations equipments and auxiliary equipments, etc.
• Mapping with PEOs : 3 (b)

List of Contents

A TERM-WORK containing the record of the following:

1. Assignments (Any three of the following)
   a. Problems on calculation of heat exchangers
   b. Problems on design of evaporators.
   c. Problems on tray column design.
   d. Problems on design of packed columns.

2. Half Imperial Size Drawing Sheets (Any two of the following)
   a. Design of heat exchangers.
   b. Design of tray tower.
   c. Design of packed tower.
   d. Design of auxiliary vessels.

Text Books

Reference Books
CH 30204 :: CHEMICAL REACTION KINETICS (Tutorial)

Credits: 01  
Teaching Scheme: - Tutorial 1 Hr/Week

Prerequisites: : Nil

Objectives:
- Write a rate law and define reaction order and activation energy
- Demonstrate the ability to quantitatively predict the performance of common chemical reactors using simplified engineering models
- Demonstrate the ability to regress the experimental data from which they determine the kinetic model of a multi-reaction system and use this information to design a commercial reactor.
- Mapping with PEOs : 3 (b)

List of Contents
A TERM-WORK containing the record of the following:

1. Assignments :
   a. Preparation of reaction mechanism for the non elementary reaction
   b. Preparation of reaction mechanism for the biochemical reaction derive Michelis Menton kinetics mechanism
   c. Find the overall order of the irreversible reaction using half life period data
   d. Two problems based on best arrangement of in set of series reactors

2. Polymaths program :
   a. Solving problem based on series of reaction, considering differential equationConcentration Profile of a Series Reaction
   b. Polymath Semibatch production distribution profile

Text Books

Reference Books
CH30304 :: CHEMICAL REACTION KINETICS LABORATORY

Credits: 01  Teaching Scheme: - Laboratory  2 Hrs/Week

Prerequisites : Nil

Objectives:
- Write a rate law and define reaction order and activation energy
- Demonstrate the ability to quantitatively predict the performance of common chemical reactors using simplified engineering models
- Demonstrate the ability to regress the experimental data from which they determine the kinetic model of a multi-reaction system and use this information to design a commercial reactor.
- Mapping with PEOs : 3,5 (b,c)

List of Practical

1. To calculate value of rate constant ‘k’ for the saponification of ethyl acetate with NaOH in batch reactor – I (Where M=1)
2. To calculate value of rate constant ‘k’ for the saponification of ethyl acetate with NaOH in batch reactor – II (Where M=2)
3. To calculate value of rate constant ‘k’ for the saponification of ethyl acetate with NaOH in straight tube, colli Bent Tube reactor and CSTR and PFR
4. To calculate value of rate constant ‘k’ for the saponification of ethyl acetate with NaOH in mixed flow reactor.
5. To calculate value of rate constant ‘k’ for the saponification of ethyl acetate with NaOH in mixed flow reactors in series.
6. Verification of Arrhenius law.
7. Autoclave reactor: Reaction CO₂ Carbonization in the reactor
8. Residence time Distribution in PFR and CSTR, Finding Dispersion Number
9. Semibatch Reactor Addition of NaOH in Ethyl acetate, Utilization of POLYMATHS for finding Behavior of products with respective of time
10. Finding τ optimum using polymaths for parallel Reactions
11. Finding conversion and rate of polymerization reactions using gravimetric method

Text Books

Reference Books
**CH30308 :: SEPARATION TECHNIQUES LABORATORY**

**Credits: 01**

**Teaching Scheme:** - Laboratory 2 Hrs/Week

**Prerequisites:** Nil

1. **Objectives:** Apply mass transfer fundamentals to study the performance of various separation devices in practical situations.
2. Analyze the performance of columns with different types of packing (e.g. Raschig rings, berl saddles, structured packings)
3. Support the separation techniques theory course by practical experience.
4. Mapping with PEOs : 3,5 (b,c)

**List of Practical**

1. Simple Distillation
2. Total Reflux
3. Steam Distillation
4. Equilibrium Diagram for Liquid – Liquid Extraction
5. Characterization of Spray Extraction Column
6. Distillation using Sieve Plate, Bubble Cap Column
7. Batch/ Continuous Leaching
8. Adsorption and Ion Exchange
9. Two assignments based on multi component distillation using ASPEN software.

**Text Books**


**Reference Books**

CH37302 :: PROJECT – I

Credits: 02  |  Teaching Scheme: - Laboratory 2 Hrs/Week

Prerequisites: Nil

Objectives:
- Student should be able to apply Chemical Engineering knowledge.
- They should learn How to Work in Team.
- They should learn to take task (problem) and execute it.
- The aim of the project work is to carry out research and development work.
- Mapping with PEOs: 1, 4, 5, 6 (a-e, g, i, j)

Contents:
This stage will include a report consisting of synopsis, the plan for experimental/theoretical work and the summary of the literature survey carried out till this stage. Students may undertake studies in application chemical engineering knowledge for manufacturing project, synthesis, design and development, experimental work, testing on the product or system, generation of new ideas and concept, modification in the existing process/system, development of computer programs, solutions, modeling and simulation related to the subject. Topics of interdisciplinary nature may also be taken up. A detailed literature survey is expected to be carried out as a part of this work. The group of students is required to choose the topic in consultation with the Guide. A technical report of 15 pages is required to be submitted at the end of the term and a presentation made based on the same. Modern audio-visual techniques may be used at the time of presentation.

Text Books
1. “Project Writing Manual” B.A. Bhanvase, Chemical Engineering Department, VIT, Pune

Reference Books: Nil
## Module VII, B.E. Chemical Engineering
(FF 653, Issue No. 3, Rev 01 Dated 02/04/2011)

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## CH40101 :: CHEMICAL REACTION ENGINEERING

### Credits: 03  
**Teaching Scheme:** - Theory 3 Hrs/Week

### Prerequisites:
Nil

### Objectives:
- Define a catalyst, a catalytic mechanism and a rate limit step
- Describe the steps in a catalytic mechanism and how one goes about deriving a rate law and a mechanism and rate limiting step consistent with the experimental data Size isothermal reactors for reactions with Langmuir-Hinschelwood kinetics
- Analyze catalyst decay and conversion for CSTRs and PFRs with temperature-time trajectories, moving bed reactors, and straight through transport reactors
- Demonstrate the ability to predict the effectiveness factor and its impact on the disguise of the intrinsic kinetics of catalytic reactions.
- Mapping with PEOs : 3 (b)

### Unit I  
(8 Hrs)

**Non-Ideal flow**

A. Residence time distribution in vessels: E, F and C curve, and their relationship for closed vessels, conversion in reactors having nonideal flow; models for non-ideal flow:
B. Early and late mixing of fluid, models for partial segregation, mixing of two miscible fluids,

### Unit II  
(8 Hrs)

**Heterogeneous processes:**

A. Global rate of reaction, Types of Heterogeneous reactions, Catalysis, The nature of catalytic reactions, Adsorption: Surface Chemistry and adsorption, adsorption isotherm, Rates of adsorption. Solid catalysts : Determination of Surface area, Void volume and soliddensity, Pore volume distribution, Theories of heterogeneous catalysis,
B. Classification of catalysts, Catalyst preparation Promoters and inhibitors, Catalyst deactivation (Poisoning ). Deactivating catalysts: Mechanism of deactivation, Rate equation for deactivation, Regeneration of catalyst

### Unit III  
(8 Hrs)

**Fluid particle reactions :**

A. Selection of a model for gas-solid non catalytic reaction, Un-reacted core model, Shrinking core model, Rate controlling resistances, Determination of the rate controlling steps, Application of models to design problems.
B. Various contacting patterns and their performance equations
Unit IV  
**Fluid particle reactions :**  
<table>
<thead>
<tr>
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<th>(8 Hrs)</th>
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<tbody>
<tr>
<td><strong>A.</strong> Introduction to heterogeneous fluid - fluid reactions, Rate equation for instantaneous, Fast and slow reaction, Equipment used in fluid- fluid contacting with reaction, Application of fluid -fluid reaction rate equation to equipment design,</td>
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<tr>
<td><strong>B.</strong> Towers for fast reaction, Towers for slow reactions</td>
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Unit V  
**Fluid - solid catalyzed reactions:**  
<table>
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<th>(8 Hrs)</th>
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<tbody>
<tr>
<td><strong>A.</strong> Introduction, Rate equation, Film resistance controlling, surface flow controlling, Pure diffusion controlling, Heat effects during reaction, Various types of catalytic reactors : Fixed bed reactor- construction, operation and design, Isothermal operation, Adiabatic</td>
<td></td>
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<tr>
<td><strong>B.</strong> Experimental methods for finding rates, Product distribution in multiple reactions,</td>
<td></td>
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</tbody>
</table>

**Text Books**  

**Reference Books**  
CH40103 :: INSTRUMENTATION AND PROCESS CONTROL

Credits: 03  |  Teaching Scheme: - Theory 3 Hrs/Week

Prerequisites: NIL

Objectives:
- To understand mathematical modeling and solution procedures of chemical process dynamics
- To understand design of single loop feedback control system
- To have an overview of multivariable and advanced process control systems
- Mapping with PEOs : 3,5 (b)

Unit I (8 Hrs)
Instrumentation
A. Measurement fundamentals. Temperature, flow, pressure, level and composition measuring instruments.
B. Control valves – sizing and valve characteristics.

Unit II (8 Hrs)
Process Dynamics
B. Process identification

Unit III (8 Hrs)
Single loop feedback control
B. Industrial PID controllers

Unit IV (8 Hrs)
Stability check for feedback control systems
B. ratio control, selective control, digital control

Unit V (8 Hrs)
Design of feedback control system using frequency response

A. Frequency response analysis, Design of feedback control systems. PID controller tuning methods such as Bode plot, Ziegler-Nichols. Multiloop and multivariable control

B. Plantwide control, Distributed control systems

<table>
<thead>
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<th>Textbooks:</th>
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<th>Reference Books:</th>
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</table>
CH40201 :: CHEMICAL REACTION ENGINEERING (Tutorial)

Credits: 01

Teaching Scheme: - Tutorial 1 Hr/Week

Prerequisites:
Knowledge of basic principles of unit operations
Knowledge of solution of first-order differential equations
Chemical Reaction Engineering I, POLYMATHS Programming

Objectives:
- Define a catalyst, a catalytic mechanism and a rate limit step
- Describe the steps in a catalytic mechanism and how one goes about deriving a rate law and a mechanism and rate limiting step consistent with the experimental data
- Isothermal reactors for reactions with Langmuir-Hinschelwood kinetics
- Analyze catalyst decay and conversion for CSTRs and PFRs with temperature-time trajectories, moving bed reactors, and straight through transport reactors
- Demonstrate the ability to predict the effectiveness factor and its impact on the disguise of the intrinsic kinetics of catalytic reactions.
- Mapping with PEOs : 3 (b)

List of Contents

A TERM-WORK containing the record of the following:

1. Assignments:
   a. RTD data analysis and model fitting and solutions using POLYMATHS such as mixing model, dispersion model, two parameter model etc
   b. Kinetics model formulation for heterogeneous reaction (Hinshelwood, or Eley ridel mechanism)
   c. Adsorption data analysis and isotherm model fitting

2. A short written paper (<5 pages, double spaced) is required for this assignment. Assignments will be assessed by the content of quantitative kinetic information as opposed to qualitative mechanistic description. A critical approach to quantitative kinetics and reactor design will be considered as a good measure of assignment. An acceptable paper must contain at least three references from peer reviewed journals

Text Books

Reference Books
CH40203 :: INSTRUMENTATION AND PROCESS CONTROL
(Tutorial)

Credits: 01
Teaching Scheme: - Tutorial 1 Hrs/Week

Prerequisites: NIL

Objectives:
• To get better inside to Process dynamics through numericals.
• Mapping with PEOs : 3,5 (b)

List of Assignment

1. Assignment based on Instruments for temperature, pressure, flow, level compositions, their performance criteria and graphs
2. on numerical for laplace transform revision Process Flow Diagram.
3. numerical for first and second order system operation
4. numerical for interacting and no interacting systems.
5. numerical for single loop feedback control
6. numerical for Routh stability criteria,
7. numerical using root locus technique
8. numerical based on design of feedback system using bode plot
9. on numerical using Zigler-Nichols parameters for system tuning.

Textbooks:

Reference Books:
CH40303 :: INSTRUMENTATION AND PROCESS CONTROL
LABORATORY

Credits: 01  Teaching Scheme: - Laboratory 2 Hrs/Week

Prerequisites: NIL

1. Objectives: Carry out experiments to understand:
   a. process dynamics
   b. P, I and D modes of PID controller
   c. PID controller tuning
2. Carry out design of feedback control systems using Matlab
3. Mapping with PEOs : 3,5 (b,c,e)

List of Practicals

1. Measurements for temperature, pressure, flow and level
2. Process dynamics: first order, second order etc
3. PID Controlled system:
4. P, I and D modes
5. Controller tuning methods
6. Level control, flow control, pressure control etc
7. Feedback control system design using Matlab:
8. Plotting root locus, Bode plot, nyquist plot
9. Control system design using the above
10. Dynamic simulation on a chemical engineering simulator such as Aspen Dynamics of Chemical Engineering Systems such as:
11. Tank level control
12. Distillation column control

Textbooks:

Reference Books:
CH40305 :: COMPUTER AIDED CHEMICAL ENGINEERING LABORATORY

Credits: 01
Teaching Scheme: - Laboratory 2 Hrs/Week

**Prerequisites:** Nil

**Objectives:** The objectives of the course are:

- To provide introduction to systematic problem solving methods
- To introduce programming languages as a powerful, broad-based tool which can be used to analyze and solve many Chemical Engineering problems in the undergraduate and industrial environments.
- To solve Example problems and laboratory projects drawn from the Chemical Engineering field whereby the student learns to apply appropriate software or numerical methods.
- Mapping with PEOs : 3,5 (b,c,e)

**List of Practical**

Minimum 6 to 8 practicals

Topics may include but are not restricted to:

1. Eigen values and Eigen vector computations.
2. Root Finding method – single equation
4. Integration of ODE – single equation.
5. Numerical differentiation.
7. Process calculation using MS-EXCEL.
8. Numerical interpolation
9. Data fitting and Regression Analysis.
10. Introduction to Aspen Plus software
13. Linear programming
14. Non-linear optimization methods
15. Advanced method of optimization (e.g.: sequential quadratic programming)
16. Advanced numerical method – method of characteristic, Galerkin method, finite difference methods, methods of lines etc.
17. HAZOP and HAZAN analysis.
18. Design of heuristic.
20. Data reconciliation calculations.
21. Plant scale up calculations from batch data.
22. Solution of under specified and over specified systems.
23. Problems will be taken from the areas of material and energy balances, thermodynamics, transport, kinetics, data fitting and analysis of experimental data and steady state and dynamic modeling

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**CH47301 :: PROJECT – II**

<table>
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<tr>
<th>Credits: 01</th>
<th><strong>Teaching Scheme:</strong> - Laboratory 4 Hrs/Week</th>
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**Prerequisites:** Nil

**Objectives:**
- Student should be able to apply Chemical Engineering knowledge.
- They should learn How to Work in Team.
- They should be learn to take task (problem) and execute it.
- The aim of the project work is to carry out research and development work.
- Mapping with PEOs : 1,4,5,6 (a-e,g,i,j)

**Contents**
This stage will include comprehensive report on literature survey, design and fabrication of experimental setup and/or development of model, relevant computer programs and the plan for stage III.
Students may undertake studies in application chemical engineering knowledge for manufacturing project, synthesis, design and development, experimental work, testing on the product or system, generation of new ideas and concept, modification in the existing process/system, development of computer programs, solutions, modeling and simulation related to the subject. Topics of interdisciplinary nature may also be taken up. A detailed literature survey is expected to be carried out as a part of this work. The group of students is required to choose the topic in consultation with the Guide.
A technical report is required to be submitted at the end of the term and a presentation made based on the same. Modern audio-visual techniques may be used at the time of presentation.

**Text Books**
1. “Project Writing Manual” B.A. Bhanvase, Chemical Engineering Department, VIT, Pune

**Reference Books:** Nil
Module VIII, B.E. Chemical Engineering  
(FF 653, Issue No. 3, Rev 01 Dated 02/04/2011)

<table>
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<tr>
<th>Subject No.</th>
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<td>S5</td>
<td>CH40102</td>
<td>Transport Phenomena</td>
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<tr>
<td>S6</td>
<td>CH40104</td>
<td>Plant Engineering and Project Economics</td>
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<td>S7</td>
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<td>Elective III (See list after module VIII)</td>
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<td>S8</td>
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<td>CH40202</td>
<td>Transport Phenomena (Tutorial)</td>
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<td>Process Modeling and Simulation Laboratory</td>
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<td>P4</td>
<td>CH40308</td>
<td>Design Laboratory</td>
<td>0 0 2 1</td>
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<td>PS3</td>
<td>CH47302</td>
<td>Project Stage III</td>
<td>0 0 3 6</td>
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Module-independent Subject (Offered in Semester II)
### CH40102 :: TRANSPORT PHENOMENA

<table>
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<tr>
<th>Credits: 03</th>
<th>Teaching Scheme: - Theory 3 Hrs/Week</th>
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**Prerequisites:** NIL

**Objectives:**
- To present the unifying treatment of transport processes
- Develop skill for modeling of transport processes with given boundary conditions
- Mapping with PEOs: 3 (a,b,f)

#### Unit I

**Fundamentals of Transport Phenomena**

A. Basics of momentum transport, tensors, 3 dimensional system. Equation of continuity, equation of motion, equation of mechanical energy. Newton’s law of viscosity, temperature and pressure dependence of viscosity for gases and liquids

B. Molecular theory of viscosity for gases

#### Unit II

**Shell Momentum Balances**

A. Shell momentum balances and boundary conditions. Shell momentum balances for flow of falling film, flow through circular tube, flow through annulus, flow of two adjacent immiscible fluids, creeping flow around a sphere.

B. Momentum flux and velocity distribution for flow of Newtonian in pipes

#### Unit III

**Mechanism of Energy Transport and Shell Energy Balances**

A. Fourier law of energy transport and derivation for 3 coordinate system. Dependence of thermal conductivity on temperature, pressure for gases and liquids. Shell energy balances for heat conduction, heat flux and temperature distribution for heat sources such as electrical, nuclear, viscous. Heat flux through composite walls for multidimensional.

B. Dependence of thermal conductivity on temperature for solids

#### Unit IV

**Mass Transport and Concentration Distribution in Solid and Laminar Flow**


B. Mass flux for diffusion into falling liquid film
Unit V  
(8 Hrs)

Turbulence, Macroscopic balances for multicomponent system

A. Turbulent transport phenomena, Boundary layer theory  
Macroscopic mass balances. Macroscopic momentum and angular momentum balances.  
Use of macroscopic balances to solve steady state and unsteady state problems viz. sulfur dioxide converter, packed bed absorption tower, expansion of reactive gas mixture through frictionless adiabatic nozzle.  
B. macroscopic mass balance for any industrial system

Textbooks:

Reference Books:
1. ‘Elements of Transport Phenomena’, Sissom L.S., Pitts D.R., McGraw-Hill. New k,  
CH40104 :: PLANT ENGINEERING AND PROJECT ECONOMICS

Credits: 03  
Teaching Scheme: - Theory 3 Hrs/Week

Prerequisites: Nil

Objectives:
To introduce students to:
1. the concept of process design,
2. financial management of the project, scientific management, levels of management, industrial management, project management.
3. Factorial approach to capital costs. Cost of product, Cash flow diagrams, rate of return and discounted cash flow, taxes and Insurance, Depreciation, Profitability.
4. Mapping with PEOs : 3 (b)

Unit I  (8 Hrs)
Chemical Engineering Plant Design
A. General Overall Design Considerations, Practical Design Considerations, General Design Considerations: Health and Safety Hazards, Loss Prevention: Hazard Assessment Techniques: HAZOP, HAZAN, Fault Tree Analysis, etc., Environmental Protection, Plant Location, Plant Layout, Plant Operation and Control, etc
B. Patent considerations

Unit II  (8 Hrs)
Feasibility Study, Pilot Plant And Engineering Flow Diagrams
A. Basic engineering in process, thermodynamic and kinetic feasibility, process feasibility, capacity identification, and selection process specification equipment specification material selection, Pilot Plant: Importance of laboratory development to pilot plant, scale up methods.
B. Engineering Flow Diagrams: BFD, PFD, and P & ID.

Unit III  (8 Hrs)
Chemical Plant Cost Estimation
B. Cost Indexes

Unit IV (8 Hrs)
Project Financing, Interest, Investment Costs, Taxes and Insurance

A. Project Financing: Greenfield projects, Add-on projects, ongoing business Interest & Investment Costs: Types of interest: simple interest, ordinary and exact simple interest, nominal and effective interest rates, compound interest, continuous interest. Loan repayment, Periodic payments, annualized cost, capitalized cost, Present worth and discount, annuities, costs due to interest on investment, borrowed capital versus owned capital, source of capital, income-tax effects, design-engineering practice for interest and investment costs.

B. Taxes and Insurance: Types of taxes: property taxes, excise taxes, income taxes.
Insurance: types of insurance.

Unit V (8 Hrs)
Depreciation, Profitability Analysis And Project evaluation

A. Depreciation: purpose of depreciation as a cost, types of depreciation, depletion, service value, salvage value, present value, depreciation in chemical project, methods for determining depreciation, appreciation of depreciation concept, depreciation rates, the depreciation schedule. Profitability, Estimate of working results. Project Evaluation: Break even analysis, incremental analysis, ratio analysis, discounted profit flow technique. Feasibility report, Annual report.

B. alternative investments, and replacements,

Text Books

Reference Books
## CH40202 :: TRANSPORT PHENOMENA (Tutorial)

<table>
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<tr>
<th>Credits: 01</th>
<th>Teaching Scheme: - Tutorial 1 Hrs/Week</th>
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### Prerequisites:
NIL

### Objectives:
- To get hands on and better understanding of transport processes
- Mapping with PEOs : 3 (b)

### List of Assignment

1. Numerical for momentum transport i.e calculation of viscosity.
2. Numerical based on equations giving dependence of thermal conductivity on temperature, pressure for gases
3. Numerical based on equations giving dependence of thermal conductivity on temperature, pressure for liquids and solids
4. Numerical based on equations giving dependence of molecular diffusivity on temperature, pressure for gases
5. Numerical based on equations giving dependence of molecular diffusivity on temperature, pressure for liquids and solids
6. Numerical for shell balance equations for system for momentum transport
7. Numerical for shell balance equations for system for heat transport
8. Numericals for shell balance equations for system for mass transport.

### Textbooks:


### Reference Books:

CH40204 :: PLANT ENGINEERING AND PROJECT ECONOMICS  
(Tutorial)

**Credits:** 01  
**Teaching Scheme:** - Tutorial 1 Hr/Week

**Prerequisites:** Nil

**Objectives:**
- To understand project report development
- Mapping with PEOs : 3 (b)

**List of Contents**

**TERM-WORK**

1. Assignment based on HAZOP, HAZAN, Fault Tree Analysis, etc.
2. Assignment based on feasibility study and Engineering flow diagram.
3. Assignment based on financial pattern of chemical industry
4. Assignment based on cost estimation
5. Assignment based on project profitability analysis

**Text Books**


**Reference Books**

CH40306 :: PROCESS MODELING AND SIMULATION
LABORATORY

Credits: 01

Teaching Scheme: - Laboratory 2 Hrs/Week

Prerequisites: Nil

Objectives:
- To develop the practice of Chemical Engineering Process Modeling and Simulation
- To give a broad coverage of the field of mathematical modeling and simulation in chemical engineering involving both steady-state and dynamic models.
- To cover case studies involving real-life chemical systems and processes.
- Mapping with PEOs : 3,5 (b,c,e)

List of Practical

Six to eight practical will be conducted with the use of mathematical and chemical engineering CAD softwares such as Aspen, EnviroPro, Mathcad, Matlab etc. Development of programs for numerical methods and process simulation. Problems will be taken from the areas of material and energy balances, thermodynamics, transport, kinetics, data fitting and analysis of experimental data and steady state and dynamic modeling.

1. Introduction to Modeling and Simulation
3. Basic Modeling and Simulation: Hydraulic tank, Mixing vessel, Mixing with reaction, Simultaneous mass and energy balances, Continuous-flow system
4. Multicomponent Vapor-Liquid Equilibrium: Vapor-liquid equilibrium, Boiling operations, Batch distillation
5. Reaction Kinetics
7. Mathematical modeling and simulation of heat transfer equipments.
8. Mathematical modeling and simulation of Distillation column
9. Mathematical modeling and simulation of Compressor system (single stage and multistage)
10. Mathematical modeling and simulation of Absorption column
11. Mathematical modeling and simulation of Packed Columns
12. Steady state mathematical modeling and simulation of Separation Train
13. Mathematical modeling and simulation of other chemical processes
14. Solution of under specified and over specified systems.
15. Design Projects

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<tr>
<th><strong>Reference Books</strong></th>
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<tbody>
<tr>
<td>4. “Modeling and Simulation in Chemical Engineering”, Franks R.E.G., Wiely Intrscience, NY</td>
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# CH40308 :: DESIGN LABORATORY

<table>
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<tr>
<th>Credits: 01</th>
<th>Teaching Scheme: - Laboratory 2 Hrs/Week</th>
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## Prerequisites
NIL

## Objectives
- To introduce the students block flow diagram, process flow diagram, piping & instrumentation diagram, various process equipments design & drawing
- Mapping with PEOs : 3,5 (b,c)

## List of Practical
Minimum 6 sheets related to design and drawing mentioned below using AutoCAD should be conducted.

1. Introduction to Design.
4. Design of Pressure Vessels.
5. Design of Vessel Supports.
6. Design of Storage Tanks
8. Design of Tray Towers.

## Textbooks

## Reference Books
CH47302 :: PROJECT – III

Credits: 01  
Teaching Scheme: - Laboratory 6 Hrs/Week

Prerequisites: Knowledge of all subjects till third year.

Objectives:
- Student should be able to apply Chemical Engineering knowledge.
- They should learn How to Work in Team.
- They should be learn to take task (problem) and execute it.
- The aim of the project work is to carry out research and development work.
- Mapping with PEOs: 1,4,5,6 (a-e,g,i,j)

Contents:
This is the final stage in the project work. This stage will include comprehensive report on the work carried out at this stage and relevant portions from stage I and stage II, including experimental studies, analysis and/or verification of theoretical model, conclusions etc. Students may undertake studies in application chemical engineering knowledge for manufacturing project, synthesis, design and development, experimental work, testing on the product or system, generation of new ideas and concept, modification in the existing process/system, development of computer programs, solutions, modeling and simulation related to the subject. Topics of interdisciplinary nature may also be taken up. A detailed literature survey is expected to be carried out as a part of this work. The group of students is required to choose the topic in consultation with the Guide.

A technical report is required to be submitted at the end of the term and a presentation made based on the same. Modern audio-visual techniques may be used at the time of presentation.

Text Books
1. “Project Writing Manual” B.A. Bhanvase, Chemical Engineering Department, VIT, Pune

Reference Books: Nil
## Electives I - IV, B. E. Chemical Engineering

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<tr>
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<td>CH42101</td>
<td>Advanced Materials</td>
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<tr>
<td>CH42102</td>
<td>Analytical Chemistry</td>
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<td>CH42103</td>
<td>Bioengineering</td>
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<td>Computational Fluid Dynamics</td>
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<td>Piping Engineering</td>
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<tr>
<td>CH42115</td>
<td>Polymer Technology</td>
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</table>
CH42101 :: ADVANCED MATERIALS

Credits: 03  Teaching Scheme: - Theory 3 Hrs/Week

Prerequisites: NIL

Objectives:
1. Learn advanced materials systems involving metals, ceramics, polymers and composites
2. Have an understanding of the correlation between structure and properties of the materials
3. Study materials exhibiting electronic, optical, magnetic and superconducting properties
4. Learn chemical engineering processes involved in the fabrication of microelectronic circuits
5. Mapping with PEOs : 4 (d,f)

Unit I
Advanced Metallic, Polymeric and Ceramic Materials
(8 Hrs)
Superalloy steels. Superalloys.
Engineering polymers s.a. polyamide, polycarbonates etc. Specialty polymers s.a liquid-crystal polymers, conductive polymers etc. Applications.
Engineering ceramics s.a. silicon carbide, silicon nitride, alumina, zirconia.

Unit II
Composite materials
(8 Hrs)
Matrices, reinforcements. Metal Matrix Composites.
Polmer Matrix Composites: Processing, commercial PMCs
Ceramic Matrix Composites: Processing, commercial CMCs

Unit III
Physics of Materials
(8 Hrs)
Basics of quantum mechanics, statistical mechanics and physics of materials with a focus on applications to electronic and other materials

Unit IV
Electrical, optical, magnetic properties of materials; Smart materials
(8 Hrs)

Unit V
Fabrication of microelectronics integrated circuits


Unit VI
Self Study

Any one material / materials processing technology of your choice from each of the following categories (You should choose materials which are not covered in the course): Metals, Ceramics, Polymers, Composites, Electronic materials, optical materials, magnetic materials, smart materials

Text Books:

Reference Books:
CH42102 :: ANALYTICAL CHEMISTRY

Credits: 03  |  Teaching Scheme: - Theory 3 Hrs/Week

Prerequisites: Nil

Objectives:
- To get an exposure to range of analytical instruments.
- To better understand the applicability of analytical science in real life.
- To understand how decision regarding quality control & quality assurance are taken based on analysis of samples.
- Mapping with PEOs : 4 (d,f)

Unit I
A] Conductometric & Potentiometric Titrations

B] Bipotentiometry – Principle, instrumentation and applications

Unit II
A] Polarography
Theory, apparatus, DME, diffusion and kinetic and catalytic currents, current – voltage curves for reversible and irreversible systems, qualititative and quantitative applications of polarography to organic and inorganic systems. Derivative polarography, Test polarography, Pulse polarography – Normal and derivative, square wave polarography and AC polarography. Linear sweep and cyclic voltammetry, anodic and cathodic stripping voltammetry. Amperometric titrations – Theory, apparatus, types of titration curves, successive titrations and two indicator electrodes – applications. Technique of amperometric titrations with the dropping mercury electrode – Titration with the rotating platinum microelectrode. Examples of amperometric titrations using a single polarized electrode.

B] Biamperometry – Theory and applications, Microelectrode deposition including radioactive metal ions.

Unit III
A] Coulometric and Electrogravimetric Analysis
Theory. Faraday’s laws, coulometers – types of macro and micro techniques, coulometric titrations, external and insitu generation, coulogravimetry and applications, Elementary aspects of chronocoulometry.
Electrogravimetry – Theory of electrogravimetry, order of deposition, over potential, polarization curves, constant potential and consecutive deposition, selective deposition, constant current deposition, assembly of electrode and deposition of complex ions.

B] Autoelectrogravimetry, Principle and instrumentation, electrography and its applications,

Unit IV
A] Basic Separation Techniques
General aspects of separation techniques – Role of separation technique in analysis, Classification choice of separation method distribution processes
Extraction – Distribution law and derivation, solvents and their choice, techniques – batch and continuous, multiple extraction, column and their choice, extraction of solids and their applications. Solvent micro-extraction - In-vial liquid–liquid extraction (in-vial LLE), Single-drop micro-extraction (SDME), Liquid-phase micro-extraction (LPME), Liquid–liquid–liquid micro-extraction (LLLME), Sorption micro-extraction and liquid desorption - Solid-phase extraction (SPE), In-tube solid-phase micro-extraction (in-tube SPME), Fiber-in-tube solid-phase extraction (fiber-in-tube SPE), Single short column (SSC), Solid-phase micro-extraction (SPME), Thermal desorption - Solid-phase micro-extraction (SPME), Stir-bar-sorptive extraction (SBSE), Matrix solid-phase dispersion - Matrix solid-phase dispersion (MSPD), Enhanced fluid/solvent extraction - Supercritical-fluid extraction (SFE), Pressurized liquid extraction (PLE), Subcritical-water extraction (SWE), Microwave-assisted extraction (MAE), Sonication-assisted solvent extraction (SASE), Thermal desorption from solids - Direct thermal desorption (DTD)

GPC and UPLC
Gel permeation chromatography – Instrumentation, heterogeneity factor, determination of molecular weights - weight average and number average, analytical and industrial applications. New development in chromatography – Plasma chromatography, super critical fluid chromatography, Ultra Performance Liquid Chromatography – Theory and Practice, Lab-on-a-chip – introduction, merits, limitations, applications vis-à-vis conventional techniques.

B] Classical Chromatographic techniques

Unit V
A] Microscopy
Chemical microscopy – Microscope – Parts and optical path: Numerical aperture and significance. Techniques – Kofler’s hot stage microscope, fluorescence, polarizing, interference and phase microscopy, application and qualitative and quantitative study. Electron microscopy – SEM, TEM, AFM - Principle, Microscope and its operation, sample preparation, replicas, shadowing, application to analysis, electron probe analyzer, ion microscope

B] Metallography – metallurgical microscopic examination, specimen preparation
Text Books

Reference Books
CH42103 :: BIOENGINEERING

| Credits: 03 | Teaching Scheme: - Theory 3 Hrs/Week |

**Prerequisites:** Nil.

**Objectives:**
- To understand use of biotechnology in chemical manufacturing. Understand the kinetics and mechanism of biocatalysts
- Mapping with PEOs : 4 (d,f)

**Unit I**

Biotechnology in the developing world

A. The promise and potential of biotechnology, Impact of biotechnology in agriculture, food, chemical, medicine and public health products, livestock breeding and animal health.

B. Impact of biotechnology energy bioconversion and recycling of materials.

**Unit II**

Introduction to biomass and Bio-chemicals

A. Introduction to structure of cells, important cell of types, growth of microbial cells. Bio-chemicals: Primary, secondary, tertiary structure of biomacromolecules such as lipids, sugars and polysaccharides, nucleotides, RNA, DNA, amino acids, proteins, hybrid biochemical etc interactions of these molecules, The central Dogma of cell, DNA replications, transcription, translation, metabolic regulations.

B. Structure and functions of biomembranes, Osmoregulations interacting toxins, how cell senses its extra cellular environment.

**Unit III**

Major metabolic pathways

A. Bioenergetics, Glucose metabolism, respiration, control sites in aerobic glucose metabolism, metabolism of nitrogenous compounds, nitrogen fixation, metabolism of hydrocarbons, overview of biosynthesis.

B. Anaerobic metabolism, autotrophic metabolism.

**Unit IV**

Kinetics of Enzyme catalyzed reactions

A. Enzyme substrate complex and enzyme action with example from industrial enzymes, simple enzyme, kinetics with one and two substrate. Michaelis-Menten kinetics. Models of enzymes kinetics with brief introduction, Protein denaturation by chemical agent and heat. Numerical problems based on theory.

B. Substrate activation and inhibition. Multiple substrates reacting on a single enzyme.
Unit V

Applied Enzyme Catalysis
B. Production formation and biomass production in cell cultures.

Text Books

Reference Books
CH42104 :: BIOTECHNOLOGY

Credits: 03  |  Teaching Scheme: - Theory 3 Hrs/Week

Prerequisites: Nil

Objectives:
- To understand bioprocesses in chemical industry, design aspects, separation and recovery operations in biochemical plants.
- Mapping with PEOs: 4 (d,f)

Unit I  
Applications of Bioprocesses in Chemical Industry

A. Discuss manufacturing process for major products produced by biochemical reactions such as vitamins B, alcohol, acetic acid and vinegar, acetone, lactic acid, citric acid, wine, proteins. Aerobic and anaerobic waste-water treatment.

B. Discuss manufacturing process for major products produced by biochemical reactions such as penicillin.

Unit II  
Selection, scale-up and control of bioreactors

A. Overview of reactor types, scale up and its difficulties, considerations on aeration, agitation, and heat transfer, scale-up, scale-down chemostat and chemostat with recycle.

B. Bioreactor instrumentation and control

Unit III  
Transport Phenomena in bioprocess system


B. Multiphase bioreactors, fermentation technology

Unit IV  
Biological Waste treatment processes

A. Aerobic and anaerobic waste water treatment, dissolved oxygen balance, dissolved oxygen model, organic discharge and stream ecology, growth and food utilization, suspended culture system, activated sludge, ponds and lagoons.

B. Attached culture system. Microorganisms used, refractory chemicals.

Unit V  
Product recovery operations and Bioprocess Technical aspects

A. Product recovery operations:- Dialysis, Reverse osmosis, ultra-filtration, and Micro-filtration, Chromatography, electrophoresis, electro dialysis. Technical aspects:-Bioprocess
economics. Genetic information: potential uses and abuses, ideas and research, typical sequence of events, risk and rewards,

B. Crystallization and drying, patents and the protection of ideas.

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CH42105 :: CATALYSIS

Credits: 03  |  Teaching Scheme: - Theory 3 Hrs/Week

Prerequisites: NIL

Objectives:
- To understand the complex phenomenon of catalysis and actors affecting the rate of reaction.
- Mapping with PEOs : 4 (d,f)

Unit I  (8 Hrs)
Introduction to Catalysis
A. Introduction to Catalysis. Application to industrial processes – one example each from Inorganic, Fine organic chemical, petroleum refining, petrochemical and biochemical industries. Types of catalysis: Homogeneous Catalysis
B. Biocatalysts – enzymes, lipases and microbes as catalysts

Unit II  (8 Hrs)
Heterogeneous Catalysis
A. Heterogeneous Catalysis: Introduction, Phase transfer and tri-phase catalysis, liquid – liquid and solid – liquid catalysis, mechanism, engineering problems, mass transfer considerations. Reactor types
B. Mechanism of participation of enzymes in a few typical reaction.

Unit III  (8 Hrs)
Mechanism
B. Michaelis – Menten Kinetics for biocatalyst

Unit IV  (8 Hrs)
Catalyst Preparation
A. Preparation of catalysts – Supported metal and metal oxide catalyst. Major steps involved in catalysts preparation and formation. Physical methods of catalyst characterization for determination of surface area, pore volume and average pore size. BET equation
B. Inhibition. Reactions and denaturation of two biopolymers

Unit V  
Zeolites 

A. Zeolites – Structural considerations. Temepalted molecular sieves, size and shape selectivity, 4 – 5 industrial applications of zeolites. Modification of zeolites.

B proteins and nucleic acids in biocatalyst

Textbooks:

Reference Books:
### CH42106 :: COMPUTATIONAL FLUID MECHANICS

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**Prerequisites:** Nil

**Objectives:**
1. To develop an understanding for the major approaches and methodologies used in CFD, the interplay of physics and numerics, the methods and results of numerical analysis.
2. To gain experience in the actual implementation of methods (e.g. boundary conditions, etc.)
3. Increase skills in: implementing and using basic CFD methods, computer use and programming and debugging.
4. Mapping with PEOs: 4 (d,f)

#### Unit I

(8 Hrs)

**Fluid Dynamics and Conjugate Heat Transfer (CHT)**


B. Flow characteristics over various bodies. Introduction to CHT, Fluid boundary conditions, CHT solid boundary conditions, CHT interface conditions.

#### Unit II

(8 Hrs)

**Structured and Unstructured Grid Generation**

A. Basic theory of structured grid generation, Surface grid generation, Mono block, multi block, hierarchical multi block, Moving and sliding multiblock, Grid clustering and grid enhancement. Basic theory of unstructured grid generation, advancing front, Delaunay triangulation and various point insertion methods, Unstructured quad and hex generation, grid based methods, various elements in unstructured grids, Surface mesh generation, Surface mesh repair, Volume grid generation, Volume mesh improvement, mesh smoothing algorithms, grid clustering and quality checks for volume mesh.

B. Adaptive, Moving and Hybrid Grids, Need for adaptive and, moving grids, Tet, pyramid, prism, and hex grids, using various elements in combination.

#### Unit III

(8 Hrs)

**Introduction to CFD**
A. Philosophy of CFD, Governing equations of fluid dynamics and their physical meaning, Mathematical behavior of governing equations and the impact on CFD simulations, Simple CFD techniques and CFL condition. Finite Difference, Finite Volume, and Finite Element, Upwind and downwind schemes, Simple and Simpler schemes,
B] Higher order methods, Implicit and explicit methods, Study and transient solutions

Unit IV  
Introduction to Turbulence Modeling  
(8 Hrs)
A] Introduction and background, Algebraic models, One equation models, Two equation models, Near wall treatment, Reynolds stress models, Eddy viscosity models (EVM), Nonlinear eddy viscosity models, LES, RANS, and, hybrids.
B. Direct numerical simulation (DNS)

Unit V  
Introduction to Multiphase Modeling  
(8 Hrs)
A. Fundamentals of multiphase flows, Eulerian-Lagrangian (ELAG) approach, Eulerian-Eulerian (E2P) approach, Volume of Fraction (VOF) approach, Solving example problems.
B. Multiphase flow systems

Text Books

Reference Books
Prerequisites: Nil

Objectives:
1. To understand various types of pollutions, pollution standards and abatement techniques.
2. Mapping with PEOs : 4 (d,f)

Unit I (8 Hrs)
Introduction
A. An overview of environmental engineering, pollution of air, water and soil, impact of population growth on environment, environmental impact of thermal, hydro and nuclear energy, chemical pollution, solid wastes, prevention and control of environmental pollution
B. Water and air pollution laws

Unit II (8 Hrs)
Air Pollution- Sources, Effects and Measurement
A. Definition of air pollution, sources scales of concentration and classification of air pollutants. Effects of air pollutants on human health, plants, animals, materials, economic effects of air pollution, sampling and measurement of air pollutants, particulate pollution: cleaning methods, collection efficiency, particulate collection systems, Basic design and operating principles of settling chamber, cyclone separator, fabric filter, electrostatic precipitator, gaseous pollution: principles of control
B. Air pollution control standards: WHO, BIS, MPCB, CPCB

Unit III (8 Hrs)
Air Pollution
A. Domestic and industrial wastewater, types, sources and effects of water pollutants. Waste water characteristics–DO, BOD, COD, TOC, total suspended solids, colour and odour, bacteriological quality, oxygen deficit, determination of BOD constants.
B. Water quality standards: ICMR, WHO, MPCB and CPCB.

Unit IV (8 Hrs)
Waste Water Treatment
A. Primary and secondary treatment, design and basic operating principles of activated sludge process, sludge treatment and disposal, trickling filter. Advanced methods of waste water treatment, UASB, photo catalytic reactors, wet-air oxidation, and biosorption.
B. Pollutants and methods of waste water treatment

Unit V (8 Hrs)
Tertiary Water Treatment and Solid Waste Management
A. Tertiary treatment: disinfection by chlorine, ozone and hydrogen peroxide, UV rays, recovery of materials from process effluents, micro-screening, biological nitrification and denitrification, granular medium filtration, land Pollution: Sources and classification of solid wastes, disposal methods, incineration, composting, recovery and recycling.
B. Laws and standards of land pollution and noise pollution

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CH42108 :: FOOD TECHNOLOGY

Credits: 03  Teaching Scheme: - Theory 3 Hrs/Week

Prerequisites: Nil

Objectives:
- To understand food processing and preservation techniques, find the similarities with chemical processes.
- Mapping with PEOs : 4 (d,f)

Unit I  (8 Hrs)
Properties Of Food And Processing Theory
A. Properties of liquid, solids and gases used in food processing, water activity, effect of processing on sensory, nutritional properties. Food safety, good manufacturing practices and quality assurance
B. Food processing scenario of India. Need of food processing in India.

Unit II  (8 Hrs)
Ambient Temperature Processing
A. Raw material preparations, size reduction, mixing and forming, separation and concentration of food components, fermentation and enzyme technology, irradiation, processing using electric field, high hydrostatic pressure, light or ultrasound.
B. Survey of fermented food, advantages and disadvantages of fermented food.

Unit III  (8 Hrs)
Processing By Application Of Heat
A: Heat Processing using steam or water, pasteurization, heat sterilization, evaporation and distillation, extraction, dehydration, dielectric, ohmic and infrared heating
B. Baking, roasting and frying.

Unit IV  (8 Hrs)
Processing By The Removal Of Heat
A. Chilling, controlled or modified atmosphere storage and packaging, freezing, freeze drying and concentration
B. Ice cream manufacture flow-sheet and process

Unit V  (8 Hrs)
Post Processing Operation
A. Coating or enrobing, packaging, filling and sealing of containers, materials handling, storage and distribution.
B. Advertising of food products

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CH42109 :: GREEN CHEMISTRY

Credits: 03
Teaching Scheme: - Theory 3 Hrs/Week

Prerequisites: Nil

Objectives:
- To Acquire knowledge of issues in sustainability as they relate to business and industry internationally and nationally.
- To Examine and evaluate case studies of sustainable practices in business and industry.
- To Identify best trends and business practices in various concerned organizations.
- To Understand and analyze the interconnectivity of global concerns.
- Mapping with PEOs : 4 (d,f)

Unit I
Green Chemistry : An Overview

A] Introduction, underlying philosophy and focus, Twelve principles of green chemistry & Green Engineering, Ten Commandments of sustainability, The Chemistry of the Atmosphere, The structure of the atmosphere, stratospheric chemistry

B] Environmental spheres, Tropospheric chemistry

Unit II
Ecological Threats & Green Chemistry

A] The Greenhouse Effect, Climate Change, photochemical smog, Old Technology vis-à-vis Green Technology : Suitable examples to understand comparative advantage of Green Technology over Old one, Renewable resources, Process intensification

B] Pragmatic Green Chemistry Challenges

Unit III
Green Synthetic Methods & Catalysis

Green chemistry with new solvents, Catalytic methods in synthesis, Synthesis in aqueous media, Unconventional energy sources in synthesis, Catalysis: history, hydrogenation, ammonia synthesis, catalyst types, basics of catalysis, transition states, examples, selectivity and engineering, atom economy, and atom efficiency, characteristics of general reaction types, Methanol reactivity, Catalysis and innovation, ionic liquids : Examples and properties, Supercritical fluids (SCFs): examples and properties, Extraction with SCFs, Solvent less reactions

B] Use of microwaves and sonic waves in Chemistry in isolation and coupled with solvent
less reactions

Unit IV

Green Chemistry & Nonconventional Fuels
Green chemistry in batteries, production and recycling, Fuel cell and electric vehicles, Solar energy and hydrogen production, biodiesel, bio-hydrogen, Green batteries

B] Li ion batteries

Unit V

Green Chemistry & Sustainable development
Esterification: transesterification, autogeneous pressure of methanol, transesterification under supercritical conditions
Optimisation: catalyst concentration, methanol to oil ratio, reaction temperature, reaction time
B] Best practices in Green Chemistry for sustainable development with suitable examples

Text Books

1. Paul T. Anastas ; “Green Chemistry – Theory and Practice”

Reference Books

CH42110 :: MASS TRANSFER WITH CHEMICAL REACTION

Credits: 03  
Teaching Scheme: - Theory 3 Hrs/Week

Prerequisites: NIL

Objectives:
- Understanding of solid fluid reactions/catalysis
- Mapping with PEOs : 4 (d,f)

Unit I  
(8 Hrs)
Introductions
A. Different types of reactions with industrial examples, catalyst kinetics and reaction modeling, diffusion in solid catalysts
B. Slow reaction

Unit II  
(8 Hrs)
Pore diffusion
A. Role of pore diffusion in simple and complex reactions
B. Absorption of gas into two reactants

Unit III  
(8 Hrs)
External mass transfer
A. Role of external mass transfer, mass transfer limitation effect, catalyst deactivation and experimental methods in catalytic kinetics.
B. Estimation of effective transport properties for external mass transfer

Unit IV  
(8 Hrs)
Mass transfer accompanied by reversible and irreversible reactions
A. Various regimes for mass transfer with irreversible and irreversible reactions and governing equations.
B. Absorption and reaction of two gases.

Unit V  
(8 Hrs)
 Fluid-Fluid system with solid catalyst
A. Examples, slurry reactor kinetics, procedure for kinetic determination, types of contactors and their relative merits  

B. Bubble column reactor

**Textbooks:**

**Reference Books:**
CH42111 :: NANOTECHNOLOGY

Credits: 03  
Teaching Scheme: - 3 Hrs/Week

Prerequisites: Nil

Objectives:
- Obtain an overview of the various facets of nanotechnology including:
  1. historical development
  2. characterisation techniques
  3. physics and chemistry
  4. synthesis / fabrication
- Mapping with PEOs : 4 (d,f)

Unit I
Introduction
(8 Hrs)
Histroical development of nanotechnology.
Overview of nanotechnology. Global trends.
Overview of typical products in market utilizing nanotechnology.

Unit II
Physics of Nanomaterials
(8 Hrs)
Coverage of physics of materials appropriate for applications to nanotechnology

Unit III
Characterisation of Nanomaterials
(8 Hrs)
Microscopy techniques (SEM, TEM; STM, AFM), spectroscopy techniques, XRD etc

Unit IV
Synthesis / fabrication of nanomaterials
(8 Hrs)
Top-down and bottom-up approaches for synthesis of nanomaterials

Unit V
Applications of Nanotechnochnology
(8 Hrs)
Current and potential applications of nanotechnology. Biological nanomaterials.
Nanoelectronics. Nanomachines & nanodevices etc.
Research directions. Economic, environmental and societal aspects of nanotechnology.
Unit VI
Self Study

Detailed study of at least two commercial nanoproducts / nanotechnologies or research articles of your choice (not covered in the course)

**Text Books:**

**Reference Books :**
CH42112 :: NONCONVENTIONAL ENERGY SOURCES

Credits: 03

Teaching Scheme: - Hrs/Week

Prerequisites: Nil

Objectives:
- Provide an overview of the promising areas of new and renewable sources of energy.
- Give an understanding of environmental consequences of energy conversion and how renewable energy can reduce air pollution and positively affect the global climate change.
- Provide analysis of energy conversion, utilization and storage for renewable technologies such as wind, solar, biomass, fuel cells and hybrid systems and for more conventional fossil fuel-based technologies.
- Mapping with PEOs: 4 (d,f)

Unit I
Introduction

A. Energy scene of supply and demand in India and the world, energy consumption in various sectors, potential of non-conventional energy resources.
B. Detailed study of the following sources with particular reference to India.

Unit II
Solar Energy

B. Photovoltaic power generation using silicon cells.

Unit III
Bio-fuels

A. Importance, combustion, pyrolysis and other thermo chemical processes for biomass utilization. Alcoholic fermentation
B. Anaerobic digestion for biogas production.

Unit IV
Wind and Tidal Power

A. Wind Power: Principle of energy from wind, windmill construction and operational details and electricity generation and mechanical power production.
Tidal Power: Its meaning, causes of tides and their energy potential, enhancement of
tides, power generation from tides and problems. Principles of ocean thermal energy
conversion (OTEC) analysis
B. Sizing of heat exchangers for OTEC.

Unit V

Geothermal Energy, Energy Storage and Distribution

A. Geo technical wells and other resources dry rock and hot aquifer analysis
Importance, biochemical, chemical, thermal, electric storage. Fuel cells
B. Harnessing geothermal energy resources, distribution of energy

Text Books:

Reference Books:
CH42113 :: PETROLEUM REFINING

Credits: 03
Teaching Scheme: - Theory 3 Hrs/Week

Prerequisites: NIL

Objectives:
- Understanding of chemical processes used in petroleum refining and applications
- Mapping with PEOs: 4 (d,f)

Unit I (8 Hrs)
Petroleum and Products
A. Petroleum composition, specifications of petroleum and some petroleum products such as LPG, Gasoline, Kerosene, Diesel oil and Engine oil.

B. Petrochemical products

Unit II (8 Hrs)
Pre-refining Operations
A. Pre-refining operations such as, Settling, Moisture removal, Storage, Heating through exchangers and pipe seal heaters, Atmospheric distillation, Vacuum distillation.

B. Recent trends in petroleum in terms of Distillation

Unit III (8 Hrs)
Reforming and Cracking Units
A. Significant conversion units such as, Reforming, Cat-Cracking, Hydro-cracking and coking.

B. Recent trends in petroleum in terms Packing materials

Unit IV (8 Hrs)
Product Refining
A. Refining of petroleum products such as Acid refining, Chemical refining, Hydro-refining, HDS, HDM, HAD.

B. Recent trends in petroleum in terms Catalyst
Unit V  
(8 Hrs)

Post Production Operations

A. Blending, Additives, Storage of products, Transportation, House keeping, Marketing of petroleum and petroleum products.

B. Safety norms for petroleum products

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CH42114 :: PIPING ENGINEERING

Credits: 03  
Teaching Scheme: - Theory 3 Hrs/Week

Prerequisites:
Basic stress-strain analysis theory; engineering graphics; introduction to engineering materials.

Objectives:
1. To present the unifying treatment of transport processes.
2. To solve process design problems involving transport operations
3. To learn to use dimensionless groups and application to scale-up of processes.
4. Mapping with PEOs : 4 (d,f)

Unit 1. Piping drawings (layouts), piping material and pump hydraulics
A. (7 Hrs)
PFD (ISA 5.1); Introduction to pipes and piping material, piping specification, pump/compressor hydraulics, types and selection of valves and Add control loops, basic instrumentation and interlocks to form P&ID. Unit plot plan, Plant layout (GA drawing), process P&ID, utility P&ID, process plant layout, equipment layout and utility layouts within battery limits.

B. Piping and valve material specification sheet; line size calculation; more details and types of types and pressure relief valve / safety valve; plot plans; utility distribution system P&ID, Interconnecting or rack P&ID, vendor P&ID.

Tutorial submission.
T1. Valves and control valves.
T2. Pipe fittings and pipe connectors.
T3. Pump and compressor selection and layouts

Unit 2. Piping layouts, isometrics and equipment piping
A. (7 Hrs)
Piping layouts and pipe routing, isometrics (2D, 3D), bill-of-material (BOM) and material-take-off (MTO), piping spool drawings, bill-of-quantity (BOQ). Equipment piping; detailed layout and general considerations.

B. Tutorial submission.
T4. Piping material engineering
T5. Piping insulation, coloring codes and hazardous area classification details.
T6. Preparation of basic and detail engineering P&IDs.
Unit 3. ASME Codes, NFPA, OSHA and other standards.
A.
ASME B31.3 (process piping) and ASME B31.1 (power piping) Codes; design of pipe fittings ASME B16, stress analysis, piping materials (ASME II) and Codes, NFPA, OSHA and OISD, piping insulation and coloring.
B.
Design of flanges and gaskets; design of nuts & bolts; applications of NFPA codes in piping system design; Standards for piping insulation (detail engineering).
Tutorial submission.
T8. Tutorial problems for power piping.

Unit 4. Pipe stress analysis
A. (7 Hrs)
Pipe stress analysis (internal and external pressure); Introduction to CAESAR-II, static and dynamic stress analysis using Codes; wind and seismic loads; detail engineering and design & selection of pipe supports.
B.
Codes for and selection of pipe supports and FEA analysis; linear dynamic analysis.
Tutorial submission.
T9. Stress analysis simulation sheets and pipe support selection.
T10. Short duration projects.

Unit 5. Pipe racks, Fitness of Service and Piping system fabrication.
A. (7 Hrs)
Design of pipe racks; pipe class components; hazardous area classification and drawings; project activities (procurement and erection of plant & piping system); preparation of commercial P&IDs and costing other system details such as heat tracing etc. Fitness of service. Introduction to piping system fabrication.
B.
Detail engineering to find use and applications of pipe class components (see list in Liptak’s Handbook); methods of inspection and repair in Fitness of service in brief; preparation of piping fabrication diagrams.
Tutorial submission.
T12. Pipe rack design and racks on skids.
T13. Inspection and maintenance of piping system as per ASME Codes.
T14. Piping fabrication and heat tracing etc.

Group Project: Plant piping system. Process and Utility piping system design.
(Inclusive of battery limit costing using ASPEN Icarus).
(All basic files will be provided by teacher. ASPEN University package.)
Text Books
3. “Flow of Fluids Through Valves, Fittings and Pipe, Crane Co. Staff

Reference Books
1. Problem sheets on pipe stress analysis using CAESAR-II software
3. GlobalSpec search engine on Internet for Design data.
CH42115 :: POLYMER TECHNOLOGY

Credits: 03  Teaching Scheme: - Theory 3 Hrs/Week

Prerequisites: Nil

Objectives:
1. To acquire fundamental chemical and physical understanding of the synthesis, production and characterization of polymer materials
2. To appreciate the breadth of polymer properties and applications
3. To learn in depth about use of polymers in a particular application area.
4. Mapping with PEOs: 4 (d,f)

Unit I
Introduction to polymers, Molecular Weight Determination

B. Synthesis procedure for monomers Styrene, ethylene, Vinyl monomers etc.

Unit II
Polymerization Processes and Techniques

B. Suspension Polymerization

Unit III
Kinetics and Mechanism of Polymers Synthesis

B. Chain transfer agents.

Unit IV
Polymerization reactors

A. Polymerization reactors, types and mode of operation. Polymerization reactor design,
control of polymerization, Post polymerization unit operations and unit processes High
Performance and Specialty Polymers, Polymer additives, compounding. Fillers plastisizers lubricants colourants Different moulding methods of polymers
B. Polymer Additives: UV stabilizers, fire retardants, antioxidants.

Unit V
Polymers and commercial synthesis procedures

(8 Hrs)

A. Mechanical Properties of Polymers, Thermodynamics of Polymer Mixtures, ASTM
and ISO methods for testing of polymers Manufacturing of typical polymers with flow-
sheet diagrams, their properties & applications: PE, PP, Polyesters, Nylons, PC
Thermosets like Epoxies, unsaturated polyesters, phenolics, etc.
B. Polystyrene, ABS

B. Multiphase flow systems

Text Books

Reference Books
HONORS / MINORS
Honors / Minor Courses Offered By the Chemical Engineering Department

Honors in chemical Engineering

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CH28102 :: PROCESS INSTRUMENTATION AND INSTRUMENTAL ANALYSIS

Credits: 03  Teaching Scheme: - Theory 3 Hrs/Week

Prerequisites: Nil

Objectives:
- To make students understand basic principle behind measurements and their applicability in chemical processes.
- Mapping with PEOs : 4 (a,d,g)

Unit I  (7 Hrs)
Measurement Fundamentals
A. Scope of Process Instrumentation, classification of process variables; measuring instruments & characteristics- functions of instruments; static and dynamic characteristics; calibration.

B. Analog & digital sensors.

Unit II  (9 Hrs)
Temperature, Pressure,
A. Temperature measurement: temperature scales, thermocouples, filled system thermometers, radiation & optical pyrometer, liquid in glass thermometers, pyroelectric thermometers etc.
Pressure measurement: Mechanical pressure elements, liquid column element, elastic element, design of Bourdon Spring elements. Vacuum measurements, electronic pressure sensors. high pressure sensors like dead weight, strain gauge and capacitance.
B. Continuous measurement of temperature and pressure. Coriolis Effect Mass flowmeters..

Unit III  (8 Hrs)
Control System and P and I Diagram
Symbols for PFD and P&ID, Basic control logic and loops for reactors and unit operation equipments. Instrumentation Symbols and Identification, Standards & Practices for Instrumentation & Control design and integration with DCS, SCADA linkages and hook-up diagrams. Graphic Symbols for Distributed Control-Shared Display Instrumentation, Given PFD and control schemes, prepare P&IDs for simple and automated plants. Interlock logic and description, audio-visual alarm systems, measuring instruments and safety, Interlock logic description Instrument loop summary.

B. Control Valve Selection and Sizing; Hydraulics and Pneumatics operated valves.

Unit IV

(8 Hrs)

Chemical Variable Measurement I

A. Composition measurement methods and their applications in chemical engineering. Analytical Methods: Principles, working and applications of pH meter, Refractometer, Conductivity meter, Polarimeter, UV-Vis, FTIR, Atomic absorption Spectroscopy etc

B. NMR for analysis

Unit V

(8 Hrs)

Chemical Variable Measurement II

A. Theory and Practice and instrumentation of GC, GC Columns and stationary phases, Gas-Liquid and Gas-Solid Chromatography, GC-MS, HPLC – Partition and Adsorption, Ion Exchange and Size Exclusion Chromatography, HPLC-MS, Comparison of HPLC and GC. Ion chromatograph, continuous composition analysers, Online Measurement of variables.

B. HPTL analyzer, principle and applications

Text Books

Reference Books
CH38101 :: CHEMICAL SYNTHESIS

Credits: 03  
Teaching Scheme: - Theory 3 Hrs/Week

Prerequisites: Nil

Objectives:
- The focus of the course is on understanding strategies and methods used in chemical synthesis for a wider range of applications.
- The course intends to train students in the use of research methods and technique involved in the discovery and development of chemical species.
- Mapping with PEOs: 4 (a,d,g)

Unit I  
Synthesis of natural products

A. Analysis of pathways of reactions, strategies for bond recognition, chemoselectivity, effect of solvent and stereocontrol, kinetic and thermodynamic control, group chemistry, classes of biologically active natural products.

B. Making and breaking of bonds, Energetic of reaction

Unit II  
Synthetic chemistry

A. Synthesis of dyes, drugs, proteins, carbohydrates, vitamins, steroids etc, evaluation of different routes to the same compound, convergent and divergent synthesis.

B. Simple reaction mechanism. Classification of organic reactions, Carbanion and free radical generation and their stability order.

Unit III  
Stereochemistry and Asymmetric synthesis

A. Optical active compounds- properties and applications in pharma industry.
Design of asymmetric synthesis, Diels -Alder reaction; drugs, dyes and pigments; asymmetric synthesis of inorganic compounds.

B. Structural isomers, stereoisomers, diastereomers, enantiomers, chirality, optical activity, naming conventions- by configuration, by optical activity.
Bansilal Ramnath Agarwal Charitable Trust’s  
Vishwakarma Institute of Technology, Pune – 411 037  
Department of Chemical Engineering  

Structure & Syllabus of B.E. (Chemical Engineering) – Pattern ’A11’, Issue No.3, Rev 01, dated 02-04-2011  

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# CH38102 :: PROCESS MODELING AND SIMULATION

<table>
<thead>
<tr>
<th>Credits: 03</th>
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<td>Prerequisites: Nil</td>
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**Objectives:**
- The objective is to develop the theory and practice of chemical engineering process modeling and simulation.
- Mapping with PEOs: 4 (a,d,g)

## Unit I (7 Hrs)
**Introduction to Modeling and Fundamental Laws**

A. Introduction, definition of Modeling and simulation, different types of models, application of mathematical modeling, scope of coverage, Continuity equation, energy equation, equation of motion, transport equation
B. equation of state, phase and chemical equilibrium, chemical kinetics

## Unit II (8 Hrs)
**Heat Transfer and Other Equipments**

A. Heat exchangers, evaporators, agitated vessels, pressure change equipments, mixing process
B. fluid – solid operations

## Unit III (9 Hrs)
**Mass Transfer Equipments**

A. Flash distillation, differential distillation, continuous binary distillation in tray and packed column, vaporizers, single phase and multiphase separation, multi-component separation, drying equipments
B. adsorption, absorbers and strippers

## Unit IV (8 Hrs)
**Reaction Equipments**

A. Batch reactor, Semi batch reactor, Continuous stirred tank reactor, Plug flow reactor, Slurry reactor, Trickle bed reactor, Bubble column reactor, Packed column reactor
B. Bioreactors, Reactors used in effluent treatments, Fluidized bed reactor

## Unit V (8 Hrs)
**Applications and Solution of Mathematical Modeling**
A. Applications of modeling and simulation in distillation, Transient analysis of staged absorbers, unsteady state analysis in reactor system, Use of numerical methods to solve different models, The analysis and modeling of chemical processes using either a mechanistic or an empirical input/output approach

B. Linearization of non-linear processes

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<th>Text Books</th>
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<table>
<thead>
<tr>
<th>Reference Books</th>
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<tbody>
<tr>
<td>4. “Modeling and Simulation in Chemical Engineering”, Franks R.E.G., Wiely Intrscience, NY</td>
</tr>
</tbody>
</table>
CH48101:: CHEMICAL PROCESS SYNTHESIS AND PRODUCT DESIGN

Credits: 03  
Teaching Scheme: - Theory 3 Hrs/Week

Prerequisites: Nil

Objectives:
1. The major objective is to understand how to invent/synthesize chemical process flow sheets, develop process alternatives, evaluate and screen them quickly.
2. Develop understanding of synthesizing and designing individual process units in the context of the total process flow sheet.
3. Develop understanding of energy integration, design and synthesis of heat exchanger networks.
4. Mapping with PEOs: 4 (a,d,g)

Unit I  
Introduction Of Chemical Process and Product Design
B. Case studies of product design.

Unit II  
Choice Of Reactor and Separator
A. Reaction Path, Types of Reaction Systems, Reactor Performance, Idealized Reactor Models, Reactor Concentration, Temperature, Pressure, Phase.
Separation of Heterogeneous Mixtures, Separations of Homogeneous Mixtures, Distillation, Azeotropic Distillation, Absorption, Evaporation, Drying etc.
B. Choice of catalyst

Unit III  
Distillation Sequencing
A: Distillation Sequencing using simple columns, Heat Integration of Sequences of Simple Distillation Columns, Optimization of Reducible Structure reactions
B. Distillation Sequencing using thermal coupling

Unit IV  
Heat Exchanger Network And Utilities
B. Energy audit

Unit V (8 Hrs)
Safety And Health Considerations
B. Safety factors used in design of columns.

<table>
<thead>
<tr>
<th>Text Books</th>
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<tbody>
<tr>
<td>2. “Chemical Process design and Integration” Robin Smith, Willy Publication,</td>
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<tr>
<td>1. “Unit processes in organic Synthesis” Groggins P.H. Tata McGrove Hill</td>
</tr>
<tr>
<td>2. “Chemical Product design” Cussler E. L.; Moggridge G. D., Cambridge</td>
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</table>
CH48102 :: ADVANCES IN CHEMICAL ENGINEERING

Credits: 03
Teaching Scheme: - Theory 3 Hrs/Week

Prerequisites: Nil

Objectives:
- To introduce students to:
  - Novel separation techniques, reactors, control techniques used in Industry
  - Process Intensification and Process Integration
- Mapping with PEOs: 4 (a,d,g)

Unit I (8 Hrs)
Novel Separation Techniques
A. Separation using novel extraction processes such as liquid membranes, ionic solvents, separation coefficient, mathematical modeling. Membrane separation techniques and equations for flux, melt crystallization for separation, phase diagram, separation coefficient and techniques.
B. Supercritical fluid extraction

Unit II (8 Hrs)
Novel Reactors In Chemical Industry
A. Fluidized bed reactor and design, micro-reactors concept, applications, advantages and design considerations, solid state fermentor, applications, design considerations and design equations.
B. Reactor with ultrasound.

Unit III (8 Hrs)
Advance Process Control
A. Multivariable control, model predictive control, distributed control system, Industrial applications.
B. Adaptive control technique

Unit IV (8 Hrs)
Process Intensification
A. Examples of process intensification, advantages, modeling of some of such techniques
B. Reactive distillation
Unit V  
(8 Hrs)  
Process Integration

A. Various process integration techniques used in Industry, advantages, mathematical modeling, case studies.  
B. Pinch technology

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MINOR
## Minor in chemical Engineering

### Credit Break – up for Honors / Minor Course

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<th>Subject Code</th>
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</table>
CH29112 :: INTRODUCTION TO CHEMICAL ENGINEERING

Credits: 03  |  Teaching Scheme: - Theory 3 Hrs/Week

Prerequisites: Nil

Objectives:
- To get hands on experience of different unit operations and should be able to handle them efficiently and independently.
- Mapping with PEOs: 4 (a,d,g)

Unit I  (7 Hrs)
Basic Chemical Calculations
A. Dimensions and Units, chemical calculations including mole, equivalent weight, solids, liquids, solutions and their properties, humidity and saturation.
B. Properties of gases

Unit II  (9 Hrs)
Material and Energy Balance
A. Material Balances in the absence and in the presence of chemical reactions. General analysis of variables and equations.
Energy balances in the absence and in the presence of chemical reactions. Forms of Energy and the first law of thermodynamics.
B. Material balances for systems of process units, Physical and chemical thermodynamic properties.

Unit III  (8 Hrs)
Particle Technology & Size analysis
A. Particle size and shape, Mixtures of particles, Determination of particle size, Standard screen series, screen analysis, Screen effectiveness and capacity, Storage of solids, characteristics of Bulk solids, Size reduction equipments.
B. Different types of conveyors.

Unit IV  (8 Hrs)
Mixing & Agitation
A. Necessity of mixing & agitation in chemical industries, Types of Impellers & propellers, Different flow patterns in mixing, Calculation of power requirement of mixing equipment, Solid – Solid Mixing, Agitator selection.
B. Mixing equipment

Unit V  (8 Hrs)
Filtration and Sedimentation


B. Filtration Equipments

Text Books

Reference Books
CH39111 :: CHEMICAL ENGINEERING THERMODYNAMICS

Credits: 03 | Teaching Scheme: - Theory 3 Hrs/Week

Prerequisites: Nil

Objectives:
• To understand the fundamental concepts of chemical engineering
• To introduce students to thermodynamics for application to Chemical Engineering.
• To solve complex chemical engineering problems using thermodynamic concepts, data, and models.
• Mapping with PEOs : 4 (a,d,g)

Unit I (8 Hrs)
Volumetric Properties of Pure Fluids
A. Introduction, the P.V.T. behavior of pure substance, the Viral equation, Compressibility factor, the ideal gas, the constant volume, constant pressure, adiabatic, polytrophic processes, real gas, applications of Viral equation, critical properties, Vander Wall equation
B. Redlich –Kwong equation

Unit II (7 Hrs)
Thermodynamic Properties of Fluids
A. Maxwell relationships, homogeneous phases, residual properties, two-phase systems
B. Clausius-Clapeyron equation, tables and diagram of thermodynamic properties

Unit III (9 Hrs)
Solution Thermodynamics and Applications
A. Fundamental property relations, chemical potential, criteria for phase equilibrium, partial properties, ideal gas mixtures, fugacity and fugacity coefficients for pure species, for species in solution, ideal solutions, VLE data- fugacity, Activity coefficients
B. Excess properties, Excess Gibb’s energy

Unit IV (8 Hrs)
Phase Equilibria
A. Vapour – liquid equilibrium: The nature of equilibrium, criteria of equilibrium, phase rule, Duham’s theorem, Raoult’s law, VLE by modified Raoult’s law, dew point and
bubble point calculations, Flash calculations, Determine whether azeotrope exist, Equilibrium and stability.
B. liquid -liquid equilibrium, solid liquid equilibrium

Unit V (8 Hrs)  
Chemical Reaction Equilibria

A. Criteria for equilibrium to chemical reactions, the standard Gibbs free energy change and the equilibrium constant. Effect of temperature on equilibrium constant, evaluation of the equilibrium constant, relation of equilibrium constant to composition, calculation of equilibrium conversion for single reaction

B. The phase rule and Duhem’s theorem for reacting systems

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CH39112 :: CHEMICAL TECHNOLOGY

Credits: 03  
Teaching Scheme: - Theory 3 Hrs/Week

Prerequisites: Nil

Objectives:
- To understand process flow sheet, unit operations, major engineering problems in inorganic and organic chemical process industry.
- Mapping with PEOs : 4 (a,d,g)

Unit I  (7 Hrs)
Basic Concepts
A. Unit operations and Unit processes, Development of flow diagram
B. schematic representation and application for unit operations and unit processes

Unit II  (8 Hrs)
Chlor-Alkali and Nitrogen Industry
A. Chlor-alkali chart and importance of chlor-alkali industry, Manufacturing of soda ash, Role of nitrogen in fertilizers, manufacturing of ammonia
B. caustic soda, chlorine and engineering problems. Nitric acid, urea
(The above study must involves different routes adopted, limitations, advantages and disadvantages of the process)

Unit III  (8 Hrs)
Phosphorus and Paper Pulp Industry
A. Importance, manufacturing of super phosphate, triple super phosphate, production of pulp, engineering problems involved, paper manufacturing from pulp.
B. phosphoric acid, electro thermal processes and NPK fertilizers, comparison of methods of manufacturing for pulp and paper

Unit IV  (9 Hrs)
Petroleum and Petrochemical Industry
A. Petroleum Industry: History and production of crude petroleum, characteristics of refinery operation, pyrolysis, cracking.
Petrochemical Industry:
  C1 compounds: Methanol, formaldehyde.
  C2 compounds: Ethylene and acetylene production, production of vinyl chloride.
  C3 compounds: Production of acetone and cumene.
B. Isomerisation, hydrogenation, Chemicals from aromatics: Production of phenol, styrene, and production of phthalic anhydride
Unit V  
Sulfur and Sugar Industry  
(8 Hrs)

A. Importance, manufacturing of sulfur by Frasch process, technology for the manufacturing of sulfuric acid, chamber and DCDA process, detailed study and comparison Sugar Industry: Manufacture of sugar and engineering problems associated

B. Dextrin and starch derivatives

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CH49111 :: ENERGY, MASS AND MOMENTUM TRANSFER

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<th>Credits: 03</th>
<th>Teaching Scheme: - Theory 3 Hrs/Week</th>
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</table>

**Prerequisites:** Nil

**Objectives:**
- To understand different transport processes in chemical engineering such as fluid flow, heat transfer and mass transfer.
- To understand analogy between fluid flow, heat and mass transfer.
- Mapping with PEOs: 4 (a,d,g)

**Unit I (9 Hrs)**

**Fluid Flow Operations**

Flow of fluids: Introduction, definition and nature of fluid, viscosity, Newton’s law of viscosity pressure and temperature dependence, velocity profile, flow field, types of fluid motion, Rheological classification of fluids, laminar and turbulent flow, laminar flow through circular tube (Hagen-Poiseuille equation), on inclined plane, through annular space (concentric pipes), Concept of Reynolds number; transition and turbulent flow in pipes.

B. Darcy-Weisbach equation, Moody diagram for obtaining friction factor, Reciprocating, rotary, and centrifugal pumps

**Unit II (9 Hrs)**

**Heat Transfer Operations**

A. Heat transfer: Conduction, convection (omit correlations for calculation of heat transfer coefficients, heat transfer with change in phase) and radiation. Flow arrangement in heat exchangers, variation of fluid temperatures in heat exchangers, heat transfer equipment (double pipe & Shell and tube heat exchanger), evaporation, long tube vertical type and forced circulation type evaporators

B. multiple effect evaporation, methods of feeding

**Unit III (7 Hrs)**

**Mass Transfer Operations -I**

A. Mass transfer: Diffusion, mass transfer coefficients, absorption, Vapour-Liquid Equilibrium, Relative Volatility, Boiling point diagram, Distillation, reflux, Equipment for gas-liquid operations

B. selection of equipment for gas-liquid operations

**Unit IV (7 Hrs)**

**Mass Transfer Operations -II**
A. Liquid-liquid extraction, extraction schemes, distribution coefficient, triangular diagram, selection of disperse phase, classification of industrial liquid-liquid contactors
B. industrial liquid-liquid contactors. Selection of liquid-liquid extraction contactors

Unit V

Mass Transfer Operations - III

A. Drying, crystallization, humidification and dehumidification, adsorption
B. equipment for drying, crystallization equipment, adsorption equipment

Text Books

Reference Books
CH49112 :: CHEMICAL REACTION ENGINEERING

Credits: 03 | Teaching Scheme: - Theory 3 Hrs/Week

Prerequisites: Nil

Objectives:
- Write a rate law and define reaction order and activation energy
- Demonstrate the ability to quantitatively predict the performance of common chemical reactors using simplified engineering models
- Demonstrate the ability to regress the experimental data from which they determine the kinetic model of a multi-reaction system and use this information to design a commercial reactor
- Mapping with PEOs : 4 (a,d,g)

Unit I (7 Hrs)
Introduction
A. Chemical Kinetics and thermodynamics of reaction; Classification of reactions - Homogeneous and Heterogeneous reactions. Rate of reaction -broad definition for homogeneous and heterogeneous reactions
B. Irreversible and reversible reactions

Unit II (9 Hrs)
Kinetics of Homogeneous Reactions
A. Equilibrium; Order and molecularity of reaction. Elementary and non elementary reactions; Stoichiometry, Fractional conversion. Rate of reaction based on all components of the reaction and their interrelation. Law of mass action, Rate Constant-Based on thermodynamic activity, partial pressure, mole fraction and concentration of the reaction components and their interrelation
B. Temperature dependency of rate Constant -Arrhenious law, Transition state theory and collision theory

Unit III (8 Hrs)
Interpretation of Batch Reactor Data
A. Batch reactor concept, Constant volume Batch reactor system; Design equation for zero, first, Second and third order irreversible and reversible reactions, graphical interpretation of these equations and their limitations, Multiple reactions-stoichiometry and Rate equations for series and parallel reactions; Development of rate expression; Chain reactions development of rate expressions
B. Variable volume Batch reactors. Design equation for zero, first and second order irreversible and reversible reactions, Graphical interpretation of their limitations
Unit IV  (8 Hrs)
Ideal Flow Reactors I

A. Concept of ideality, Types of flow reactors and their differences, Space-time and Space velocity, Design equation for plug flow reactor and CSTR; Design equations for first reversible and irreversible constant volume, Graphical interpretation of these equations
B. Design equations for second order reversible and irreversible constant volume, Graphical interpretation of these equations

Unit V  (8 Hrs)
Ideal Flow Reactors II

A. Mean holding time, Development of rate expression for mean holding time for a plug flow reactor, Size comparison of single reactors; Optimum size determination; Staging of reactors.
B. Reactors in series and parallel

Text Books

Reference Books
## Minor in Nanotechnology and Advanced Materials

### Credit Break – up for Honors / Minor Course

<table>
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<tr>
<th>Subject Code</th>
<th>Subject Name</th>
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</table>
CH29132 :: INTRODUCTION TO MATERIALS SCIENCE AND ENGINEERING

Credits: 03  Teaching Scheme: -  3 Hrs/Week

Prerequisites: Nil

Objectives:
- Study fundamental concepts of materials science
- Learn about relationships between structure and properties of materials
- Learn how processing of materials can be used to dictate the structure.
- Mapping with PEOs : 4 (a,d,g)

Unit I
Introduction, Atomic and Crystal Structures


B. Effect of temperature on diffusion in solids.

Unit II
Mechanical and Electrical Properties of Materials

A. Stress-strain diagram, hardness, plastic deformation, fracture, fatigue, creep Electrical conduction in metals and the energy-band model. Intrinsic and extrinsic semiconductors and semiconductor devices.

B. Stress rupture of metals. Compound semiconductors.

Unit III
Phase Diagrams, Engineering Alloys


B. Magnesium and Titanium alloys

Unit IV
Polymeric, ceramic materials and composites

(8 Hrs)

(8 Hrs)

(8 Hrs)

B. Metal-matrix and Ceramic-matrix composites.

Unit V

Magnetic and Optical Properties of Materials


B. Optical fibers.

Text Books:


Reference Books:

# CH39131 :: PHYSICS OF MATERIALS

| Credits: 03 | Teaching Scheme: - 3 Hrs/Week |

**Prerequisites:** Nil

**Objectives:**
- To learn basic principles of quantum mechanics along with one-dimensional models with a view to understand development of various models of behaviour of materials of relevance to nanotechnology.
- To understand mechanical, thermal, electronic properties of a crystal from a fundamental point of view.
- Mapping with PEOs: 4 (a,d,g)

## Unit I
**Quantum Mechanics**

Review of classical mechanics.
Postulates of quantum mechanics.
One-dimensional problems: particle in a box, rectangular barrier and quantum tunneling.
Finite potential well, periodic lattice.
Relevance of quantum mechanics to nanotechnology.

## Unit II
**Quantum Statistical Mechanics**


## Unit III
**Crystal structure, Lattice vibrations**

Periodic array of atoms, basis and primitive lattice cell. Types of lattices, simple crystal structures.
Crystal binding. Elastic properties of a crystal.
Phonons: Vibration of crystals with monatomic basis. Phonon momentum. Inelastic scattering by phonons.
Phonon specific heat, thermal conductivity.

## Unit IV

Electron theory of metals
Drude and Sommerfeld theories of metals. Failures of free electron model.

Unit V
Band theory of Solids
(8 Hrs)

Unit VI
Self Study
(8 Hrs)

Text Books:

Reference Books:
CH39132 :: NANOTECHNOLOGY

Credits: 03  Teaching Scheme: - 3 Hrs/Week

Prerequisites: Nil

Objectives:
- Obtain an overview of the various facets of nanotechnology including:
  - historical development
  - characterisation techniques
  - physics and chemistry
  - synthesis / fabrication
- Mapping with PEOs : 4 (a,d,g)

Unit I
Introduction
(8 Hrs)
Historical development of nanotechnology.
Overview of nanotechnology. Global trends.
Overview of typical products in market utilizing nanotechnology.

Unit II
Physics of Nanomaterials
(8 Hrs)
Coverage of physics of materials appropriate for applications to nanotechnology

Unit III
Characterisation of Nanomaterials
(8 Hrs)
Microscopy techniques (SEM, TEM; STM, AFM), spectroscopy techniques, XRD etc

Unit IV
Synthesis / fabrication of nanomaterials
(8 Hrs)
Top-down and bottom-up approaches for synthesis of nanomaterials

Unit V
Applications of Nanotechnology
(8 Hrs)
Current and potential applications of nanotechnology. Biological nanomaterials.
Nanoelectronics. Nanomachines & nanodevices etc.
Research directions. Economic, environmental and societal aspects of nanotechnology.
Unit VI
Self Study

(8 Hrs)

Detailed study of at least two commercial nanoproducts / nanotechnologies or research articles of your choice (not covered in the course)

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CH49131 :: ADVANCED MATERIALS

Credits: 03  
Teaching Scheme: - Theory 3 Hrs/Week

Prerequisites: NIL

Objectives:
1. Learn advanced materials systems involving metals, ceramics, polymers and composites
2. Study materials exhibiting electronic, optical, magnetic and superconducting properties
3. Learn engineering processes involved in the fabrication of microelectronic circuits
4. To understand the systems approach to materials / nanomaterials in the design context.
5. Mapping with PEOs : 4 (a,d,g)

Unit I  
Advanced Metallic, Polymeric and Ceramic Materials  
(8 Hrs)

Superalloy steels. Superalloys.
Engineering polymers s.a. polyamide, polycarbonates etc. Specialty polymers s.a liquid-crystal polymers, conductive polymers etc. Applications.
Engineering ceramics s.a. silica on carbide, silicon nitride, alumina, zirconia.

Unit II  
Composite materials  
(8 Hrs)


Unit III  
Materials for Electrical, optical, magnetic applications; Smart materials  
(8 Hrs)

Selected applications of state-of-the-art and futuristic applications of materials exhibiting special electrical, optical, magnetic properties etc. (eg Superconductive materials, quantum computing etc.)
Smart materials.

Unit IV  
Fabrication of microelectronics integrated circuits  
(8 Hrs)

Introduction. Unit processes and technologies. Semiconductor substrates. Hot processing and ion implantation.
Pattern Transfer: optical and nonoptical lithography, vacuum science and plasmas, etching.
Thin films: Physical deposition – evaporation and sputtering, CVD, epitaxial growth.
Process integration.

Unit V
Systems Approach: Materials / Nanomaterials in Design
(8 Hrs)
The design context: materials in design. Product design, architecture and engineering.
Environments, systems and assemblies. The design and development process.
Material property charts and their uses.

Unit VI
Self Study
(8 Hrs)
Any one material / materials processing technology of your choice from each of the following categories. (You should choose materials which are not covered in the course): Metals, Ceramics, Polymers, Composites, Electronic materials, optical materials, magnetic materials, smart materials

Text Books:

Reference Books:
CH49132 :: SELECTED TOPICS IN MATERIALS SCIENCE AND ENGINEERING

Credits: 03    Teaching Scheme: - 3 Hrs/Week

Prerequisites: Nil

Objectives:
- To cover selected topics in Nanotechnology and Advanced Materials in an open-ended manner based on composition of the minor course / interests of students/faculty
- Mapping with PEOs : 4 (a,d,g)

Unit I
Advanced Materials for Vertical Markets
A. Applications of advanced materials / nanotechnology in Automotive, Space, Aerospace, Electronic, Construction markets.
B. Usage of advanced materials / nanotechnology in any one application area

Unit II
Materials Simulations
A. Overview of ab-initio, molecular, mesoscopic simulations of materials.
B. Study of any one open source materials simulation software such as PWSCF, Gromacs etc.

Unit III
Nanoelectronics
B. Spintronics

Unit IV
Biomaterials and Biomedical Devices
A. Introduction to biomaterials science. Biomineralization. Self-assembly. Hierarchical structuring of materials, biomimetics, biopolymers. Overview of biomedical devices such as contact lenses, hip implants, pace makers etc.
B. Artificial heart valves
Unit V (8 Hrs)
Quantum Computing


B. Ion-trap based implementations of quantum computing.

**Text Books:**
1. Internet resources (Wikipedia, arxiv.org etc)

**Reference Books:**
1. Internet resources
MINOR
# Minor in Environmental Technology and Biotechnology

## Credit Break – up for Honors / Minor Course

<table>
<thead>
<tr>
<th>Subject Code</th>
<th>Subject Name</th>
<th>Theory (Hr./week)</th>
<th>Laboratory (Hr./week)</th>
<th>Tutorial (Hr./week)</th>
<th>Credits</th>
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<tr>
<td>CH29152</td>
<td>Microbial and Environmental Chemistry</td>
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<tr>
<td>CH39151</td>
<td>Bioprocess Engineering</td>
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<td>Environmental Science and Engineering</td>
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<td>CH49151</td>
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<td>Environmental Regulations and Standards</td>
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</tbody>
</table>
CH29152 :: MICROBIAL AND ENVIRONMENTAL CHEMISTRY

Credits: 03  
Teaching Scheme: - Theory 3 Hrs/Week

Prerequisites: Nil

Objectives:
- To make understand the microorganism and their use in pollution control
- To learn in detail techniques for control of air, water and solid pollution
- Mapping with PEOs : 4 (a,d,g)

Unit I  
8 Hr

Carbohydrate

A. Carbohydrate – Classification, structure, general properties and functions of polysaccharides and complex carbohydrates; amino sugars, proteoglycans and glycoproteins.

B. Mutarotation of hexose, structure of DNA.

Unit II  
8 Hr

Lipids and Proteins

A. Lipids – Classification, structure, properties and functions of fatty acids, essential fatty acids, fats, phospholipids, sphingolipids, cerebrosides, steroids, bile acids, prostaglandins, lipoaminos, lipoproteins, proteolipids, phosphatidopeptides, lipopolysaccharides.

B. Preparation of peptide bond linkage.

Unit III  
8 Hrs

Special feature of bacterial metabolism


B. Morphology and structure of bacteria, gram positive and gram negative

Unit IV  
8 Hrs

Toxicity and pollution-I
A. Toxicity: acute, chronic, LC\textsubscript{50}, LD\textsubscript{50}, model organisms used in environmental monitoring. Air pollution: Sources, smog, suspended particulate matter (SPM), air quality, analysis of air pollutants, permissible levels acid rain, effects of air pollution on flora, fauna and human beings, control of air pollution. Water pollution: sources, permissible levels ground water pollution, surface water pollution, water bodies pollution, marine pollution, BOD, COD, control of water pollution.
B. Waste water management, effluent treatment methods

Unit V 8 Hrs
Toxicity and pollution-II
Chlorofluorocarbons (CFC): sources, ozone layer, mechanism of ozone depletion, harmful Instrumental methods of analysis - chromatographic methods, spectroscopic methods- UV-visible, IR and NMR and other techniques such as XRD with focus on interpretation of data. Numerical on interpretation of data, affects of ozone depletion, CFC substitutes.
B. Theory and interpretation of UV-visible, IR and NMR spectral data.

Text Books

Reference Books

CH39151 :: BIOPROCESS ENGINEERING
Credits: 03  
Teaching Scheme: - Theory 3 Hrs/Week

Prerequisites: Nil

Objectives:
- To understand bioprocesses, catalytic functions, and use them in the design of bioprocess plant.
- Mapping with PEOs: 4 (a,d,g)
Bansilal Ramnath Agarwal Charitable Trust’s
Vishwakarma Institute of Technology, Pune – 411 037
Department of Chemical Engineering

Unit I
Overview of Biological Basics
(7 Hrs)
A. Types of cells, types of microorganisms, cell constructions, cell nutrients, metabolic pathways.
B. Indian scenario of bioprocesses

Unit II
Enzyme and Enzyme Kinetics
(9 Hrs)
A. How enzymes works, model, mechanisms, rate expression, enzyme immobilization, its kinetics, industrial utilization of enzymes
B. International Nomenclature of enzymes and microbes

Unit III
Traditional Industrial Bioprocesses
(8 Hrs)
A: Anaerobic Bioprocesses – Ethanol Production, lactic acid production, Acetone Butanol production. Aerobic processes – Citric acid production, Production of Baker’s yeast, Production of Penicillins, Production of High Fructose Corn syrup
B. Wine manufacture

Unit IV
Bioreactors
(8 Hrs)
A. Selection of bioreactors, scale up problems, considerations of aeration, agitation, and heat transfer, bioreactor instrumentation and control, sterilization
B. Death kinetics of microorganisms

Unit V
Bioprocess Considering Plant Cell Culture and Genetically Engineered Organisms
(8 Hrs)
B. Comparison of plant cell cultures and microbes

Text Books

Reference Books
### CH39152 :: ENVIRONMENTAL REGULATIONS AND STANDARDS

| Credits: 03 | Teaching Scheme: - Theory 3 Hrs/Week |

| Prerequisites: Nil |

<table>
<thead>
<tr>
<th>Objectives:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. To learn the environmental regulations and standards.</td>
</tr>
<tr>
<td>2. To learn and understand principles, process, and necessary techniques for environmental impact assessment, mitigation and monitoring.</td>
</tr>
<tr>
<td>3. Mapping with PEOs : 4 (a,d,g)</td>
</tr>
</tbody>
</table>

#### Unit I (8 Hrs)
**Indian Constitution and Environment**

A. Introduction -Fundamental Rights-Directive principles of state policy-Article 48(A) and 51-A(g) Judicial enforceability-Constitution and resources management and pollution control-Indian forest policy(1990) –Indian Environmental policy(1992)

B. Administration regulations-constitution of pollution control Boards Powers, functions, Accounts, Audit etc

#### Unit II (8 Hrs)
**Environmental Regulations in India**


B. Ozone Depleting Substance (R&C) Rules, Noise Pollution (Regulations and Control)

#### Unit III (8 Hrs)
**Air and Water Quality Standards**

A. CPCB, WHO and EPA standards for water and waste water, air quality, soil, noise, pesticides

B. Standards for industrial effluents

#### Unit IV (8 Hrs)
**Environmental Impact Assessment**

A. Analysis of environmental impact using technical and non-technical parameters.

Environmental impact assessment applied to solid and liquid waste management, effluent control, air pollution control, urban development, and transportation systems.

Environmental Risk Assessment (ERA) - Legal and Regulatory aspects in India. Types and limitations of EIA

B. Terms of Reference in FIA- Issues in FIA - national - cross sectoral - social and
## Unit V

### Documentation and Monitoring (8 Hrs)


B. Environmental Management Plan.

### Text Books


### Reference Books

2. [www.cpcb.nic.in](http://www.cpcb.nic.in)
3. [www.who.int](http://www.who.int)
8. Environmental policy, Forest Policy, Bare Acts-Government Gazettes and Notification
**CH49151 :: POLLUTION CONTROL**

<table>
<thead>
<tr>
<th>Credits: 03</th>
<th>Teaching Scheme: - Theory 3 Hrs/Week</th>
</tr>
</thead>
</table>

**Prerequisites:** Nil

**Objectives:**
1. To understand various types of pollutants, pollutant analysis and abatement techniques.
2. Mapping with PEOs: 4 (a,d,g)

**Unit I**

**Analysis of the pollutants**

(8 Hrs)

A. Introduction, Industrial waste water analysis, industrial gaseous effluent analysis, particle size distribution
B. Methods of analysis of the pollutants

**Unit IV**

**Removal of Specific Pollutants**

(8 Hrs)

A. Removal of BOD, removal of mercury, removal of chromium, Removal of particulate matter
B. Removal of Organic Vapour from Effluent Gases

**Unit IV**

**Removal of Specific Pollutants**

(8 Hrs)

A. Removal of ammonia/urea, removal of phenolic components and removal of oxides of nitrogen,
B. Removal of sulphur dioxide

**Unit V**

**Pollution control in process industries**

(8 Hrs)

A. Pollution control in fertilizer industry, petrochemical units, pulp and paper industry.
B. General considerations of pollution control in chemical industry

**Text Books**

Reference Books
CH49152 :: ENVIRONMENTAL REGULATIONS AND STANDARDS

Credits: 03  |  Teaching Scheme: - Theory 3 Hrs/Week

Prerequisites: Nil

Objectives:
1. To learn the environmental regulations and standards.
2. To learn and understand principles, process, and necessary techniques for environmental impact assessment, mitigation and monitoring.
3. Mapping with PEOs : 4 (a,d,g)

Unit I  (8 Hrs)
Indian Constitution and Environment
A. Introduction -Fundamental Rights-Directive principles of state policy-Article 48(A) and 51-A(g) Judicial enforceability-Constitution and resources management and pollution control-Indian forest policy(1990) –Indian Environmental policy(1992)
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B. Standards for industrial effluents

Unit IV  (8 Hrs)
Environmental Impact Assessment
A. Analysis of environmental impact using technical and non-technical parameters. Environmental impact assessment applied to solid and liquid waste management, effluent control, air pollution control, urban development, and transportation systems. Environmental Risk Assessment (ERA) - Legal and Regulatory aspects in India. Types and limitations of EIA.
B. Terms of Reference in EIA- Issues in EIA - national - cross sectoral - social and cultural.

Unit V (8 Hrs)
Documentation and Monitoring
B. Environmental Management Plan.

Text Books

Reference Books
2. www.cpcb.nic.in
3. www.who.int
8. Environmental policy, Forest Policy, Bare Acts-Government Gazettes and Notification
MINOR
### Minor in Chemistry

#### Credit Break – up for Honors / Minor Course

<table>
<thead>
<tr>
<th>Subject Code</th>
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</table>
CH29192 :: BASIC POLYMER CHEMISTRY

Credits: 03  
Teaching Scheme: - Theory 3 Hrs/Week

Prerequisites: Nil.

Objectives:
- To develop industrial awareness amongst students.
- To enhance employability of the students.
- To impart applied chemistry principles.
- To increase industry-institute interaction.
- Mapping with PEOs : 4 (a,d,g)

(8 Hrs)

Unit I
Basic concepts of macromolecules


B. Self study: Kinetics of Bi-functional systems. Poly functional systems.

(8 Hrs)

Unit II
Addition polymerization


B. Self Study: Diene polymerization, Kinetics- Ring opening polymerization

(8 Hrs)

Unit III
Copolymerization:


B. Self Study: Determination of Monomer reactivity ratios.

(8 Hrs)

Unit IV
Molecular weights of polymers:

A. Molecular weight averages, Molecular weight distribution. Degree of polymerization,
Molecular weight determination. Basic concepts of end group analysis, colligative properties, osmometry, Viscosity of polymers solutions, size of the polymer molecules.

**B Self Study:** Unidispersity, Polydispersity, light scattering, and gel permeation chromatography.

**Unit V (8 Hrs)**

**Chemical reactions of polymers:**


B. **Self Study:** Mechanochemical degradation, Oxidative degradation, Hydrolytic degradation.

**Text Books**


**Reference Books**

CH39191 :: PROPERTIES OF POLYMERS

Credits: 03

Teaching Scheme: - Theory 3 Hrs/Week

Prerequisites: Nil.

Objectives:
- To develop industrial awareness amongst students.
- To enhance employability of the students.
- To impart applied chemistry principles.
- To increase industry-institute interaction.
- Mapping with PEOs : 4 (a,d,g)

Unit I
Structure of polymers

A. Linear, branched, crosslinked, and network polymers - Homochain and hetero atomic chain polymers - Copolymers - Linear and cyclic arrangement - Prediction of polymer properties, Volumetric properties - molar volume, density, Van der Waals volume - Coefficient of linear thermal expansion and volumetric thermal expansion - Pressure volume temperature (PVT) relationship.
B. Self study: Group contribution techniques, topological techniques.

Unit II
Mechanical properties of polymers:

A. Stress-strain properties of polymers - Effect of polymer structure on modulus of elasticity, tensile strength, flexural strength, impact strength, yield strength, fracture toughness - Crazing in glassy polymers - Ductile brittle transition.
B. Self Study: Effect of additives on mechanical properties of polymers - Creep, stress relaxation, and fatigue.

Unit III
Thermodynamic and transition properties:

A. Transition temperature in polymers, glass transition (Tg), melt transition (Tm), relationship between Tg and Tm - other transitions like β-transitions, upper and lower glass transition temperatures - Prediction of Tg and Tm of polymers by group contributions.
B. Self Study: Calorimetric properties - Heat capacity, specific heat, latent heat of crystallization and fusion, enthalpy and entropy - Calculation of heat capacities of polymers.
Unit IV (8 Hrs)

Electrical and optical properties:

A. Effect of polymer structure on dielectric constant, power factor, dissipation factor, and loss factor - effect of frequency of voltage and temperature on dielectric properties - Prediction of molar polarization and effective dipole moment. Effect of additives on electrical properties of polymers. Optical properties - Effect of polymer structure on optical properties - clarity, transparency, haze, transmittance, reflectance, and gloss.

B Self Study: Prediction of refractive indices of polymers by group contributions.

Unit V (8 Hrs)

Chemical Properties of polymers:


B. Self Study: Cohesive energy, cohesive energy density, Influence of structure in prediction of flame retardancy, water repellency

Text Books

Reference Books
### CH39192 :: POLYMER MANUFACTURING METHODS

<table>
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<th>Teaching Scheme: - Theory 3 Hrs/Week</th>
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<table>
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<tr>
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<tr>
<td>- To develop industrial awareness amongst students.</td>
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<tr>
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</tr>
<tr>
<td>- Mapping with PEOs : 4 (a,d,g)</td>
</tr>
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</table>

**Unit I**  
**Methods of manufacturing I**


B. **Self study:** Mechanisms of addition polymerization.

**Unit II**  
**Methods of manufacturing II:**

A. Properties and applications of poly(vinyl chloride)- Poly(vinylidene chloride)-Poly(vinyl alcohol) - Poly(vinyl acetate)- Chlorinated poly(vinyl chloride)- Plastisols.

B. **Self study:** Study of thermal stability of halogenated polymers.

**Unit III**  
**Methods of manufacturing III:**

A. Methods of manufacturing - Properties and applications of polystyrene. Copolymers - Copolymer of acrylonitrile, butadiene and styrene - Copolymer of styrene and acrylonitrile.

B. **Self study:** High impact polystyrene- expanded polystyrene

**Unit IV**  
**Methods of manufacturing IV:**

A. Properties and applications of Acrylates - Poly (methyl methacrylate)-Polyacrylonitrile. Polyethylene terephthalate, polybutylene terephthalate, polydihydroxymethyl cyclohexyl terephthalate.
B. **Self study**: Polybutylene terephthalate - Polycetals and copolymers - Polycarbonates.

**Unit V**  
**Methods of manufacturing V:**  
A. Properties and applications of Fluoro polymers - Polytetrafluoroethylene, Polychlorofluoroethylene, Thermoplastic polyurethanes.  
B. **Self study**: Cellulose nitrate - Cellulose acetate- ethyl cellulose-Cellulose esters.

<table>
<thead>
<tr>
<th><strong>Text Books</strong></th>
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<tr>
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</thead>
</table>
CH49191 :: CHEMISTRY OF NATURAL RUBBER

Credits: 03  
Teaching Scheme: - Theory 3 Hrs/Week

Prerequisites: Nil.

Objectives:
- To develop industrial awareness amongst students.
- To enhance employability of the students.
- To impart applied chemistry principles.
- To increase industry-institute interaction.
- Mapping with PEOs : 4 (a,d,g)

Unit I

Chemistry of rubber/latex I:

A. Introduction on the application of latex and rubber for the manufacture of rubber goods. Natural rubber from latex, concentration and stabilization of latex. Latex compounding. Rubber additives and compounding.

B. Self Study: Compound development for runner.

Unit II

Chemistry of rubber/latex II:

A. Natural Rubber: Source, Chemical formula, molecular weight distribution, the protein effect, elasticity of rubber chain, elasticity of a network, network defects, Structure property relationships in rubber and non rubber. Chemical reactivity, solution properties, electrical, structure and processing properties of rubber.

B. Self Study: Thermodynamics of rubber elasticity.

Unit III

Diene Homopolymer Rubbers:


B. Self Study: Chemical and thermal property of cross linking, reactivity of diene rubber.

Unit IV

Oxidation Properties of Rubber:
A. Oxidation of saturated and unsaturated hydrocarbons, sulphides and olefin sulphide systems, oxidation of di-ene rubber, butadiene, nitrile rubbers, reactivity of diene rubber network. Use of anti-degradants.

B. Self Study: Theory of mastication and mechanochemistry.

Unit V

Manufacture of latex product:

A. Manufacture of latex product by impregnation and spreading process, casting impregnation, dipping process, latex coating, latex cement and adhesives, latex thread coir and latex foam.

B. Self Study: manufacture of rubber products, tubes, hoses, and footwear.

Text Books

Reference Books
CH49192 :: SPECIALITY POLYMERS

Credits: 03 | Teaching Scheme: - Theory 3 Hrs/Week

Prerequisites: Nil.

Objectives:
- To develop industrial awareness amongst students.
- To enhance employability of the students.
- To impart applied chemistry principles.
- To increase industry-institute interaction.
- Mapping with PEOs : 4 (a,d,g)

Unit I
Natural Polymers:
A. Study of following natural polymers:
Proteins and peptides: Amino acids, Peptide linkages, Primary structure of protein.
Sequencing techniques, End group analysis, secondary structure of protein.
Carbohydrates: Linear polysaccharides, Branched polysaccharides. Structure and properties
of amylose, amylopectin and cellulose.
Nucleic acids: Chemical Structure of DNA, nucleotides and nucleotides, helical model of
DNA.
B. Self Study: Nomenclature of peptides, carbohydrates: D/ L and d/l isomerism.
Chemical properties of sugars.

Unit II
Inorganic Polymers:
A. Classification, Structure, property and uses of silicones, polyphosphazenes, polythiazyl,
polygermanes and polystannes.
Mechanism of inorganic polymerisation: Step, Chain and ring opening mechanism.
B. Self Study: Study of types of chemical linkages, study of preparation property and uses
of sodium polysialate.

Unit III
Specialty Polymers & Functional Polymers:
A. Specialty Polymers: Thermally stable polymer, polyphenylene sulphide polysulphene,
polyphenyl imidazole. Electroconducting polymers, Liquid crystal and Bio-degradable
Polymers.
Functional Polymers: Photoconductive, piezoelectric, light sensitive polymers. Ion
exchange resins, Polymeric reagents.
B. Self Study: Relation between structure and thermal stability, relation between structure
and conductivity, relation between structure and biodegradability.
Unit IV  
(8 Hrs)  
Study of following synthetic polymers:

Ether polymers: Introduction, polyacetal, polyethylene glycol, polypropylene glycol, epoxy resins, polyethylene phylene oxide.  
Polyamides: Introduction, aliphatic polyamide, aromatic polyamide, polyamide imides, and polyimides.


Unit V  
(8 Hrs)  
Techniques in polymer chemistry:

A. Spectral analysis of polymers: IR and raman spectra, UV and visible absorption spectra, NMR and ESR spectra, Mass spectra.  
Thermal analysis of polymers: Thermogravimetric analysis, Differential thermal analysis, Differential scanning colorimetry, TMA-DTMA.

B. Self Study: Polymer crystallinity: Unit cells, Chain packings, estimation of degree of crystallinity.

Text Books

Reference Books
ACADEMIC INFORMATION

A) Mid Semester Examination

1. Students reporting in morning slot will have examination in morning slot. Those in evening slot will have examination in evening slot.
2. 20 multiple choice based questions to be attempted in 30 minutes x no. of theory courses i.e. 100 questions in 150 minutes for F.E., 80 questions in 120 minutes for S.E., T.E., B.E., M.E., 20 questions in 30 minutes for Honors, Minor, Fast Track, etc.
3. A scrambled mix of questions will be generated through software.
4. Mid Semester Examination will be based on Unit II & Unit III.
5. There will be one mark for each correct answer and (-) 0.25 marks for every wrong answer.
6. For a typical 3 hour Mid Semester Examination, first 15 minutes would be used for student attendance, record keeping, seat allocation, log in procedure if any, etc. Next 150 minutes for actual examination. A timer indicating time remaining to be provided by ERP. 15 minutes for processing & results.
7. A visual alarm / flash would be given 10 minutes before completion of 150 minutes as a warning. For auto generation of every theory course result out of 20 and dispatch of the marks on student mobile and mail ID as well as parent mail ID.
8. No repeat examination under any circumstances.
B) Seminar – Conduct, Evaluation, etc.

Seminar– (T.E.- Semester I)

1. Review – I: during Mid Semester Examination (Compulsory) as per the Academic Calendar.
2. Review – II : The last week of November (Optional)
3. For poor performing students identified by the examination panel, a second review to be taken. Review II optional for other students. For Review II, deduction of 10 marks will take place.
4. Seminar is an individual activity with separate topic and presentation.
5. Duration of presentation – 20 minutes
   Question and answer session – 10 minutes

Seminar Evaluation Scheme :

1. Attendance during Semester – 10 marks
2. Attendance during Seminar presentation self & peer – 10 marks
3. Relevance of Seminar topic – 10 marks
4. Timely Abstract submission – 10 marks
5. Literature review – 10 marks
6. Technical contents – 10 marks
7. Presentation – 25 marks
8. Question & answer Session – 15 marks

-----------------
100 marks
-----------------
C) **Equivalence**

For the courses belonging to 2008 structure counseling sessions for failure students will be arranged. The Head of Department will appoint faculty identified as subject experts as counselors. The previous examination scheme i.e.

- Class Test – 10 marks
- T.A. through Home assignment – 10 marks
- A written paper MSE – 30 marks
- A written paper ESE – 50 marks

Will be followed. The entire processing based on 2008 structure related coding scheme will be followed. Counseling + Administration + Examination charges will be the basis for fees considered for such students.
D) Extra Credits

A student planning to take extra credits may be considered under following categories:

(a) A student carrying a backlog and re-registering for the previous course – Re-registration charges as applicable. Consideration of all courses registered for during that Semester of Academic Year for SPI calculation.

(b) Student planning to take extra courses as a fast track opportunity – Administration, processing and examination charges will be considered. In any case the student has to pay the college fees for four years. This fast track facility would enable the student to undergo an industrial training, an exchange programme, research contribution in I.I.T. under scheme such as KVPY without any academic compromises for credit transfer. The phasedevelopment and completion of project activity cannot be considered at an accelerated pace under fast track scheme. The registration under fast track is subject to having a CPI 8.0 or above and no backlog for consideration of registration to an additional course.

(c) Students opting for earning extra credits by selection of courses in addition to the courses prescribed by respective BOS which are single Semester activities and not the part of Honors / Minor scheme. Such students will be expected to pay charges equivalent to re-registration (proportionate credit based payment). The registration for such courses is subject to permission given by the Chairman BOS of the Board in the purview of which the subject is identified. Such permissions will be given based on meeting with prerequisite subject.

1. In any case (a), (b) or (c) the candidate cannot register for more than 8 credits.

2. A suitable reflection of completion of the said course will be made in the candidate’s Grade statement.

For part (c) a separate grade & GPA will be calculated. That GPA will not be clubbed with the other regular courses for SPI, CPI calculation.
E) **Home Assignment**

A Home Assignment Calendar for Semester is prepared as under:

<table>
<thead>
<tr>
<th>Week No.</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>No Home Assignments</td>
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<tr>
<td>4</td>
<td>S1 / S2 – HA1</td>
</tr>
<tr>
<td>5</td>
<td>S3 / S4 / S5* – HA1</td>
</tr>
<tr>
<td>6</td>
<td>S1 / S2 – HA2</td>
</tr>
<tr>
<td>7</td>
<td>S3 / S4 / S5* – HA2</td>
</tr>
<tr>
<td>8</td>
<td>S1 / S2 – HA3</td>
</tr>
<tr>
<td>9</td>
<td>S3 / S4 / S5* – HA3</td>
</tr>
<tr>
<td>10</td>
<td>S1 / S2 – HA4</td>
</tr>
<tr>
<td>11</td>
<td>S3 / S4 / S5* – HA4</td>
</tr>
<tr>
<td>12</td>
<td>S1 / S2 – HA5</td>
</tr>
<tr>
<td>13</td>
<td>S3 / S4 / S5* – HA5</td>
</tr>
<tr>
<td>14</td>
<td>No Home Assignments</td>
</tr>
<tr>
<td>15</td>
<td>No Home Assignments</td>
</tr>
<tr>
<td>16</td>
<td>No Home Assignments</td>
</tr>
</tbody>
</table>

The Home Assignments will be based on the self study component i.e. part B of every theory course syllabus. The Saturday or last working day will be the default deadline for submission of Home Assignment of that week. For example by the Saturday ending Week No. 9, Home Assignment No. 3 for subject S3/ S4/ S5 (if applicable) must be submitted.

1. *S5 can be OE1 / OE2 / OE3 / Honors/ Minor / Re-registration category (a) / Category (b) / Category (c).
2. For subjects S1, S2, S3, S4 & S5 (if any), the composition of the Teacher Assessment marks will be as follows:


200
<table>
<thead>
<tr>
<th></th>
<th>S1,S2 with Tutorial</th>
<th>S3,S4,S5 without Tutorial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Home Assignment</td>
<td>30 marks</td>
<td>30 marks</td>
</tr>
<tr>
<td>Tutorial</td>
<td>30 marks</td>
<td></td>
</tr>
<tr>
<td>Test</td>
<td>30 marks</td>
<td>30 marks</td>
</tr>
<tr>
<td>Attendance :</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) &gt; 90%</td>
<td>10 marks</td>
<td>10 marks</td>
</tr>
<tr>
<td>(b) 75% to 90%</td>
<td>5 marks</td>
<td>5 marks</td>
</tr>
<tr>
<td>(c) &lt;75%</td>
<td>0 marks</td>
<td>0 marks</td>
</tr>
<tr>
<td></td>
<td>100 marks converted to 15 marks</td>
<td>70 marks converted to 15 marks</td>
</tr>
</tbody>
</table>

**Explanation :**

1. Tutorials to be conducted with continuous assessment throughout the Semester. Final assessment out of 30 marks for Tutorial.
2. Class Test to be conducted during a regular theory class within the time period mentioned in the Academic Calendar.
3. Class Test marks are to be entered immediately as mentioned in Academic Calendar.
4. Attendance percentage to be calculated at the end of Semester after completing all lectures as per the lesson plan.
F) **Mini Project**

Teaching Scheme: Theory – 0 ; Tutorial – 0 ; Laboratory – 2 Hrs / week

For F.E., S.E. & T.E. students in every Semester a Mini Project be carried out. The objectives behind the Mini Project are:

1. Scope for creativity
2. Hands on experience
3. Academic occupancy

Mini Project will be based on all subjects of that Semester except GP.

1. The Semester Mini Project will be for a group of 3 to 5 students. Head of Department to appoint Mini Project Guides. 2 credits will be awarded to the candidate after the viva voce and project demonstration at the End of Semester.
2. Group formation, discussion with faculty advisor, formation of the Semester Mini Project statement, resource requirement, if any should be carried out in the earlier part of the Semester. The students are expected to utilize the laboratory resources before or after their contact hours as per the prescribed module.

The Assessment Scheme will be:

(a) Continuous Assessment 50 marks
(b) End Semester 50 marks

---------------
100 marks
--------------
G) **Project Stage I Evaluation**

The project activity is broken in 3 stages:

The Project Stage I will be in T.E Semester II irrespective of student module. The evaluation of Project Stage I will be as follows:

<table>
<thead>
<tr>
<th>Evaluation Area</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group formation &amp; attendance / reporting to guide</td>
<td>20 marks</td>
</tr>
<tr>
<td>Topic finalization / Statement</td>
<td>20 marks</td>
</tr>
<tr>
<td>Literature Survey</td>
<td>20 marks</td>
</tr>
<tr>
<td>Abstract</td>
<td>20 marks</td>
</tr>
<tr>
<td>Presentation</td>
<td>20 marks</td>
</tr>
</tbody>
</table>

Project Stage II and Project Stage III evaluations will be based on Department specific norms.
H) Composition for Selection of 5 Credits for Honors / Minor Course
   (Applicable for B11 and A11 Patterns)

(A) Comprehensive Viva Voce – Compulsory at the end of Semester VIII – 1 Credit

(B) Elective Component
   a. Laboratory courses – Maximum Credits - 2
      (for award of 1 Credit the lab course would have a teaching scheme of 2 Hrs. / week
       and a plan of 12 practicals). The credit to be awarded as per the ISA and ESA
       guidelines for the compulsory lab courses.

   b. Research publication – Maximum Credits – 1
      (Research Publication in a Magazine / Transaction / Journal as decided by the honors
       / minor co-ordinator)

   c. Seminar - Maximum Credits – 1
      (Seminar to be given on a topic consistent with the scope of the Honors or Minor. The
       topic Selection is to be approved by the honors / minor co-ordinator. The assessment
       and evaluation scheme would as per the guidelines used for Technical Seminar at UG
       level by respective Dept.)

   d. Honors / Minors Project – Maximum Credits – 2
      (Project Topic and Scope, its progress and final assessment consistent with the scope
       of the Honors or Minor. The topic Selection is to be approved by the honors / minor
       co-ordinator. The assessment would as per the guidelines and evaluation scheme used
       for Project Work at UG level by respective Dept.)

   e. Industrial Training – Maximum credits – 4
      (An Industrial Training in an Industry identified by the student, approved by the
       honors / minor co-ordinator & Head of Department. The assessment would as per the
       guidelines and evaluation scheme used for Industrial Training at UG level by
       respective Dept.)
Note:

a. 4 Credits would be awarded to the students for a complete 12 Week Industrial Training and meeting with the assessment and evaluation requirements

b. Provision can be made for the students unable to procure a 12 week Industrial Training. A 4 week or 8 week Industrial Training may also be offered. 2 credits will be awarded for 8 week Industrial Training and 1 Credit would be awarded to the students for a 4 Week Industrial Training, meeting with the assessment and evaluation requirements

c. No Industrial Training less than 4 weeks be considered for award of 1 Credit

d. No cumulative addition of Industrial Training period would be considered for award of credits

The student is expected to earn 1 Credit from Part (A) and remaining 4 Credits from Part (B)