

**Dharmsinh Desai University  
(Faculty of Technology)  
Nadiad 387001 (Gujarat)**

**Structure & Syllabus  
of  
B.E(Chem) Degree Course**

**(2008 – 2009)**

## SEMESTER – I (EC/IC/CE/CH/CL)

### AF – 111 MATHEMATICS – I

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (3 hrs.)	SES (1 hr.)	PR	TW	TOTAL
3	1		60	40			100

#### 1. Differential Calculus

applications of differential calculus to geometrical problems, equation of tangent & normal, angle between two curves, subtangent, subnormal, length of tangent & length of normal, pedal equation, radius of curvature of plane curves in cartesian, polar and parametric equations, radius of curvature at origin by Newton's method and by method of expansion

#### 2. Successive Differentiation

Leibnitz's theorem, Maclaurin's theorem, Taylor's theorem, applications to obtain expansion of functions, indeterminate forms

#### 3. Integral Calculus

curve tracing, applications for finding area, length of arc, volume and surface area of solids of revolution, centre of gravity

#### 4. Reduction Formula for

$$\int_0^{\frac{\pi}{2}} \sin^n x \, dx \quad \int_0^{\frac{\pi}{2}} \cos^n x \, dx \quad \int_0^{\frac{\pi}{2}} \sin^m x \cos^n x \, dx \quad \int_0^{\frac{\pi}{4}} \tan^n x \, dx \quad \int_0^{\frac{\pi}{4}} \cot^n x \, dx \text{ etc...}$$

#### 5. Beta and Gamma Functions

definition, properties, relation between beta and gamma functions, use in evaluation of definite integrals, error and elliptic functions

#### 6. Ordinary Differential Equations

formulation of differential equations, general and particular solutions, equations of first order and first degree of the type: variable separable, homogeneous, non-homogeneous, linear equations, exact equation and those reducible to these forms, Clairut's form, application to geometrical and physical problems

#### Text Books

Engineering Mathematics - II by Shanti Narayan

S. Chand & Co. Pvt. Ltd., Delhi

Higher Engineering Mathematics by Dr. B. S. Garewal

Khanna Publishers, Delhi

#### Reference Books

Applied Mathematics by P. N. Wartiker & J. N. Wartiker

Engineering Mathematics - I by I. B. Prasad

## AF-112 BASIC ELECTRICAL ENGINEERING

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (3 hrs.)	SES (1 hr.)	PR	TW	TOTAL
3	1	2	60	40	25	25	150

### 1. Fundamentals of Current Electricity and DC Circuits

introduction – definition, symbols and unit of quantities, multiple and sub-multiple units, computation of resistance at constant temperature, temperature dependence of resistance, computation of resistance at different temperatures, Ohm’s law – statement, illustrations and limitations, unit work, power, and energy (electrical, thermal and mechanical), circuits – identifying the elements and the connected terminology, Kirchhoff’s law – statement and illustrations, resistances in series and parallel and current division technique, method of solving a circuit by Kirchhoff’s laws

### 2. Magnetic Circuits

introduction, definition, magnetic circuit, leakage flux, fringing effect, comparison between magnetic and electric circuits

### 3. Electromagnetic Induction

introduction, magnetic effect of electric current, current carrying conductor in magnetic field, laws of electromagnetic induction, induce EMF, self inductance (L), mutual induction (M), coupling coefficient between two magnetically coupled circuits (K)

### 4. AC Fundamentals

introduction, generation of alternating EMF, waveform terminology, concept of 3 phase EMF generation, root mean square (RMS) to effective value, average value of AC, phasor representation of alternating quantities, analysis of AC circuit

### 5. Single Phase AC Circuits

introduction, I operator, complex algebra, representation of alternating quantities in rectangular and polar forms, R-L series circuit, R-C series circuit, R-L-C series circuit, admittance and its components, simple methods of solving parallel AC circuits, resonance

### 6. Electrical Machines

introduction, DC generator, DC motor, transformer, 3-phase motor, application of electrical machines

### 7. Passive Circuit Components

constructional details of resistors, capacitors & inductors.

### Practical & Term Work

Experiments & demonstrations based on the syllabus

### Text Book

Basic Electrical, Electronics and Computer Engineering by R. Muthusubramaniam, S. Salivahanan, K.A. Muraleedharan

Tata McGraw Hill Publications Co. Ltd., New Delhi

## AX – 113 COMPUTER PROGRAMMING-I

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (3 hrs.)	SES (1 hr.)	PR	TW	TOTAL
2	1	2	60	40	25	25	150

**1. Introduction to digital computer-Introduction to DOS-Overview of C-Constants, Variables and data types-Operators and Expressions-scanf() and printf() functions.**

2. Decision making with if statement, if-else statement, nesting of if-else statement, else-if ladder-Switch statement.

**3. ?: Operator- goto statement-While ,do While-for statement-Jumping in loops- Break and continue statement-Arrays(one dimensional).**

### Practical & Term Work

The laboratory and term work will be based on above topics.

### Text Book

Programming in ANCI C by E. Balagurusamy  
2<sup>nd</sup> Edition, Tata McGraw-Hill Publishing Company Limited-New Delhi.

## AF – 114 ENGINEERING MECHANICS

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (3 hrs.)	SES (1 hr.)	PR	TW	TOTAL
3	1	3	60	40	25	25	150

### 1. Statics

introduction, engineering & SI units, accuracy in engineering calculations, vectors – composition & resolution, concept of rigid bodies

Resultant of a force system

concurrent coplanar force system

non-concurrent coplanar force system

parallel

non parallel

simple cases of concurrent force system in space

concept of internal force, free body diagram, equilibrium of force systems listed above  
friction – friction on inclined plane, ladder friction, wedge friction, screw friction, belt and rope drive, centre of gravity of – lines, plane figures volumes, bodies & Pappu's theorem, principle of virtual work & its applications, types of beams, types of supports, support reaction for statically determinate beams

### 2. Dynamics

rectilinear motion, circular motion, projectiles, relative velocity, instantaneous centre in plane motion, laws of motion, motion along inclined plane, principle of conservation of

momentum, mass moment of inertia in rotational motion, motion of connected bodies, impulse & momentum, impact, work, motion along smooth curve & super elevation

**Term Work**

1. Experiments based on theory
2. Problems based on theory

**Text Book**

1. Mechanics for Engineers – Static by F. P. Beer & E. R. Johnston Jr.
2. Mechanics for Engineers – Dynamic by F. P. Beer & E. R. Johnston Jr.
3. Engineering Mechanics: Static & Dynamic by A. K. Tayal

**AF – 116 WORK SHOP – I**

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (3 hrs.)	SES (1 hr.)	PR	TW	TOTAL
		3				50	50

**1. Instruction**

kinds of wood, types of carpentry tools, carpentry joints, plumbing tools, pipe fittings, tin smithy & soldering tools.

**2. Demonstrations**

operation of wood working machines

**Term Work**

Each candidate shall submit the following term work.

- i. practice job in carpentry 1 job
- ii. simple job in carpentry 1 job
- iii. simple carpentry joint 1 job
- iv. tin smithy and soldering 1 job

## SEMESTER – II (EC/IC/CE/CH/CL)

### AF – 201 MATHEMATICS – II

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (3 hrs.)	SES (1 hr.)	PR	TW	TOTAL
3	1		60	40			100

#### 1. Partial Differentiation & its Applications

partial derivatives, homogenous functions, Euler's theorem, total derivatives – differentiation of implicit functions, change of variables, errors and approximations, maxima & minima of functions of two variables, Lagrange's method of undetermined multipliers

#### 2. Multiple Integrals & their Applications

double integrals – definition, evaluation change of order, double integrals in polar co-ordinates and area enclosed by plane curves, triple integrals, change of variables, volume of solids

#### 3. Infinite Series

introduction, definitions - convergence, divergence and oscillation of series, P-test, comparison test, ratio test, root test, higher ratio test, Raabe's test, log test, alternating series, Leibnitz's rule

#### 4. Complex Numbers

definition, elementary operations, Argand's diagram, De Moivre's theorem & its applications to expand  $\sin n\theta$ ,  $\cos n\theta$  in powers of  $\sin \theta$  &  $\cos \theta$  respectively, to expand  $\sin^n \theta$ ,  $\cos^n \theta$  &  $\sin^m \theta \cos^m \theta$  in a series of Sine or Cosine of  $\theta$ , hyperbolic functions, formulae of hyperbolic functions, inverse hyperbolic functions, logarithm of complex quantities, separation of real & imaginary parts, summation of series by  $C + iS$  method

#### 5. Laplace Transforms

introduction, definition, transform of elementary functions, properties of Laplace Transforms, inverse Laplace Transforms, note on partial fractions, transforms of derivatives, transforms of integrals, multiplication & division by  $t$ , convolution theorem

#### Text Book

Higher Engineering Mathematics by Dr. B. S. Grewal  
Khanna Publishers, Delhi

#### Reference Books

1. Applied Mathematics for Engineers and Physicists by Pipes & Harvill  
McGraw Hill – Kogakusha Ltd.
2. Applied Mathematics by P. N. Waritkar & J. N. Wartikar

## AF – 202 BASIC ELECTRONICS

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (3 hrs.)	SES (1 hr.)	PR	TW	TOTAL
3	1	2	60	40	25	25	150

### 1. Diode Theory

semiconductor theory, conduction in crystals, doping source, the unbiased diode, forward bias, reverse bias, linear devices, the diode graph, load lines, diode approximations, D. C. resistance of a diode

### 2. Diode Circuits

the Sine wave, the transformer, the half wave rectifier, the full wave rectifier, the bridge rectifier, the capacitor input filter

### 3. Special Purpose Diodes

the zener diode, the zener regulator, optoelectric devices

### 4. Bipolar Transistor

some basic ideas, forward-reverse bias, the CE connection, transistor characteristics, DC load lines, the transistor switch

### 5. Transistor Biasing Circuits

base bias, emitter – feedback bias, collector – feedback, voltage divide bias, emitter bias, moving ground around, PNP circuits

### 6. CE Amplifiers

coupling & bypass capacitors, the superposition theorem for amplifiers, AC resistance of the emitter diode, AC beta, the grounded emitter amplifier, the AC mode of a CE stage

### 7. CC & CB Amplifiers

the CC amplifier, the AC model of an emitter follower, types of coupling, direct coupling

### 8. Class A & B Power Amplifier

the AC load line of a CE amplifier, AC load lines of other amplifiers, class A operation

### 9. OP-AMP Circuits

non-inverting voltage amplifiers, the inverting voltage amplifiers, the summing amplifier, comparators

### 10. Oscillators and Timers

theory of sinusoidal oscillation, the Wien-bridge oscillator

### 11. Thyristors

the ideal latch, the four layer diode, the silicon controlled rectifier

### 12. Frequency Domain

the Fourier series, the spectrum of a signal.

### 13. Frequency Mixing

nonlinearity, medium signal operation with one sine wave, medium signal operation with two sine waves

### 14. Amplitude Modulation

basic idea, percent modulation, AM spectrum, the envelope detector, the Superhetrodyne receiver

### 15. Digital IC

number system, Boolean algebra, logic gates

### Practical & Term Work

The practical & term work shall be based on the above syllabus.

### Text Books

1. Electronic Principles (Third Edition) by Albert Paul Malvino  
Tata McGraw Hill Publications Co. Ltd., New Delhi
2. Basic Electrical, Electronics and Computer Engineering by R. Muthusubramaniam, S. Salivahanan, K.A. Muraleedharan  
Tata McGraw Hill Publications Co. Ltd., New Delhi

## AX – 213 COMPUTER PROGRAMMING-II

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (3 hrs.)	SES (1 hr.)	PR	TW	TOTAL
2	1	2	60	40	25	25	150

#### 1. Arrays:

Introduction and Initialization of two-dimensional arrays, Multidimensional arrays.

#### 2. Handling of Character Strings:

Introduction, Declaring and initializing string variables, Reading strings form terminal, Writing strings on screen, Arithmetic operations on characters, Putting strings together, Comparison of strings, String handling functions, Table of strings.

#### 3. User Defined Functions:

Introduction, Need for user defined functions, A multi-function program, Forms of C functions, Return values and their types, Calling a function, Category of functions, No arguments and no return values, Arguments and no return values, Arguments and return values, Handling of non-integer functions, Nesting of functions, Recursion, Functions with arrays, The scope and life time of variables in functions, Ansi C functions.

#### 4. Structures and Unions:

Introduction, Structure definition, Giving values to members, Structure initialization, Comparison of structure variables, Arrays of structures, Arrays within structures, Structures within structures, structures and functions, Unions, Size of structures, Bit-fields.

#### 5. Pointers:

Introduction, Understanding pointers, Accessing the address of a variable, Declaring and initializing pointer, Pointer expressions, Pointer increments and scale factor, Pointer and arrays, Pointer and character strings, Pointer and functions, Pointer and structures.

#### **6. File Management in C:**

Introduction, Defining and opening a file, Closing a file, Input/Output operations on files, Error handling during I/O operations, Random access to files, Command line arguments.

#### **7. Dynamic Memory Allocation and Linked Lists:**

Introduction, Dynamic memory allocation, Concepts of linked lists, Advantages of linked lists, Types of linked lists, Pointers revisited, Basic list operations, Application of linked lists.

#### **8. The Preprocessors:**

Introduction, Macro substitution, File inclusion, Compiler control directives, ANSI additions.

### **Practical & Term Work**

The laboratory and term work will be based on above topics.

### **Text Book**

Programming in ANCI C by E. Balagurusamy  
2<sup>nd</sup> Edition, Tata McGraw-Hill Publishing Company Limited-New Delhi.

### **AF – 204 MECHANICS OF SOLIDS**

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (3 hrs.)	SES (1 hr.)	PR	TW	TOTAL
3	1	2	60	40	25	25	150

#### **1. Simple Stresses and Strains**

introduction, stress, strain, tensile stress, compressive stress, shear stress, elastic limit, Hooke's law, Poisson's ratio, modulus of elasticity, modulus of rigidity, bulk modulus, bars of varying sections, extension of tapering rods, bars of uniform strength, temperature stresses, Hoop's stress, stress on oblique sections, stat of simple shear, relation between elastic constants

#### **2. Mechanical Properties of Materials**

ductility, brittleness, toughness, malleability, behaviour of ferrous and non-ferrous metals in tension & compression, shear and bending tests, standard test pieces, influence of various parameters on test results, true and nominal stress, modes of failure, characteristic stress-strain curves, strain hardening, hardness, different methods of measurement – Izod impact test, Charpy impact test & tension impact test, fatigue, creep, correlation between different mechanical properties, effect of temperature, Testing machines and special features, different types of extensometers & compressometers, measurement of strain by electrical resistance strain gauges

### 3. Bending Moment and Shear Force

bending moment, shear force in statically determinate beams subjected to uniformly distributed, concentrated & varying loads, relation between bending moment, shear force & rate of loading

### 4. Moment of Inertia

concept of moment of inertia, moment of inertia of plane areas, polar moment of inertia, radius of gyration of an area, parallel axis theorem, moment of inertia of composite areas, product of inertia, principle axes and principle moments of inertia

### 5. Stresses in Beams

theory of simple bending, bending stresses, moment of resistance, modulus of section, built up & composite sections, beams of uniform strength, distribution shear stress in different sections

### 6. Torsion

torsion of circular solid & hollow section shafts, shear stress, angle of twist, torsional moment of resistance, power transmitted by shaft, keys & couplings, combined bending & torsion, close coiled helical springs

### 7. Principle Stresses and Strains

compound stresses, principle planes & principle stresses, Mohr's circle of stress, principle strains, angle of obliquity of resultant stresses, principle stresses in beams, principle stresses in shafts subjected to bending, torsion & axial force

### Term Work

1. Experiments based on theory
2. Problems based on theory

### Text Book

1. Strength of Materials by Timoshenko Vol. 1 & 2
2. Strength of Materials by Popov
3. Mechanics of Structure by Junarkar S. B.
4. Strength of Materials by S. Ramamrutham

## AF – 215 HEAT POWER

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (3 hrs.)	SES (1 hr.)	PR	TW	TOTAL
3	1	2	60	40	25	25	150

### 1. Properties of Steam

distinction between gas & vapour, sensible heat, latent heat, total heat & super heat of steam, conditions of steam, dryness fraction, methods of determination of dryness fraction, internal energy of steam, specific volume, critical pressure & temperature

### 2. Fuels

solid, liquid & gaseous fuels used for boilers and I.C. engines, combustion of fuel, air required, products of combustion of fuel, analysis of flue gases, calorific value of fuel & its determination

### **3. Boilers**

classification of boilers, Cochran and Babcock & Wilcox boilers, boiler mountings and accessories, draught – natural & artificial

### **4. Properties of Gases**

zeroth, first & second laws of thermodynamics, laws of perfect gases, Boyle's law, Charles's law, Regnault's law, Joule's law. Characteristic equation, gas constant, internal energy, specific heat at constant pressure & at constant volume, relation between specific heats, thermodynamic processes of perfect gases

### **5. I. C. Engine**

prime-movers, classification of prime-movers with examples of each class, advantages of I. C. engines over E. C. engines, classification of I. C. engines, thermodynamics air cycles, - Carnot cycle, constant volume Otto cycle, constant pressure Joule cycle & Diesel cycle, air-standard efficiency, construction & working of two stroke & four stroke cycle engines, P-V diagram, determination of indicated power & brake power, mechanical fuel supply in I. C. engines, ignition systems of I. C. engines, cooling of I. C. engines, lubrication of I. C. engines, governing of I. C. engines

### **6. Solar Energy**

introduction, solar energy systems.

### **Practical & Term Work**

The practical & term work shall be based on the above syllabus.

### **Text Book**

Elements of Heat Engines (SI Units) Vol. – I by R. C. Patel & C. J. Karamchandani  
Acharya Book Dept, Baroda

OR

Elements of Heat Engines (SI Units) by N. C. Pandya & C. S. Shah  
Charotar Publishing House, Anand.

### **Reference Book**

1. Heat Engine by P. L. Ballaney
2. A Course in Thermodynamics & Heat Engines by Kothandaraman

## AF – 206 WORK SHOP – II

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (3 hrs.)	SES (1 hr.)	PR	TW	TOTAL
		3				50	50

### 1. Instructions

introduction to fitting shop tools, taps, dies, drills, drilling machines, welding process, welding equipment for arc welding, forging tools, forging, bending, upsetting, drawing, adhesive bonding

### 2. Demonstrations

demonstration of general operation of drilling turning & shaping

### Term Work

Each candidate shall submit the following term work

- |  |       |
|--|-------|
| i. filing and fitting practice               | 1 job |
| ii. simple welding of joint                  | 1 job |
| iii. forging practice                        | 1 job |
| iv. wooden utility job with adhesive bonding | 1 job |
| v. PCB making                                | 1 job |

## SEMESTER – III (CH)

### AF – 301 MATHEMATICS – III

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (3 hrs.)	SES (1 hr.)	PR	TW	TOTAL
4	-		60	40			100

#### 1. Fourier Series

Euler's formula, conditions for Fourier expansion, functions having points of discontinuity, change of interval, odd & even functions, expansion of odd & even periodic functions, half range series, practical harmonic analysis

#### 2. Integral Transforms

definition, Fourier integral, Fourier sine & cosine integrals, complex form of Fourier integral, Fourier transform, Fourier sine & cosine transforms, finite Fourier sine & cosine transform, Fourier transform of the derivative of a function, inverse Laplace transform by method of residues, application of transforms to boundary value problems

#### 3. Matrices

fundamental concepts, operations, associated matrices, matrix method of solution of simultaneous equations, rank of matrix, linear dependence of vectors, consistency of a system of linear equations, characteristic equation, Eigen vectors & Eigen roots, Cayley – Hamilton theorem, reduction of quadratic form to canonical form

#### 4. Ordinary Differential Equations

linear differential equations – definition, rules for finding complementary function, rules for finding the particular integral, working procedure, Cauchy's & Legendre's linear equation, simultaneous linear equations with constant coefficients, application of linear differential equation to simple harmonic motion, oscillation of a spring, simple pendulum, oscillatory electrical circuits, electro-mechanical analogy, deflection of beam, whirling of shafts, application to simultaneous equations, series solution of differential equations of the second order with variable coefficients & special functions

#### 5. Partial Differential Equations

introduction, formation, solution of a partial differential equation solvable by direct integration, linear equation of first order, non-linear equations of first order – Charpit's method, homogenous linear equations with constant coefficient, homogeneous linear equations with constant coefficients by finding complimentary function & particular integral, nonhomogeneous linear equations with constant coefficients, solution of non-linear equation of second order by Monge's method, applications of partial differential equation- method of separation of variables, vibrating string problem, heat flow, etc.

#### 6. Laplace Transforms

application to differential equations, simultaneous linear equation with constant coefficients

#### Text Book

Higher Engineering Mathematics by Dr. B. S. Grewal

#### Reference Book

1. A Text Book of Applied Mathematics by P. N. Wartikar & J. N. Wartikar
2. Mathematics for Engineering by Chandrika Prasad
3. A Text Book of Engineering Mathematics by Dr. K. N. Srivastva & G. K. Dhawan

## CH – 302 GENERAL CHEMICAL TECHNOLOGY

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (3 hrs.)	SES (1 hr.)	PR	TW	TOTAL
4	-		60	40			100

### 1. Water Conditioning and Environmental Protection

demineralisation, deionisation, industrial waste treatment & air pollution control

### 2. Fuels & Energy

coal & coal chemicals

### 3. Chloro-Alkali Industry

manufacture of soda ash, caustic soda, chlorine hydrogen & hydrochloric acid

### 4. Cement & Glass Manufacturing

### 5. Sulphuric Acid Manufacturing

### 6. Electrolytic Manufacturing of Aluminium & Magnesium

### 7. Pulp & Paper Manufacturing

### 8. Sugar & Starch Industry

### 9. Oils, Fats, Soaps & Detergents

### 10. Nitrogenous Fertilizers

manufacture of synthesis gas, ammonia, urea, ammonium nitrate & ammonium sulphate

### 11. Phosphatic Fertilizers

manufacture of phosphoric acid, single & triple super phosphate

### 12. Mixed Fertilizers

compositions & constituents, granulation

### 13. Environmental Aspects of Various Industries

### Reference Book

Chemical Process Industries, 4<sup>th</sup> Ed. by R. Norris Shreve & J. A. Brink, Jr.  
International Student's Edition

Shreve's Chemical Process Industries, 5<sup>th</sup> Ed. By, George F. Austin  
McGraw Hill International Edition

Dryden's Outlines of Chemical Technology, 2<sup>nd</sup> Ed. By M. Gopala Rao & Marshall  
Sitting  
East West Press Pvt. Ltd., New Delhi

Pollution Control in Chemical Process Industries, 1<sup>st</sup> Ed. By S. P. Mahajan  
Tata McGraw Hill Publications, New Delhi

## CH – 305 THEORY OF MACHINES & MACHINE DESIGN

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (4 hrs.)	SES (1.5 hr.)	PR	TW	TOTAL
4	-	3	60	40		50	150

### Theory of Machines (40% weightage)

#### 1. Cam

types of cam, types of followers, nomenclature of cam mechanism, types of motions of follower – uniform velocity, simple harmonic, uniform equal acceleration & retardation, design of cam profile, applications of cam

#### 2. Friction

screw friction, bearing friction in – journal bearing, flat pivot thrust bearing, collar pivot thrust bearing & conical pivot thrust bearing, friction clutches – plate or disc clutches & cone clutches, ball & roller bearing

#### 3. Belt Drive

types of flat belt drive, velocity ratio of simple & compound belt drive, slip and creep of belt, length of belt, power transmitted by belt, ratio of driving tension for flat belt drive, centrifugal tension, condition for transmission of maximum power, V-belt drive, advantages & disadvantages of V-belt drive, ratio of driving tension for V-belt drive

#### 4. Toothed Gearing

nomenclature & classification of toothed gears, types of gear trains – simple & compound, reverted & epicyclical spur gear trains

#### 5. Brakes

types of brakes – simple block or shoe brake & band brake

### Machine Design (60% weightage)

#### 1. Design of Operational Joints

cotter joints, sleeve type cotter joint, gib & cotter joint, knuckle joints, pinned joints, threaded fasteners, design load for fasteners, turn buckle, bolt of uniform strength

#### 2. Welded Connections

types of welded joints, weld symbols, strength & design of welds, direct loading, asymmetric loading, designation and representation, design procedure

#### 3. Pressure Vessels & Pipes

classification of pressure vessels, stresses in thin cylinder due to internal pressure, circumferential stresses, longitudinal stresses, thin spherical shells, thick cylinders, thickness of cylinder heads & cover plates, design of pipes, pipe joints, design of circular flanged pipe joints, design of oval flanged pipe joints, design of square flanged pipe joints, standard pipe flanges, hydraulic pipe joint for high pressure

#### **4. Shafts, Keys & Couplings**

design of shafts on basis of strength & rigidity, shaft subjected - to torque, bending moment & combined bending moment & torque, types of keys, design of shank key, design of shear pins, design of shaft coupling, design of flange coupling, design of bush pin type flexible coupling

#### **5. Levers**

types of levers, design of levers – hand lever, foot lever, bell crank lever & lever of safety valve

#### **6. Design of Springs**

types of springs, materials, allowable working stress, design of closely coiled spring subjected to axial load

#### **7. Belt & Pulley Drive**

design of belt & pulley drive

#### **8. Eccentric Loading**

eccentric loading on rivets & bolts

#### **9. Columns & Struts**

types of end conditions of column, slenderness ratio, Euler's formula, Rankine's formula, design of simple column, design of piston rod & connecting rod

#### **Practical & Term Work**

The term work shall be based on the above syllabus which involves designing & preparation of detailed drawings.

#### **Text Book**

1. Theory of Machines by R. S. Khurmi & J. K. Gupta
2. Machine Design by R. S. Khurmi & J. K. Gupta

#### **Reference Book**

1. Theory of Machines by P. L. Ballaney
2. Theory of Machines by N. C. Pandya & C. S. Shah
3. Theoretical Dynamics by L. B. Shah, R. C. Patel & B. M. Patel
4. Machine Design Vol. 1 by R. C. Patel, A. D. Pandya, H. J. Rajput & S. S. Shikh

## CH – 311 INTRODUCTION TO CHEMICAL ENGINEERING

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (3 hrs.)	SES (1 hr.)	PR	TW	TOTAL
4	-	2	60	40	25	25	150

### 1. Introduction

systematic analysis to chemical process, flow sheet symbols for various operations, simple problems

### 2. Chemical Engineer

his role in the chemical process industry in various aspects such as research, process development, process design & evaluation, plant design, construction, process supervision, plant technical service, product sales, general aspects of chemical engineering such as communication, human relations, professional activities & technical reading

### 3. Useful Mathematical Methods

presentation & correlation of data, curve fitting, graphical addition & subtraction, graphical integration, graphical differentiation, trial & error solution, mean values, dimensions & units, conversion of units, illustrative problems on the listed topics

### 4. Physical and Chemical Principles

process variables – temperature, pressure, density, composition & flow rate, physical states, phase equilibria, fundamentals of reaction rates, illustrative problems on the listed topics

### 5. Mass Balance

overall balance, balance applied to phase equilibria, humidity, chemical reactions, by-pass, recycle, purge, differential mass balances, reaction equilibria, illustrative problems on the listed topics

### 6. Energy Balance

forms of energy, total energy balance, energy balance in non-flow systems, illustrative problems on the listed topics

### 7. Computer Oriented Numerical Methods

elementary problems

### Practical & Term Work

Writing codes in C- Language to solve simple mathematical & chemical engineering problems.

### Text Book

1. Introduction to Chemical Engineering by L. B. Andersen & L. A. Wenzel  
McGraw – Hill Kogakusha Company Ltd.
2. Introduction to Chemical Engineering by E. V. Thompson & W. H. Cekler  
McGraw – Hill Kogakusha Company Ltd.
3. Basic Principles & Calculations in Chemical Engineering by D.M.Himmelblau  
Prentice Hall
4. Numerical Methods with Fortran IV Case Studies by W. S. Dorn & D.D. McCrackern

John Wiley & Sons

## CH – 306 CHEMISTRY – I

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (3 hrs.)	SES (1 hr.)	PR	TW	TOTAL
3	-	3	60	40	25	25	150

### 1. Physical Properties & Chemical Constitution

additive & constitutive properties, molar volume, surface tension & parachor, viscosity, refractivity & molar refractivity, dipole moments, spectroscopy - the visible & invisible spectrum, spectrum analysis, different types of spectra

### 2. Phase Equilibria

definition, statement of phase rule, application to one & two component system, distribution law, Henry's law, critical solution temperature, solvent extraction, phase rule & applications

### 3. Chemical Kinetics

rate of a reaction, rate constant, order & molecularity, first & second order reaction, determination of order of reaction, theories of reaction rates, effect of temperature

### 4. Photochemistry

Lambert & Beer's law, law of photochemistry, quantum yield, high & low quantum yield, method of determination of quantum efficiency, types of photochemical reaction, luminescence

### 5. Surface Chemistry and Colloids

absorption & adsorption, Freundlich adsorption isotherms, Langmuir adsorption isotherms, partition & adsorption, chromatography, classification of colloids, preparation of colloids, purification of colloids, properties of colloids, industrial application of colloidal chemistry, emulsions & gels, catalysis, types of catalysis, theory of catalysis

### 6. Thermodynamics

first & second law of thermodynamics, spontaneous process, entropy, efficiency of reversible cycle, free energy & maximum work, Clapeyron equation, Clausius – Clapeyron equation, Gibb's – Helmholtz equation, Van't Hoff isotherm & isochore, thermo chemistry – heat of reaction, heat of combustion, heat of formation, heat of neutralisation, Hess's law of constant heat summation, heat of reaction at constant volume & at constant pressure

### 7. Acids & Bases

modern concept of acids & bases, hydrolysis, relative strength of acids & bases, theory of indicator

### Practical & Term Work

Experiments based on theory are performed in the laboratory class

### Text Book

1. Essentials of Physical Chemistry by B. S. Bhal & G. D. Tuli  
S. Chand & Co., New Delhi
2. Elements of physical Chemistry by S. Glasstone  
Macmillan & Co. Ltd., London

## CH – 307 CHEMISTRY – II

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (3 hrs.)	SES (1 hr.)	PR	TW	TOTAL
3	-	3	60	40	25	25	150

### 1. Purification of Organic Compounds

by crystallisation, fractional crystallisation, sublimation & different types of distillation.

### 2. Detection & Estimation of Elements

detection of elements (C, H, N, S, P & halogens), estimation of elements (C, H, S, P & halogens) by combustion estimation of nitrogen by Dumas method & Kjeldahl's method, Carius method, chemical reactions involved in the methods of detection & determination of elements

### 3. Nomenclature of Organic Compounds

IUPAC nomenclature of organic compounds including heterocyclic & alicyclic compounds.

### 4. Stereochemistry

isomerism – structural & stereoisomerism, optical isomers of lactic acid & tartaric acid, geometrical isomerism

### 5. Organic Reactions

general nature of Organic reactions – substitution, addition, elimination, rearrangement, nucleophilic & electrophilic reactions with their mechanism

### 6. Aliphatic Compounds

general methods of preparation & important chemical properties, general methods of preparation & important chemical properties with their uses of the following compounds – chloroform, carbon tetrachloride, iodoform, ethanol, ethylene glycol, glycerine, formaldehyde, acetaldehyde, acetone, lactic acid, oxalic acid, citric acid, succinic acid, diethyl ether, acetoacetic ether, malonic ester

### 7. Organometallic Compounds

preparation & industrial uses of organolead compounds, organozinc compounds, organolithium compounds, organomagnesium compounds

### 8. Aromatic Compounds

general nature of aromatic reaction with their mechanism, halogenation, sulphonation, nitration, alkylation, acylation & addition reaction

### 9. Arylhalides

study of chlorobenzene, bromobenzene, benzylchloride, D.D.T & B.H.C

### 10. Amines & Amino Compounds

study of aniline, acetanilide, sulphanilic acid, sulphanilamide, diphenylamine, dimethylamine, distinguishing tests for different amines

### **11. Phenols & Aromatic Alcohols**

preparation & important chemical properties of phenol, catechol, resorcinol, quinol & phloroglucinol

### **12. Aromatic Aldehydes & Ketones**

study of benzaldehyde, salicylaldehyde, cinnamaldehyde, acetophenone & benzophenone

### **13. Aromatic Acids**

study of benzoic acid, salicylic acid, phthalic acid, cinnamic acid

#### **Note:**

1. Study term include discussion of important methods of preparation & chemical properties with industrial & commercial uses.

#### **Practical & Term Work**

Practical – Laboratory experiments may be given relating to theory as:

- i. Quantitative analysis of organic compounds
- ii. Preparation of nitrobenzene, m-dinitrobenzene, acetanilide, sulphonic acid, saccharine, phenol & its derivatives, aniline, diazo derivatives, etc
- iii. Purification of impure organic solids & liquids
- iv. Measurement of melting & boiling points

#### **Text Book**

1. A Text Book of Organic chemistry by P. L. Soni
2. Advance Organic Chemistry by Fischer & Fischer
3. Advance Organic Chemistry by Robert & Cassero

## SEMESTER – IV

### AF – 401 MATHEMATICS – IV

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (3 hrs.)	SES (1 hr.)	PR	TW	TOTAL
4	-		60	40			100

#### 1. Functions of Complex Variables

analytic functions, Cauchy – Reimann equations, harmonic functions, orthogonal system, complex potential, determination of conjugate function, conformal transformation, some standard transformations – translation, magnification & rotation, inversion & reflection & bilinear transformations, line integral, properties of complex integration, Cauchy’s theorem, Cauchy’s integral formula

#### 2. Numerical Methods

solution of algebraic and transcendental equations by Newton – Raphson method, direct iteration method & false position method, solution of linear simultaneous equations by Gauss elimination method, Gauss – Jordan method & Gauss – Siedel, numerical methods to solve first order & first degree ordinary differential equations by Picard’s method, Taylor’s series method, modified Euler’s method, Milne’s method, Runge’s method, Runge – Kutta method

#### 3. Finite Differences & Difference Equations

finite difference, interpolation, Newton’s forward, backward & central difference, Lagrange’s formula, Stirling & Bessel’s formula, numerical differentiation, numerical integration – trapezoidal rule, Simpson’s rules, difference equations with constant coefficient, Z-transform

#### 4. Vector Calculus

vector function of a single scalar variable, differentiation of vectors, simple applications to plane, motion, scalar & vector point functions, del applied to scalar point function (gradient), divergence of a vector point function, curl of a vector, second order expressions, line integrals, surface integrals, Gauss theorem, Stoke’s theorem

#### 5. Statistical Methods

binomial distribution, Poisson’s distribution, normal distribution, calculation of errors, probable errors, standard error, coefficient of correlation, lines of regression

#### Text Book

Higher Engineering Mathematics by Dr. B. S. Grewal

#### Reference Book

1. A Text Book of Applied Mathematics by P. N. Wartikar & J. N. Wartikar
2. Mathematics for Engineering by Chandrika Prasad
3. A Text Book of Engineering Mathematics by Dr. K. N. Srivastva & G. K. Dhawan

## CH – 404 CHEMISTRY – III

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (3 hrs.)	SES (1 hr.)	PR	TW	TOTAL
3	-	3	60	40	25	25	150

### 1. Inorganic

general metallurgy, chemistry of the following metals beryllium, lithium, thorium, tungsten, uranium, molybdenum, rare earth metals

### 2. Electrochemistry

theory of electrolytic dissociation, Arrhenius theory, buffer solution, buffer capacity, theory of ionic interaction, activity & activity coefficient, Debye – Huckel model of electrolytic solution.

### 3. Electrical Conductance

specific & equivalent conductance its measurement & applications, Kohlrausch's law, transport number & its determination, Debye – Onsager theory, thermodynamic expression for equilibrium electrode potential, classification of electrodes, types of electrochemical systems (electrochemical cells), Faraday's laws, current efficiency, types of over potential & hydrogen over voltage, instrumental analytical techniques – potentiometry, pH-metry, conductometry, voltametry, polarography, colorimetry, spectrophotometry, flame photometry, nephelometry & turbidimetry, principles & applications of thermogravimetry, differential thermal analysis

### Practical & Term Work

Experiments based on topics 2 & 3.

### Text Book

1. Text book of Inorganic Chemistry by P. L. Soni  
S. Chand & Sons
2. Theoretical Electrochemistry by L. Antropov  
Mir Publishers
3. Instrumental Method of Analysis by Willard, Merritt & Dean  
EWP
4. Instrumental Method of Analysis by B. K. Sharma

## CH – 413 CHEMICAL ENGINEERING MATERIALS

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (3 hrs.)	SES (1 hr.)	PR	TW	TOTAL
4	-		60	40			100

### 1. Crystal Structure & Basic Concepts

atomic crystal structure of metals & non metals, microstructure & properties, determination of crystal structure, structural imperfections in solids – point defects, line defect, Fick's law, etc., stages of aggregation of matter formation & structure of high polymers, basic concepts of phase transformation, mechanical properties like elasticity, plasticity, deformation of metals elastic & plastic deformations, twinning plane, failure of metals, creep, fracture & fatigue with illustrative example, properties related to **strength reduction**, damage to metals, ceramic & organic materials

### 2. Equilibrium Diagrams

equilibrium diagram with special reference to iron – carbon diagram, metallic compounds, eutectic, peritectoid reactions to be covered in detail, heat treatment – quenching, tempering, annealing, normalising, case hardening, precipitation hardening, nitriding, etc., physico-chemical principles should be covered in detail

### 3. Ferrous Materials

cast iron, high silicon iron, plain carbon steel, low alloy steels, high alloy steels & special steels, effect of alloying elements on structure & mechanical properties, heat treatment should be stressed, effects of acids & alkali on metals & alloys

### 4. Non-ferrous Material

aluminium & its alloys, titanium, zirconium, copper & its alloys, lead & its alloys, nickel & its alloys, noble metals, micro structure & properties, heat treatment effect of impurities, chemical resistance, etc., effects of acids & alkali on metals & alloys

### 5. Inorganic, Organic & Other Materials

glass, vitreous, silicon, concrete & ceramic materials, high polymers, rubbers, wood, graphite, insulating & cementing materials

### 6. Corrosion

mechanism of corrosion, dry & wet corrosion, other forms of corrosion, factors influencing corrosion, atmospheric corrosion, corrosion control & prevention – cathodic & anodic control, inhibitors & other protective measures, testing methods

### 7. Coatings

protective coatings, metallic coating & metal cladding, physico-chemical principles involved, chemical conversion coating, organic coating, enamels, ceramic protective materials

### Text Book

1. Nature & Properties of engineering Materials, by D. Zaster Zebski
2. Chemical Engineering Materials by F. Rumford
3. Engineering Physical Metallurgy & Heat Treatment by Lakhtin
4. Elements of Material Science by Van Valk

## CH – 415 CHEMISTRY – IV

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (3 hrs.)	SES (1 hr.)	PR	TW	TOTAL
3	-	3	60	40	25	25	150

### 1. Naphthalene & its Derivatives

nomenclature and isomerism of naphthalene & its derivatives, manufacture of naphthalene, chemical properties – orientation, derivatives of naphthalene, nitro, halo, sulphonic acid, naphthalamines, naphthols & naphthaquinones

### 2. Anthracene & its Derivatives

nomenclature & isomerism of anthracene & its derivatives, preparation of anthracene, properties of anthracene, uses of anthracene, structure of anthracene, derivatives of anthracene – anthraquinone, alizarin, phenanthrene

### 3. Aromatic Heterocyclic Compounds

introduction, furan, furfural, thiophene, pyrrole, pyridine

### 4. Carbohydrates

introduction, classification, glucose, constitution of glucose, reactions of glucose, mutarotation, fructose, constitution of fructose, reactions of fructose, some typical conversions in monosaccharides, disaccharides, sucrose, manufacturing of sucrose, properties & uses of sucrose, starch & cellulose

### 5. Proteins

introduction, composition of proteins, classification of proteins according to composition & functions, isolation of proteins, general characteristics of proteins, physical characteristics of proteins, analytical tests, properties & uses of proteins

### 6. Alkaloids

introduction, occurrence & extraction of alkaloids, general properties, determination of chemical constitution of alkaloids, Hofmann exhaustive methylation, some individual members – coniine, piperine & nicotine

### 7. Synthetic Drugs

introduction, chemotherapy, sulpha drugs – sulphapyridine, sulphathiazole, sulphadizine, sulphanilamide, mode of action of sulpha drugs, chemotherapy in malaria, antimalarial drugs, synthetic antimalarial drugs, aminoacridine, 4-aminoquinol, mode of action, derivatives of 8-aminoquinolines, antipyretics & analgesics, tranquillizers, sedatives, antidepressants, anaesthetics

### 8. Polymers

introduction, classification of polymers, types of polymerisation reactions, the process of addition polymerisation, free radical polymerisation, chain transfer agents, ionic polymerisation, thermoplastic & thermosetting plastics, plasticizers, classification of resins & plastics, synthetic & natural rubbers – polychloroprene, buna-S and buna-N

## **9. Colour & Dyes**

colour sensation, dyes & dyeing, colour & constitution, chromophore – auxochrome theory, chromogen, valence bond theory of colour, classification of dyes, direct dyes, mordant dyes, vat dyes, classification based on chemical structure, nitro & nitroso dyes, triphenyl dyes

## **10. Oils, Fats & Waxes**

occurrence, classification of oils, chemical properties, soaps, detergents

## **Practical & Term Work**

Experiments involving estimation of various inorganic & organic elements

## **Text Book**

1. A Text Book of Organic Chemistry by P. L. Soni  
S. Chand & Co., New Delhi
2. Synthetic Organic Chemistry by O. P. Agarwal
3. Natural Products Vol. 1 by O. P. Agarwal

## CH – 411 ENERGY TECHNOLOGY

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (3 hrs.)	SES (1 hr.)	PR	TW	TOTAL
4	-		60	40			100

### 1. An Introduction to Energy Sources

energy sources (conventional & non-conventional), renewable energy resources, primary & secondary energy sources, energy chain, energy demand, national energy strategy & plan, energy management, energy audit & conservation

### 2. Definitions, Units & Measures

proximate & ultimate analysis, calorific values, rank of coal, coking & caking, gasification, basis for reporting results of analysis, units & conversion factors

### 3. Solid Fuels

wood & charcoal, peat, lignite, sub-bituminous & bituminous coals, semi-anthracite and anthracite coals, cannel & boghead coal, origin of coal, composition of coal, analysis & properties of coal, problems

### 4. Processing of Solid Fuels

coal preparation, washability curve, dry & wet washing methods of coal, washer efficiency, gasification & liquefaction of solid fuels, problems

### 5. Solar Energy

solar constant, solar radiation & related terms, measurement of solar radiation, solar energy collectors – flat plate collector, air collector, collectors with porous absorbers, concentrating collectors, applications & advantages of various collectors, selective absorber coatings, solar energy storage systems (thermal, electrical, chemical & mechanical), solar pond, applications of solar energy

### 6. Wind Energy

basic principles, power in wind, force on blades & turbines, wind energy conversion, site selection, basic components of wind energy conversion systems (WECS), classification of WECS, wind energy collectors, applications of wind energy

### 7. Energy from Biomass

introduction, energy plantation, biomass conversion technologies, photosynthesis, biogas generation, factors affecting biogas generation, classification of biogas plants & their comparisons, types of biogas plants (including those used in India), biogas from plant wastes, community plants & site selection, digester design considerations, design calculations, methods of maintaining & starting biogas plants, properties & utilisation of biogas, thermal gasification of biomass, pyrolysis, alternative liquid fuels

### 8. Geothermal Energy

geothermal resources, hydrothermal resources, liquid dominated systems, geopressed resources, petrothermal systems, magma resources, energy conservation & comparison with other resources, applications of geothermal energy

### **9. Energy from Oceans**

OTEC, methods (open cycle & close cycle) energy from tides, components of tidal power plants, operation, methods of utilisation of tidal energy, storage, ocean waves, wave energy conversion devices

### **10. Fuel Cell**

introduction, hydrogen – oxygen fuel cell, ion exchange membrane cell, fossil fuel cell, molten carbonate cell, advantages & disadvantages, conversion efficiency, polarisation, type of electrodes, applications of fuel cells

### **11. Hydrogen & Methanol**

properties of Hydrogen, production of hydrogen, thermochemical methods, fossil fuel methods, solar methods, storage & transportation, safety & management

### **12. Magneto Hydro-Dynamic (MHD) Power Generation**

principle, MHD system, open cycle system, closed cycle system, design problems & developments, advantages, materials for MHD generators, magnetic field & super conductivity

### **13. Nuclear Energy**

fission, fusion, fuel for nuclear fission reactor (exploration, mining, milling, concentrating, refining, enrichment, fuel fabrication, fuel use, reprocessing, waste disposal), storage & transportation, fast & slow neutrons, multiplication factors & reactor control, uranium enrichment process, nuclear reactor power plant, fast breeder reactor, boiling water reactor, pressurised heavy & light water reactor

### **Text Book**

1. Energy Sources 2<sup>nd</sup> Ed. by G. D. Rai  
Khanna Publications, New Delhi
2. Fuels & combustion by Samir Sarkar  
Orient Longmans(1974)
3. Solar Energy by Sukatame  
Tata McGraw Hill, New Delhi
4. Energy Technology by Rao & Parulaker

## CH – 414 GENERAL CHEMICAL TECHNOLOGY – II

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (3 hrs.)	SES (1 hr.)	PR	TW	TOTAL
4	-	3	60	40	25	25	150

### 1. Petroleum Refining

### 2. Petrochemical Industry

### 3. Polymer Industries

polymerisation fundamentals, manufacture of phenol & urea formaldehyde resins, manufacture of PVC, polyethylene, etc, manufacture of synthetic rubber

### 4. Synthetic Fibre Industries

nylon, polyester, acrylic, rayon, etc.

### 5. Fine Chemicals & Drugs

classification of pharmaceuticals, manufacture of important drugs and pharmaceuticals – salicylic acid, methyl salicylate, aspirin, antibiotics, & vitamins

### 6. Intermediates & Dyes

classification of dyes, azo dyes, reactive dyes, disperse dyes

### 7. Biochemical Engineering

fundamentals, micro organisms, strains, culture, etc., kinetics of biochemical reactions, fermentation, aeration, agitation, important products, enzyme engineering

### 8. Environmental Aspects of Various Industries

### Practical & Term Work

Experiments to determine pour point, flash point, etc, estimation of ammonia, carbonate etc., in given compounds, estimation of casein present in milk etc.

### Text Book

1. Chemical Process Industries, 4<sup>th</sup> Ed. by R. Norris Shreve & J. A. Brink, Jr.  
International Student's Edition
2. Shreve's Chemical Process Industries, 5<sup>th</sup> Ed. By, George F. Austin  
McGraw Hill International Edition
3. Dryden's Outlines of Chemical Technology, 2<sup>nd</sup> Ed. By M. Gopala Rao & Marshall  
Sitting  
East West Press Pvt. Ltd., New Delhi
4. Biochemical Engineering Fundamental 2<sup>nd</sup> Ed. by Bailey & Ollis  
International Student Edition
5. Petroleum Refinery Processes by Nelson  
McGraw Hill Publication

## CT – 415 YOGA & MEDITATION

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (1.5 hrs.)	SES (1 hr.)	PR	TW	TOTAL
1	-	1	50			50	100

### Training in Yogic Asanas, Pranayams & Mudras

#### 1. Basics

kapalbhati pranayam, anulom vilom pranayam, omkar pranayam, bhramari pranayam, body rotation, shavasan, suryanamaskar

#### 2. Asanas for Meditation

padmasan, swastikas an, sidhbhasan, bhadrasan, vajrasan, sukhasan, mararasa, sevasan

#### 3. Asanas to be Performed in Standing Position

trikonasan, parvatasan, utkatukasan

#### 4. Asanas to be Performed while in Supine Position

sarvangasan, halasan, savasan, kosthavishramasan, matshendrasan, suptavajrasan

#### 5. Asans to be Performed Lying in Prone Position

uttanapadasan, uttanadhadasan, sarpasan, bhujasan, salabhasan, dhanurasan, makarasan

#### 6. Asanas to be Performed in Sitting Position

pavanmuktasan, hastapadasan, vajrasan, ardhamatshyendrasan, shishiasan, saptamudrasan, gomukhasan

#### 7. Yoga Mudras (Seven Types)

#### 8. Pranayam (Seven Types)

#### 9. Rajyog Meditation – Theory & Practice

the true concept of yoga, science of consciousness & dynamics of mind, philosophical basis of yoga, concept of god & true secularism, principles of spiritual science, stages of yoga, practical meditation & yoga practice

#### 10. Moral, Ethical & Spiritual Dimensions in Development of Inner Personality

the concept of holistic health & its various dimensions, addictions, cures & remedies to get rid of addiction, stress management & relaxation technique, how to get rid of examination fear, world religions, scriptures & the common extracts from them.

#### Term Work

Practice of asanas, pranayam & meditation



## SEMESTER – V (CH)

### CH – 501 FLUID FLOW OPERATIONS

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (3 hrs.)	SES (1 hr.)	PR	TW	TOTAL
4	-	3	60	40	25	25	150

#### 1. Fluid Properties & Dimensional Analysis

definition of a fluid, types of fluids, perfect or ideal fluid, properties of fluids – viscosity, density, specific volume, specific weight, specific gravity, pressure, bulk modulus of elasticity, vapour pressure & surface tension, systems of unit, dimensional analysis & its applications to fluid flow problems

#### 2. Fluid Statics & its Applications

pressure concept & types of pressure, hydrostatic equilibrium & its applications – barometric equation, hydrostatic equilibrium in a centrifugal field, design of continuous gravity decanter & continuous centrifugal decanters, pressure measuring devices – static pressure & its measurement, types of manometers – open U tube & open gauge type, the differential U tube, closed U tube, mercury barometer, tube size estimation of manometers, multiplying gauges, change of manometric fluids, inclined U tube, draft gauge & two fluid U tube, mechanical pressure gauges – bourdon tube gauge, diaphragm gauge, pressure signal transmission – the differential pressure cell

#### 3. Fluid Flow Phenomena

types of flow – potential flow, steady flow, one dimensional flow, laminar flow & turbulent flow, Reynolds number, transition from laminar to turbulent flow, Reynolds number for non-Newtonian fluids, nature of turbulence, eddy viscosity & eddy diffusivity of momentum, flow in boundary layers, laminar & turbulent flow in boundary layer, calculation of boundary layer thickness & friction factor in streamline portion of boundary layer, turbulent portion of boundary layer, laminar sub layer portion of boundary layer, boundary layer formation in straight tubes, transition length for laminar & turbulent flow, boundary layer separation & wake formation

#### 4. Basic Equations of Fluid Flow

continuity equation, average velocity, mass velocity, momentum balance, momentum correction factor, momentum balance in potential flow – Bernoulli equation without friction, mechanical energy equation, kinetic energy & its correction factor, Bernoulli equation with friction & pump work.

#### 5. Friction in Pipes & Channels

shear stress distribution in fluid, resistance to flow in pipes, friction factor charts, calculation of pressure drop along a pipe, roughness of pipe surface, velocity distribution for streamline flow for pipes of circular cross section, volumetric flow rates & average velocity calculations, kinetic energy of fluid, flow between two parallel plates, flow through an annulus, velocity distribution for turbulent flow – flow in non circular ducts, flow through curved pipes, miscellaneous friction losses for incompressible fluids – sudden enlargement, sudden contraction, pipe fittings & flow over banks of tubes, flow in open channels – uniform flow

## **6. Flow of Compressible Fluids & Two Phase Flow**

continuity equation, total energy balance, mechanical energy balance, velocity of sound, ideal gas equations, acoustic velocity & Mach number of ideal gas, stagnation temperature, process of incompressible flow – flow through variable area conduits (i.e. converging – diverging nozzle), equations for isentropic flow, change in gas properties during flow, velocity in nozzle, effect of cross section area in nozzle flow, adiabatic frictional flow – friction parameter, equation for adiabatic frictional flow, property equations, maximum conduit length & mass velocity, isothermal frictional flow, heat transfer in isothermal, two phase flow – flow pattern, hold up, pressure, momentum & energy relations & erosion

## **7. Flow Past Immersed Bodies**

drag, drag coefficient, stagnation point, stagnation pressure, friction in flow through beds of solids, motion of particles through fluids – mechanics of particle motion, types of settling, fluidisation, conditions for fluidisation, minimum fluidisation velocity & types of fluidisation

## **8. Fluid Flow Measurement**

pitot tube, orifice meter, nozzle, venturimeter, pressure recovery in orifice type meter, variable area meters- rota meter, notches & weirs, other methods of measuring flow rates – hot wire anemometer, magnetic meter, quantity meter & liquid meters

## **9. Pumping of Fluids**

pumping equipment for liquids – reciprocating pumps, positive displacement rotary pumps, centrifugal pumps, use of compressed air for pumping air lift pumps, pumping equipment for gases – reciprocating compressor, rotary blowers & compressors, centrifugal blowers & compressors including turbo compressor, vacuum producing equipment, power required for compression of gases – clearance volume, multistage compressors, compressor efficiencies, power required for pumping through pipelines, types of turbines

## **10. Agitation & Mixing of Liquids**

agitation of liquids – purpose of agitation, agitation equipment, impellers, flow patterns in agitated vessels, standard turbine design, circulation velocities & power consumption in agitated vessels, blending & mixing – mixing of miscible liquids, suspension of solid particles, blending of miscible liquids, motionless mixers, mixer selection, scale up of agitator design, dispersion operations – characteristics of dispersed phase, mean diameter, gas dispersion – bubble diameter, gas dispersion in agitated vessels, gas handling capacity & loading of turbine impellers, power input to turbine dispensers, dispersion of liquids in liquids

## **Practical & Term Work**

1. Experiments based on metering devices such as venturimeter, orifice meter, pitot tube, rotameter & notched weirs
2. Experiments based on characteristics of pumps, blowers, compressors, vacuum jet ejectors, etc.
3. Experiments based on measurement of pressure drop like flow through various pipes, flow through packed beds, flow through pipe fittings & valves, etc.
4. Experiments based on practical applications of theory like Bernoulli's theorem, Ergun equation, Reynold's experiment, etc.

**Text Book**

1. Unit Operation of Chemical Engineering by Warren L. McCabe, Julian C. Smith & Peter Harriott 4<sup>th</sup> Ed,  
McGraw Hill Publications
2. Chemical Engineering Vol. 1 3<sup>rd</sup> Ed. by J. M. Coulson & J. F. Richardson  
Pergamon International, 1984, Great Britain

**Reference Book**

1. Fluid Mechanics by Victor L. Streeter, E. Benjamin Wylie, 7<sup>th</sup> Ed.  
McGraw Hill Publications
2. Fluid Dynamics & Heat Transfer by J. G. Knudson & Donald L. Kala  
McGraw Hill Publications
3. Perry's Chemical Engineer's Handbook by Robert H. Perry, Don W. Green  
McGraw Hill Publications

## CH – 502 MECHANICAL OPERATIONS

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (3 hrs.)	SES (1 hr.)	PR	TW	TOTAL
4	-	3	60	40	25	25	150

### 1. Solids

characteristics of solids, particles, types of standard screen series

### 2. Size Reduction & Enlargement

principle of comminution, types of crushers, grinders & disintegrators for coarse, intermediate & fine grinding, energy & power requirement, laws of crushers & work index, close & open circuit grinding, feed control, mill discharge, removal & supply of heat in wet grinding, size enlargement by agglomeration, briquetting, compacting, granulation, tableting etc.

### 3. Screening & Other Separation Methods

types of screens, screen analysis, estimation of particle sizes, surface area & particle population based on screen analysis, comparison of ideal & actual screens, capacity & effectiveness of screens, principle of elutriation, floatation, jigging, electrostatic & magnetic separation processes

### 4. Sedimentation

settling velocities in free & hindered settling, flocculation, rate of sedimentation, types of thickener & thickener area calculation, batch & continuous settling chambers, sorting classifiers, centrifugal settling process, cyclone, principle of centrifugal sedimentation

### 5. Fluidisation

mechanism, dense phase fluidisation & boiling beds, minimum porosity of bed & bed height, minimum fluidisation velocity & pressure drop in fluidised beds, applications of batch & continuous fluidisation

### 6. Filtration

types of filters, filter media, filter aids, batch & continuous filtration equipments – filter press, leaf filter, cartridge filter, rotary drum filter, theories of filtration, washing of cake, principle of centrifugal filtration, suspended basket centrifuge, etc.

### 7. Mixing & Agitation

fundamentals of mixing & agitation, characteristics of mixing equipments, agitation of liquids, types of impellers, power consumption in agitated vessels in liquid – liquid, liquid – solid & solid – liquid mixing, mixing of pastes & paste masses, pony mixers, beater mixer, mixing of dry powder, ribbon blender, tumbler mixer, etc.

### 8. Conveying

mechanical & pneumatic conveying, elevators, etc. storage of solids, liquids & gases

**Practical & Term Work**

Experiments based on screening, screen efficiency, sedimentation, filtration, fluidisation, etc.

**Text Book**

1. Unit Operations in Chemical Engineering by Warren L. McCabe, Julian C. Smith & Peter Harriot 4<sup>th</sup> Ed.  
McGraw Hill Publications
2. Introduction to Chemical Engineering by Badger & Banchero  
McGraw Hill Publications
3. Chemical Engineering Vol. 2 by J. M. Coulson & J. F. Richardson  
Pergamon International, 1984, Great Britain
4. Unit Operations by Brown & Associates  
John Wiley & Sons

## CH – 503 CHEMICAL ENGINEERING THERMODYNAMICS – I

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (3 hrs.)	SES (1 hr.)	PR	TW	TOTAL
4	-		60	40			100

### 1. Introduction

conservation of energy & first law of thermodynamics, application to steady state flow process, enthalpy, internal energy, equilibrium state, phase rule, irreversible & reversible processes, heat capacity & specific heat

### 2. Properties of Pure Substances

PVT behaviour of pure substance, ideal & non-ideal gases, different equations of state for real gases like Virial equation, Vander wall's equation, Redlich – Kwong equation, etc., calculation of constants in terms of P, V, & T conditions to be satisfied, corresponding states theory, Pitzer's modification to law of corresponding states

### 3. Heat Effects

heat capacity of gases as a function of temperature, heat capacities of gases, liquids & solids, concept of C, heat of vaporisation, heat of fusion, heat of sublimation, heat of formation, heat of combustion, calculation of heat of formation from heat of combustion, calculation heat of reaction from heat of formation, etc.

### 4. Second Law of Thermodynamics

second law of thermodynamics, thermodynamics temperature scale, ideal gas temperature scale, concept of entropy, change & irreversibility, introduction to third law of thermodynamics

### 5. Thermodynamic Properties of Fluids

network of thermodynamic equations, mathematical relations among thermodynamic functions, Maxwell's relations, interrelation between H, S, U, G,  $C_p$ ,  $C_v$ , etc. in terms of PVT relations, thermodynamic properties of single phase & two phase systems, types of thermodynamic diagrams, generalised correlation of thermodynamic properties

### 6. Thermodynamics of Flow Processes

fundamental equations & relationships for flow in pipes, maximum velocity in pipe flow, throttling process, flow through nozzles, single stage multistage compressors

### 7. Refrigeration & Liquefaction

Carnot refrigeration cycle, air refrigeration cycle, vapour compression cycle, absorption refrigeration, choice of refrigerant, heat pump, liquefaction processes

### Text Book

1. Introduction to Chemical Engineering Thermodynamics 4<sup>th</sup> Ed. by J. M. Smith & H. C. Van Ness  
McGraw Hill Book Company
2. Chemical Engineering Thermodynamics by B. F. Dodge  
McGraw Hill Book Company

## CH – 504 MASS TRANSFER – I

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (3 hrs.)	SES (1 hr.)	PR	TW	TOTAL
4	-		60	40			100

### 1. Introduction to Mass Transfer Operations (MTO)

classification, methods of conducting MTO

### 2. Molecular Diffusion in Fluids

steady state molecular diffusion in fluids (both liquids & gases), diffusivity of liquids & gases

### 3. Mass Transfer Coefficients

MT coefficients in laminar flow & turbulent flow, theories of MT, heat, mass & momentum transfer in laminar & turbulent flow & their analogies, simultaneous heat & mass transfer

### 4. Diffusion in Solids

Fick's law, unsteady state diffusion, types of solid diffusion

### 5. Inter Phase Mass Transfer

equilibrium, diffusion between phases, local & overall diffusion, various processes & material balance for each of them

### 6. Equipments for Gas – Liquid Operations

gas dispersion, liquid dispersion equipments

### 7. Distillation

VLE data, flash distillation, simple distillation, continuous rectification, McCabe Thiele & Ponchon Sovarit methods, distillation in packed columns & vacuum distillation

### Text Book

1. Mass Transfer Operations 3<sup>rd</sup> Ed. by R. E. Treybal  
McGraw Hill Publications
2. Unit Operations in Chemical Engineering by Warren L. McCabe, Julian C. Smith & Peter Harriot 4<sup>th</sup> Ed.  
McGraw Hill Publications

## CH – 505 HEAT TRANSFER

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (3 hrs.)	SES (1 hr.)	PR	TW	TOTAL
4	-	3	60	40	25	25	150

### 1. Introduction

modes of heat transfer & basic equations, classification of heat flow processes, Fourier's law, steady state heat conduction through composite wall, cylinder & sphere, steady & unsteady state processes, partial differential equation for one dimensional heat flow, flow of heat through solid slab

### 2. Convection

heat transfer by convection, fluid with & without phase change, free & forced convection, laminar & turbulent flow, heat transfer inside & outside tubes, concepts of thermal boundary layer, individual and overall heat transfer coefficients, LMTD, fouling factor, transfer units, laminar flow over flat plate, heat transfer in turbulent flow, Re, Pr & other dimensionless numbers, dimensional analysis, empirical correlations, heat transfer in packed & fluidised beds

### 3. Natural Convection

Gr, analogies, heat transfer to molten metals

### 4. Boiling

definition, phenomena of boiling, regimes of boiling, heat transfer to boiling liquids

### 5. Condensation

definition, film type & drop wise condensation, condensation on horizontal & vertical tubes

### 6. Evaporation

definition, basic principles, single effect evaporators, boiling point elevation, multi effect evaporation, forward & backward feed systems, different types of evaporators

### 7. Heat Exchangers

basic types of heat exchangers, performance, design parameter of heat exchangers, parallel, counter current & cross flow heat exchangers, shell & tube type heat exchangers, double pipe heat exchanger

### 8. Radiation

definition, emission of radiation, laws of radiation, black body, radiation between surfaces, radiation shield, radiation through gases

### 9. Extended Surfaces

different types of fins, fin efficiency, applications of extended surfaces

**Practical & Term Work**

Experiments to measure heat transfer coefficients, boiling, heat transfer in agitated vessel, condensation, radiation, etc.

**Text Book**

1. Unit Operations in Chemical Engineering by Warren L. McCabe, Julian C. Smith & Peter Harriot 4<sup>th</sup> Ed.  
McGraw Hill Publications
2. Chemical Engineering Vol. 1 by J. M. Coulson & J. F. Richardson  
Pergamon International, 1984, Great Britain
3. Heat Transfer by Holman J. P.  
McGraw Hill Publications

**Reference Books**

1. Heat Transfer – Basic Approach by Ozisic M. N.  
Tata McGraw Hill
2. Heat Transfer by Gebhart B.  
Tata McGraw Hill
3. Engineering Heat Transfer by Wiley  
John Wiley & Sons

## CH – 511 CHEMICAL PROCESS CALCULATIONS

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (3 hrs.)	SES (1 hr.)	PR	TW	TOTAL
4	-		60	40			100

### 1. Dimensions & Units

dimensions & system of units, fundamental & derived units, dimensional consistency, dimensional equations & empirical equations, different ways of expressing units of quantities & physical constants

### 2. Basic Chemical Calculations

composition of gaseous mixtures, liquid mixtures, solutions, ideal gas law & its application, Dalton's & Amagat's Law, Henry's law, solubility & distribution coefficient, humidity & saturation

### 3. Material Balance without Chemical Reaction

process flow sheet, material balance with & without recycle, bypass, purge stream, material balance around equipments related to unit operations like absorber, stripper, distillation tower, extractors, dryers, evaporators, crystallisers, humidification & dehumidification towers, material balance of unsteady state operations like mixing

### 4. Material Balance with Chemical Reaction

concept of limiting & excess reactants, percent conversion, yield, etc., material balance involving reactions with special reference to fertilizers, electrochemical industries, petrochemicals, dyestuffs

### 5. Energy Balance

heat capacity of gases & gaseous mixtures, heat capacity of liquids & solids, sensible heat change in liquids & gases, enthalpy changes during phase change transformation, enthalpy changes accompanied by chemical reactions, thermo chemistry of mixing process, dissolution of solids

### 6. Fuels & Combustion

types of fuels, calorific value of fuels, problems on combustion of coal, liquid fuels, gaseous fuels, sulphur & sulphur pyrites, etc., proximate & ultimate analysis

### Text Book

Stoichiometry 3<sup>rd</sup> Ed. By B. I. Bhatt & S. M. Vora  
Tata McGraw Hill Company

### Reference Book

1. Chemical Process Principles by Hougen, Watson & Ragatz  
Asia Publishing House
2. Industrial Stoichiometry 2<sup>nd</sup> Ed. by W. K. Lewis, A. H. Radaxh & H. C. Lewis  
McGraw Hill Kogakusha Co.
3. Stoichiometry for Chemical Engineers by E. Williams & C. Johnson
4. Basic Principles & Calculations in Chemical Engineering by D.M.Himmelblau  
Prentice Hall

## CT –515 PERSONALITY DEVELOPMENT

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (2 hrs.)	SES (1 hr.)	PR	TW	TOTAL
2	-	-	50				50

The course comprises of the following areas:

- 1. Introduction: The Contemporary Need of the Developed Personality at all Levels of Life.**
- 2. Health, Hygiene and High-Spirits.**
- 3. Proper Use of Language and Communication Skills.**
- 4. HRD, Inter-Actions and Facing People.**
- 5. Goal Setting and Time Management.**
- 6. Leadership and Team Spirit.**
- 7. Motivating Morale and Will to Work.**
- 8. Effective Concentration and Memory.**
- 9. Ways to Plan and Organise Work.**
- 10. Mannerism, Self-Bearing and Reflexes.**
- 11. Importance of Values and Virtues.**
- 12. Effective Self-Presentation and Facing Interviews.**

## SEMESTER – VI (CH)

### CH – 601 CHEMICAL REACTION ENGINEERING – I

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (3 hrs.)	SES (1 hr.)	PR	TW	TOTAL
4	-	3	60	40	25	25	150

#### 1. Introduction

thermodynamics, chemical kinetics, classification of reactions, variables affecting the rate of reaction, definition of reaction rate

#### 2. Kinetics of Homogeneous Reactions

concentration dependent term of a rate equation, single & multiple reactions, elementary & non elementary reactions, kinetic view of equilibrium for elementary reactions, molecularity & order of reaction, rate constant, representation of a rate constant, kinetic models for non elementary reactions, temperature dependence of rate equation, Arrhenius theory, collision theory & transition state theory, comparisons of the theories

#### 3. Interpretation of Batch Reactor Data

constant volume batch reactor, integral method & differential method of analysis of data, variable volume batch reactor, integral method of analysis, differential method of analysis

#### 4. Introduction to Reactor Design

material and energy balances

#### 5. Single Ideal Reactors

ideal batch reactor, space time & space velocity, steady state mixed flow reactor, steady state plug flow reactor, holding time & space time for flow systems

#### 6. Design for Single Reactions

size comparison of single reactors, batch reactor, mixed reactor versus plug flow reactors, first & second order reactions, variation of reaction rates for second order reactions, general graphical comparison, multiple reactor system, plug flow reactors in series and/or in parallel, equal sized mixed reactors in series, mixed flow reactors of different sizes, reactors of different types in series, recycle reactor

#### Practical & Term Work

Experiment pertaining to determination of order of reaction using integral & differential methods of analysis, effect of temperature on rate of reaction, study of pilot scale reactor

#### Text Book

Chemical Reaction Engineering 2<sup>nd</sup> Ed. by Octave Levenspiel  
John Wiley & Sons

#### Reference Book

1. Chemical Engineering Kinetics 3<sup>rd</sup> Ed. by J. M. Smith  
McGraw Hill Publishing
2. Reaction Kinetics for Chemical Engineers by S. M. Nolas  
McGraw Hill Publishing

## CH – 602 CHEMICAL SYSTEM MODELLING

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (3 hrs.)	SES (1 hr.)	PR	TW	TOTAL
4	-		60	40			100

### 1. Introduction

physical modelling, mathematical modelling, principles of similarity in physical modelling, definitions of independent variables, dependent variables & boundary conditions

### 2. Mathematical Modelling of Chemical Systems

single stage, 2 stage & N stage extraction of steady state mass transfer process, unsteady state formulation of single stage extraction, steady state heat conduction through hollow cylindrical pipe using various boundary conditions, unsteady state process of steam heating of liquid, heat transfer through extended surfaces (triangle & rectangle), steady state counter current cooling of tanks, unsteady state heat loss through maturing tank, diffusion with chemical reaction in a tubular reactor, gas pre-heater, heat loss through circular flanges

### 3. Laplace Transforms

thermometer system, mixing tank, fixed bed reactor formulation

### 4. Partial Differential Equations & Finite Difference

unsteady state continuity equation, unsteady state heat conduction, unsteady state mass transfer (Fick's second law), gas absorption accompanied by chemical reaction (mathematical model formulation), finite difference – solvent extraction in N stage process, gas absorption in N stages (Kremser – Brown), N stirred tanks reactors in series, etc.

### 5. Numerical Methods

Simpson's rules, Gauss's method, trapezoidal rule, solving differential equations by Taylor's series method, modified Euler's method, Runge – Kutta Method

### 6. Treatment o Experimental Results

errors, method of averages, linear least squares method

### 7. Optimisation

simplex method, method of steepest descent, method of Lagrange's multiplier

### 8. Introduction to Computers

analog & digital computers, linear computers involving summer, integrators, potentiometer, multiplication, examples of solving the differential equations

### Text Book

1. Mathematical Methods in Chemical Engineering by V. G. Jensen & G. V. **Jeffreys**  
Academic Press, New York
2. Applied Mathematics in Chemical Engineering 2<sup>nd</sup> Ed. by H. S. Mickley, T. S. Sherwood & C. E. Reed  
Tata McGraw Hill Publishing Co. Ltd., New Delhi
3. Cybernetic Methods in Chemistry & Chemical Engineering by V. Kafarov  
Mir Publishers

## CH – 603 CHEMICAL ENGINEERING THERMODYNAMICS – II

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (3 hrs.)	SES (1 hr.)	PR	TW	TOTAL
4	-		60	40			100

### 1. Thermodynamic Properties of Fluids

partial molar properties, chemical potential, ideal & non-ideal solution, fugacity & fugacity coefficient, evaluation of fugacity coefficient – for a pure component, for a mixture of gases & for liquids, effect of temperature & pressure on fugacity & fugacity coefficient of a pure component as well as a gaseous mixture, Lewis – Randall rule & Henry's law, excess properties, activity & activity coefficient

### 2. Phase Equilibrium

criterion of phase equilibrium, phase rule, Duhem's theorem, vapour – liquid equilibrium calculations, phase diagrams for miscible systems, phase diagrams for immiscible systems, phase diagrams for partially miscible systems, testing of vapour – liquid equilibrium data, Gibb's – Duhem equation, Van Laar equation, Margule's equation, evaluation of constants in these equations, Redlich – Kister equation, P-x,y & T-x,y & x-y diagrams, vapour – liquid equilibrium of ideal & non-ideal solutions, Raoult's law & Henry's law, positive & negative deviations from Raoult's law

### 3. Chemical Equilibrium

criteria for chemical equilibrium, equilibrium conversion (x), equilibrium constant (k), effect of temperature & pressure on k, evaluation of equilibrium constants by various methods, evaluation of equilibrium conversion for gas phase reactions, liquid phase reaction, heterogeneous reactions etc., phase rule for chemically reacting systems

### 4. Introduction to Statistical Thermodynamics

different thermodynamic distributions like Boltzmann distribution, Bose – Einstein distribution, Fermi – Dirac distribution, corrected Boltzmann statistics, partition function, evaluation of properties for monoatomic gases using partition function, group contribution methods

### Text Book

1. Introduction to Chemical Engineering Thermodynamics 4<sup>th</sup> Ed. by J. M. Smith & H. C. Van Ness  
McGraw Hill Book Company
2. Chemical Engineering Thermodynamics by B. F. Dodge  
McGraw Hill Book Company
3. Fundamentals of Statistical Thermodynamics by Sonntag & Van Wylen

## CH – 604 MASS TRANSFER – II

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (3 hrs.)	SES (1 hr.)	PR	TW	TOTAL
4	-	3	60	40	25	25	150

### 1. Absorption

equilibrium, material balance for single component transfer, multistage & packed tower operation

### 2. Humidification

equilibrium, vapour – gas mixture, gas liquid contact operations, adiabatic & non-adiabatic operations

### 3. Liquid Extraction

equilibrium, stage wise contact, single stage type contactor, continuous contact extractor

### 4. Adsorption & Ion-exchange

equilibrium, stage wise operation, continuous contact operation

### 5. Drying

equilibria, batch drying, mechanism of batch drying, continuous drying

### 6. Leeching

equilibrium, steady state & unsteady state operations, methods of calculations

### 7. Crystallisation

equilibrium, operations, equipments

### 8. Introduction to Recent Separation Techniques using Mass Transfer

thermal diffusion, reverse osmosis, membrane processes, etc.

### Practical & Term Work

Experiments on diffusion in liquids, diffusion through solids, distillation, leeching, liquid – liquid extraction, crystallisation, drying, adsorption, humidification, etc.

### Text Book

1. Mass Transfer Operations 3<sup>rd</sup> Ed. by R. E. Treybal  
McGraw Hill Publications
2. Unit Operations in Chemical Engineering by Warren L. McCabe, Julian C. Smith & Peter Harriot 4<sup>th</sup> Ed.  
McGraw Hill Publications

## CH – 605 INSTRUMENTATION & PROCESS CONTROL

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (3 hrs.)	SES (1 hr.)	PR	TW	TOTAL
4	-	3	60	40	25	25	150

### 1. Process Control

introduction, steady state & unsteady state design equation for an agitated heated tank, introduction to P, PI & PID controls, dynamics of first order systems subjected to various disturbance like step, ramp, impulse & sinusoidal, examples of the above systems viz. liquid level tanks, mixing process, thermometer, etc., response of the first order system in series, dynamics of the second order systems subjected to various disturbances like step, impulse & sinusoidal, transportation lag, linear closed loop system – servo & regulator problem, closed loop transfer function, block diagram for various simple systems, transient response of a control system, stability of control system, Routh test criterion, frequency analysis for simple order systems, Bode diagrams, advanced controls like feed forward, cascade & ratio control, controller & control element, control values

### 2. Instrumentation

measuring instruments for temperature, pressure, level & flow

### Practical & Term Work

Experiments to study the response of first order systems and second order system to various inputs

### Text Book

1. Process System Analysis & Control by D. R. Coughanowr  
McGraw Hill Publishing Co.
2. Instrumentation by Eckman

### Reference Book

Introduction to Control Systems by Stephenopolis

## CH – 608 BIOCHEMICAL ENGINEERING

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (3 hrs.)	SES (1 hr.)	PR	TW	TOTAL
4	-		60	40			100

(1) Introduction

Structure of cells, Cell types, Chemicals of life – lipids, sugar, polysaccharides, RNA, DNA, Amino acids, proteins etc.

(2) Enzymed Catalyzed reactions

Enzyme substrate complex & Enzyme action, Simple enzyme kinetics with one & two substrate, determination of elementary rate constant, other patterns of substrate concentration dependence, modulations & regulation of enzymatic activities, Enzyme deactivation.

(3) Kinetics of substrate utilization , product formation & bioproduction in cell culture

(4) Design & analysis of biological reactors

(5) Fermentation technology & industrial microbiology

Introduction, uses, type of fermenters, downstream processes, roll of yeast, solid state fermentation, fermented foods, lactose utilization, single cell protein, enzymes, immobilization of enzymes etc.

(6) Genetics

Introduction, plasmids, cloning vehicles, strain construction, genetic recombination, antisense RNA technology , gene machine, DNA hybridization, genetic disease, human gene therapy, biolistic missiles. Molecular engineering, etc.

(7) Production of useful substances by microorganisms like penicillin, lactic acid, vitamins alcohol etc.

(8) Environment & energy

Text books:

- (i) Biochemical engineering fundamentals  
Second edition- By J.E.Bailey & D.F.Ollis
- (ii) A textbook on biotechnology- By H.D.Kumar

Reference book:

Chemical Engineering –Vol-3, Coulson & Richardson

## SEMESTER – VII (CH)

### CH – 701 CHEMICAL REACTION ENGINEERING – II

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (3 hrs.)	SES (1 hr.)	PR	TW	TOTAL
4	-	3	60	40	25	25	150

#### 1. Residence Time Distribution of Fluid in Vessels

E, the age distribution of fluid leaving vessel, experimental methods, the F curve, the C curve, relation among E, F & C curves & mean time for closed vessel, useful mathematical tools, the mean & variance ways of using age distribution information, linear & non-linear systems with flow models, finding RTD by experiment, conversion directly from tracer information, model for non-ideal flow dispersion model, fitting the dispersion model for small extents of dispersion & large extent of dispersion, chemical reaction & dispersion, tanks in series model

#### 2. Introduction to Design for Heterogeneous Reacting Systems

rate equation for heterogeneous reactions, combining linear & non-linear rate expressions, the concept of rate controlling step, linearisation of a non-linear rate equation, contacting patterns for two phase systems

#### 3. Fluid Particle Reactions

unreacted core model for spherical particles of unchanging size, diffusion through gas film, ash layer & chemical reaction control, rate of reaction for shrinking spherical particles (chemical reaction & gas diffusion control), determination of the rate controlling step, application to design, mixture of particles of unchanging size & uniform gas composition, application to fluidised bed with entrainment of solid fines

#### 4. Fluid – Fluid Reaction

kinetic regimes for mass transfer & reaction, detailed treatment for all the cases, film conversion parameter M, kinetic regime from experiment, slurry reaction kinetics, design of towers for fast & slow reactions

#### 5. Solid Catalysed Reactions

effectiveness factor for first order reaction, experimental methods for finding rates

#### Practical & Term Work

Experiments to determine RTD & conversion from RTD for various geometries under laminar & turbulent flows, heterogeneous reaction system, application of tank in series & dispersion models, RTD in a pilot scale batch reactor

**Text Book**

Chemical Reaction Engineering 2<sup>nd</sup> Ed. by Octave Levenspiel  
John Wiley & Sons

**Reference Book**

1. Chemical Engineering Kinetics 3<sup>rd</sup> Ed. by J. M. Smith  
McGraw Hill Publishing
2. Reaction Kinetics for Chemical Engineers by S. M. Walas  
McGraw Hill Publishing

## CH – 702 TRANSPORT PHENOMENA

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (3 hrs.)	SES (1 hr.)	PR	TW	TOTAL
4	-	3	60	40	25	25	150

### 1. Transport by Molecular Motion

review of momentum, energy & mass transport by molecular motion

### 2. Transport in Laminar One Dimensional Flow

- i. Momentum Transport: shell momentum balances, velocity profiles in cases like adjacent flow of two liquids
- ii. Energy Transport: shell energy balances, temperature profiles, heat conduction with an electrical heat source, heat conduction viscous heat source & heat conduction chemical heat source
- iii. Mass Transport: concentration distribution in solids & laminar flow, shell mass balances, diffusion with heterogeneous chemical reaction, diffusion in falling liquid film

### 3. Transport in Arbitrary Continuum

- i. Momentum Transport: equation of change for isothermal system, equation of continuity & motion in rectangular, cylindrical & spherical co-ordinates
- ii. Energy Transport: non-isothermal systems, equation of energy of motion for forced & free convection in non-isothermal flow
- iii. Mass Transport: equation of continuity for binary mixtures, equation of change for multi-component systems, mass flux in terms of transport properties, use of equation of change

### 4. Transport with Two Independent Variables

- a. Momentum Transport: unsteady state viscous flow, two dimensional viscous flow, boundary layer momentum transport
- b. Energy Transport: heat conduction in viscous flow, boundary layer energy transport
- c. Mass Transport: unsteady diffusion, diffusion in viscous flow, two dimensional diffusion in solids, boundary layer theory

### 5. Transport in Turbulent Flow

- i. Momentum Transport: time smoothing of equation of change for incompressible fluid & review of logarithmic law of viscosity
- ii. Energy Transport: temperature fluctuations & time smoothing of temperature & energy equation, semi-empirical equations for turbulent energy flux
- iii. Mass Transport: time smoothing of equation of change, turbulent concentration profiles

## **6. Transport between Two Phases**

- i. Momentum transport: friction factors for flow in tubes, flow rate & pressure drop relations, friction factor for packed beds
- ii. Energy Transport: non-isothermal system, heat transfer coefficients, dimensionless correlations for forced & free convection in tubes & around submerged objects, heat transfer coefficient for forced convection through packed bed
- iii. Mass Transport: mass transport coefficient, correlations for binary systems in one phase & at low mass transfer rates, definition & correlation for binary mass transfer coefficients in two phases at low mass transfer rates, transfer coefficients for high mass transfer rates, boundary layer theory

## **7. Transport in Layer Flow System**

microscopic mass balance & mechanical energy balances, estimation of friction losses, macroscopic energy balance in non-isothermal systems, use of balances to solve steady state & unsteady state problems

### **Note:**

While teaching the above topics more stress is to be given on the following unit operations;

1. Transport Phenomena in liquid extraction
2. Transport Phenomena in gas absorption
3. Transport Phenomena in distillation

### **Practical & Term Work**

Experiments on based on the above mentioned topics

### **Text Book**

1. Transport Phenomena by R. B. Bird, W. E. Stewart & F. W. Lightfoot  
John Wiley & Sons
2. Momentum Transfer Operations by S. K. Gupta  
Tata McGraw Hill Corp,

### **Reference Book**

- Transport Phenomenon in Liquid Extraction by G. S. Laddha & T. E. Degaleesan  
McGraw Hill Publishing
- Absorption & Extraction by T. K. Sherwood & R. L. Pigford  
McGraw Hill Publishing
- Multi-component Distillation by D. D. Holland  
Prentice Hall, India

## CH –703 PROCESS EQUIPMENT DESIGN & DRAWING

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (3 hrs.)	SES (1 hr.)	PR	TW	TOTAL
4	-	3	60	40	25	25	150

### 1. Introduction

basic considerations in mechanical design of process equipments, selection of type of vessel, method of fabrication, economic consideration

### 2. Vessel Design

criteria in vessel design, excessive elastic deformation, plastic instability, brittle rupture, creep

### 3. Vessels Under Internal Pressure

design of pressure vessels under internal pressure, construction features – pressure vessel codes, design of shell, types of heads for pressure vessel, design of thickness of heads

### 4. Vessels under External Pressure

use of stiffeners, design of shell, analytical & graphical methods, design of circumferential stiffeners, design of covers, pipes, tubing under external pressure

### 5. Reaction vessels

various jackets, half coiled jacket design & combined stress calculation, channel jackets

### 6. Storage Vessels

design of storage vessel, storage of non-volatile & volatile liquids, storage of gases, types & constructional features of storage vessels, rectangular tank design, design of cylindrical storage tank, bottom design, roof design, shell design

### 7. Design of Tall Columns

design of tall distillation or fractionation columns, plate (tray type) & packed tower calculations, construction & features in column stress & determination of shell thickness, design & construction features of column internal such as trays, packing, bubble caps, distribution, etc.

### 8. High Pressure Vessel

types, design of high pressure vessel, auto clave, construction features, materials for high pressure shell design, types of vessel closures

### 9. Design of Heat Exchanger

types & design of shell & tube heat exchanger, tube sheet, channels, shell joints, baffles, tie rods, expansion provision, etc, mechanical & thermal design

### 10. Supports for Vessels

types – bracket or leg support, skirt support & saddle support, design calculations

### 11. Other Process Equipments

design & constructional features of evaporators, crystallisers, dryers & filters

**12. Safety**

process hazards, safety measures in equipment design, analysis of hazard, pressure relief devices, other safety devices

**Practical & Term Work**

Designing of equipment and preparation of fabrication drawings for the same

**Text Book**

1. Process Equipment Design by M. V. Joshi  
McMillan Co., India
2. Process Equipment Design & Drawing by L. E. Brownel & E. H. Young  
Wiley Eastern Ltd., New Delhi

## CH – 704 CHEMICAL ENGINEERING PLANT DESIGN & ECONOMICS

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (3 hrs.)	SES (1 hr.)	PR	TW	TOTAL
4	-		60	40			100

### 1. Introduction

basic considerations in chemical engineering plant design, identification – preliminary techno-economic feasibility

### 2. Process Design Aspects

selection of process, factors affecting selection, importance of laboratory development, pilot plant, scale-up methods, safety factors, type of flow diagrams

### 3. Selection of Process Equipments

standard vs. special equipment, material of construction for process equipments, selection criteria, specifications sheet

### 4. Process Auxiliary

piping design, layout, supports for piping, insulation, pipe fittings, types of valves, selection of valves, process control & instrumentation, control system design

### 5. Process Utilities

process water, boiler feed water, water treatment, waste treatment & disposal, steam, oil heating system, chilling plant, compressed air & vacuum

### 6. Plant Location & Layout

factors affecting location, factors in planning layout, principles of layout, use of scale models

### 7. Cost Estimation

factors involved in project cost estimation, total capital investment, fixed capital investment, fixed capital & working capital, type & methods for estimation of total cost, investment, estimation of cost of equipment & cost of production

### 8. Estimation of Total Product Costs

factors involved in total cost of production, factors affecting investment & production costs

### 9. Depreciation

types & methods of determining depreciation, evaluation of depreciation methods

### 10. Profitability, Alternative Investment & Replacement

methods for profitability evaluation, practical factors in alternative investment & replacement studies

### 11. Economic Considerations in Process & Equipment Design

inventory control, scheduling project using CPM/PERT methods, project management

## 12. Optimum Design

general production rates in plant operation, optimum conditions, optimum production rates in plant operation, optimum conditions in cyclic operations

### Text Book

Plant Design & Economics for Chemical Engineers by M. S. Peters & K. D. Timmerhaus  
2<sup>nd</sup> Ed.

McGraw Hill Publication

Chemical Engineering Plant Design by F. C. Vilbrant & C. E. Dryden

McGraw Hill Publication

## CH – 705 ENVIRONMENTAL ENGINEERING

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (3 hrs.)	SES (1 hr.)	PR	TW	TOTAL
4	-		60	40			100

### 1. Introduction

types of pollution & their impact on the environment

### Air Pollution

#### 2. Sources & Effects

definition, ways of expressing concentration, classification & properties of air pollutants, emission sources – classification according to source types, major emissions from global sources & emission source in India, behaviour & fate of air pollutants, effect of air pollution on – human health, vegetation & materials, air pollution laws & standards

#### 3. Meteorological Aspects of Air Pollution

pollutant dispersion, temperature lapse rate & stability, wind velocity & turbulence, plume behaviour, dispersion of air pollutants – atmospheric dispersion model & the Gaussian plume model, estimation of plume rise

#### 4. Air Pollution Sampling & Measurement

ambient air sampling & stack sampling, analysis of air pollutants

#### 5. Air Pollution Control Methods & Equipment

source correction methods, particulate emission control methods & gaseous emission control methods

#### 6. Control of Specific Gaseous Pollutants

control of sulphur oxides, nitrogen oxides, carbon monoxide & hydrocarbon emissions

### Water Pollution

#### 7. Origin of Waste Water (W. W) & W. W. Flow Rates

#### 8. W. W. Characteristics

W. W. composition & physical, chemical & biological characteristics of W. W.

#### 9. W. W. Sampling

methods of sampling, methods of analysis & water quality standards

### **10. W. W. Treatment**

objectives & classification of W. W. treatment methods

### **11. Physical Unit Operation & their Design**

screening, comminution, grit chambers, flow equalisation, mixing, flocculation, sedimentation, floatation & filtration.

### **12. Chemical Unit Processes**

chemical precipitation, gas transfer, adsorption, disinfection with chlorine & ozone, dechlorination

### **13. Biological Unit Processes**

fundamentals of microbiology, bacterial growth & biological oxidation, kinetics of growth, aerobic suspended growth, treatment processes, activated sludge process & its design, aerobic aerated lagoons, aerobic digestion, aerobic stabilisation ponds, aerobic attached growth treatment processes – trickling filters & its design, rotating biological contactors, anaerobic suspended growth, treatment processes – anaerobic digestion, anaerobic attached growth treatment process – anaerobic filter & anaerobic ponds, combined aerobic/anoxic or anaerobic treatment processes – facultative lagoons (ponds), sludge treatment & disposal

### **14. Solid Waste Management**

sources & classification, methods of collection & disposal

### **15. Noise Pollution**

sources of noise pollution & their control methods

### **16. Environmental Legislation**

water and air act, hazardous waste handling & management act, environmental impact assessment, environmental audit

### **Text Book**

Environmental Pollution Control Engineering by C. S. Rao  
Wiley Eastern Ltd.

Waste Water Engineering – Treatment, Disposal & Reuse by Metcalf & Eddy Inc.  
Tata McGraw Hill Publications

### **Reference Book**

1. Introduction to Environmental Engineering by Mackenzie L. Davis & David A. Cornwell  
McGraw Hill International Publications
2. Environmental Engineering by Raw, Peavy & Tchobanoglous
3. Chemistry for Environmental Engineering 3<sup>rd</sup> Ed. by Sawyer & McCarty  
McGraw Hill Publications

## SEMESTER – VIII (CH)

### AF – 801: PROJECT/INDUSTRIAL TRAINING

#### SEMINAR:

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (3 hrs.)	SES (1 hr.)	PR	TW	TOTAL
		6				100	100

Under the above subject, each student will be assigned one topic related to chemical engineering field by his/her guide. The student will make an up-to-date literature survey with reference to the topic assigned to him under the supervision of his/her guide.

#### PROJECT/TRAINING

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (3 hrs.)	SES (1 hr.)	PR	TW	TOTAL
		24			300	100	400

Each student is required to undergo practical training in a chemical industry for 16 weeks and he is required to submit a project report on the designing of a chemical plant. The report will consist of important chapters such as,

- i. Introduction
- ii. Literature survey
- iii. Selection of the process & process details with justification
- iv. Thermodynamic & Kinetic consideration
- v. Physico-chemical data & properties
- vi. Material balance with flow sheet
- vii. Energy balance with flow sheet
- viii. Process design of various equipments & optimum operating conditions
- ix. Fabrication drawing of the major equipment with all relevant necessary details
- x. Other important considerations such as instrumentation & process control, plant layout, safety, precautions, etc.
- xi. Cost estimation
- xii. Conclusions

\* \* \* \* \*

### **ELECTIVES FOR SEM: V & SEM:VI & SEM:VII**

1. Environmental Engineering
2. BioChemical Engineering
3. Multicomponent Distillation
4. Numerical Techniques
5. Mass Transfer with Chemical Reaction
6. Petrochemical Technology
7. New Separation Techniques
8. Fluidization
9. Polymer Technology
10. Advanced Control Systems
11. Fermentation Technology
12. Catalysis
13. Computer aided Design
14. Bioreactor Design and Operation
15. Petroleum Refinery Engineering
16. Chemical Engineering Practice
17. Introduction to Nanotechnology

**New Syllabus (WEF Dec 08) Elective E01**  
**CH – 705 ENVIRONMENTAL ENGINEERING**

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (3 hrs.)	SES (1 hr.)	PR	TW	TOTAL
4	-		60	40			100

**1. Introduction**

Types of pollution & their impacts on the environment

**Air Pollution**

**2. Sources & Effects**

Definition, ways of expressing concentration, classification & properties of air pollutants, emission sources – classification according to source types, major emissions from global sources & emission source in India, behaviour & fate of air pollutants, effect of air pollution on – human health, vegetation & materials, air pollution laws & standards

**3. Meteorological Aspects of Air Pollution**

Pollutant dispersion, temperature lapse rate & stability, wind velocity & turbulence, plume behaviour, dispersion of air pollutants – atmospheric dispersion model & the Gaussian plume model, estimation of plume rise

**4. Air Pollution Sampling & Measurement**

ambient air sampling & stack sampling, analysis of air pollutants

**5. Air Pollution Control Methods & Equipment**

source correction methods, particulate emission control methods & gaseous emission control methods with special emphasis to Control of sulphur oxides, nitrogen oxides, carbon monoxide & hydrocarbon emissions

**Water Pollution**

**6. Origin, Characteristics and Flow Rates of Waste Water (W. W)**

Sources of wastewater in process industries, W. W. composition & physical, chemical & biological characteristics of W. W., Flow rates and general characteristics of waste water from various industries. Methods of waste water sampling, methods of analysis & water quality standards.

**7. W. W. Treatment**

Objectives & classification of W. W. treatment methods, Use of physical unit operations like screening, communiton, grit chambers, flow equalisation, mixing, flocculation, sedimentation, floatation & filtration in waste water treatment. Use of chemical unit processes like chemical precipitation, gas transfer, adsorption, disinfect ion with chlorine & ozone, dechlorination in wastewater treatment

**8. Biological Unit Processes**

fundamentals of microbiology, bacterial growth & biological oxidation, kinetics of growth, aerobic suspended growth, treatment processes, activated sludge process & its design, aerobic aerated lagoons, aerobic digestion, aerobic stabilisation ponds, aerobic attached growth treatment processes – trickling filters & its design, rotating biological contactors, anaerobic suspended growth, treatment processes – anaerobic digestion, anaerobic attached growth

treatment process & design – anaerobic filter & anaerobic ponds, combined aerobic/anoxic or anaerobic treatment processes – facultative lagoons (ponds), sludge treatment & disposal

**9. Solid Waste Management:** sources & classification, methods of collection & disposal

**10. Noise Pollution:** sources of noise pollution & their control methods

**11. Environmental Legislation:** Water and air act, hazardous waste handling & management act, environmental impact assessment, environmental audit

**12.** Introduction to concept of cleaner production and a case study on cleaner production.

**13.** Introduction to pollution prevention and resource conservation techniques.

### **Text Book**

1. Environmental Pollution Control Engineering by C. S. Rao  
Wiley Eastern Ltd.
2. Waste Water Engineering – Treatment, Disposal & Reuse by Metcalf & Eddy Inc.  
Tata McGraw Hill Publications

### **Reference Book**

18. Introduction to Environmental Engineering by Mackenzie L. Davis & David A. Cornwell  
McGraw Hill International Publications
19. Environmental Engineering by Raw, Peavy & Tchobanoglous
20. Chemistry for Environmental Engineering 3<sup>rd</sup> Ed. by Sawyer & McCarty  
McGraw Hill Publications

**Elective E02**  
**CH – 608 BIOCHEMICAL ENGINEERING**

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (3 hrs.)	SES (1 hr.)	PR	TW	TOTAL
4	-	-	60	40	-	-	100

- (9) Introduction [5]  
 Structure of cells, Cell types, Chemicals of life – lipids, sugar, polysaccharides, RNA, DNA, Amino acids, proteins etc.
- (10) Enzymed Catalyzed reactions [8]  
 Enzyme substrate complex & Enzyme action, Simple enzyme kinetics with one & two substrate, determination of elementary rate constant, other patterns of substrate concentration dependence, modulations & regulation of enzymatic activities, Enzyme deactivation.
- (11) Kinetics of substrate utilization, product formation & bioproduction in cell culture.[5]
- (12) Design & analysis of biological reactors [7]
- (13) Fermentation technology & industrial microbiology [5]  
 Introduction, uses, type of fermenters, downstream processes, roll of yeast, solid state fermentation, fermented foods, lactose utilization, single cell protein, enzymes, immobilization of enzymes etc.
- (14) Genetics [4]  
 Introduction, plasmids, cloning vehicles, strain construction, genetic recombination, antisense RNA technology , gene machine, DNA hybridazation, genetic disease, human gene therapy, biolistic missiles. Molecular engineering, etc.
- (15) Production of useful substances by microorganisms like penicillin, lactic acid, vitamins alcohol etc. [3]
- (16) Environment & energy [3]

**Text books:**

- (iii) Biochemical engineering fundamentals  
 Second edition- By J.E.Bailey & D.F.Ollis
- (iv) A textbook on biotechnology- By H.D.Kumar

**Reference book:**

- (i) Chemical Engineering –Vol-3, Coulson & Richardson

## Elective E03

### MULTICOMPONENT DISTILLATION

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (3 hrs.)	SES (1 hr.)	PR	TW	TOTAL
4	-	-	60	40	-	-	100

1. Design variables: [4]
2. Fundamental Concepts Involved in Multi-Component Distillation: [4]
3. Equilibrium flash separations: [4]  
Calculations for Bubble Point and Dew Point Temperatures
4. Multicomponent separations: [6]  
General short cut methods
5. Multicomponent separations: [4]  
Alternate shortcut distillation methods
6. Multicomponent separations: [6]  
Rigorous methods for distillation
7. Multicomponent separations: [4]  
Azeotropic and extractive distillation
8. Design of multi-component separations and rectifying [4]
9. Tar, and packed column internal design for multicomponent separations [4]

#### Reference:

1. 'Design of equilibrium stage processes' by B D. Smith, MGH Chemical Engg series.
2. Multi-Component Distillation, Holland Charles D., Prentice Hall Inc, Englewood Cliffs N.J., U.S. A. 1963.

# Elective E04

## Numerical Techniques

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (3 hrs.)	SES (1 hr.)	PR	TW	TOTAL
4	-	-	60	40	-	-	100

1. Error analysis [3 hrs]  
Significant figures, accuracy and precision, error definitions and round of errors, truncation errors, error propagation, Taylor series, total numerical errors, formulation errors and data uncertainty.
2. Solution of polynomial equation [5 hrs]  
Roots of equations, bracketing methods – graphical, bi section and false position methods, Open methods – Newton Raphson, secant methods, Roots of polynomials – computing methods like Mular method and Bair Stows methods
3. Linear algebraic equations [5 hrs]  
Gauss elimination, gauss Jordan, non-linear system of equations, gauss seidel method
4. Matrices and eigen value identification [4 hrs]  
Matrix inverse, error function and analysis, special matrices, eigen values and eigen vectors
5. Ordinary Differential Equations [7 hrs]  
Euler's methods, Runge-Kutta method, systems of equations, multistep methods, boundary value problem, eigen value problem
6. Partial Differential Equation [7 hrs]  
Finite difference method, elliptic equations, parabolic equations, finite element method
7. Matlab introduction and hands on practice [4 hrs]  
Introduction to mathematical equation solutions, programming, use of different tool boxes.
8. Introduction to Optimization [5 hrs]  
One dimensional unconstrained optimization – golden section search and newton's methods, multidimensional unconstrained optimization – direct and gradient methods, constrained optimization – linear programming

### Books:

1. Numerical methods for engineers by Steven C. Chapra, Raymond P. Canale (Tata McGraw Hill 4<sup>th</sup> Ed.)
2. Applied mathematical methods for chemical engineers by Norman W. Loney (CR press 2<sup>nd</sup> Ed)
3. Problem solving in chemical engineering with numerical methods by M.B. Cutlip and Mordechai Shacham (Prentice hall international series)
4. Applied mathematics and modeling for chemical engineers by Rice and Do (John Wiley publication)

## Elective E05

### Mass Transfer with Chemical Reaction

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (3 hrs.)	SES (1 hr.)	PR	TW	TOTAL
4	-	-	60	40	-	-	100

1. Introduction to mass transfer and Chemical Reaction Engineering – diffusion, eddy diffusion, inter-phase mass transfer, and mass transfer coefficient etc. Types of reactions, types of reactors, design equations for reactors, heterogeneous reactions
2. Absorption with chemical reaction
3. Coupled heat and mass transfer in non-isothermal liquid phase tubular reactors with strong exothermic reactions, Coupled heat and mass transfer with chemical reaction in batch reactors
4. Derivation of mass transfer equations-laminar boundary layer mass transfer around solid spheres, gas bubbles & other submerged objects, Diffusion & chemical reaction across spherical gas-liquid interfaces
5. Kinetic mechanisms & rate expressions for heterogeneous surface – catalyzed chemical reactions
6. Mass transfer & chemical reaction in isothermal catalytic pellets - Diffusion & heterogeneous chemical reaction in, complete analytical solution for diffusion & zero order, first order, chemical reactions in isothermal catalytic pellets, numerical solution of  $n^{\text{th}}$  order chemical reaction in isothermal catalytic pellets, internal mass transfer limitations, diffusion coefficients & Damkohler No., isothermal design of heterogeneous packed catalytic reaction, metal catalyst coated
7. Gas-liquid-solid reactions – film and penetration theory, analysis of G-L & G-L-S reactions, RTD & models for macro-mixing, mathematical models for G-L-S reactors, dynamics of co-current down-flow, counter-current down-flow, up-flow fixed bed column, G-L-solid suspended column etc.

#### Books

1. Transport Phenomena for Chemical Reactor Design – by Laurence A. Belfiore, Wiley Inter-science
  2. Gas-Liquid-Solid Reactor Design – by Yatish. T. Shah, McGraw-Hill Pub.
- Chemical Engineering Handbook – Edited by R. H. Perry, McGraw-Hill Pub.

## ELECTIVE E06

### PETROCHEMICAL TECHNOLOGY

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (3 hrs.)	SES (1 hr.)	PR	TW	TOTAL
4	-	-	60	40	-	-	100

- Introduction: [2]  
Petrochemical Industry, feed stocks, purification, mechanical and chemical impurities, separation of gases, separation of aromatics,
- Chemicals from methane: [3]  
Methanol(formaldehyde, acetic acid), ethanol, halides of methane(PTFE), methyl amines  
Chemicals from ethane: [4]  
Ethylene, acetylene, ethylene production, naphtha cracking, ethylene derivatives(VCM-direct chlorination, oxychlorination, VAM, ethanol, acetaldehyde), acetylene production (calcium carbide, Wuffs process), Acrylic acid
- Chemicals from C3, C4 and higher carbon atoms: [6]  
Propane, propylene, acetone, acrylonitrile(SOHIO process), phenol, separation of C4 cuts, butanes, butanes, butanol, butadiene, MTBE, isoprene.
- Synthesis Gas and chemicals: [4]  
Steam reforming of hydrocarbons, reformer, pressure swing adsorption system, processes(Lurgi process),OXO synthesis, Fischer Tropsch synthesis
- Petroleum aromatics: [5]  
BTX production, catalytic reforming, fractionation, aromatics from polymer gasoline, isomerization of xylene,xylene separation(o,p, m, parex process) benzene derivatives, toluene derivatives (caprolactum, terephthalic acid)
- Polymers, rubbers and synthetic fibers, plastics: [6]  
Polyethylene, polypropylene, nylon 6, polyester, acrylic fibers, PET, BUNA rubber, SBR, chloroprene rubber, engg plastics, phenol-formaldehyde resins, ABS plastics and polyurethanes.  
Synthetic detergents: [5]  
Anionic detergents, cationic detergents, production of LAB, mfg of sulphonates, nonionic detergents, finishing of detergents.
- Elements of design of steam reformer, naphtha cracker, catalytic reformer, etc.[5]

#### REFERENCE:

DR. B.K. Rao, 'A text on Petrochemicals', Khanna Publications, Delhi.

## Elective E08 FLUIDIZATION

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (3 hrs.)	SES (1 hr.)	PR	TW	TOTAL
4	-	-	60	40	-	-	100

### 1.Characteristics of fluidized systems (9 hrs)

Properties of gas-solid and liquid-solid system, effect of fluid velocity on pressure gradient, minimum fluidization velocity, minimum fluidization velocity in terms of terminal falling velocity, types of fluidization, Circulating fluidized bed systems, risers, importance of CFB, comparison with fluidization ,

### 2.Behavior of fluidized bed (4 hrs)

Fixed bed-particles of one size, solids with distribution sizes, bubble formation, importance of distributors, voidage in fluidized bed

### 3. Flow pattern of gas through fluidized beds (4 hrs)

experimental findings, Bubbling bed model for gas interchange, residence time distribution of gas, interpretation of gas-mixing data in terms of bubbling bed models

### 4. Mass and Heat transfer between fluid and solid (4 hrs)

Mass transfer rate, heat transfer rate from bubbling bed models, distribution of solids among the bubbles, cloud and emulsion region

### 5 Entrainment and Elutriation (4 hrs)

model for entrainment from a dense fluidized bed, applications of the entrainment model to elutriation, Entrainment at or above the TDH, entrainment below TDH

### 6. Residence time distribution and size distribution of solids in fluidized bed (5 hrs)

Particles of changing size, derivation of general performance equation , single size feed, performance equation, rate expression for particle growth and shrinking, particles of unchanging size, single and multistage bed, feed of wide size distribution

### 7. Circulation systems (4 hrs)

Flow of high bulk density mixture, detail of circulation rate for solids, for deactivating catalyst, for a required heat removal rate, flow of low bulk density mixture

### 8.Industrial applications of fluidized bed (6 hrs)

Physical operations, transportation, heat exchange, mixing of fine powders, drying and sizing, adsorption, synthesis reaction, Carbonization and gasification of coal and coke

Text book:

- (i) Fluidization engineering  
D.Kunii and O.Levenspiel, Krieger publication

Reference Books :

- (i) Chemical Engineering Vol.-II(4<sup>th</sup> ed.)  
J.M.Coulson and J.F. Richardson,Pergamon press
- (ii) Fluidization Technology Vol. I  
D.L.Keairns, McGraw Hill publication

## ELECTIVE E09

### POLYMER TECHNOLOGY

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (3 hrs.)	SES (1 hr.)	PR	TW	TOTAL
4	-	-	60	40	-	-	100

- 1. Introduction to Polymers (5):** polymers, polymerization, history of polymers, pioneers in polymer science, molecular weight and molecular weight distribution, degree of polymerization, addition polymerization (free radical, cationic, ionic, coordination catalyst), condensation polymerization (step-growth), polymerization conditions (bulk, solution, precipitation, suspension, emulsion, interfacial), amorphous and crystalline polymers, copolymers, basic polymer properties
- 2. Plastics (15):** preparation, properties, applications of thermoplastics and thermoset resins - polyethylene; polypropylene; polystyrene; acrylic polymers; PVC, poly(vinyl esters); Teflon; Nylon; polyesters; cellulose polymers; phenolic and amino resins; epoxy resins; polyurethanes; silicone polymers; composites, others
- 3. Fibers (5):** denier, tenacity, fiber spinning – melt spinning, wet spinning, dry spinning, fiber properties
- 4. Elastomers (5):** natural and synthetic elastomers, classification, preparation, properties, application of elastomers, vulcanization; reinforcement.
- 5. Adhesives (2):** classification, properties, applications
- 6. Polymer Additives and Compounding (2):** fillers; colorants; stabilizers; plasticizers; flame retardants; lubricants; others
- 7. Measurement of Molecular Weight and Size (3):** light scattering; solution viscosity; gel permeation chromatography, colligative properties
- 8. Polymer Rheology (5):** Newtonian fluids, non-Newtonian fluids, Hookean solids, viscous flow, rubber-like elasticity, viscoelasticity, viscoelastic models, glassy state, glass transition temperature, crystalline melting temperature, mechanical properties of polymers, orientation
- 9. Polymer Processing (6):** extrusion, compression molding, injection molding, blow molding, cast film, calendering, other processing techniques

#### Text Book

“Textbook of Polymer Science” by Fred W. Billmeyer, Jr.

#### Reference Books

“Polymer Science” by V.R. Gowariker, N.V. Vishwanathan, J.Sreedhar

“Principles of Polymer Science” by P. Bahadur and N.V. Sastry

“Polymer Science & Technology” by P. Ghosh

## Elective E10

### ADVANCED PROCESS CONTROL

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (3 hrs.)	SES (1 hr.)	PR	TW	TOTAL
4	-	-	60	40	-	-	100

1. Review of Single Input Single Output (SISO) Control. [3]
2. Model Based Control; Multivariable control strategies [4]
3. Internal Model Control Preliminaries and Model Predictive Control, Model forms for Model Predictive Control. [4]
4. Parametric and Non-parametric Models, State space and Transfer Function Representations and their inter relationships. [5]
5. Control Relevant Process identification; Choice of Input Signals and Model Forms. [5]
6. Parameter Estimation using batch and Recursive Least Squares. [3]
7. Model Validations using Correlation Concepts. [3]
8. Model Predictive Control; Analysis of Dynamic Matrix Control (DMC) and Generalized Predictive Control (GPC) Schemes. [5]
9. Controller Tuning and Robustness Issues; Extensions to Constrained and Multivariable Cases. [5]
10. Case studies including dynamic simulation and control with the help of Matlab and Simulink [4]

#### ***Text/References***

- L.Ljung, "System Identification - Theory for the User", Prentice Hall, 1987.
- E. Camacho and C. Bordons, "Model Predictive Control in the Process Industry", 1995

**Elective E11**  
**FERMENTATION TECHNOLOGY**

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (3 hrs.)	SES (1 hr.)	PR	TW	TOTAL
4	-	-	60	40	-	-	100

1. Introduction and scope of microbial processes. Alcoholic fermentation and recent developments. Glycerol fermentation. [7]
2. Malting and brewing: beer production, wine manufacturing and other distilled liquors. [7]
3. Microbial production of organic acids and fermentation processes. [6]
4. Biomass as a fermentation product: Baker's yeast, Bioinsecticides, Biofertilizers. [6]
5. Amino acids: Lysine and glutamic acid. Commercial enzymes: Solid and submerged fermentation, recovery etc. [7]
6. Citric acid production by (a) solid state and (b) submerged fermentation. [7]

**REFERENCE:**

1. Fermentation and enzyme Technology  
By Wang Daniel, Cooney Charles, Demon Arnold.  
John Wiley Publication, New York.
2. Fermentation and Bio Chemical Engineering  
By Vogel Henry.  
Noyes Publication, New Jersey.

## Elective E12

### CATALYSIS

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (3 hrs.)	SES (1 hr.)	PR	TW	TOTAL
4	-		60	40			100

1. Introduction to catalysis [4]
2. Homogeneous catalysis: Basic functions of catalysis , carriers, promoters, accelerators, poisons, surface area of catalyst, pore size distribution, determination of selectivity of a catalyst [4]
3. Kinetics of heterogeneous catalytic reactions, experimental reactors, power law type rate equations, Adsorption Langmuir equation, LHHW Maxwell rate equation , Initial rates approach [8]
4. Fixed bed fluidized bed catalytic reactors, relative merits and demerits of these reactors [4]
5. Design of isothermal adiabatic fixed bed and fluidized bed catalytic reactors [6]
6. Three phase reactors: Introduction to design and analysis of slurry and trickle bed reactors [6]
7. Case studies of some independent industrial reactors [4]
8. Introduction to enzyme catalyzed reactions [4]

#### ***Texts/References***

- J M. Smith Introduction to chemical kinetics Mc. Graw hill London
  - Somorjai, G. A., Introduction to Surface Chemistry and Catalysis, New York, 1994.
  - Satterfield, C. N. and Sherwood, T.K., the Role of Diffusion in Catalysis, Addison-Wisley, 1963.
  - Dumesic, J. A., Rudd, D. F., and Aparicio, L. M., The Microkinetics of Heterogeneous Catalysis, ACS, 1993.
  - Masel, R. I., Chemical kinetics and catalysis, Wiley-Interscience, 2001.
- Leach, B. E., Applied Industrial Catalysis, Vols. 1-3, Academic press, 1984.

## Elective E13

### COMPUTER AIDED DESIGN

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (3 hrs.)	SES (1 hr.)	PR	TW	TOTAL
4	-	-	60	40	-	-	100

1. Introduction to Computer Aided Design (CAD) [2]
2. Engineering Tools for CAD [2]
3. Development of simple algorithms for problems related to chemical engineering. [5]
4. Computer aided design of chemical process equipments. [6]
5. Concept of modular design, optimum design, parameter optimization. [5]
6. Principles of process synthesis, Pinch technology, Optimal design of processes. Problem solving in the areas of Process Synthesis [5]
7. Process Control. [5]
8. Methodology involved in Steady state and dynamic simulation of Processes [5]
9. Process Simulators – Steady State Simulators, Dynamic Simulators with the help of one case study which includes energy and material recycle [5]

#### *Texts/References*

- Lesley, M. L. (Editor), Computer Aided Process Plant Design, 1982.
- Westerberg, A.W. (Editor), Proceedings of the Second International Conference on Foundations of Computer Aided Process Design, 1984.
- User Manuals of Selected Commercial Software Packages, namely, Aspen Plus, HYSYS, Design II, Fluent, MATLAB, and GAMS.
- Computer Aided Design of Chemical Equipments, B.C. Bhattacharya and Narayan, 1980
- Product And Process Design Principles 2nd Ed., W.D.Seider, J.D.Seader, D.R.Lewis

# Elective E14

## Bioreactor Design and operation

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (3 hrs.)	SES (1 hr.)	PR	TW	TOTAL
4	-	-	60	40	-	-	100

1. Introduction to bioreactor and basic principles: Definition of bioreactor, basic principles of bioreactor. classification of bioreactors (Batch, plug flow reactor (PFR), continuous stirred rank reactors (CSTR), fluidized bed reactor, bubble column, air life fermenter etc.) and their configurations (4)
2. Concept of ideal and non-ideal reactor:- Residence time distribution; Models of non-ideal reactors – plug flow with axial dispersion, tanks-n-series model, age distribution model. (5)
3. Multiphase bioreactors: Packed bed with immobilized enzymes or microbial cells; three – phase fluidized bed trickling bed reactor. Chemostat model with cell growth kinetics. (5)
4. Design and analysis of reactors: Batch, plug flow reactor (PFR), continuous stirred rank reactors (CSTR), fluidized bed reactor, bubble column, air life fermenter, fed batch and semi-continuous bioreactors, etc. mechanical design of bioreactors and its components. (9)
5. Optimization of reactor systems: Optimization of parameters, like temeperature, flowrates and products (5)
6. Gas liquid reactors; Unconventional bioreactors like Hollow fiber reactor, membrane reactor, perfusion reactor for animal and plant cell culture. (4)
7. Bio reactor operation: control of bioreactor; bioreactor modelling and stability analysis. Introduction to Transient Bioreactor Behavior and the Stability Criteria; Recycle Systems. (8)

Text Books:

Landfill **Bioreactor Design and Operation**, by Debra R. Reinhart, Timothy G. Townsend – 1998, Lewis publishers

Reference books:

B. Atkinson, “Biochemical Reactors”, Pion Ltd., London, 1974.

**Bioreactor System Design - Page 47**

by Juan A. Asenjo, José C. Merchuk - 1995

## ELECTIVE E15

### PETROLEUM REFINING ENGINEERING

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (3 hrs.)	SES (1 hr.)	PR	TW	TOTAL
4	-	-	60	40	-	-	100

1. Origin, formation and composition of petroleum: [2]  
Origin and formation of petroleum, composition of petroleum. Types of Crudes-composition, classification of petroleum.  
Oil fields and Refineries in India- Indian petroleum Industry, crude and gas reserves, refining picture.
2. Oil Exploration and drilling: [3]  
Types of rocks, formation of oil, oil banks, drilling operation, offshore drilling, onshore drilling, oil recovery- primary, secondary and tertiary recovery methods,
3. Petroleum processing data:[3]  
Evaluation of petroleum, the crude assay, characterization factors, ASTM distillation, TBP distillation, equilibrium flash vaporization, inter conversion of boiling points, important crude products , their properties, Test methods for various refinery products, refinery configuration development.
4. Fractionation of petroleum: [8]  
Dehydration and desalting of crude, heating of crude (pipe still heaters), arrangement of towers, (types of reflux), Atmospheric distillation unit, Vaccum Distillation unit, design aspects, topping operations, blending of gasolines
5. The conversion and Treatment techniques: [10]  
impurities, treating of chemical impurities, treatment of LPG(sweetening operation for gases), treatment of Gasoline(lead doctoring, merox sweetening etc), treatment of Kerosene(liquid sulfurdioxide extraction of aromatics) and treatment of Lubes(sulfuric acid treatment, solvent treatment, phenol extraction, furfural extraction), treatment of Wax and purification(dewaxing, propane deasphalting).
6. Thermal and catalytic processes: [12]  
Cracking: thermal cracking reactions, visbreaking catalytic cracking:carbonium ion chemistry, types of catalytic crackers, catalytic cracking processes, FCC (reactions, factors, catalyst), fixed bed process, catalytic reforming(reactions, conditions, catalysts, processes-platforming), naphtha cracking, coking(delayed coking, fluid coking, flexi coking), hydrogen processes (hydrocracking, catalysts, processes, hydrodesulfurization, hydrotreatments, alkylolation- HF alkylolation) isomerization processes.
7. Corrosion in refineries. [2]
8. Safety and environmental considerations in petroleum refineries [3]

#### REFERENCE:

1. B.K. Rao, 'Modern Petroleum Refinery Process', Oxford-IBH Publishing Co.(1990).
2. Nelson, 'Petroleum Refinery Engineering', TMG Pub.

# Elective E16

## Chemical engineering practice

- Chapter I [5]
- 1) Getting the details of the product and total capacity overall capacity in the world
  - 2) Market value of the product and raw materials
  - 3) Competitors technical as well as commercial
  - 4) Technology providers
  - 5) Block diagram of the process
  - 6) Tracing the lines and identifying the line codes
- Chapter- II [5]
- 1) Thermodynamic/physiochemical properties of all the materials used in the process
  - 2) Material balance of the process for the capacity specified by the guide
  - 3) What are various type of reactors and separation equipment present in the industry
  - 4) Various type of pumps used in the plant their characteristics, suppliers
- Chapter- III [5]
- 1) Energy balance of the process with block diagram
  - 2) Details of the control valves required
  - 3) What are various control valve options available and why a particular valve is selected
  - 4) Cost of the control valves
  - 5) Operational details of control valves
  - 6) Draw all control loops in the plant
- Chapter IV [5]
- 1) Design all separation equipment (minimum of Three)
  - 2) Identify all safety measures taken in the industry
  - 3) Identify all safety related equipment their location and reason for selecting that location
  - 4) Identify all the auxiliary equipment related to safety
- Chapter V [8]
- 1) Design major equipments
  - 2) Collect the cost of each of the equipment including, auxiliary equipment (with standby), piping
  - 3) Estimate the cost of the plant designed
  - 4) Identify the breakeven point and payback period etc.
- Chapter- VI [7]
- 1) Complete the mechanical design
  - 2) Draw the P& ID of the plant on a drawing sheet which is signed by your guide
  - 3) Identify various pollution control measures taken by the industry
  - 4) Identify proper location for each equipment based on the wind robs of the region
  - 5) Draw the plant layout
- Chapter VII [5]
- 1) Raw material consumption pattern and sustainability
  - 2) Suggestions to improve the conversion and yield

- 3) Suggestions you feel like giving to the industry
- 4) Statutory requirements to start a project

**Elective E17**  
**NANOTECHNOLOGY**

Teaching Scheme (hr/week)			Exam Scheme (Marks)				
L	T	PR	TH (3 hrs.)	SES (1 hr.)	PR	TW	TOTAL
4	-	-	60	40	-	-	100

1. Introduction

2. Nanostructure and properties of nanomaterial, crystal structures, measurement of properties of nanostructures. Particle size and surface area, use of SEM, TEM, AFM, X-Ray Diffraction, etc. Molecular cluster of metals, semiconductors, gases, etc. Quantum wells, wires and dots.

3. Carbon nanostructure, carbon molecules, carbon clusters, carbon nanotubes Application of carbon nanotubes.

4. Catalysis, self-assembly, monolayres, surface area, porosity, colloidal.

5. Monomers and polymers, homo and copolymers. Supramolecules and dendrimers.

6. Methods of preparation of nanomaterials, chemical vapor deposition, physical vapour deposition, microscopy, lithography, colloids, emulsion and size reduction, etc.

7. Applications of nanotechnology in process industries. Energy, separations and purification, new molecules for dyes, pharmaceuticals and speciality chemicals.

8. Nano-Biotechnology: Tissue Engineering, Biosensors, drug delivery, diagnostics and therapeutics.

**Text Books :**

- 1) Introduction to nanotechnology  
Chartes P. Poole Jr. & Frank J. Owens, Wiley Intersei, N.J. 2003
- 2) Nanotechnology, M. Ratner & D. Ratner, Pearson Education, Delhi, 2003

**Reference Books:**

- 1) Hand book of Nano Structured Materials and Nanotechnology Vol. 1 to 5, Academic Press, Boston, 2000
- 2) Springer Hand book of Nanotechnology, Bharat Bhusan(Ed.) Springer verlag, Berlin, 2004.