SCHEME AND SYLLABI

OF

BACHELOR OF TECHNOLOGY

IN

CHEMICAL ENGINEERING

MAHATMA GANDHI UNIVERSITY

FOR
THIRD TO EIGHTH SEMESTERS

(2013 ADMISSION ONWARDS)

SEMESTER S3

Code	Subject	Hours/week			Marks		End sem Duration (Hours)	Credits
		L	T	P/ D	Internal	End Sem		
EN010 301	Engineering Mathematics II	2	2	-	50	100	3	4
EN010 302	Economics and Communication Skills	3	1	-	50	100	3	4
CH010 303	Physical and Analytical Chemistry	2	2	-	50	100	3	4
CH010 304	Process Calculations	3	1	-	50	100	3	4
CH010 305	Computer Programming	3	1	-	50	100	3	4
CH 010 306	Fluid and Particle Mechanics	3	1	-	50	100	3	4
CH010 307	*Analytical Chemistry Lab*	-	-	3	50	100	3	2
CH010 308	*Software Lab*	-	-	3	50	100	3	2
	Total	**16**	**8**	**6**				**28**

SEMESTER S4

Code	Subject	Hours/week			Marks		End sem Duration (Hours)	Credits
		L	T	P/D	Internal	End Sem		
EN010 401	Engineering Mathematics III	2	2	-	50	100	3	4
CH010 402	Heat Transfer I	3	1	-	50	100	3	4
CH010 403	Organic Chemistry	2	2	-	50	100	3	4
CH010 404	Mechanical Operations	3	1	-	50	100	3	4
CH010 405	Machine Drawing	3	1	-	50	100	3	4
CH010 406	Chemical Engineering Thermodynamics I	3	1	-	50	100	3	4
CH010 407	*Fluid and particle mechanics lab*	-	-	3	50	100	3	2
CH010 408	*Physical And Organic Chemistry Lab*	-	-	3	50	100	3	2
	Total	**16**	**8**	**6**				**28**

SEMESTER 5

Code	Subject	Hours/week			Marks		End sem Duration (Hours)	Credits
		L	T	P/D	Internal	End Sem		
EN010 501	Engineering Mathematics IV	2	2	-	50	100	3	4
CH010 502	Chemical Reaction Engineering I	3	1	-	50	100	3	4
CH010 503	Heat Transfer II	2	2	-	50	100	3	4
CH010 504	Chemical Technology I	2	2	-	50	100	3	4
CH010 505	Mass Transfer Operations I	3	1	-	50	100	3	4
CH010 506	Chemical Engineering Thermodynamics II	3	1	-	50	100	3	4
CH010 507	*Chemical Technology Lab*	-	-	3	50	100	3	2
CH010 508	*Mechanical Operations Lab*	-	-	3	50	100	3	2
	Total	**15**	**9**	**6**				**28**

SEMESTER 6

Code	Subject	Hours/week			Marks		End sem Duration (Hours)	Credits
		L	T	P/D	Internal	End Sem		
CH010 601	Mass Transfer Operations II	2	2	-	50	100	3	4
CH010 602	Environmental Engineering	2	2	-	50	100	3	4
CH010 603	Chemical Technology II	3	1	-	50	100	3	4
CH010 604	Process Dynamics and Control	3	1	-	50	100	3	4
CH010 605	Chemical Reaction Engineering II	3	1	-	50	100	3	4
CH010 606Lxx	Elective I (Separate List Provided)	2	2	-	50	100	3	4
CH010 607	*Environmental Engineering Lab*	-	-	3	50	100	3	2
CH010 608	*Heat Transfer Operations lab*	-	-	3	50	100	3	2
	Total	**15**	**9**	**6**				**28**

Elective I
CH010 606L01 Material Science and Engineering
CH010 606L02 Bioinformatics
CH010 606L03 Fertilizer Technology
CH010 606L04 Energy Engineering
CH010 606L05 Modeling and Simulation in Process Industries

SEMESTER 7

Code	Subject	Hours/week			Marks		End sem Duration (Hours)	Credits
		L	T	P/ D	Internal	End Sem		
CH010 701	Chemical Engineering Design and Drawing I	2	2	-	50	100	3	4
CH010 702	Process Instrumentation	3	1	-	50	100	3	4
CH010 703	Transport Phenomena	2	1	-	50	100	3	4
CH010 704	Petroleum Refinery Engineering and Petrochemicals	2	1	-	50	100	3	3
CH010 705	Economics and Management for Process Industries.	2	1	-	50	100	3	3
CH010 706Lxx	Elective II(Separate List Provided)	2	2	-	50	100	3	3
CH010 707	*Chemical Engineering Design Software Lab*	-	-	3	50	100	3	2
CH010 708	*Mass Transfer Operations Lab*	-	-	3	50	100	3	2
CH010 709	*Seminar*	-	-	2	50	-	-	2
CH010 710	*Project*	-	-	1	50	-	-	1
	Total	**13**	**8**	**9**				**28**

Elective II

CH010 706 L01 Computational Fluid Dynamics
CH010 706 L02 Polymer Technology
CH010 706 L03 Separation Processes
CH010 706 L04 Food Technology and Engineering
CH010 706 L05 Biochemical Engineering

SEMESTER 8

Code	Subject	Hours/week			Marks		End sem Duration (Hours)	Credits
		L	T	P/D	Internal	End Sem		
CH010 801	Chemical Engineering Design and Drawing II	3	2	-	50	100	3	4
CH010 802	Nano Technology	2	2	-	50	100	3	4
CH010 803	Chemical Process Optimization	2	2	-	50	100	3	4
CH010 804 Lxx	Elective III(Separate list provided)	2	2	-	50	100	3	4
CH010 805 Gxx	Elective IV(Separate list provided)	2	2	-	50	100	3	4
CH010 806	*Chemical Reaction Engineering and Process Control Lab*	-	-	3	50	100	3	2
CH010 807	Project	-	-	6	100	-	3	4
CH010 808	Viva Voce	-	-	-	-	100	3	2
	Total	**11**	**10**	**9**				**28**

Elective III
CH010 804 L01 Bioprocess Engineering
CH010 804 L02 Water and Waste water Engineering
CH010 804 L03 Total Quality Management
CH010 804 L04 Operations Research
CH010 804 L05 Numerical Methods for Chemical Engineers

Elective IV
CH010 805 G01 Project Engineering
CH010 805 G02Composite Technology
CH010 805 G03 Corrosion Engineering
CH010 805 G04 Safety in Chemical Industries

THIRD SEMESTER

EN010 301 ENGINEERING MATHEMATICS II

(Common to all branches)

Teaching Scheme **Credits: 4**

2 hours lecture and 2 hour tutorial per week

Objectives

- *To apply standard methods and basic numerical techniques for solving problems and to know the importance of learning theories in Mathematics.*

MODULE I: (12 hours) **Vector differential calculus**

Scalar and vector fields – gradient-physical meaning- directional derivative-divergence and curl - Physical meaning-scalar potential conservative field- identities - simple problems

MODULE II: (12 hours) **Vector integral calculus**

Line integral - work done by a force along a path-surface and volume integral-application of Greens theorem, Stokes theorem and Gauss divergence theorem

MODULE III: (12 hours) **Finite differences**

Finite difference operators $\Delta,,\epsilon,\mu$ and δ - interpolation using Newtons forward and backward formula – problems using Stirlings formula, Lagrange's formula and Newton's divided difference formula

MODULE IV: (12 hours) **Difference Calculus**

Numerical differentiation using Newton's forward and backward formula – Numerical integration – Newton's – cotes formula – Trapezoidal rule – Simpsons 1/3rd and 3/8th rule – Difference equations – solution of difference equation

MODULE V: (12 hours) **Z transforms**

Definition of Z transforms – transform of polynomial function and trigonometric functions – shifting property, convolution property - inverse transformation – solution of 1st and 2nd order difference equations with constant coefficients using Z transforms.

REFERENCES

1. Erwin Kreyszing – Advance Engg. Mathematics – Wiley Eastern Ltd.
2. B.S. Grewal – Higher Engg. Mathematics - Khanna Publishers
3. B.V. Ramana - Higher Engg. Mathematics – McGraw Hill Publishers
4. K Venkataraman- Numerical methods in science and Engg -National publishing co
5. S.S Sastry - Introductory methods of Numerical Analysis -PHI
6. T.Veerarajan and T.Ramachandran- Numerical Methods- McGraw Hill Publishers
7. Babu Ram – Engg. Mathematics –Pearson Publishers
8. H.C.Taneja Advanced Engg. Mathematics Vol I – I.K.International

EN010 302 ECONOMICS AND COMMUNICATION SKILLS

(Common to all branches)

Teaching scheme **Credits: 4(3+1)**

2 hours lecture and 2 hours tutorial per week `

Objectives

• *To impart a sound knowledge of the fundamentals of Economics*

Economics

MODULE I (7 hours)

Reserve Bank of India-functions-credit control-quantitative and qualitative techniques Commercial banks-functions- Role of Small Industries Development Bank of India and National Bank for Agriculture and Rural Development The stock market-functions-problems faced by the stock market in India-mutual funds

MODULE II (6 hours)

Multinational corporations in India-impact of MNC's in the Indian economy Globalisation-necessity-consequences Privatisation-reasons-disinvestment of public sector undertakings, The information technology industry in India-future prospects

MODULE III (6 hours)

Direct and indirect taxes- impact and incidence- merits of direct and indirect taxes progressive and regressive taxes-canons of taxation-functions of tax system tax evasion-reasons for tax evasion in India-consequences-steps to control tax evasion Deficit financing-role-problems associated with deficit financing

MODULE IV (5 hours)

National income-concepts-GNP, NNP, NI, PI and DPI-methods of estimating national income-difficulties in estimating national income

Inflation-demand pulls and cost push-effects of inflation-government measures to control inflation

MODULE V (6 hours)

International trade-case for free trade-case for protectionism

Balance of payments-causes of disequilibrium in India's BOP-General Agreement on Tariffs and Trade-effect of TRIPS and TRIMS in the Indian economy-impact of WTO decisions on Indian Industry

TEXT BOOKS

1. Ruddar Datt, Indian Economy, S.Chand and Company Ltd.
2. K.K.Dewett, Modern Economic Theory, S.Chand and Company Ltd.

REFERENCES

1. Paul Samuelson, Economics, Tata McGraw Hill22
2. Terence Byres, The Indian Economy, Oxford University Press
3. S.K.Ray, The Indian economy, Prentice Hall of India
4. Campbell McConnel, Economics, Tata McGraw Hill

Communication Skills

Objectives

- *To improve Language Proficiency of the Engineering students*
- *To enable them to express themselves fluently and appropriately in social and professional contexts*
- *To equip them with the components of different forms of writing*

MODULE 1 (15 hours)

INTRODUCTION TO COMMUNICATION

Communication nature and process, Types of communication - Verbal and Non verbal, Communication Flow-Upward, Downward and Horizontal, Importance of communication skills in society, Listening skills, Reading comprehension, Presentation Techniques, Group Discussion, Interview skills, Soft skills

MODULE II (15 hours)

TECHNICAL COMMUNICATION

Technical writing skills- Vocabulary enhancement-synonyms, Word Formation-suffix, affix, prefix, Business letters, Emails, Job Application, Curriculum Vitae, Report writing- Types of reports

Note: No university examination for communication skills. There will be internal evaluation for 1 credit.

REFERENCES

1. The functional aspects of communication skills, P.Prasad and Rajendra K. Sharma, S.K. Kataria and Sons, 2007
2. Communication skills for Engineers and Scientists, Sangeeta Sharma and Binod Mishra, PHI Learning private limited, 2010
3. Professional Communication, Kumkum Bhardwaj, I.K. International (P) House limited, 2008
4. English for technical Communication, Aysha Viswamohan, Tata Mc Graw Publishing company limited, 2008

CH010 303 PHYSICAL AND ANALYTICAL CHEMISTRY

Teaching Scheme **Credits: 4**

2 hours lecture and 2 hour tutorial per week

Objectives

- *To impart a sound knowledge of the fundamentals of physical chemistry*

MODULE I: (12 hours) Analytical Chemistry

Electrochemistry- electrolytic conductance and transference, ionic strength, Debye limiting law of activity coefficients, electrochemical cells, determination of enthalpy, entropy and free energy changes from EMF of cells, concentration cells with and without transference, fuel cells (methanol fuel cell, molten carbonate fuel cell), structure of electrical double layer (Helmholtz-Perrin) Guoy-Chapman and Stern models), electro-kinetic potential, Butler-Volmer and Tafel equations, polarography, half wave potential, diffusion current, dropping mercury electrode, Ilkovic equation, applications of polarography.

Ionic equilibrium: Kohlrauches law- Transport number and its determination- Degree of dissociation- Ionic equilibrium- Ostwald's dilution formula-Anomaly of strong electrolytes-Theory of strong electrolytes-Solubility products and its applications- Henderson equation.

Surface chemistry: Types of adsorption. Heat of adsorption- The Langmuir theory derivation-Langmuir and classical isotherms- Chemisorption- Differences with physical adsorption-Applications of adsorption. Spectroscopy: Brief study of Raman, Mass and ESR spectroscopy.

MODULE II: (12 hours) Gases and Liquids

Gaseous state: Kinetic theory of gases-Vander Waals equation-Critical constants- Liquifaction of gases- Solutions: Raoults law -statement and limitation - Ideal solutions-Partially miscible liquids- Phenol water system-Henry's law- Duhem Moargus equation. Dilute solutions: Introduction- Colligative properties- determination of molecular weight by lowering of vapour pressure-Elevation of boiling point- Depression of freezing point- Osmotic pressure. Phase rule: Introduction- One component system (water and sulphur)- Two component system- Eutectic system, Pb- Ag system, Bi-Cd system-Compound formation, Zn-Mg system- Incongruent system.

MODULE III: (12 hours) Chemical Kinetics and catalysis

Review of basic concepts, differential and integral forms of rate equations, third order reactions, determination of order, effect of temperature on reaction rates, theories of gas phase reactions, Lindeman's theory, steady state approximation, kinetics of complex reactions, opposing, consecutive and parallel reactions, chain reactions exemplified by acetaldehyde decomposition, and hydrogen-bromine reaction, explosive reactions, reaction kinetics in solutions, solvent and salt effect. Enzyme catalysis (Michelis Menten model), influence of pH and temperature on catalytic activity, inhibition of enzyme catalysed reactions.

MODULE IV: (12 hours) Colloids and Catalysis

The colloidal state: Multi-molecular, macromolecular and associated colloids. Stability of

colloids. The zeta potential. Kinetic, optical and electrical properties of colloids. Electro-kinetic phenomena: Electrophoresis, electro osmosis, sedimentation potential and streaming potential. Donnan membrane equilibrium. Catalysis: Mechanism and theories of homogeneous and heterogeneous catalysis. Acid-base and enzyme catalysis. Bimolecular surface reactions. Langmuir-Hinshelwood mechanism. Separation Methods: Classical separation methods: Theories of distillation, fractional distillation, steam distillation, sublimation and zone refining- Solvent extraction- Distribution law- Separation of mixtures, Craig method.

MODULE V: (12 hours) Analysis of Materials

Analysis of milk products: Theory of the analysis of milk, butter and other diary items. Analysis of fats and oils. Characterization of fats and oils. Iodine value, iodine-bromine value and saponification value, and their significances. Analysis of drugs and pharmaceuticals: Classical and modern methods of drug analysis.

TEXT BOOKS

1. Peter Atkins and Julio de Paula, Physical Chemistry, 7thEdn., Oxford University Press,New York, 2002.
2. Robert J. Silbey and Robert A Alberty, Physical Chemistry, 3rdEdn., John-Wiley and Sons, Singapore, 2002.
3. Puri, L.R. and Sharma, B.R., Physical Chemistry, 14thEdn, Chand S & Co., New Delhi, 1998.
4. Puri and Sharma, Physical chemistry,.
5. D.A.Skoog, D.M.West and F.Jholler, "Fundamentals of Analytical Chemistry", Saunder College Publishing
6. J.N.Gurtu and H.Snehi, "Advanced Physical Chemistry", Pragati Prakash.
7. Physical chemistry by K.L Kapoor(vol 1 and 2)
8. Quantitative analysis by Vogel(vol 1 and 2)

REFERENCES

1. Dogra, S.K. and Dogra, S., Physical Chemistry through Problems, Wiley Eastern Ltd., Hyderabad, 1994.
2. Koltz, I.M. and Rosenberg, R.M., Physical Thermodynamics, Wiley Interscience, New York, 2000.
3. Hillert, M., Phase Equilibria, Phase Diagrams and Phase Transformations: A Thermodynamic Basis, Cambridge University Press, UK, 1998

***UNIVERSITY EXAMINATION PATTERN*:** Question Paper consists of Part A, Part B and Part C. Part A is for 15 marks and comprises of 5 compulsory short answer questions, each carrying 3marks, covering the entire syllabus. Part B is for 25 marks, comprises of 5 compulsory questions from each module. And Part C is for 60 marks candidate has to answer one full question of 12 marks from each module**.**

CH010 304 PROCESS CALCULATIONS

Teaching Scheme **Credits: 4**

3 hours lecture and 1 hour tutorial per week

Objectives

- *To introduce the students the basic calculations in Chemical Engineering*

MODULE I :(12 hours) Basic Concepts

Introduction to Chemical Engineering, Chemical process Industry, Unit Operations and Unit Processes -Units and Dimensions: System of Units, Basic and Derived quantities, Conversion of units, Conversion of equations- problems- Concepts of atomic weight, equivalent weight and mole- Composition of solids, liquids and solutions (weight percent, mole percent, molarity, molality, Normality, Density and Specific gravity, Composition relationships, Stoichiometric principles), other expressions for concentration.

MODULE II: (12 hours) Properties of Gases and Liquids

Fluids- Ideal gases, Real Gases- Ideal gas laws, gaseous mixtures, real gas laws, gas constant. Average molecular weight and density. Compressibility factor, compressibility factor charts, Critical properties, pseudo critical properties-problems. Vapour Pressure: Effect of temperature on vapour pressure. Application of Clausius Clapeyron equation. Vapour pressure plots, Cox charts, Duhrings Lines, Solutions - Henry's law, Raoult's law, Bubble point, vapour pressure of immiscible liquids.

MODULE III : (12 hours) Material Balance

Material Balance without chemical reactions- Introduction, key component, steps for solving material balance problems, material balance for unit operations-distillation, drying, evaporation, absorption etc. Recycling and bypass operations- Simplifications for steady-state processes without chemical reaction, element balance, material balance problems involving multiple subsystems, recycle, bypass and purge calculations- Material balance problems with chemical reactions, concept of limiting, excess reactants, fractional conversion and percentage of conversion, percentage yield, Orsat analysis, ultimate and proximate analysis of fuels, excess air, air-fuel ratio calculations, material balance problems involving simultaneous equations.

MODULE IV : (12 hours) Energy Balance

Energy Balance: Thermophysics.

Heat capacity, estimation of heat capacities-heat capacity of solids, liquids and gaseous mixtures, Effect of temperature on heat capacity of gas, Mean heat capacity of gas,
Kopp's rule, Latent heats, Heat of fusion, Heat of vaporization, Trouton's rule,
Kistyakowsky equation for non-polar liquids, calculation of enthalpy changes with and without phase change - enthalpy change for mixtures, enthalpy-concentration charts
and applications. Kirchoff's equation. Adiabatic and non-adiabatic reactions. (without phase change), enthalpy change for phase transitions, General energy balance, energy balance for flow and non flow processes.

MODULE V :(12 Hours) Thermochemistry:

Standard heats of reaction, combustion, and formation- effect of temperature and pressure on heat of reaction. Heat balance calculations in processes with chemical reaction. Hess law of constant heat summation, temperature of reaction, adiabatic reaction temperature. Process Flow sheeting with sequential modular calculations, Unsteady State Balances.

TEXT BOOKS

1. Bhatt and Vora, Stochiometry, T. M. H.
2. Himmelblau David M., "Basic Principles and Calculations in Chemical Engineeing", Prentice Hall of India.
3. K. V. Narayanan and B. Lakshmikutty, "Stochiometry and Process Calculations", Prentice Hall of India.

REFERENCES

1. Hougen, O.A, Watson, K.M and Ragatz R.A, Chemical Processes Principles (Part-1): Material and Energy Balances, 2ndEdn., Asia Publication House, New Delhi, 2001.
2. Felder, R.M. and Rousseau, R.W., Elementary Principle and Chemical Processes, 3rd Edn.,John Wiley & Sons Inc., 2000

***UNIVERSITY EXAMINATION PATTERN*:** Question Paper consists of Part A, Part B and Part C. Part A is for 15 marks and comprises of 5 compulsory short answer questions, each carrying 3marks, covering the entire syllabus. Part B is for 25 marks, comprises of 5 compulsory questions from each module. And Part C is for 60 marks candidate has to answer one full question of 12 marks from each module**.**

CH010 305 COMPUTER PROGRAMMING

Teaching Scheme **Credits: 4**

3 hours lecture and 1 hour tutorial per week

Objectives:

- *To present the concept of object oriented programming and discuss the important elements of C++*
- *Write simple applications using C++.*

Module 1 (12 hrs)

Introduction to object oriented concepts, features of object oriented programming, C++ programming basics, Data types, operators, precedence of operators, control flow – Decision Making (if, if…else, else… if, switch statements, conditional operators), Looping Statements (while, do… while, for), break, continue, goto statements.

Module 2 (12 hrs)

Functions, arrays and strings, operations on arrays, string manipulations, Classes and objects, constructors, destructors, objects as function arguments, inline functions, friend functions, friend classes, array of objects

Module 3 (12 hrs)

Overloading, operator overloading, overloading unary operators, overloading binary operators, function overloading, Inheritance – single, multiple, multilevel, hierarchical and hybrid. Base class and derived class, public inheritance, private inheritance, constructors in derived class

.

Module 4 (12 hrs)

Pointers, memory management, new and delete, pointers within a class, pointers to objects, array of pointers to objects, pointer to object members, pointer to derived class objects, pointers to pointers, polymorphism, virtual function, pure virtual function, abstract classes , late binding, early binding

Module 5 (12 hrs)

Files and streams, streams, predefined console streams, string I/O, object I/O, files, file modes, file pointers, file input/output, command line arguments, templates.

TEXT BOOKS:

E.Balaguruswamy, Object Oriented Programming in C++
Object Oriented Programming in C++: Robert Lafore, Galgotia Publications

***UNIVERSITY EXAMINATION PATTERN*:** Question Paper consists of Part A, Part B and Part C. Part A is for 15 marks and comprises of 5 compulsory short answer questions, each carrying 3marks, covering the entire syllabus. Part B is for 25 marks, comprises of 5 compulsory questions from each module. And Part C is for 60 marks candidate has to answer one full question of 12 marks from each module**.**

CH010 306 FLUID AND PARTICLE MECHANICS

Teaching Scheme **Credits: 4**

3 hours lecture and 1 hour tutorial per week

Objectives

- *To impart the basic concepts of fluid mechanics by providing exposure to diverse real world engineering examples.*
- *To develop understanding about basic laws and equations used for analysis of static and dynamic fluid*

MODULE I (16 Hours) Introduction to Fluid Mechanics

Definition of fluid-Physical properties of fluid-specific weight, mass density, specific gravity, compressibility, bulk modulus, viscosity surface tension capillarity,-Variation of Viscosity and density with temperature and pressure. Rheology of fluids- Classification of Fluids-Fluid Statics and application-Pascal's law-Hydrostatic equilibrium in gravity and Centrifugal field-Barometric equation –Atmospheric – absolute gauge and negative pressure – piezometer-Principle of Manometer-, U tube manometer, differential manometer, single column manometer, Inclined tube manometer, micro differential manometer- Principles of continuous gravity and centrifugal decanter. Introduction to fluid flow phenomenon-Reynolds experiment-Reynolds number-Classification of flow-Turbulence- Different types-Reynolds stress-Flow in boundary layer-Boundary layer separation and wake formation-Boundary layer separation in straight tubes-Potential flow.

MODULE II (12 Hours) Basic equations of fluid flow

Continuity, Bernoulli's and Momentum equation-Torricelli Equation. Kinetic energy and Momentum correction factors-Correction for fluid friction and Pump work for Bernoulli's equation. Laminar flow of incompressible fluids in pipes and Conduits. Shear stress and Velocity distribution-Maximum and average velocity-Hagen Poiseuille and Darcy Wiesbach equation

MODULE III (12 Hours) Definition of Friction factor

Turbulent flow of incompressible fluids in pipes and conduits-classification of turbulence-scale of turbulence-Universal Velocity distribution equation-Friction factor and Reynolds number relationship-Nikuradse and Karman equation Coole brook equation-Blasius equation (derivation not required) Prantl one seventh power Law-Friction factor chart-Frction from changes in velocity or direction-Sudden expansion and contraction-Fittings and valves. Flow through Non circular cross section-Equivalent length.

MODULE IV (12 Hours) Flow past immersed Bodies

Drag, Drag coefficient for typical shapes. Stream lining, Stagnation point-Friction in flow through bed of solids-Ergun, Kozney Carman and Blake Plummer equation. Motion of particle through fluids in gravity and centrifugal field. Terminal Settling velocity in Stokes law. Intermediate law and Newton's law range-Free and Hindered Settling. Fluidization-Minimum fluidization velocity, Minimum porosity, Pressure drop Calculation, Different type of

fluidization. Slugging. Industrial application. Flow of Compressible fluids-Sonic velocity and Mach number-Basic equations for Compressible fluid Flow-Isothermal and adiabatic-Stagnation properties.

MODULE V (12 Hours)

Flow rate equation for Venturi, Orifice, Mouth piece, Pitot tube, Rectangular, Triangular, Trapezoidal weir, Rotameter. Transportation of liquid through pipes-Economic pipe Diameter-Pipes and tubes. Different types of fittings and Valves. General description, Classification and application of Centrifugal, Reciprocating, Gear and Lobe pumps. Various Losses-Characteristic curves-NPSH-Cavitation-Specific speed-Priming of Centrifugal pumps. Fans, Blower, Compressor-Different types-Compressor efficiency, Ejector-Principle and different type.

TEXT BOOKS:

1. McCabe W.L. & Smith J.C., Unit Operations of Chemical Engg, McGraw Hill
2. Noel de Nerves, Fluid Mechanics for Chemical Engineers, McGraw Hill.

REFERENCES:

1. Streeter V.L., Fluid Mechanics, McGraw Hill
2. Coulson J.M. & Richardson J.F., Chemical Engg. Vol. 1, Pergamon
3. Foust, Wenzel, Clump, Maus & Anderson, Principles of Unit Operation
4. Perry R.H., Chemical Engineers Handbook, McGraw Hill
5. Rajput R.K., A textbook of Fluid Mechanics
6. Fluid Dynamics and Heat Transfer, Knudsen and Katz.
7. K.A. Gavhane, Unit Operations- Fluid Flow and Mechanical Operations, Pragati Books Pvt Ltd.

***UNIVERSITY EXAMINATION PATTERN*:** Question Paper consists of Part A, Part B and Part C. Part A is for 15 marks and comprises of 5 compulsory short answer questions, each carrying 3marks, covering the entire syllabus. Part B is for 25 marks, comprises of 5 compulsory questions from each module. And Part C is for 60 marks candidate has to answer one full question of 12 marks from each module**.**

CH010 307 ANALYTICAL CHEMISTRY LAB

Teaching Scheme **Credits: 2**

3 hour practical per week

Objectives

- *To provide experience on analysis, estimation and preparation of few organic Chemical.*
- *To acquaint the students with the handling and analyzing chemicals*

A. **Volumetric analysis**

1. Preparation of standard solution of sodium carbonate, standardisation of strong acids (Eg.
2. HCl) and estimation of unknown concentration of NaOH.
3. Estimation of carbonate- bicarbonate mixture.
4. Preparation of standard oxalic acid, standardisation of potassium permanganate and estimation of unknown solutions of hydrated ferrous sulphate.
5. Preparation of standard ferrous sulphate solution and standardisation of potassium permangnate and estimation of Mohs salt.
6. Preparation of standard solution of potassium dichromate and estimation of iron.
7. Standardisation of sodium thiosulphate against dichromate
8. Preparation of standard sodium chloride and standardisation of silver nitrate.
9. Estimation of total and permanent hardness by EDTA method.

B. **Analysis of ores and alloys**

1. Estimation of iron in heamatite.
2. Estimation of copper in brass.
3. Estimation of calcium in lime stone or dolamite.

C. **Potentiometric measurements**

1. Estimation of strength of given HCl solution by titrating against sodium hydrode solution.
2. Determination of electrode potential and emf of an electrochemical cell.

D. **Conductometric Titrations**

1. Strong acid with strong base
2. Strong acid with Weak base
3. Mixture of acid with base

E. **PH metric measurements**

1. Preparation of buffer and standardisation of PH meter.
2. Determination of molarity of HCl with M/10 NaOH.

REFERENCES:

1. Practical chemistry by A.O. Thomas.
2. A.I.Vogel, "A Text Book of Quantitative Inorganic Analysis", Longman
3. Laborarory manual on engineering chemistry by Dr. Sudha Rani. (Dhanpat Rai Publishing company)

CH010 308 SOFTWARE LAB

Teaching Scheme **Credits: 2**

3 hour practical per week

Objectives

- *To provide experience on the measurement and working of the various electrical machines.*

A. C++ Programming exercises

Develop programs to implement the following numerical methods

1. Basic C++ programs
2. Simple Programs using Functions & Arrays
3. Implementation of String handling function
4. Implementation of classes and objects
5. Implementation of constructors
6. Implementation of Function & Operator overloading
7. Implementation of Inheritance
8. Programs using pointers
9. Implementation of Files
10. Nonlinear and transcendental equations
11. Linear Algebraic Equations, Set of equations
12. Methods for interpolation and extrapolation
13. Numerical Differentiation and Integration
14. Solution of Ordinary Linear Differential Equations
15. BVP Ordinary and Partial Differential Equations
16. Fitting Models to data

B. Learning and Use of Mat lab

Exercises in Mat lab application to Solution of Engineering problems, Systems Simulation, Optimization and Control.

FOURTH SEMESTER

EN010 401 ENGINEERING MATHEMATICS III

(Common to all branches)

Teaching Scheme **credits 4**

2 hours lecture and 2 hour tutorial per week

Objectives:

- *Apply standard methods of mathematical &statistical analysis*

MODULE I (12 hours)

Fourier series: Dirichlet conditions – Fourier series with period 2 π and 2l – Half range sine and cosine series – Harmonic Analysis – r.m.s Value

MODULE II (12 hours)

Fourier Transform: Statement of Fourier integral theorem – Fourier transforms – derivative of transforms convolution theorem (no proof) – Parsevals identity

MODULE III (12 hours)

Partial differential equations: Formation by eliminating arbitrary constants and arbitrary functions – solution of Lagrange's equation – Charpits method –solution of Homogeneous partial differential equations with constant coefficients

MODULE IV (12 hours)

Probability distribution: Concept of random variable, probability distribution – Bernoulli's trial – Discrete distribution – Binomial distribution – its mean and variance- fitting of Binominal distribution –Poisson distribution as a limiting case of Binominal distribution – its mean and variance – fitting of Poisson distribution – continuous distribution- Uniform distribution – exponential distribution – its mean and variance – Normal distribution – Standard normal curve- its properties

MODULE V (12 hours)

Testing of hypothesis: Populations and Samples – Hypothesis – level of significance – type I and type II error – Large samples tests – test of significance for single proportion, difference of proportion, single mean, difference of mean – chi –square test for variance- F test for equality of variances for small samples

REFERENCES

1. Bali & Iyengar – A text books of Engg. Mathematics – Laxmi Publications Ltd.
2. M.K. Venkataraman – Engg. Mathematics vol II 3rd year part A & B – National Publishing Co.
3. I.N. Sneddon – Elements of partial differential equations – McGraw Hill

4. B.V. Ramana – Higher Engg. Mathematics – McGraw Hill
5. Richard A Johnson – Miller Fread's probability & Statistics for Engineers- Pearson/ PHI
6. T. Veerarajan – Engg. Mathematics – McGraw Hill
7. G. Haribaskaran – Probability, Queueing theory and reliability Engg. – Laxmi Publications
8. V. Sundarapandian - probability ,Statistics and Queueing theory – PHI
9. H.C.Taneja – Advanced Engg. Mathematics Vol II – I.K. International
10. A.K.Mukhopadhyay-Mathematical Methods For Engineers and Physicists-I.K. International

CH010 402 HEAT TRANSFER I

Teaching Scheme **Credits: 4**

3 hours lecture and 1 hour tutorial per week

Objectives

- *To provide a useful foundation and basic knowledge of the subject required for innovative work and advanced studies.*
- *To motivate the students and to develop interest in the subject by providing information along with practical application of different formulae from an engineering point of view.*

MODULE I (12hours)

Basic Concepts: Overview of applications of heat transfer in different fields of engineering, Modes of heat transfer- conduction, convection and radiation, heat transfer with and without change of phase.

One dimensional steady state heat conduction without generation of heat: Mechanism of heat conduction, isotropic and anisotropic materials- Fourier law, thermal conductivity measurement; thermal conductivity of solids, liquids and gases- comparison between them, thermal conductivity measurement of solids and liquids, Effect of temperature on thermal conductivity. General heat conduction equation in cartesian, cylindrical and spherical coordinates (derivation is required only for Cartesian geometry). Reduction of general equation to Laplace, Poisson, heat diffusion and Fourier equations. Different Boundary conditions applied in heat transfer problems. Formulation of heat transfer problems with and without generation of heat (uniform and non Uniform heat generation) at steady and unsteady state for different boundary conditions. Thermal diffusivity.

Conduction through systems of constant thermal conductivity: - conduction through plane, cylindrical and spherical wall, combined boundary condition systems (conduction-convection systems), conduction through Composite slab:- multilayered plane, cylindrical and spherical shells. Electrical analogy to heat flow. Numerical problems of practical importance based on the above topics.

MODULE II (12 hours)

Steady state heat conduction in systems with uniform generation of heat (Constant thermal

Conductivity**):** Expression for temperature distribution for one dimensional heat conduction in flat solids, cylindrical and spherical solid walls. Numerical problems based on the above aspects.

Heat Conduction in systems with variable thermal conductivity (without generation of heat**):** Steady state one dimensional heat conduction in plane walls, cylindrical and spherical hollow surfaces without generation of heat- expressions for heat flux and temperature distribution. Numerical problems of practical interest based on the above aspects.

Unsteady state heat conduction**:** Analysis of transient heat flow with negligible internal resistance-lumped capacity analysis, concept of Biot Modulus and Fourier number- Numerical problems of practical importance.

Thermal insulation: Analysis of critical radius of insulation for cylindrical and hollow spheres; Optimum thickness of insulation. Industrial insulating materials-cold and hot temperature insulating materials, refractories- examples. Concept of optimum thickness of insulation. Concept of thermal contact resistance. Numerical problems based on the above aspects

MODULE III (12 hours)

Convection: Mechanism, boundary layer concepts- thermal and velocity boundary layers, boundary layer thickness, relationship between hydrodynamic and thermal boundary layer thickness for flow over flat plates, the convective heat transfer coefficient, reference temperatures, and thermal boundary layers for the cases of flow over a flat plate and flow through pipe,

Forced Convection: General methods for estimation of convection heat transfer coefficient, Correlation equations for heat transfer in laminar and turbulent flow for external and internal Flows for constant heat flux and wall temperature conditions- flow in a circular tube (both developing and developed flows with constant wall temperature-its analysis and constant heat flux conditions) and non-circular tubes, flow over flat plates, flow over cylinder, spheres and tube banks. Heat transfer in liquid metals- empirical correlations. Numerical problems of practical interest. Dimensional analysis- Rayleigh and Buckingham's pi theorem, its limitations, principle of similarity, application of dimensional analysis to forced convection.

Natural Convection: Dimensional analysis**,** natural convection from vertical and horizontal Surfaces under laminar and turbulent conditions for plates, cylinders under constant heat flux and wall temperature conditions, physical significance of Grashoff and Rayleigh numbers. Numerical Problems of practical interest. Dimensionless numbers in heat Transfer and their significance

Analogy between momentum and heat transfer: Development of Reynold's analogy. Overview of Prandtl, Colburn and Von-Karman analogies (No derivation required).
Comparison of different analogy expressions

MODULE IV (12 hours)

Heat Transfer in extended Surfaces: Types of extended surfaces (fins), General conduction analysis of fins, boundary conditions. Reduction of general equation to determine temperature. distribution and heat flux for fin of uniform cross section for infinitely long fin and fin with insulated tip. Expression for temperature distribution and heat flux for fin of uniform cross section with convective boundary condition at the fin tip (No derivation is required).

Effectiveness of fins- justification for providing fins on a surface; efficiency of fins-expression for fin efficiency. Numerical problems of practical importance.

MODULE V (12 hours)

Heat transfer by radiation: Introduction- theories of radiation, electromagnetic spectrum, thermal radiation, spectral emissive power, surface emission- total emissive power, emissivity. Radiative properties- Emission, irradiation, radiosity, absorptivity, reflectivity and transmissivity. Concept of black and grey body, radiation intensity, Laws of black body radiation, non-black surfaces- Grey, white and real surface, Lambert's cosine law. Radiation between black surfaces and gray surfaces, radiation shape factor, reciprocity theorem, radiation between large parallel gray planes-derivation of expression for rate of radiant energy exchange, Concentric cylinders and spheres (no derivation required), radiation between a small gray body and a large gray enclosure. Radiation shields. Radiation heat transfer between black surfaces; radiation heat exchange between grey bodies. Radiation in gases. Errors in the measurement of temperature in a thermowell.

TEXT BOOKS:

1. Sachdeva R.C, "*Fundamentals of Engineering Heat and Mass transfer",* New Age International, India
2. Holman J. P, "*Heat Transfer*", McGraw Hill Ltd.
3. McCabe W.L. & Smith J.C., Unit Operations of Chemical Engg, McGraw Hill

REFERENCES:

1. Özisik M. N, "Heat *Transfer—A Basic Approach"*, McGraw-Hill.
2. Binay. K. Dutta, "*Heat Transfer Principles and applications*" Prentice Hall ofIndia
3. Incropera F. P. and DeWitt D. P, "*Introduction to Heat Transfer*". John Wiley & Sons.
4. Rao Y.V.C, *"Heat Transfer",* University Press, India
5. Cengel A. Yunnus. "*Heat Transfer – A Practical Approach",* McGraw Hill
6. Kothandaraman C.P, "*Heat and Mass Transfer Data Book*" New Age International, India

***UNIVERSITY EXAMINATION PATTERN*:** Question Paper consists of Part A, Part B and Part C. Part A is for 15 marks and comprises of 5 compulsory short answer questions, each carrying 3marks, covering the entire syllabus. Part B is for 25 marks, comprises of 5 compulsory questions from each module. And Part C is for 60 marks candidate has to answer one full question of 12 marks from each module**.**

Note: Reference no. 6 and steam table allowed for university examination

CH010 403 ORGANIC CHEMISTRY

Teaching Scheme **Credits: 4**

2 hours lecture and 2 hour tutorial per week

Objectives

- *To impart the basic concepts of organic chemistry*
- *To develop understanding about concepts on organic reactions for analysis of unit Processes*

MODULE-1 (12 hours)

Reaction mechanism

Electron displacement effects- Inductive effect, Electromeric effect, Mesomeric effect and Hyper conjugation- Hemolytic and heterolytic fission- Structure and Stability of C+ and C- ions, free radicals, Electrophiles and neucleophiles, Examples- Substitution reactions: Free radical substitution-Nucleophilic substitution, SN1 and SN2 Mechanism. Addition reactions: Electrophilic addition: Addition of Br_2 and HBr to alkenes. Nucleophilic Addition: Addition of HCN to aldehydes and ketones. Rearrangements: Mechanism of Beckmann rearrangement and Aldol condensation. Elimination Reactions (E1 and E2)

MODULE-2 (12 hours)

Benzene and its homologues

Aromaticity- Huckels rule- Aromatic and non aromatic ring structures- Resonance structure of Benzene, its stability. Mechanism of nitration, Sulphonation, Friedel Crafts alkylation and Acetylation- Orientation in aromatic substitution. Directive influence of substituents. Ortho, Para and Meta directing groups- Anomalous behavior of halogen substituents.

MODULE 3(12 hours)

Aromatic compounds

Aryl amines- structure and basicity, comparison with alkyl amines-Bromination, nitration and Carbylamines reaction of aniline. Diazonium salts: Preparations and applications. Phenols: Acidity- Riemer Tiemann reaction and. lederer manasse reaction.

Dyes - chromophores and auxochromes,– preparation, color and application of Azodyes, – Congo red, Bismark brown, – Triphenyl methane dyes – Malachite green, Rosaniline

MODULE-4 (12 hours)

Carbohydrates: Glucose, fructose and sucrose, Preparation and properties

Heterocyclic compounds: Pyrrole and pyridine-structure, synthesis and properties.

Alkaloids: Nicotine, Structure, synthesis and properties. Terpenes: Isoprene rule. Citral, Structure, synthesis and properties

Amino acids: Classification and properties, Zwitter ion, isoelectric point, Synthesis- Gabriels Strecker, Erlen Meyer and Azlactone method, Peptides and proteins (fundamental aspects only)

Module 5 (12 hours)

Organic Spectroscopy: principles and applications of UV, IR, NMR (^{1}H and ^{13}C), Mass and, ESR spectroscopic techniques for the structure elucidation of organic compounds (problem solving approach)

TEXTBOOKS:

1. Morrison & Boyd, Organic Chemistry, Prentice Hall. New Delhi, 6th edition,1992
2. B.S.Bahl and Arun Bhal, Advanced Organic Chemistry, S. Chand & Co. Ltd., New Delhi, 15th edition, 1998
3. I.L.Finar, Textbook of Organic Chemistry, ELBS, 5th edition, 1996 Vol I and II
4. Organic Spectroscopy**,** William Kemp (Author) Palgrave Macmillan; 3rd edition (26 July 1991)
5. Spectroscopy of Organic Compounds, P S Kalsi, New Age International (01-Jan-2007)
6. A textbook of Organic Chemistry, Rino laly Jose, Sajith Kurain and Soney C George (2014)

REFERENCES :

1. Advanced Organic Chemistry, Part-A: Structure and Mechanism – Francis A. Carey, Richard J. Sundberg
2. Advanced Organic Chemistry, 2.Part-B : Reactions and Synthesis - Francis A. Carey, Richard J. Sundberg
3. Spectroscopy 1. Spectrometric Identification of Org. Compounds – R. M. Silverstein, F. X. Webster
4. Jerry March, Advanced Organic Chemistry, John Wiley & Sons, New York, 1992

***UNIVERSITY EXAMINATION PATTERN*:** Question Paper consists of Part A, Part B and Part C. Part A is for 15 marks and comprises of 5 compulsory short answer questions, each carrying 3marks, covering the entire syllabus. Part B is for 25 marks, comprises of 5 compulsory questions from each module. And Part C is for 60 marks candidate has to answer one full question of 12 marks from each module**.**

CH010 404 MECHANICAL OPERATIONS

Teaching Scheme **Credits: 4**

3 hours lecture and 1 hour tutorial per week

Objectives

- *Study different properties of particulate solids, handling and mixing and methods of size reduction of solid particles.*
- *Understand mechanical separation methods such as screening, filtration, sedimentation, transportation of solids etc and associated equipments used for achieving these methods..*

MODULE I (12 hours) **Particle Technology:**

Particle shape, particle size, different ways of expression of particle size, shape factor, sphericity, mixed particles size analysis, screens – ideal and actual screens, differential and cumulative size analysis, effectiveness of screen, specific surface of mixture of particles, number of particles in a mixture, standard screens industrial screening equipment, motion of screen, grizzly, gyratory

screen, vibrating screen, trommels, sub sieve analysis – Photo sedimentation - sedimentation balance, sedimentation and decantation – ICI sedimentation - Elutriation, Laser beam Particle size analysis, Online particle analysis.

MODULE II (12 hours) Size Reduction:

Introduction – types of forces used for communition, criteria for communition, characteristics of communited products, laws of size reduction, work index, energy utilization, methods of operating crushers – free crushing, choke feeding, open circuit grinding, closed circuit grinding, wet and dry grinding, equipment for size reduction – blake jaw crusher, gyratory crusher, smooth roll crusher, tooth roll crusher, hammer mill - ball mill-critical speed of ball mill - rod mill - disk attrition mills impactor, attrition mill , ultra fine grinders, fluid energy mill, colloid mill, Cutters – knife cutter .

MODULE III (12 hours) Classification, ore beneficiation and Sedimentation of Solids

Classification - Principles of free and hindered settling - Sizing and sorting. Classifiers - Hydraulic classifiers - Rake classifier-Spiral Classifier - Bowl classifier - Pneumatic classifier - Hydroclones.

Mineral beneficiation: Ore Sorting- electronic sorting, assay sampling, recovery, liberation, locked particles, classification as a means of concentration - Heavy media separation – Jigging- Wilfly table - Froth flotation - Magnetic separation - High voltage separation. Gas cleaning methods: Bag filters, cyclone separation, electrostatic separation, scrubbing

Sedimentation: Batch settling test, application of batch settling test to design of continuous thickener, Coe and Clevenger theory, Kynch theory, thickener design, determination of thickener area.

MODULE IV (12 hours) Filtration

Filtration: Introduction, classification of filtration, cake filtration, clarification, batch and continuous filtration, pressure and vacuum filtration constant rate filtration and cake filtration, characteristics of filter media, industrial filters, sand filter, filter press, leaf filter, rotary drum filter, horizontal belt filter, bag filter, centrifugal filtration – suspended batch centrifuge, filter aids, application of filter aids, principles of cake filtration, modification of Kozeny – Carman for filtration.

MODULE V (12 hours) Mixing and Transportation of Solids

Agitation and Mixing: Application of agitation, Agitation equipment, types of impellers – propellers, paddles and turbines, flow patterns in agitated vessels, prevention of swirling, standard turbine design, power correlation and power calculation, mixing of solids, types of mixers- change can mixers, muller mixers, mixing index, ribbon blender, internal screw mixer, tumbling mixer.

Sampling, Storage and Conveying of Solids: Sampling of solids, storage of solids, open and closed storage, bulk and bin storage, conveyors – belt conveyors, chain conveyor, apron conveyor, bucket conveyor, bucket elevators, screw conveyor, slurry transport, pneumatic conveying.

TEXT BOOKS

1. McCabe, W.L. and Smith, J.C., Unit Operation of Chemical Engineering, 5th Edn. McGraw Hill, New York, 1993.
2. Coulson, J.M. and Richardson, J.F., Chemical Engineering, Vol. II, 4th Edn. Butterworth -Heinemann, 1991.
3. Brown G. *et.al.*, Unit Operation, I Edition, CBS Publishers, New Delhi, 1995.
4. Badger and Banchero, "Introduction to Chemical Engineering", 1st Edn. McGraw Hill, New York, 1954.

REFERENCES

1. Raymond A. Kulweic, Materials Handling Handbook, 2nd Edn., Wiley- Interscience Publications, 1985.
2. Tim Napier-Munn, Barry A. Wills, Mineral Processing Technology: An Introduction to the Practical Aspects of Ore Treatment and Mineral Recovery, Butterworth-Heinemann, 2011
3. Perry, R.H. and Green, W.D., Perry's Chemical Engineers' Hand Book, 7th Edn. McGraw Hill International Edn., New York, 2000
4. Foust A.S. *et.al*, Principles Of Unit Operation, III Edition, John Wiley and Sons, New York,1997.

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CH010 405 MACHINE DRAWING

Teaching Scheme **Credits: 4**

3 hours lecture and 1 hour tutorial per week

Objectives :

- *To impart the fundamental concepts of machine drawing.*
- *To develop primary knowledge of working drawings.*
- *To produce orthographic drawing of different machine parts.*
- *To develop skill to produce assembly drawings.*
- *To develop skill to produce detailed drawings of machines parts from assembly drawing*

MODULE I (15hours)

Conversion of pictorial views into orthographic views-dimensioning techniques-preparation of drawing- Limits and tolerances of machine parts - Hole system and shaft system of tolerances -

Designation of fundamental deviation - Types of fits and their selection - Indication of dimensional tolerances and fits on simple machine parts - Geometrical tolerances –
Recommended symbols - Indication of geometrical tolerances on simple machine parts – Surface roughness – Indication of surface finish on drawings - Preparation of shop floor drawings of simple machine parts. Types of screw threads-different forms-conventional representation sketching orthographic views of hexagonal bolts and nuts -dimensional drawing-square headed bolts and nuts –sketching of different types of lock nuts and locking devices- foundation bolts.
Forms of rivet heads – riveted joints-lap and butt joints with single and multiple riveting in chain and zig – zag arrangements –dimensional drawing. Sketching of conventional representation of welded joint.

MODULE II (20 hours)

Fully dimensioned and sectional drawing of the following Joints knuckle joint-jib and cotter shaft couplings-types of keys- protected types of flanged couplings-bushed pin type flexible coupling- Oldham's coupling Pipe joints-spigot and socket joint-flanged joint- Shaft bearings and support-Plummer block IC engine parts-piston-connecting rod

MODULE III (25hours)

Assembly and working drawings of the following- Valves -stop valve-spring loaded safety valve –dead weight safety valve-feed check valve-feed check valve Machine elements-screw jack – lathe tool post-spindle-tailstock

Note:

• Drawing practical classes have to be conducted by using any standard CAD software and using drawing instruments in alternate weeks (3Hours) preferably for each half of the student.
Semester End examination (3Hours) shall be conducted by using drawing instruments only
• All drawing exercises mentioned above are for class work. Additional exercises wherever necessary may be given as homework.

TEXT BOOKS:

1. N.D.Bhatt and Panchal, *Machine Drawing*, Charator Publishing House
2. P I.Varghese, *Machine Drawing*, VIP Publishers, Thrissur

REFERENCES:

1. Ajeet Singh, *Machine Drawing*, Tata McGraw Hill Education Private Ltd
2. P.S.Gill , *Machine Drawing*, S.K.Kataria &Sons

UNIVERSITY EXAMINATION PATTERN:

Question I: Two questions of 7.5 marks each out of three questions from module-1
Question II: One questions of 25 marks from module-2.
Question III:One question of 60 marks from module-3

CH010 406 CHEMICAL ENGINEERING THERMODYNAMICS I

Teaching Scheme **Credits 4**

3 hours lecture and 1 hour tutorial per week

Objectives

- *To impart the basic concepts of thermodynamics for chemical engineers*

MODULE I (12 hours)

Fundamental concepts and definitions - closed, open and isolated system - intensive and Extensive properties - path and state functions - reversible and irreversible process – temperature scale - Zeroth law of thermodynamics - First law of thermodynamics - internal energy - Enthalpy - heat capacity - first law for cyclic, non-flow and flow processes - applications - P-V-T behavior of pure fluids - ideal gases and ideal gas processes - equations of state - Vander Waals equation, Redlich-Kwong equation, Virial equation - principle of Corresponding states - critical and pseudo critical properties - Compressibility charts.

MODULE II (12 hours)

Heat effects in chemical reactions - standard heat of formation, combustion and reaction- Effect of temperature on heat of reaction - temperature of reactions - adiabatic reaction Temperature - Second law of thermodynamics - limitations of first law - general statements of Second law - concept of entropy - calculation of entropy changes - Carnot's principle - Absolute scale of temperature - Clausius inequality - entropy and irreversibility - statistical Explanation of entropy - Third law of thermodynamics.

MODULE III (12 hours)

Thermodynamic properties of pure fluids - Gibbs free energy, work function - Maxwell's Equations - Clapeyron equation - entropy-heat capacity relationships - equations for entropy, Internal energy and enthalpy in terms of measurable quantities - effect of temperature and Pressure on U, H and S - relationship between C_P and C_V - effect of pressure and volume on Heat capacities - Joule-Thomson coefficient

MODULE IV (12 hours)

Gibbs - Helmholtz equation - method of Jacobians - thermodynamic diagrams - fugacity and activity of pure fluids - selection of Standard state - determination of fugacity of pure gases and liquids - effect of temperature and Pressure on fugacity and activity.

MODULE V (12 hours)

Flow processes - total energy balance - mechanical energy balance - Bernoulli equation - flow in pipes and maximum velocity - flow through nozzles and ejectors - critical pressure Ratio in nozzles - compressors - single-stage and multistage compression - refrigeration and liquefaction - COP - refrigeration cycles - Carnot, vapour compression, air compression and absorption refrigeration cycle - general properties of refrigerant - Joule-Thomson expansion and

liquefaction processes - power cycles - steam-power plant cycles - internal combustion Engine cycles - gas-turbine power plant cycle.

TEXTBOOKS:

1. Smith J. M. & Van Ness H.V., Introduction to Chemical Engineering Thermodynamics, McGraw Hill Ltd
2. Narayanan K. V., A Textbook of Chemical Engineering Thermodynamics, Prentice-Hall of India.

REFERENCES:

1. Hougen A., Watson K.M. & Ragatz R.A., Chemical Process Principles Vol.2, Asia Pub
2. Kyle B.G., Chemical and Process Thermodynamics, Prentice-Hall of India
3. Y.V.C. Rao, Chemical Engineering Thermodynamics, Universities Press

***UNIVERSITY EXAMINATION PATTERN*:** Question Paper consists of Part A, Part B and Part C. Part A is for 15 marks and comprises of 5 compulsory short answer questions, each carrying 3marks, covering the entire syllabus. Part B is for 25 marks, comprises of 5 compulsory questions from each module. And Part C is for 60 marks candidate has to answer one full question of 12 marks from each module**.**

CH010 407 FLUID AND PARTICLE MECHANICS LAB

Teaching Scheme **Credits: 2**

3 hours practical per week

1. Measurement of flow using notch and weirs
2. Measurement of flow using orifices and mouth pieces under constant and varying heads
3. Calibration of flow meters
4. Reynolds's experiment to demonstrate laminar and turbulent flow
5. Measurement of viscosity and surface tension of liquids
6. Study of Plumbing tools, pipe fittings, valves, gauges and meters
7. Determination Losses in pipes and fittings
8. Determination of Darcy's coefficient
9. Determination of equivalent length
10. Determination of velocity profile using Pitot tube
11. Study and experiments on reciprocating pumps and centrifugal pumps
12. Terminal settling velocities in viscous medium
13. Flow through packed bed
14. Flow through fluidized bed
15. Efflux times and velocities in tanks
16. Verification of Bernoulli's principle

CH010 408 PHYSICAL AND ORGANIC CHEMISTRY LAB

Teaching Scheme **Credits: 2**

3 hours practical per week

A. Gravimetric analysis

1. Estimation of percentage of water of hydration in hydrated barium choride.
2. Estimation of barium as barium sulphate.
3. Estimation of sulphate as barium sulphate.
4. Estimation of iron as ferric oxide.

B. Physical chemistry experiments

1. Determination of partition coefficient of
    i. Iodine between water and carbon tetra chloride.
    ii. Benzoic acid between water and benzene.
2. Determination of molecular weight by Rast's method
3. Determination of molecular weight by depression in freezing point and elevation of boiling point.
4. Determination of critical solution temperature of phenol water system and calculation of composition of a given mixture of liquids.
5. Determination of velocity constants of the following reactions.
    iii. First order reaction-Hydrolysis of ethyl acetate with dil HCl.
    iv. Second order reaction-Hydrolysis of ethyl acetate with NaOH.
6. Determination of heat of nuetralisation reaction.

C. Organic preparations

1. Preparation of urea formaldehyde resin.
2. Preparation of phenol formaldehyde resin.
3. Preparation of aspirin.
4. Preparation of azodyes.
5. Preparation of phenyl benzoate.
6. Preparation of urea nitrate.

TEXTBOOKS:

1. Practical chemistry by A.O. Thomas.
2. A.I.Vogel, "A Text Book of Quantitative Inorganic Analysis", Longman
3. Laborarory manual on engineering chemistry by Dr. Sudha Rani. (Dhanpat Rai Publishing company)

FIFTH SEMESTER

EN010 501 ENGINEERING MATHEMATICS IV

Teaching Scheme **Credits: 4**

2 hours lecture and 2 hour tutorial per week

Objectives:

- *Use basic numerical techniques to solve problems and provide scientific techniques to decision making problems.*

MODULE I: (12 hours) Function of Complex variable:

Analytic functions – Derivation of C.R. equations in Cartesian co-ordinates – harmonic and orthogonal properties – construction of analytic function given real or imaginary parts – complex potential – conformal mapping of z^2 , *1/z*- Bilinear transformation – cross ratio – invariant property (no proof) – simple problems

MODULE II: (12 hours) Complex integration:

Line integral – Cauchy's integral theorem – Cauchy's integral formula – Taylor's series- Laurent's series – Zeros and singularities – types of singularities – Residues – Residue theorem – evaluation of real integrals in unit circle – contour integral in semi circle when poles lie on imaginary axis.

MODULE III: (12 hours) Numerical solution of algebraic and transcendental equations:

Successive bisection method – Regula –falsi method – Newton –Raphson method - Secant method – solution of system of linear equation by Gauss – Seidel method

MODULE IV: **(12 hours) Numerical solution of Ordinary differential equations**:

Taylor's series method – Euler's method – modified Euler's method – Runge – Kutta method (IV order) – Milne's predictor – corrector method

MODULE V: (12 hours) Linear programming problem:

Definition of L.P.P., solution, optimal solution, degenerate solution – graphical solution – solution using simplex method (non degenerate case only) Big -M method – Duality in L.P.P. – Transportation problem –Balanced T.P. – initial solution using Vogel's approximation method - Modi method (non degenerate case only)

REFERENCES:

1. B.V. Ramana – Higher Engg. Mathematics – McGraw Hill Ltd.
2. M.R.Spicgel , S.Lipschutz , John J. Schiller, D.Spellman – Complex variables, schanm's outline series - McGraw Hill Ltd.
3. S.Bathul – text book of Engg.Mathematics – Special functions and complex variables –PHI
4. B.S. Grewal – Numerical methods in Engg. and science - Khanna Publishers
5. Dr.M.KVenkataraman- Numerical methods in science and Engg -National publishing co
6. S.S Sastry - Introductory methods of Numerical Analysis -PHI
7. P.K.Gupta and D.S. Hira – Operations Research – S.Chand

8. PanneerSelvam– Operations Research – PHI
9. H.C.Taneja – Advanced Engg. Mathematics Vol II – I.K.International.

CH010 502 CHEMICAL REACTION ENGINEERING I

Teaching Scheme **Credits: 4**

3 hours lecture and 1 hour tutorial per week

Objectives

- *To impart the basic concepts of chemical reaction engineering*
- *To develop understanding about reactor analysis and design*

MODULE I: (12 hours)

Introduction: Scope of Chemical Reaction Engineering. Classification of reactions. Rate equation and rate of reaction. Factors affecting rate of reaction. Chemical kinetics and Thermodynamics/Equilibrium. Temperature dependency of rate constant from Arrhenius, Collision and Transition state theories. Molecularity and order of reaction. Non-elementary reactions: Difference between elementary and non-elementary reactions. Active intermediates, pseudo steady state hypothesis (PSSH), searching for a mechanism, General considerations, hydrogen bromide reaction, polymerisation - steps in free radical polymerisation . Other examples of non-elementary reactions.

MODULE II: (12 hours)

Homogeneous reactions: Interpretation of batch reactor data. Constant Volume batch reactor. Analysis of total pressure data in a constant volume system. Integral method of Analysis of data. Irreversible, zero, first, second, and nth order reactions (Uni- molecular and bi molecular type). Reversible first order reactions, series and parallel reactions, Autocatalytic reactions. (For both constant and variable volume reactions). Differential method. Overall orders from half-life method.

MODULE III: (12 hours)

Design of ideal reactors: Concept of ideality. Development of design expressions for batch, tubular, and stirred tank reactors for both constant and variable-volume reactions. Evaluation of rate equations from data obtained in these reactors.

MODULE IV: (12 hours)

Comparison of ideal reactors: General graphical comparison. Multiple Reactor Systems: Plug flow and/or Mixed flow reactors in Series, parallel and series parallel. Reactors of different types and sizes in series. Recycle reactors: Introduction and qualitative treatment for single reactions only.

MODULE V: (12 hours)

Design of reactors for multiple reactions: Design of Batch reactor, Plug and

Mixed flow reactors for Parallel, Series and Series-Parallel reactions (Only irreversible reactions must be considered). Evaluation of laboratory reactors, Integral (fixed bed) reactor, stirred batch reactor, stirred contained solid reactor (SCSR), Differential reactors: Continuous stirred tank reactor (CSTR), Laminar flow reactor, straight- through transport reactor, recirculating transport reactor.

TEXT BOOKS:

1. Octave Levenspeil, Chemical Reaction Engineering, 3rd Edition, John Wiley & Sons, 2001.
2. H. Scott Fogler, Elements of Chemical Reaction Engineering, 3rd Edition, Prentice Hall, 2001.

REFERENCES:

1. Smith J.M, "Chemical Engineering Kinetics," McGraw Hill Pvt. Limited.
2. Hill C.G., An Introduction to Chemical Engineering Kinetics& Reactor Design, John Wiley.

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CH010 503 HEAT TRANSFER II

Teaching Scheme **Credits: 4**

2 hours lecture and 2 hour tutorial per week

Objectives

- *To impart the basic concepts of heat transfer with phase change*
- *To impart knowledge of heat transfer equipments.*

MODULE I (12 hours)

Classification of heat exchangers: Classification according to transfer processes: Indirect-contact heat exchangers, direct-contact heat exchangers; Classification according to number of fluids; Classification according to surface compactness: gas-to-fluid exchangers, liquid-to-liquid and phase-change exchangers; Classification according to construction features: tubular heat exchangers, plate-type heat exchangers, extended surface heat exchangers, regenerators; Classification according to flow arrangements: single-pass exchangers, multi-pass exchangers; Classification according to heat transfer mechanisms. Basic construction of a shell and tube heat exchanger with details of the various parts, concept of overall heat transfer coefficient derivation of expression for LMTD and overall heat transfer coefficient, concept and types of fouling, fouling factors, determination of overall heat transfer coefficient with and without fouling. Heat exchanger analysis, concept of sizing and rating problems. Numerical problems on

rating problems. Concept of logarithmic mean temperature difference and its correction factor, Heat exchanger analysis using LMTD method in parallel flow, counter flow exchanger, cross flow and multi-pass heat exchangers, Temperature - distance plots for different flow arrangements in single and multi-pass heat exchangers. Determination of area, length, number of tubes required for a given duty in different configurations using LMTD method of analysis.

MODULE II (12 hours)

Concept of Effectiveness- NTU method, definition of effectiveness, effectiveness NTU relations for single pass exchangers in counter-flow and parallel flow configurations, - development of equations for effectiveness for parallel and counter-flow configurations, Determination of area, length and number of tubes using Effectiveness- NTU method, use of effectiveness- NTU charts for design of various heat exchanger configurations, *(the students will be permitted to use the Effectiveness- NTU charts in the examination hall),* interpretations of effectiveness-NTU plots. Heat transfer augmentation: General study of various methods available heat transfer augmentation for heat transfer with and without change of phase,

MODULE III (8 hours)

Determination of individual heat transfer coefficients using Wilson's plot, Compact heat exchangers - heat transfer and flow characteristic for specific configurations. Double pipe heat exchangers: - construction, various steps for the design of double pipe heat exchangers. Thermal design of agitated vessels, empirical correlations for individual heat transfer coefficients. Construction of compact heat exchangers: Plate heat exchangers, design considerations of spiral heat exchangers. General selection guide lines for major heat exchangers types.

MODULE IV (16 hours) Boiling and Condensation

Dimensionless parameters in boiling and condensation. Pool boiling - Boiling curve, hysteresis in the boiling curve, mechanism of nucleate boiling - modes of pool boiling, pool boiling correlations - Nucleate pool boiling -Correlation for minimum heat flux - Zuber correlation. Correlations for film pool boiling. Parametric effects on pool boiling, numerical problems. Forced convection boiling - Brief over view of external forced convection boiling and internal forced convection boiling.

Condensation: Physical mechanisms, types of condensation, factors affecting condensation, Laminar film condensation on a vertical plate - detailed analysis by Nusselt to determine the heat transfer coefficient. Laminar film condensation on radial systems - condensation on spheres, horizontal tubes and for a vertical tier of horizontal tubes, condensation inside a horizontal tube, correlations, film condensation inside horizontal tubes. Drop wise condensation – correlations- Numerical problems. Comparison between drop-wise and film type condensation, promoters and inhibitors used in condensation. Effect of non- condensables on condensation.

MODULE V (12 hours)

Evaporation: Principle of Evaporation, types of evaporators- their construction and operation- Natural circulation evaporators, short tube vertical or calandria type evaporators, basket type

vertical evaporators, long tube vertical evaporators, forced circulation evaporators, falling film evaporators, climbing or rising film evaporators, agitated thin film evaporators, the plate evaporator. Evaporator auxiliaries: - vacuum devices, steam traps and its variants, entrainment separators. Single effect and multiple effect evaporators, Performance of evaporators, capacity and economy of evaporators, factors affecting the performance of evaporators. Overall heat transfer coefficient, effect of liquid head and boiling point elevation. Material and energy balances for single effect evaporator and the calculations on single effect evaporator. Multiple effect evaporators: temperature profile of liquids in the evaporator, enthalpy of solution, Different feeding arrangements in multiple effect evaporators – their merits and demerits. Multiple effect evaporator calculations. Evaporator selection considerations. Vapour recompression evaporators- Mechanical and thermal recompression- Energy balance, numerical problems.

TEXT BOOKS

1. Binay K. Dutta, *Heat Transfer- Principles and Applications*, Prentice Hall of India.
2. McCabe W.L. & Smith J.C., "Unit Operations of Chemical Engg", McGraw Hill
3. Kern D Q, *Process Heat Transfer*, McGraw Hill Book Co. (1997).

REFERENCES:

1. Ramesh K. Shah and Dušan P. Sekulic, *Fundamentals of Heat Exchanger Design*, John Wiley & Sons, Inc. 2003
2. M.Necati. Ozizik, *Heat transfer - A basic Approach*, McGraw-Hill College (1985)
4. Geankopolis C J, *Transport Processes and Separation Process Principles*, Prentice Hall of India, 4th Edition, Eastern Economy Edition (2004)
5. Holman J P, *Heat Transfer*, McGraw Hill Book Co. (1992).
6. Incropera F P and DeWitt D P, *Introduction to Heat Transfer*, 2nd Ed John Wiley New York (1996).
7. Coulson J M and Richardson J F, *Chemical Engineering* Volume 1, Pergamon Press (1999).
8. Kothandaraman C.P, "*Heat and Mass Transfer Data Book*" New Age International, India

Note to question paper setters:

*Reference **No. 8** indicated in the group of references given below is allowed in the examination hall, which may be mentioned along with the directions to be provided on the facing sheet of the question paper. Steam tables are also permitted in the examination hall. No other charts, tables and codes are permitted in the Examination hall. Necessary relevant data shall be given along with the question paper by the question paper setter.*

***UNIVERSITY EXAMINATION PATTERN*:** Question Paper consists of Part A, Part B and Part C. Part A is for 15 marks and comprises of 5 compulsory short answer questions, each carrying 3marks, covering the entire syllabus. Part B is for 25 marks, comprises of 5

compulsory questions from each module. And Part C is for 60 marks candidate has to answer one full question of 12 marks from each module**.**

CH010 504 CHEMICAL TECHNOLOGY I

Teaching Scheme **Credits: 4**

3 hours lecture and 1 hour tutorial per week

Objectives

- *To understand the manufacture methods of Inorganic materials in process industries.*

MODULE I (12 hours)

Introduction to Chemical Technology, Sectors of Chemical Industry, Overview of Indian Chemical Industry. Industrial gases: manufacture, properties and uses of hydrogen, oxygen, nitrogen, carbon dioxide, carbon monoxide, acetylene, hydrogen and rare gases, coke oven gas, producer gas, water gas.

MODULE II (12 hours)

Industrial acids: Hydrochloric acid - manufacture by synthesis process, manufacture of sulphur from fuel gases, sulphuric acid manufacture by DCDA, manufacture of Oleum.sulphuric acid concentration, nitric acid manufacture from ammonia, phosphate ore beneficiation, phosphoric acid manufacture by wet process and electric furnace process.

MODULE III (14 hours)

Fertilizers: Ammonia manufacture, manufacture of urea by once through process and total recycle process, ammonium sulphate manufacture from coke-oven gas and by direct neutralisation. Manufacture of nitrogenous fertilizers - ammonium chloride, ammonium sulphate, ammonium nitrate, ammonium phosphate, calcium ammonium nitrate, barium nitrate and nitro chalk. Phosphatic fertiizers - super phosphates. Potassium fertilizers:-, basic slag, potassium chloride, potassium sulphate. Compound and complex fertilizers:- MAP and DAP, ammonium phosphate sulphate, nitro phosphates, NPK fertilizers.

MODULE IV (14 hours)

Marine chemicals: Manufacture of sodium chloride, sodium sulphate, sodium silicate, byproducts of salt industry. Soda ash: Manufacture by Solvay process and modified Solvay process. Chlorine and caustic soda: Manufacture by electrolytic process - Diaphragm cells, membrane cells. Purification of caustic soda and chlorine. Electrothermal products: Manufacture, properties and uses of graphite, fused alumina, silicon carbide.

MODULE V (14 hours)

Cements: Raw materials, proportioning and manufacture of ordinary portland cement, dry, semi-dry and wet processes, Pozzolona Portland cement and other types of cements. Testing of cement. Glasses: Types, raw materials and methods of manufacture. Ceramics: Types, raw materials, processing methods - drying and firing of ceramic wares. Refractories: classification, manufacture and testing of refractories.

TEXT BOOKS:

1. Austin G.T. "Shreve's Chemical Process Industries" 3rd Edn
2. Gopal Rao M. & Sitting M. (eds), "Dryden's Outline of Chemical Technology" 2nd Edn.
3. Chemtech Vol. I – IV..
4. Shukla S. I. and Pandey G.N., "A Text Book of Chemical Technology"

***UNIVERSITY EXAMINATION PATTERN*:** Question Paper consists of Part A, Part B and Part C. Part A is for 15 marks and comprises of 5 compulsory short answer questions, each carrying 3marks, covering the entire syllabus. Part B is for 25 marks, comprises of 5 compulsory questions from each module. And Part C is for 60 marks candidate has to answer one full question of 12 marks from each module**.**

CH010 505 MASS TRANSFER OPERATIONS I

Teaching Scheme **Credits: 4**

3 hours lecture and 1 hour tutorial per week

Objectives

- *To impart the basic concepts of mass transport*
- *To develop understanding about gas absorption, humidification, crystallization, Adsorption and drying.*

MODULE I (12 hours)

Molecular diffusion - mass fluxes J_A and N_A - Fick's law - diffusivity and estimation - steady State diffusion of A through stagnant B and equimolar counter diffusion in binary gases, Liquids and multi component gas mixtures. Mass transfer coefficients - film theory - F-type and k-type coefficients - dimensionless groups and dimensional analysis - analogy between mass, Heat and momentum transfer . Elementary treatment of theories of mass transfer: Penetration and surface renewal theories - inter phase mass transfer - equilibrium - diffusion between phases - two-film theory - local and overall coefficients.

MODULE II (12 hours)

Gas absorption, absorption equipment, multistage absorption, tray towers, tray types and General features of tray designs (qualitative treatment), continuous contact equipment, and venture scrubbers, packed columns, packing materials and characteristics, general constructional details of packed columns, flooding and loading, choice between plate and packed columns. Solubility of gases in liquid, choice of solvent, material balance in countercurrent and co-current absorption

and stripping, L/G ratio, multistage operation, number of plates by graphical construction, Kremser equation, and tray efficiency, design of packed columns, transfer unit and general graphical method dilute solutions and simplified design methods

MODULE III (12 hours)

Humidification and dehumidification, theory of wet-bulb temperature and adiabatic saturation temperature, Lewis relation, water cooling with air, types of cooling towers, material and enthalpy balance, transfer unit.general design procedure, application of simplified methods of cooling tower design, Spray chambers for air humidification, principles of gas dehumidification by counter-current contact with water.

MODULE IV (12 hours)

Drying, equilibrium moisture content, batch drying, rate of drying, cross-circulation drying, Mechanism of moisture movement, continuous drying, parallel and countercurrent, material and enthalpy balances, rough estimate of size of rotary dryer based on heat-transfer units for drying at high temperature, industrial dryers for batch and continuous drying.

Crystallization- principles of crystallization, purity, yield, energy requirements, super saturation, nucleation, rate of nucleation, growth of crystals, growth coefficients, crystallization equipment, MSMPR crystallizer.

MODULE V (12 hours)

Adsorption, types of adsorption, nature of adsorbents, adsorption isotherm for single gases, vapors and dilute liquid solutions, Adsorption isotherms, contact filtration of liquids, single stage and multistage operation, unsteady state fixed-bed absorbers', adsorption wave, rate of adsorption and breakthrough curve.

TEXT BOOKS:

1. Treybal R.E., Mass Transfer Operations, McGraw Hill
2. K V Narayan " Mass Transfer Theory and Applications", CBS publisher.
3. Binay K Dutta, "Mass Transfer and Separation Processes", PHI

REFERENCES:

1. McCabe W.L., Smith J.C. & Harriott P., Unit Operations in Chemical Engineering, McGraw Hill Ltd.
2. Seader J.D.& Henley E.J Separation Process Principles
3. Coulson J.M. & Richardson J.F., Chemical Engineering, Vol. I & II, ELBS, Pergamon Press
4. Rousseau R.W., Handbook of Separation Process Technology, John Wiley
5. Foust A.S. et al, Principles of Unit Operations, John Wiley
6. Welty J.R., Wilson R.E. & Wicks C.E., Fundamentals of Momentum Heat and Mass Transfer, John Wiley

7. Geankopolis C J, *Transport Processes and Separation Process Principles*, Prentice Hall of India, 4th Edition, Eastern Economy Edition (2004)

***UNIVERSITY EXAMINATION PATTERN*:** Question Paper consists of Part A, Part B and Part C. Part A is for 15 marks and comprises of 5 compulsory short answer questions, each carrying 3marks, covering the entire syllabus. Part B is for 25 marks, comprises of 5 compulsory questions from each module. And Part C is for 60 marks candidate has to answer one full question of 12 marks from each module**.**

Note: Steam tables and psychometric charts are allowed in the university examination

CH010 506 CHEMICAL ENGINEERING THERMODYNAMICS II

Teaching Scheme **Credits: 4**

3 hours lecture and 1 hour tutorial per week

Objectives

- *To impart the detailed concepts of solution thermodynamics*

MODULE I (13 hours)

Properties of solutions - partial molar properties - definition - physical significance - determination -tangent-intercept method - chemical potential - definition - effect of temperature and pressure - fugacity in solution - ideal solution - Lewis-Randall rule - Raoult's law - Henry's law - activity and activity coefficients in solutions - effect of temperature and pressure on activity coefficients - Gibbs-Duhem equations - applications - property changes on mixing - heat effects of mixing processes - enthalpy composition diagrams - excess properties - relation between excess Gibbs free energy and activity coefficient

MODULE II (13 hours)

Phase equilibria - criterion of phase equilibria - criterion of stability - phase equilibrium in single - component systems - phase equilibria in multicomponent systems - phase rule for Non-reacting systems - Duhem's theorem - vapour-liquid equilibrium - phase diagram for Binary solutions - VLE in ideal solutions - non-ideal solutions - positive and negative deviation - azeotropes - VLE at low pressures - Wohl's equation - van Laar equation - Wilson Equation - application of activity coefficient equations in equilibrium calculations - basic idea on NRTL, UNIQUAC and UNIFAC methods - calculation of activity coefficients using Gibbs - Duhem equations - consistency tests for equilibrium data - Redlich-Kister method - Coexistence equation

MODULE III (13 hours)

Applied phase equilibrium - vapour-liquid equilibrium at high pressures - vaporization Equilibrium constants - bubble point, dew point and flash calculations in multi component Systems - computer programs for these calculations - vapour-liquid equilibrium in partially miscible and immiscible systems - phase diagrams - principles of steam distillation

MODULE IV (13 hours)

Phase equilibrium considerations in steam distillation - liquid-liquid equilibrium - binary and ternary equilibrium diagrams - use of triangular diagrams for ternary equilibrium - Different types of ternary systems and their representation on triangular coordinates. Thermodynamic analysis of processes - rate of entropy generation in steady flow processes - calculation of ideal work and lost work - thermodynamic analysis of steady state flow processes.

MODULE V (13 hours)

Chemical reaction equilibria - reaction stoichiometry - criteria of chemical equilibrium - Equilibrium constant - standard free energy change - standard state - feasibility of reaction - Effect of temperature on equilibrium constant - presentation of free energy data - evaluation of K - equilibrium conversion in gas-phase reactions - effect of pressure and other parameters on conversion - liquid-phase and heterogeneous reaction - reactions in solutions - pressures of decomposition in gas-solid reaction - simultaneous reactions - phase-rule for reacting systems

TEXT BOOKS:

1. Narayanan K. V., A Textbook of Chemical Engineering Thermodynamics, Prentice-Hall of India
2. Smith J. M. & Van Ness H.V., Introduction to Chemical Engineering Thermodynamics, McGraw Hill

REFERENCE:

3. Y.V.C. Rao, Chemical Engineering Thermodynamics, Universities Press.
4. Hougen A., Watson K.M. & Ragatz R.A., Chemical Process Principles Vol.2, Asia Pub.
5. Kyle B.G., Chemical and Process Thermodynamics, Prentice-Hall of India

***UNIVERSITY EXAMINATION PATTERN*:** Question Paper consists of Part A, Part B and Part C. Part A is for 15 marks and comprises of 5 compulsory short answer questions, each carrying 3marks, covering the entire syllabus. Part B is for 25 marks, comprises of 5 compulsory questions from each module. And Part C is for 60 marks candidate has to answer one full question of 12 marks from each module**.**

CH 010 507 CHEMICAL TECHNOLOGY LAB

Teaching Scheme **Credits: 2**

3 hour practical per week

Objectives

- *To provide experience on analysis, estimation and preparation of few organic Chemicals.*

1. Acid value of oils
2. Iodine value of oils
3. Saponification value of oils
4. Preparation and analysis of soap

5. Preparation of copper pigment
6. Preparation of chrome yellow pigment
7. Analysis of saw dust: Estimation of total cellulose
8. Determination of sucrose content in sugar
9. Analysis of lime, alum, activated carbon and coal
10. Determination of available chlorine in bleaching powder and hypochlorite
11. Determination of flash and fire point
12. Calibration of refractrometer
13. Calorific value of gas using gas calorimeter
14. Redwood viscometer, Saybolt viscometer, Ostwald viscometer
15. Conductivity meter calibration
16. Bomb Calorimeter
17. Smoke point apparatus

CH010 508 MECHANICAL OPERATIONS LAB

Teaching Scheme **Credits: 2**

3 hours practical per week

1. Calculation of Screen Effectiveness using Sieve analysis
2. Sub sieve analysis
3. Analysis of Elutriation
4. Determination of the efficiency of crushing of a Jaw crusher and validate Bonds Law
5. Determination of the efficiency of crushing Roll crusher
6. Determination of the efficiency of crushing Hammer mill
7. Analysis using Ball mill
8. Calculation of the efficiency of a Cyclone separator
9. Calculation of the rate of Filtration using a Leaf filter
10. Calculation of the rate of Filtration of a Plate and frame filter press
11. Calculation of the rate of Filtration of a Rotary vacuum filter
12. Design of a Continuous Thickener by using principle of Sedimentation
13. Ribbon mixer
14. Pulverizer

SIXTH SEMESTER

CH010 601 MASS TRANSFER OPERATIONS II

Teaching Scheme **Credits: 4**

2 hours lecture and 2 hour tutorial per week

Objectives

- *To impart the basic concepts of mass transport*
- *To develop understanding about Distillation, Extraction, Leaching and ion exchange*

MODULE I (12 hours)

Distillation - boiling-point diagram and equilibrium curves - application of Raoult's law - relative volatility - flash distillation - differential distillation - steam distillation – fractionation - plate columns for distillation - condensers - reboilers - principles of rectification - material and energy balance - reflux ratio and its importance - enthalpy composition diagrams

Design of distillation column - Ponchon-Savarit method - difference points and L/G ratio - number of plates - feed plate location - minimum reflux conditions, total reflux, and optimum reflux.

MODULE II (12 hours)

Design of fractionation columns by McCabe-Thiele method - basic assumptions - number of plates - feed quality and feed line - feed plate location - total reflux -minimum reflux - optimum reflux - cold reflux - open steam - intermediate streams - rectification of partially miscible mixtures - comparison of McCabe-Thiele and Ponchon-Savarit methods – plate efficiency - relation between Murphree and overall efficiency - rectification in packed columns - height of packed towers - azeotropic and extractive distillation (qualitative treatment only)

MODULE III (12 hours)

Liquid extraction - liquid-liquid equilibrium data, single stage extraction, cross current counter-current multistage extraction (without reflux only) stage efficiency, stage type extractors and extraction equipments. Design of packed extraction towers.

MODULE IV (12 hours)

Leaching - solid-liquid equilibria, leaching equipment for batch and continuous operations, calculation of number of stages. Leaching by percolation through stationary solid beds, moving bed leaching, counter current multiple contact (Shanks process), equipments for leaching operation, multistage continuous cross current and counter current leaching, stage calculations, stage efficiency.

Module V (12 Hours)

Ion Exchange : Principles of ion exchange techniques and application - Ion exchange Equilibira - Rate of ion exchange, ion exchange resins ion exchange equipments.

Membrane separation process – classification- types of membranes- flat, spiral wound hollow fiber,- dialysis – per evaporation reverse osmosis effect of operating variables concentration polarization- ultra filtration

TEXT BOOKS

1. Treybal R.E, Mass Transfer Operations, 3rd Edn., International Student Edition, Mc Graw Hill International, 1981.
2. McCabe, W.L. and Smith, J.C., Unit Operation of Chemical Engineering, 6thEdn., McGraw Hill, New York, 2001.
3. K V Narayanan, " Mass Transfer Theory and Application" CBS Publisher
4. Binay K Dutta, "Mass Transfer and separation process", Nirali Prakashan.

REFERENCES

1. Geankoplis C.J, Transport Processes and Unit Operations, 3rdEdn., Prentice Hall Inc., 1993.
2. Badger & Benchero, Introduction to Chemical Engineering, Tata Mc Graw Hill, 6threprint, 2001.
3. Foust, A.S., Wenzel, L.A., Clump, C.W., Naus, L. and Anderson, L.B., Principles of Unit operations, 2nd Edn., Wiley, 1980.
4. K.A. Gavhane, Mass Tansfer II, Nirali Prakashan

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CH010 602 ENVIRONMENTAL ENGINEERING

Teaching Scheme **Credits: 4**

3 hours lecture and 1 hour tutorial per week

Objectives

- *To impart the knowledge of importance in Environmental protection.*

MODULE I (12 hours) Environment

Introduction - Abiotic origin - Origin of the Universe- The radiation era- The matter era -The life era - Nucleo synthesis - Solid earth - Formation of the Earth - Zonal structure of the earth Differentiation of Elements - Hydrosphere - Atmosphere - Biosphere -Units of measurement liquids and gases - Law of conservation of mass and energy- Chemical equilibria - Nuclear Chemistry. Impact of man on the environment.The hydrologic cycle and measurement of precipitation, the nutrient cycle, Mathematics for Growth- Consequence of population growth -

Energy problem. Importance of environment for mankind. Pollution of air, water and soil. Dangers of pollution and its solution.

MODULE II (12 hours) Air Pollution

Air pollution: Sources and effects - Nature of air pollution classification, properties and sources of pollutants. Acid rain - Greenhouse effect- Ozone depletion - Effects on man, animal, vegetation and material dangers. Atmospheric stability, lapse rates, inversions, plume behavior, theory of pollutant dispersion-Air quality criteria and standards, methods of pollutant sampling and measurement. Control methods for particulate emulsions and pollutants - Design aspects of Cyclone separator, Electrostatic precipitator- Bag house filter - Scrubbers - Indoor Air Pollution Control.

MODULE III (12 hours) Water Pollution

Sources and classification of water pollutants and thier effects. Sampling and analysis. Waste water treatment: Design aspects of preliminary, primary, secondary and tertiary treatment of waste water. Recovery of materials from process effluents. -Anaerobic and aerobic Sludge treatment and disposal- Cake filtration and composting - Methods of physico-chemical and biological treatment of industrial effluents from fertilizer, petrochemical, pulp and paper, caustic soda, tanning and sugar industries. Alternate routes of manufacture and sequencing of operations as a means of pollution control. Alternate use for by product as means of pollution control.- Advanced treatment methods reverse osmosis and carbon adsorption.

MODULE IV (12 hours) Solid Waste Management

Sources, classification and microbiology of solid waste. Solid waste characteristics- Health Aspects, methods of collection and disposal, Solid waste processing and recovery - composting. Sanitary land filling, thermal processes, regeneration and recycling. City waste and industrial Wastes management- Nuclear waste : Sources and nature of nuclear waste, treatment, storage technology for liquid, solid and gaseous (ration active) wastes.

Noise control: Noise control program, noise control criteria, administrative and engineering controls, acoustical absorptive materials.

MODULE V (12 hours) Rules and Acts on Environment

Legislation: Legislative aspects including water (Prevention and control of pollution) Act 1974, Air (prevention and control of pollution) Act 1981, Environmental protection Act 1986 and effluent standards. Environmental Management - ISO standards - Ecomark - Green production- Kyoto protocol- Montreal Protocol - Euronorms etc Environmetnal Impact assessment- Environmental agencies - standards and legal aspects in Environmental Management.

TEXT BOOKS :

1. Venkateswaralu, "CHEMTECH-1", CEED, IIT Madras.
2. C.S. Rao, "Environmental Pollution Control Engineering", Wiley Eastern Ltd.
3. A, D, Bhide and B. B Sundaresan, "Solid Waste Managment in Developing countries",

INSDOC, New Delhi - 67.
4. Arcadio P. Sincero and Gregoria A.Sincero, "Environmental Engineering - A design approach ", Eastern Economy Edition- PHI.

REFERENCES:

1. Metcalf and Eddy, "Waste Water Engineering", TMH
2. R. M. Berthe, Van Nostrand Reinhold, "Air Pollution Control Technology", 1978.
3. M. N. Rao and H.V.N. Rao, "Air pollution", Tata McGraw Hill.
4. W. Straus, "Industrial Gas Cleaning", Pergamon Press Ltd.
5. Cunniff P.F, "Environmental Noise Pollution", John Wiley.
6. Mantell C.L., "Solid Wastes: Origin, Collection, Processing, Disposal ", John Wiley.
7. Mahajan S.P, "Pollution Control in Process Industries, TMH.
8. R. K. Trivedi, "Pollution Management in Industries", Environmental Publications, P.B. 60, Karad, 415110.
9. S.C.Bhatia, "Environmental Pollution and Control in Chemical Process Industries", Khanna Publishers.
10. Santhosh Kumar Garg, "Environmental Engineering", (Vol I and II) Khanna Publishers, New Delhi, 2004.
11. P. Venugopal Rao, "Text book of Environmental Engineering", PHI, New Delhi 2002.
12. J. P. Sharma, " Comprehensive Environmental Studies", Laxmi Publications, New Delhi 2004

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CH010 603 CHEMICAL TECHNOLOGY II

Teaching Scheme **Credits: 4**

2 hours lecture and 2 hour tutorial per week

Objectives

- *To understand the manufacture methods of Organic materials in process industries.*

MODULE I (10 hours)

Pulp and paper: Manufacture of pulp, mechanical and semi-mechanical and chemical methods - bleaching - paper making, recovery of chemicals from spent liquor, by-products and their uses. Perfumes, flavours and cosmetics. Wood and Wood chemicals: Saccharification of wood, destructive distillation of wood. Composite wood: - plywood, laminated wood, fibre board and particle board.

MODULE II (12 hours)

Manufacture of sugar, starch and starch derivatives,

Sugar: Manufacture from sugar cane and sugar beet, refining of crude sugar, byproducts of sugar industry.

Starch: Raw materials, manufacture from corn, maize, tapioca. Manufacture of Dextrin and Dextrose. Fermentation Products: Manufacture of alcohol, alcoholic beverages and High Fructose Corn Syrup (HFCS).

MODULE III (12 hour)

Pesticides:- Classification of Insecticides, Fungicides, Weedicides, Herbicides and Rodenticides. Manufacture of Malathion, Parathion, DDT, BHC, and Endosulfan. Dyes and intermediates: Classification, unit processes and unit operations in the manufacture of dyes, pigments and brighteners. Drugs and Pharmaceuticals: Classification, raw materials and manufacture of important sulpha drugs, analgesic, antipyretic, antibiotics and anti-inflammatory drugs. Formulations of Tablets, Capsules, Ointments, Liquids and Parenterals. Phytochemicals.

MODULE IV (12hours)

Organic surface coatings - raw materials, formation and manufacture of paints, varnishes, enamels and lacquers. Leather: leather making, vegetable tanning and chrome tanning - finishing operations - chamois leather. Oils, fats and waxes:-Manufacture of Vanaspati, Edible and essential oils: raw materials, manufacture, expelling methods, solvent extraction and refining.Soaps and detergents: Soap manufacture by fat splitting – by product glycerine and its purification - detergents - anionic and non-ionic - manufacture of alkyl-benzene sulphonates

MODULE V (12 hours)

Polymers - production of thermoplastic and thermosetting materials such as polyethylene, polypropylene, phenolic resins and epoxy resins, natural and synthetic rubbers, rubber compounding Plastics: Classification, techniques of polymerization, manufacture and uses of phenol formaldehyde, urea formaldehyde, polyethylene, poly vinyl resins, cellulose nitrate and cellulose acetate. Processing of plastics. Man made fibres: Manufacture of viscose rayon fibre, cellulose acetate fibres, nylons, polyesters, acrylics and modacrylic fibres, vinyl and vinylidines, glass fibres. Rubber: Manufacture of natural and synthetic rubbers. Styrene butadiene rubbers (SBR), acrylonitrile butadiene rubber (NER), polymethanes, silicon rubbers, polybutadiene. Compounding, vulcanising and reclaiming of rubber, processing of rubber.

TEXT BOOKS

1. George T Austin, Shreve's Chemical Process Industries- International Student Edition, 5th Edn.., Mc Graw Hill Inc., 1985.
2. Gopal Rao, R. and Sittig, M., Dryden's Outlines of Chemical Technology, 3rd Edn. Affiliated East-West Publishers, 1997.
3. Chem Tech IV, IIT Madras,

REFERENCES

1. Shukla, S.D. and Pandey, G.N., Text book of Chemical Technology, Vol.I, 1977.

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CH010 604 PROCESS DYNAMICS AND CONTROL

Teaching Scheme **Credits: 4**

3 hours lecture and 1 hour tutorial per week

Objectives

- *To impart the basic concepts of controllers used in chemical process industries.*

MODULE I (12 hours)

Introduction to process dynamics and control - definition of terms - Laplace transforms - Transform of simple functions - derivatives and integral - properties of Laplace transforms – final value theorem - initial value theorem - transition of translational functions - examples - inversion by partial fraction - solution of differential equations - qualitative nature of solutions - linear open loop systems

MODULE II (12 hours)

First order systems - mercury thermometer, liquid level and mixing processes - response to different types of forcing functions - systems in series - interacting and non-interacting types and generalization of results -Linear open loop systems - second order systems – mercury thermometer in a well and manometer - impulse and step response of under damped, critically damped and over damped System and their derivation

MODULE III (12 hours)

Closed loop system - servo and regulator problems - block diagram development – block diagram reduction - controllers - types, basic principles and transfer Functions - the flapper nozzle assembly - pneumatic & electronic controllers - PID, PI and PD (Derivation excluded) - Supervisory Control And Data Acquisition (SCADA) - Distributed Control system (DCS)

MODULE IV (12 hours)

Transient response of simple control systems - step response and offset - introduction to Stability of linear systems - Routh-Hurwitz criterion for stability - root locus technique - Plotting the root locus diagram - transportation lag and its effect on root locus diagram

MODULE V (12 hours)

Introduction to frequency response - substitution rule - Bode diagram for first order systems - first order systems in series - second order systems - Bode stability criterion, gain margin and Phase margin - controller tuning- Ziegler-Nichols method - reaction curve method – Comparison of closed loop responses for different controller settings. Basic principles of advanced control systems: cascade control, ratio control adaptive control, inference control and fuzzy logic.

TEXT BOOKS:

1. Coughanewr D.P., Process System Analysis & Control, McGraw Hill
2. Stephanopoulose G., Chemical Process Control, an Introduction to Theory & Practice, Prentice Hall

REFERENCES:

1. Harriot P., Process Control, Tata McGraw Hill
2. Ceaglske N.H., Automatic Process Control for Chemical Engineers
3. Eckman D.P., Principles of Industrial Process Control
4. Tsai T.H., Lane J.W. & Lom C.S., Modern Control Techniques for the Processing Industries, Marwel Dekker
5. Albert C.L. & Coggen D.A., Fundamentals of Industrial Control, ISA

***UNIVERSITY EXAMINATION PATTERN*:** Question Paper consists of Part A, Part B and Part C. Part A is for 15 marks and comprises of 5 compulsory short answer questions, each carrying 3marks, covering the entire syllabus. Part B is for 25 marks, comprises of 5 compulsory questions from each module. And Part C is for 60 marks candidate has to answer one full question of 12 marks from each module**.**

CH010 605 CHEMICAL REACTION ENGINEERING II

Teaching Scheme **Credits: 4**

2 hours lecture and 1 hour tutorial per week

Objectives

- *To impart the basic concepts of non isothermal and heterogeneous chemical reaction engineering*

MODULE I (12 hours) Non isothermal reactor design

Temperature and pressure effects - single reactions: Heat of Reaction from thermodynamic, heat of reaction and temperature, equilibrium constants from Thermodynamics, equilibrium conversion, adiabatic temperature and equilibrium, general Graphical design procedure, optimum temperature progression.

MODULE II (12 hours) Heat effects:
adiabatic operations and non-adiabatic operations, Non-isothermal continuous flow, Reactors at steady state, application to the CSTR, adiabatic tubular and batch reactor, steady state Tubular reactor with heat exchange. Product distributions and temperature for multiple reactions. Unsteady state operation: General design equations, unsteady operations of plug flow reactors, CSTR and batch reactors.

MODULE III (12 hours) Heterogeneous Reactions
Catalysis and catalytic reactors**:** Catalysts, types of catalysts, catalyst properties, steps in a Catalytic reaction, adsorption equilibrium constant, desorption, surface reaction, rate limiting step, Contacting patterns for two phase systems. Development of design equations for ideal mixed batch reactor, plug flow tubular reactor and Perfectly mixed continuous stirred tank reactor for heterogeneous systems. Heterogeneous data Analysis for reactor design, deducing the rate laws from the experimental data, catalyst Deactivation, deactivation mechanisms, weight loss. Diffusion and reaction in porous catalysts- effective diffusivity, tortuosity-modelling of diffusion With reaction on a spherical catalysts. Thiele Modulus, internal effectiveness factor, Overall Effectiveness factor. Estimation of diffusion and reaction limited regimes - Weisz - Prater Criterion for internal diffusion, Mears criterion for external diffusion.

MODULE IV (15 hours) Fluid Particle Reactions (Non catalytic)
Selection of a model: Unreacted core model for spherical particles of unchanging size, model Development for diffusion through gas film, ash layer, and chemical reaction controls. Rate of reaction for shrinking spherical particles - chemical reaction controls, diffusion controls application to design. Fluid-fluid reactions - Rate equations, Kinetic regimes for mass transfer and reactions, rate Equation for instantaneous and fast and slow reactions, two film theory, film conversion Parameters.

MODULE V (12 hours) Non-ideal Flow
Residence time distribution for chemical reactors: General characteristics - RTD functions. Measurement of the RTD - pulse input, step tracer input, integral relationships, mean residence Time, other moments of the RTD, Normalized RTD function E(theta), Interval age distribution. RTD in ideal reactors: Batch and plug flow reactors, single CSTR RTD, Laminar flow reactor, PFR/CSTR series RTD. Reactor modeling with RTD - use of RTD to determine conversion. RTD models - segregation models, tanks in series model, the dispersion model. Conversion for the tanks-in-series model, fitting the dispersion model for small extents of dispersion and large extents of dispersion. Models for small deviations from plug flow and long tails. Mixing of fluids - self mixing of fluids - degree of segregation, early and late mixing of fluids.

TEXT BOOKS:

1. Levenspiel Octave, "Chemical Reaction Engineering, Third Edition", John Wiley & Sons
2. H, Scott Fogler, "Elements of Chemical Reaction Engineering", Prentice Hall of India
3. James J Carberry, "Chemical &Catalytic Reaction Engineering", Mc Graw Hill Lim.
4. Smith "Chemical &Catalytic Reaction Engineering"

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ELECTIVE I

CH010 606L01 MATERIAL SCIENCE AND ENGINEERING

Teaching Scheme **Credits: 4**

3 hours lecture and 1 hour tutorial per week

Objectives

- *To impart the basic concepts of material science*
- *To develop understanding about selection based on properties for various applications*

MODULE I (13 hours)

Structure of atom-present concept of atom-Rutherford's and Bohr's model-Bonding in solids-Types of solids-crystalline and amorphous solids-crystal systems-Bravais lattices-miller indices coordination number-crystal defects-determination of crystal structure-X-ray diffraction-electron diffraction methods-properties of engineering materials-mechanical properties -isotropy and anisotropy-elasticity, plasticity, toughness, resilience, tensile strength, ductility, malleability, brittleness, hardness, fatigue, creep, wear resistance- Poisson's ratio-stress-strain relation-true stress and true strain- technological properties-castability, machinability, weldability, solderability, workability,formability

MODULE II (13 hours)

Phase diagrams and transformations - phase rule, single and binary phase diagrams, Micro structural changes during solidification, iron and iron carbide phase diagrams, zone refining. - eutectic systems-peritectic system, eutectoid and peritectoid systems.

Solid solutions-types of solid solutions-Hume Rothery rules-intermediate phases-mechanical mixtures systemsiorn –

carbon diagram-T-T-T diagram-plastic deformation-recrystallisation-hot and cold working of metals,Heat treatments-elementary study of various metals and alloys like cast iron,carbon steel,alloy steels.

MODULE III (13 hours)

Non-ferrous metals and alloys-aluminium and its alloys-copper and its alloys-Non ferrous metals and alloys used for high temperature services and nuclear application-organic polymers and its properties-ceramics-classification-comparison of ceramic and non-ceramic structures-properties and application of ceramics-composite materials-classification-general characteristics.
Factors effecting the selection of materials in the engineering purposes in chemical industries.

MODULE IV (13 hours)

Fracture: Bonding forces and energies, cohesive strength of metals - Griffith theory –- Crack initiation, growth and crack arrest – Effect of plastic deformation on crack propagation – Factors leading to crack propagation - Cleavage, intercrystalline, brittle, ductile fracture --Influence of slip on fracture – Effect of impact loading on ductile material and its application in forging etc.-- Fatigue: stress cycles – Effects of stress concentration, size effect, surface texture on fatigue – Corrosion and thermal fatigue – Mechanism of fatigue failure -- Creep: Creep curves – Structural change – Mechanism of creep deformation.

MODULE V (12 hours)

Thermal, electrical, optical and magnetic properties-resistivity -conductivity-ionic and electrical conductivity, semiconductors, superconductivity, insulators, ferroelectricity, piezoelectricity, magnetization, paramagnetism, ferromagnetism, and diamagnetism - solar cells, superconductors, Polarization, frequency and temperature dependence of dielectric constant, piezo and Ferroelectricity, optical absorption, optoelectronic materials. Ferri and ferromagnetism, Soft and hard magnetic materials (Fe-Si, Fe- Ni alloys, Al-Ni-Co alloy and ceramic Magnets).

TEXT BOOKS:

1. Van Vlack M., Materials Science for Engineers, Addison Welsey Publishing Company, UK, 1980.
2. William D Callister " Material Science and Engineering", Wiley Publisher
3. Hajra Choudhary, S.K., Material Science and Processes, 2nd Edn. Indian Book Distributing Co., Calcutta, 1982.
4. A.K.Gupta & R.C.Gupta., "Material Science" S. Chand & Company Ltd.
5. Chilton &Perry, Chemical Engineers Handbook
6. Nanocomposite science and technology, Pulikel M. Ajayan, Wiley-VCH 2005

REFERENCES

1. Rose M. Shepard, John Wulff, The Structure and Properties of Materials, Vol.4 (Electronic properties), Wiley, Singapore, 1984.
2. Adrianus J. Dekker, Electrical Engineering materials, Prentice H Delhi, 1992.
3. Anderson, J.C., Keith D. Leaver, Rees D. Rawlings, Patrick S. Leevers, Material Science for Engineers, 5th Edn. Nelson Thornes Ltd., UK

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CH010 606L02 BIOINFORMATICS

Teaching Scheme **Credits: 4**

3 hours lecture and 1 hour tutorial per week

Objectives

- *To impart the basic concepts of bioinformatics.*

MODULE I (12 hours)

Biology for Bioinformatics: - Basic concepts - cells- Archaebacteria, Biomembranes, Nucleus, Organelles, Mitochondria, Chloroplasts, Viruses, Bacteriophage, Genetic contents of a cell - Viral Proteins - Amino acid, DNA and RNA - Forms of DNA. Genetic Code: - Genome - Gene Expressions - Protein Synthesis - Transcription RNA - Processing- Capping- Splicing - Editing, Cell Signalling, DNA cloning Genomic library - cDNA Library - Probes - Screening.

MODULE II (12 hours)

Bioinformatics basics: Computers in biology and medicine; Importance of Unix and Linux Systems and its basic commands; Database concepts; Protein and nucleic acid databases; Structural databases; Biological XML DTD's; Pattern matching algorithm basics; Computational tools for DNA sequence analysis: GCG: The Wisconsin package of sequence analysis programs; Web-based interfaces for the GCG sequence analysis programs.

MODULE III (12 hours)

Databases and search tools: Biological back ground for sequence analysis; Identification of Protein sequence from DNA sequence; Searching of databases similar sequence; The NCBI; Publicly available tools; Resources at EBI; Resources on the web; Database mining tools. DNA sequence analysis: The gene bank sequence database; Submitting DNA sequence to the Databases and database searching; Sequence alignment; Pair wise alignment techniques; Multiple Sequence analysis; Multiple sequence alignment; Flexible sequence similarity searching with the FAST3 program package; Use of CLUSTAL W and CLUSTAL X for the multiple sequences Alignment; Submitting DNA protein sequence to databases: Where and how to submit, SEQUIN, Genome centers; Submitting aligned set of sequences, updates and internet resources.

MODULE IV (12 hours)

Protein Modeling: Introduction; Force field methods; Energy, Buried and exposed residues; Side chains and neighbors; Fixed regions; Hydrogen bonds; Mapping properties onto surfaces; Fitting monomers; rms fit of conformers; assigning secondary structures; Sequence alignment methods, Evaluation, scoring; Protein completion: backbone construction and side chain addition; Small peptide methodology; Software accessibility; Building peptides; Protein displays; Substructure manipulations, Annealing. Peptidomimetics: Introduction, classification; Conformationally restricted peptides, design, Pseudopeptides, peptidomimetics and transition state analogs; biologically active template; Amino acid replacements; Peptidomimetics and rational drug design; CADD techniques in Peptidomimetics; Development of non peptide peptidomimetics.

MODULE V (12 hours)

Protein Structure Prediction: Protein folding and model generation; Secondary structure Prediction; Analyzing secondary structures; Protein loop searching; Loop generating methods; Loop analysis; Homology modeling: potential applications, description, methodology, Homologous sequence identification; Align structures, align model sequence; Construction of Variable and conserved regions; threading techniques; Topology fingerprint approach for Prediction; Evaluation of alternate models; Structure prediction on a mystery sequence; Structure Aided sequence techniques of structure prediction; Structural profiles, alignment algorithms, Mutation tables, prediction, validation, sequence based methods of structure prediction, Prediction using inverse folding, fold prediction; Significance analysis, scoring techniques, Sequence-sequence scoring. *The virtual library:* Searching MEDLINE, Pubmed, current content, Science citation index and current awareness services, electronic journals, grants, and funding Information.

TEXT BOOKS:

1. David W. Mount, Bioinformatics: Sequence and Genome Analysis 2nd Edition, CSHL Press, 2004.
2. Baxevanis A. and Ouellette F. B. F., Bioinformatics: a practical guide to the Analysis of genes and proteins, 2nd Edition, John Wiley, 2001.
3. Jonathan Pevsner, Bioinformatics and Functional Genomics, 1st Edition, Wiley- Liss, 2003.
4. Bourne P. E. and Weissig H., Structural Bioinformatics, 2nd Edition, Wiley, 2008.
5. Branden C. and Tooze J., Introduction to Protein Structure, 2nd Revised Edition Garland Publishing, 1998.

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CH010 606L03 FERTILIZER TECHNOLOGY

Teaching Scheme **Credits: 4**

2 hours lecture and 2 hour tutorial per week

Objectives

- *To impart the knowledge about fertilizer production*

MODULE I (12 hours)

Introduction, history and development, classification - chemical, organic, inorganic and biofertilizers. Solid and liquid fertilizers. Fundamentals of nutrient management, primary, secondary and micronutrients, economics of plant nutrient use. Basic soil plant relationships, Nutrient availability in soil, fertilizer usage, fertility evaluation of soil. Manufacture of fertilizers and their intermediates: Ammonia manufacture, manufacture of urea by once through process and total recycle process, ammonium sulphate manufacture from coke-oven gas and by direct neutralisation.

MODULE II (12 hours)

Manufacture of nitrogenous fertilizers - ammonium chloride, ammonium sulphate, and ammonium nitrate, ammonium phosphate, calcium ammonium nitrate, barium nitrate, nitro chalk and urea. Phosphatic fertilizers - phosphate ore beneficiation, phosphoric acid manufacture by wet process and electric furnace process. super phosphates - single and triple super-phosphate. Potassium fertilizers - basic slag, potassium chloride, potassium sulphate.

MODULE III (12 hours)

Compound and complex fertilizers:- MAP and DAP, urea ammonium phosphate, ammonium phosphate sulphate, nitro phosphates, NPK fertilizers. Other fertilizers: Mixtures and granulated products, granulation techniques. Fluid/liquid fertilizers - Urea Ammonium Nitrate, Super phosphoric Acid, Ammonium polyphosphate, controlled release fertilizers.

MODULE IV (12 hours)

Biofertilizers: rhizobium, blue green algae, azospirillum, azolla, acetobactor and phosphate solubilizing bacteria. Organic farming Vs chemical farming. Sampling and analysis of fertilizer, Grading, regulations,

MODULE V (12 hours)

Consumption pattern, optimum dosage/fertilizer management system, storage and handling pricing and their manufacturing industries in India. Safety, health and environment – Corrosion in fertilizer industries, green house emission, effluent treatment and disposal.

TEXT BOOKS:

1. Austin G.T. "Shreves Chemical Process Industries" 3rd Edn.
2. Chemtech Vol. II

3. Gopal Rao, R. and Sittig, M., Dryden's Outlines of Chemical Technology, 3rd Edn. Affiliated East-West Publishers, 1997.

REFERENCES

1. Ferman E Bear., "Chemistry of soil"
2. John L Havlin, James D Beaton, Samuel L Tisadale, Werner L Nelson., "Soil fertility and Fertilizers". PHI publications
4. Nyle C Brady., "Nature and properties of soil", Eureshia publication
5. Govt. of Kerala proceedings of the national workshop on fertility evaluation for soil health Enhancement.
6. Fertilizer Manual., United Nations Industrial Development Organization (UNIDO) & International Fertilizer. Development Center (IFDC)., Kluwer Academic Publishers.
7. Pitam Singh & U.S. Awasthi "Fertilizer Industry in India", Karishma publishers.
8. Bench mark, "Soils of Kerala", soil survey organization, Agriculture unit.

***UNIVERSITY EXAMINATION PATTERN*:** Question Paper consists of Part A, Part B and Part C. Part A is for 15 marks and comprises of 5 compulsory short answer questions, each carrying 3marks, covering the entire syllabus. Part B is for 25 marks, comprises of 5 compulsory questions from each module. And Part C is for 60 marks candidate has to answer one full question of 12 marks from each module**.**

CH010 606L04 ENERGY ENGINEERING

Teaching Scheme **Credits: 4**

2 hours lecture and 2 hour tutorial per week

Objectives

- *To impart the knowledge of energy source and conservation*

MODULE I (12 hours)

Classification and sources of energy; problems relating to demand and supply of various energy sources- Energy, Economics and environment relations- GDP coupling- Coal: origin and formation, composition and classification, resources and production, exploration and mining; analysis and testing storage and handling- coal carbonization-briquetting,-coal hydrogenation-wood and wood products.- Petroleum; origin, occurrence; Chemical composition.-

MODULE II (12 hours)

World reserve, production, refining operations, storage and conveying, testing and analysis different products from petroleum like naphtha, aviation gasoline, kerosene, diesel oil, gas oil, lubricating oil, asphalts etc., petroleum coke, oil shale and oil sand- Combusting methods; and systems, pulverized coal furnaces; cyclone furnaces, oil fired systems, gas fired systems, waste heat boilers.

MODULE III (12 hours)

Nuclear energy: basic aspects of nuclear radiation, fission and fusion, process reactor systems; BW/PW/HW reactor; gas cooled reactors, fast breeder reactor; thermal design; problems of nuclear power generation and remedial measures. Solar energy: Facts and scope; solar radiation; radiation measuring instruments; basic flat collector; solar heat pump and heat engine cooling and refrigeration; solar pond

MODULE IV (12 hours)

Conversion of solar energy into electrical energy; solar thermal power generation; hydroelectric energy; Problems of hydro-electric energy and remedial measures. Thermal power plants, generation cycles, energy from ocean tidal wave, ocean thermal source; geothermal energy; wet steam and water, hot dry rocks, electricity from exothermal; sources; wind energy; tunnel mills and conversion cycles.

MODULE V (12 hours)

Biogas plant and its design: KVIC plants, process kinetics, digester design, sludge treatment, energy from wastes. Development in energy routes-Conversion of heat to power: Thermoelectric converters; thermo-electric refrigerators, magneto-hydrodynamics.

Fuel cells; Conversion of chemical energy into electricity, fuel cell performance; energy accounting utility and process system optimization

Energy audit, energy economics, reducing energy loss, co-generation, efficiency improvement; Energy conversion in petrochemical industries, Polymer industries, Natural organic industries, fertilizer industries etc.

TEXT BOOKS

1. S.B Pandya, Conventional Energy Technology - Fuels and chemical Energy - TMH (1987)
2. S.P. Sharma and Chander Mohan, Fuels and Combustion, TMH, 1984
3. Kash Kori, C., Energy resources, demand and conservation with special reference to India, TMH, 1975.
4. J.Twidell and T.Weir, Renewable Energy Sources, Cambridge University Press

REFERENCES:

1. Gulp Jr., Principles of Energy Conservation, MGK (1979)
2. Chemtech I, Manual of Chemical Technology, Vol.I. S. chand and Co., New Delhi (1985)
3. Pryde P.R., Non Conventional energy resources" JW (1983)
4. Connolly, T.J., Foundation of nuclear engineering JW (1978)
5. Gray T.J. and Gashos G.K., Tidel Power,Plenum Press (1972)
6. Sarkar S., Fuels and Combustion, Orient Longmahs (1974)
7. Duffie T.R. and Beckman, W.A., Solar Energy Thermal Processes JW (1974).

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CH010 606L05 MODELING AND SIMULATION IN PROCESS INDUSTRIES

Teaching Scheme **Credits: 4**

2 hours lecture and 2 hour tutorial per week

Objectives

- *To impart the basic concepts of development of mathematical models for chemical process*
- *To develop basic concepts in simulation.*

MODULE I (10 hours)

Introduction to modeling. Basic modelling principles - uses of mathematical modelling - classification of modeling techniques - fundamental laws - energy equations - continuity equation - equations of motion - transport equations - equations of state - equilibrium states and chemical kinetics – examples. Development of steady state lumped parameter models. Dynamic lumped parameter models based on first principles.

MODULE II (14 hours)

Mathematical models for chemical engineering systems - continuous flow tanks - enclosed vessel - mixing vessel - mixing with reaction - reversible reaction - steam jacketed vessel - boiling of single component liquid - open and closed vessel - continuous boiling - multicomponent boiling system - batch distillation

MODULE III (12 hours)

Analysis of ill-conditioned systems. Development of Grey-box models, Empirical model building. Statistical model calibration and validation. Population balance models, Stochastic models. Examples.

MODULE IV (10 hours)

Solution strategies for lumped parameter model. Stiff differential equations solutions. Solution for distributed parameter models. numerical integration - Euler and fourth order Runge Kutta methods -Solving parabolic, elliptic and hyperbolic partial differential equation models, Finite element and finite volume methods.

MODULE V (12 hours)

Digital simulation - simulation of gravity flow tank - CSTR in series - non isothermal CSTR - binary distillation column - batch reactor

TEXT BOOKS:

1. K. M. Hangos and I. T. Cameron, *Process Modelling and Model Analysis*, Academic Press, 2001
2. W. L. Luyben, *Process Modeling, Simulation and Control for Chemical Engineers*, 2nd edition, McGraw Hill Book Co. New York, 1990.

REFERENCES:

1. W. F. Ramirez, *Computational Methods for Process Simulation*, Butterworhs
2. Mark E. Davis, *Numerical Methods and Modelling for Chemical Engineers*, John Wiley andSons, 1984.
3. Singiresu S. Rao, *Applied numerical Methods for Engineers and Scientists*, Prentice Hall, NJ,2001
4. Franks R.G.E., Mathematical Modeling in Chemical Engineering, John Wiley
5. John Ingham et.al., Chemical Engineering Dynamics- Modeling with PC Simulation, VCH Publishers
6. Biquette W.B., Process Dynamics - Modeling Analysis and Simulation, Prentice Hall

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CH010 607 ENVIRONMENTAL ENGINEERING LAB

Teaching Scheme **Credits: 2**

3 hours practical per week

1. Determination of the hardness of water.
2. Determination of dissolved oxygen in water.
3. Determination of total nitrogen and ammoniacal nitrogen.
4. Determination of TDS and VSS of a waste water sample.
5. Estimation of COD,BOD and DO
6. Estimation of alkalinity, chloride ions in water

7. Estimation of ferrous and sulphate ions in a given sample using spectrophotometer
8. Sampling and analysis of solid waste
9. Sampling and analysis of flue gas
10. Bacterial growth kinetics
11. Electro-deposition of heavy metals
12. Flocculation studies
13. Clarifier
14. Bio-leaching
15. Determination of Sludge Volume Index
16. Analysis of oil and grease in waste water sample.
17. Determination of Fluoride, Silica, Sodium, calcium, potassium, magnesium, sulphide, sulphate, phosphate, nitrate, iron and heavy metals.
18. Flame photometer
19. Spectrophotometer
20. pH meter
21. Mercury analyzer
22. Polari meter

CH010 608 HEAT TRANSFER OPERATIONS LAB

Teaching Scheme **Credits: 2**

3 hour practical per week

1. Thickness of insulation
2. Radiation constant and emissivity of solids
3. Thermal conductivity of materials
4. Transient conduction
5. Stefan-Boltzmann constant
6. Heat transfer in double-pipe exchanger - parallel and counter current flow
7. Heat transfer in shell and tube exchanger
8. Condensation on vertical and horizontal surfaces
9. Heat transfer by natural and forced convection
10. Heat exchange in jacketed kettles
11. Heat transfer in agitated vessels
12. Open pan evaporation
13. Single and multiple effect evaporation

SEVENTH SEMESTER

CH010 701 CHEMICAL ENGINEERING DESIGN& DRAWING I

Teaching scheme **Credits: 4**

2 hours lecture, 1hour tutorial & 2 hours drawing per week

Objectives

- *To impart the basic concepts of chemical engineering drawing, mechanical design and process design of evaporators*
- *To develop understanding about P&ID, I&C drawing, pressure vessel design, storage tank design and heat exchangers*

MODULE I (18 hours)

Introduction to chemical engineering drawing – P&ID symbols and drawings – I&C drawing of heat exchangers, distillation columns and stirred tank jacketed reactors.
Introduction to pressure vessels: stress variation. Mechanical design of pressure vessels and jacketed vessels.Design of pipes- pipe diameter and thickness. Design of pumps

MODULE II (24 hours)

Mechanical design of process equipment: tall columns, column supports & accessories, etc. Mechanical design of non standard flange. Design of storage tanks for Volatile and Nonvolatile liquids.

MODULE III (24 hours)

Process design and detailed drawing of shell & tube heat exchangers and double pipe heat exchanger for single phase streams. Process design of condensers: Tubular horizontal & Tubular vertical for condensation of single vapours.

TEXT BOOKS:

1. B.C Bhattacharya, Introduction to Chemical Equipment Design, CBS Publishers & Distributors, New Delhi.
2. M.V Joshi & Mahajan V.V., Process Equipment Design, 3rd Edn, Mac-Milan & Co. India.
3. Perry. R.H & Green.D.W., Chemical Engineers Handbook, 7th Edn, Mc- Grawhill.

REFERENCES:

1. D.Q.Kern, Process Heat Transfer, Tata Mc-GRAWHILL.
2. J.M.Coulson & J.F.Richardson, Chemical Engineering, Vol.6, 3rd Edn, Butterworth-Heinemann, (Indian print)
3. Ludwig, Applied Process Design for Chemical & Petrochemical Plants, Vol I, II, II,Gulf Publication, London.
4. IS Codes.
5. Bhatt N.D., Machine Drawing, Charator Book Stall
6. Badger & Bancharo, Introduction to Chemical Engineering, McGraw Hill

7. Rase & Barrow, Project Engineering of Process Plants, John Wiley
8. McCabe W.L., Smith J.C., & Harriot P., Unit Operations In Chemical Engineering, McGraw Hill.
9. Treybal R. E., Mass Transfer Operations, McGraw Hill
10. Harriot P., Process Control, Tata McGraw Hill
11. I.S.A. code (P&ID)

Internal Continuous Assessment *(Maximum Marks-50)*

60% - Tests (minimum 2)

30% - Assignments (minimum 2) such as home work, problem solving, group discussions, quiz, literature survey, seminar, term-project, software exercises, drawings, etc.

10% - Regularity in the class

University Examination Pattern

Part A - *Analytical/Problem solving questions with drawing 1 x 30 marks=30 marks*

2 question of 30 marks from first module with choice to answer one.

Part B - *Analytical/Problem solving questions 1 x 35 marks=35 marks*

2 question of 35 marks from second module with choice to answer one.

Part C - *Analytical/Problem solving questions with drawing 1 x 35 marks=35 marks*

2 question of 35 marks from third module with choice to answer one.

Maximum Total Marks: 100

Note: Text book no. 3 &Reference item no. 4 are permitted for the examination.

CH010 702 PROCESS INSTRUMENTATION

Teaching scheme **Credits: 4**

2 hours lecture & 1 hour tutorial per week

Objectives

- *To impart the basic principles and applications of instruments used in process industries.*

MODULE I (10 hours)

Introduction-definition of instrumentation-concept of an instrument-functional elements and functions of an instrument –classification of instruments. Performance characteristics of an instrument like static and dynamic type. Temperature measurement- electrical ,non-electrical, contact and non-contact methods, thermometers of three types like liquid-filled, vapour pressure and gas-filled type, bimetallic thermometers, resistance thermometers, thermocouple type-thermoelectric principles like Seebeck effect, Peltier effect & Thomson effect and the laws of thermoelectricity-thermocouple output measurement. Radiation methods-radiation and optical

pyrometry. Thermistors-resistance characteristics and their application in temperature measurement.

MODULE II (10 hours)

Pressure measurement- manometers of U-tube type, well type and inclined type. Prandtl and air type micromanometers. Barometer method for atmospheric pressure measurement. Low pressure measurement by kenetometer, McLeod gage, thermal conductivity gauge, Pressure measurement using bourdon tube, flat and corrugated diaphragms, and capsules. Measurement of pressure in corrosive fluids using liquid seal and diaphragm seal. Transducers of electrical and mechanical type. Density measurement using constant volume hydrometer and, air pressure balance method, gas density detector and gas specific gravity measuring system.

MODULE III (10 hours)

Flow measurement using head type flowmeters based on differential pressure measurement orificemeter, venturimeter, flow nozzle and pitot tube. Open channel meters like weirs, flumes. Electromagnetic flowmeters. Variable area meters like rotameter and cone and float type. Mechanical flowmeters of positive displacement type like rotating disk and turbine type & anemometers

MODULE IV (10 hours)

Level measurement-direct type and indirect type. Differential pressure method for pressurized vessels. Solid level detectors. Moisture content and humidity definition, moisture content determination by thermal drying. Instruments for measuring humidity like hygrometer, psychrometer, dew point apparatus. pH measurement using calomel electrode

MODULE V(10 hours)

Composition analysis using spectroscopic methods like absorption, emission and mass spectrometers.Analysis of solids by X-ray diffraction. Gas analysis by thermal conductivity, polarography & chromatography.

TEXT BOOK:

1. Jain R.K., Mechanical and Industrial Measurements, Khanna
2. Eckman D.P., Industrial Instrumentation, Wiley Eastern

REFERENCES:

1. FRIBANCE, Industrial instrumentation fundamentals, T.M.H. Edition
2. Patranabis, Principles of industrial instrumentation , T.M.H
3. Beckwith and Buck, Measurement systems

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compulsory questions from each module. And Part C is for 60 marks candidate has to answer one full question of 12 marks from each module**.**

CH010 703 TRANSPORT PHENOMENA

Teaching Scheme **Credits: 4**

3 hours lecture and 2 hour tutorial per week

Objectives

- *To impart the basic concepts of transport phenomena*
- *To develop understanding about momentum transport, heat transport and mass Transport*

MODULE I (12 hours)

Viscosity and the mechanisms of momentum transfer: Newton's law of viscosity, molecular momentum transport, generalization of Newton's law of viscosity, pressure and temperature dependence of viscosity of gases and liquids, Energy Transport: Thermal conductivity and the mechanism of energy transport. Diffusivity and the mechanism of mass transport: Definition of concentrations, velocities and mass fluxes, Fick's law of diffusion, kinetic theory of diffusion in gases at low density, theory of ordinary diffusion in liquids. Prediction of transport coefficients - viscosity, thermal conductivity, diffusivity - effect of temperature, pressure and composition on transport coefficients - kinetic theories of viscosity, thermal conductivity and diffusivity of gases - relationship among viscosity, thermal conductivity and diffusivity in gases - prediction of transport coefficients of liquids

MODULE II (14 hours)

Shell momentum balance - boundary conditions - application of shell balance to simple flow systems - falling film - flow through tube - flow through annulus - flow of immiscible liquids in layers - creeping flow around solid sphere - general transport equations for momentum - derivation of continuity equation and equation of motion in rectangular coordinates – Navier Stoke's equation and Euler equation - transport equations in curvilinear coordinates (no derivation) - application of transport equations to steady flow problems - flow through tube - tangential annular flow - rotating liquid - cone and plate viscometer

MODULE III (12 hours)

Shell energy balance - boundary conditions - application of shell balance to heat conduction problems - conduction with electric, nuclear and viscous heat sources - fixed bed flow reactor - cooling fin - heat transfer by forced and free convection - equations of energy in rectangular coordinates - energy equations in curvilinear coordinates (no derivation)

MODULE IV (12 hours)

Shell mass balance - boundary conditions - diffusion through stagnant gas - diffusion with heterogeneous and homogeneous chemical reaction - diffusion into falling film – diffusion and chemical reaction in porous catalyst: the effectiveness factor.

MODULE V (14 hours)

Equation of continuity for binary mixtures in rectangular coordinates - equation of continuity in curvilinear coordinates and multi-component equations of change (no derivation) - application to combined heat and mass transfer, thermal diffusion and pressure diffusion .analogies between heat, mass and momentum transfer- Reynolds analogy, Prandtl analogy, Von karman analogy (no derivation), Chilton Colburn analogy.

Note: The students are permitted to use attested copy of the **tables of general equations: continuity, motion and energy in rectangular and curvilinear coordinates** in the University examination.

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TEXT BOOK:

1. Bird R.B., Stewart W.E. & Lightfoot E.N., Transport Phenomena, John Wiley

REFERENCES:

2. Welty J.R., Wicks C.E. & Wilson R.E., Fundamentals of Momentum, Heat & Mass Transfer, John Wiley
3. Theodore L, Transport Phenomena for Engineers by, International text book Company, U.S.A
4. Geankoplis, Transport processes and unit operations, 3rd, PHI, 1997.
5. John C Slattery, Momentum, Energy and Mass transfer in continua, McGraw Hill, Co.
6. Robert S. Brodkey and Harry C Hersing, Transport Phenomena a Unified approach McGraw Hill Book Co.
7. Bennet C U and Myers J E, Momentum, Heat and Mass Transfer, Tata McGraw Hill Publishing Co.

***UNIVERSITY EXAMINATION PATTERN*:** Question Paper consists of Part A, Part B and Part C. Part A is for 15 marks and comprises of 5 compulsory short answer questions, each carrying 3marks, covering the entire syllabus. Part B is for 25 marks, comprises of 5 compulsory questions from each module. And Part C is for 60 marks candidate has to answer one full question of 12 marks from each module**.**

CH010 704 PEROLEUM REFINERY ENGINEERING AND PETROCHEMICALS

Teaching Scheme **Credits: 3**

2 hours lecture and 1 hour tutorial per week

Objective:

- *To impart the knowledge of various petrochemicals and its production methods*

MODULE I (12 hours)

Petroleum - Origin, nature, composition, classification, exploration, drilling, transportation and storage. Petroleum processing - Nature of crude from India, Indonesia, Burma and Middle East Countries, classification of crude, evaluation of petroleum - Important properties and test Methods T.B.P. and ASTM distillation-Dewatering and desalting- Primary Oil refining - Treatments of crude-Topping, vacuum distillation.

MODULE II (12 hours)

Thermal cracking, visbreaking and coking, catalytic cracking, fluid bed and hydro cracking, reforming, chemical reforming and catalytic reforming, polymerization, alkylation, hydrogenation, isomerisation, cyclization.

MODULE III (12 hours)

Treatment process: sweetening, desalting, hydrogen treatment, hydro desulfurification process, solvent extraction of kerosene, stabilization of gasoline. Lube oil manufacture - solvent dewaxing, solvent extraction, propane deasphalting, and treatment, clay treatment, hydro finishing, hydro treatment, lube oil, additives and asphalt boiling.

MODULE IV (12 hours)

Petroleum products: LPG motor spirit, aviation gasoline, kerosene, aviation turbine fuel, white spirit, and solvents, diesel fuel, gas oil, fuel oil, petroleum coke, petroleum waxes, lubricating oil and bitumen.

MODULE V (12 hours)

Petrochemicals -Olefins, and acetylene, propylene, butadiene, isoprene, aromatics, benzene, xylone, methanol, formaldehyde, chloromethane, ethylene oxide, ethanol amine, acetone, cumene, phenol, styrene, phthalic anhydride.

TEXT BOOKS

1. Venkateswarlu (Ed), CHEMTECH IV -, CEED, Department of Chemical Engg., III Madras.

2. B.K. Bhaskara Rao, Modern Petroleum Refining process -, Oxford IBH Publishing Company, New Delhi.
3. W.L. Nelson, Petroleum Refinery Engg. Mc Graw Hill Lim. 4. R.A.Meyer's Hand Book of Petroleum Refining Process, Mc Graw Hill Ltd

REFERENCES

1. Charles E. Dryden, outlines of Chemical Technology
2. George T Austin "Shreve's Chemical Process Industries", International student edition (5ed) Mc Grawhill
3. S.D. Sukla & G.N. Pandy, A Text Book of Chemical Technology, Vol. II
4. Educational books, Sahibabad 201010 (UP)
5. Encyclopedia of Chemical Technology.
6. N. K.Sinha, Petroleum Refining & Petrochemicals

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CH010 705 ECONOMICS AND MANAGEMENT FOR PROCESS INDUSTRIES

Teaching scheme **Credits: 3**

3 hours lecture & 1 hour tutorial per week

Objectives

- *To impart the basic concepts of economics and management required for process industries.*

MODULE I (13 hours)

Introduction to engineering economy,- engineering decision - makers, problem solving decision making. Interest and interest factors - interest rate, simple interest & compound interest factors. equivalence and cost comparison - time value of money and equivalence - equations used ineconomic analysis - compound interest and continuous interest as una cost - Hoskold'sformula - capitalized cost

MODULE II (12 hours)

Cost comparison with equal and unequal duration of service life depreciation and taxes - nature of depreciation - methods of determining depreciation - straight line - sinking fund - declining balances - double declining balance - sum of years digits and units of production methods - present worth after taxes - cost comparison after taxes

MODULE III (13 hours)

Cost estimation - equipments for process plants - cost indices - construction cost indices material cost indices - labour cost indices - William's sixteenth factor - location index – types of cost estimates - order of magnitude estimate - study estimate - preliminary estimate - definitive estimate - detailed estimate - techniques of cost estimates - conference techniques - comparison techniques graphic relationship - tabular relationship - unit rate techniques – lang factor method - hand factor method - Chilton method - miller method - Peter's and Timmerhaus ratio factor method - check list of items for capital cost estimates, product cost estimates, direct production cost, administration expenses - check list of items for total product cost estimates - elements of complete costs - start up costs

Module IV (13 hours)

Profitability analysis - mathematical methods for profitability evaluation - payout time - payout time with interest - return on average investment - DCF rate of return - net present value - net present value index - incremental analysis - break even analysis - variable cost and fixed cost - economic production chart for 100% capacity and dumping - non-linear economic production chart

MODULE V (13 hours)

Inflation - cost comparison under inflation - una burden - allowance for inflation - displacement vs replacement - one year more of existent - more than one year of the existent - principles of accounting - accounting definition - trial balance - balance sheet - profit and loss accounts - financial ratios related to balance sheet and profit and loss account – financial institutions - feasibility analysis report of a venture - canons of ethics of engineers

TEXT BOOKS:

1. Jelen F.C., Cost and Optimisation Engineering, McGraw Hill
2. Davies G.S., Process Engineering Economics, Chem. Eng. Ed. Dev. Centre, IIT Madras
3. Peters & Timmerhaus, Plant Design & Economics for Chemical Engineering, McGraw Hill

REFERENCE:

4. Schweyer, Process Engineering Economics, McGraw Hill
5. Tyler, Chemical Engineering Cost Estimation
6. Aries & Newton, Chemical Engineering & Cost Estimation
7. Happel, Chemical Process Economics, Marcel Decker
8. Vilbrant & Dryden, Chemical Engineering Plant Design, Tata McGraw Hill

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ELECTIVE II

CH010 706 L01 COMPUTATIONAL FLUID DYNAMICS

Teaching scheme **Credits: 3**

2 hours lecture and 2 hour tutorial per week

Objectives

- *To introduce the primary components of learning and practicing CFD*
- *To develop an understanding of solution methods for fluid motion and energy transfer equations*

MODULE I (15 hours)

Basic concepts: conservation principles – derivation of transport equations: control volume – Langangian and Eulerian approach- mass conservation equation-momentum conservation equations-stress laws-mass transfer equation-energy equation-rate change-convection and conduction-volumetric generation-work done by surface and body forces- dimensionless form of Navier-Stokes equations- introduction to numerical methods, advantages and limitations.

MODULE II (10 hours)

One dimenensional conduction: The governing equation- grid layout-discretisation-stability and convergence-explicit, implicit and semi-implicit procedures-methods to handle nonlinearities-solution methods-Gauss-Siedel method and TDMA-Simple problems.

MODULE III (10 hours)

One dimensional conduction-convection: exact solution-discretisation- central difference scheme-upwind difference schemes- numerical false diffusion-stability of unsteady equation exact solution-explicit finite difference form-implicit finite difference form.

MODULE IV (10 hours)

Two dimensional boundary layers: governing equations- descretisation method- symmetry, wall and free stream boundary conditions- dealing with source terms –defining initial conditions choice of grid size and iterations-applications (excluding turbulence)

MODULE V (15 hours)

Two dimensional convection-cartesian grids: simple mathematical models for incompressible, in viscid, potential and creeping flows-approximations of hyperbolic, parabolic, elliptic, and mixed flows. Solution strategies for 2D convection problems- SIMPLE algorithm-descretization pressure correction equation- solution procedure- Solution methods: iterative solvers-evaluation of residuals-under relaxation-boundary conditions - simple description on treatment of turbulent flows - applications (laminar flows only).

TEXT BOOKS:

1. Anderson J.D., *Computational Fluid Dynamics*, McGraw- Hill Co.
2. Joel H. Ferzigerand Peric M., *Computational methods for Fluid Dynamics,* Springer Werlag Publishers.

REFERENCE BOOKS

1. Patankar S.V., *Numerical Fluid Flow and Heat Transfer* , Hemisphere, New York
2. Anil W. Date, *Introduction to Computational Fluid Dynamics*, Cambridge University Press
3. Hiderbrand F.B, . *Introduction to Numerical Analysis*, Tata McGraw- Hill

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CH010 706L02 POLYMER TECHNOLOGY

Teaching Scheme **Credits: 3**

2 hours lecture and 1 hour tutorial per week

Objectives

- *To impart the knowledge of properties, preparation and production of polymers.*

MODULE I (12 hours)

Properties of polymers: classification & properties of polymers-polymerization process, mechanism and kinetics of polymerization reactions -chain growth (addition polymerization),step growth (polycondensation) polymerization synthesis and application of some common industrial polymers –polyethylene, PVC, Teflon, PMMA, nylon, PF etc. mechanism and kinetics of polymerization reactions - determination of physical and chemical Properties, polymer rheology. mechanical properties of polymers.

MODULE II (12 hours)

Polymer analysis of characterization - testing methods (physical, chemical, electrical), characterization. Behaviour of polymers - crystalline, thermal, dilute solution, rheological, chemical degradation, stability of polymers - polymer waste disposal and remedies. Mechanism and kinetics of polymerization reactions, step reaction polymerization, radical chain polymerization - non radical chain polymerization - co-polymerisation - conditions of polymerization reactions and details of manufacture. Olefin polymerization - polymers derived from dienes - vinyl and vinilidene polymers - fluro carbon polymers - hetero chain thermo Plastics - cellulose polymers - thermosetting resins.

MODULE III (12 hours)

Polymer technology - plastic, fibers, elastomers, adhesives, polymer additives - plasticizers, fillers and reinforcements etc. Moulding - plastification - injections and compression moulding - transfer moulding - calendaring - cast blowing - coating - extrusion -forming - thermo fusion - fillers - plasticizers and other additives. polymer processing -casting, thermoforming, forming lamination reinforcing, processing of fibers, moulding process, calendaring` . Polymer bleeds, toughened plastic and phase separated bleeds, mechanical properties and fabrication.

MODULE IV (12 hours)

Commodity of plastic & fibers – poly olefins – vinyl polymers – thermoplastic polymers – fibers (natural) and synthetic fibers – cellulosic – non cellulosic – fiber spinning operations natural polymers – poly saacharides – proteins – nucleic acids – natural rubber – inorganic polymers – silicons, poly phosphene – organo metallic co polymers – coordinate polymers – net work polymers- elastomers and thermo sets – diene elastomers – non diene elastomers – thermo plastic elastomer – thermo sets – epoxys – unsaturated polymers – formaldehyde resins

MODULE V (12 hours)

Engineering and speciality polymers – engineering thermo plastics – poly amides – ABS – poly carbonates – engineering polyester specialty polymers – Polyamides – ionic polymers – poly acryl ether ketone – speciality poly olefins – liquid crystalline polymers – conductive polymers – bio medical polymers – polymers for combating environmental pollution

TEXT BOOKS:

1. Kumar and Gupta - Fundamentals of Polymer Science and Engineering, Tata McGraw Hill Ltd.
2. P. Bahadur, N.V.Sastri, "Principles of Polymer science", Narosa Publication

REFERENCES

1. Billmeyar, - F.W, Text book of Polymer Science.
2. Schmidt - Marlier - Principle of High Polymer Theory and practical.
3. Rodriguax Terdianol - Principles of Polymer systems, Mc Graw Hill Kusha (1970)
4. Joel R. Fried ,"Polymer Science & Technology", Prentice Hall India Ltd
5. R.Sinha, "Outlines of Polymer Science &Technology – Processing Polymers", Prentice Hall of India, New Delhi

***UNIVERSITY EXAMINATION PATTERN*:** Question Paper consists of Part A, Part B and Part C. Part A is for 15 marks and comprises of 5 compulsory short answer questions, each carrying 3marks, covering the entire syllabus. Part B is for 25 marks, comprises of 5 compulsory questions from each module. And Part C is for 60 marks candidate has to answer one full question of 12 marks from each module**.**

CH010 706L03 SEPARATION PROCESSES

Teaching Scheme **Credits: 3**

2 hours lecture and 1 hour tutorial per week

Objectives

- *To expose students to different areas of noval separation techniques.*

MODULE I (12 hours)

Limitations of common separation techniques like sedimentation, screening, filtration, evaporation, distillation, absorption, liquid-liquid and solid liquid extraction. thermal Separation: thermal Diffusion: basic rate law, theory of thermal diffusion phenomena for gas and liquid mixtures, equipments, design and Applications.

MODULE II (12 hours)

Zone melting: equilibrium diagrams, controlling factors, apparatus and applications. Concepts and definitions in adsorption: adsorbent types; their preparation and properties; different types of adsorption isotherms and their importance; adsorption types; basic mathematical modeling with suitable initial and boundary conditions for different cases such as thermal swing, pressure swing, and moving bed adsorption.

MODULE III (12 hours)

Introduction to membrane processes. types of membranes, membrane processes and their applications, porous sand solid membranes, osmosis, micro – filtration, ultra filtration, nanofiltration, reverse osmosis, piezodialysis, electro dialysis, dialysis, membranes for gas separation, pervaporation. applications to these processes. liquid membranes: supported and unsupported liquid membranes, applications and mathematical modeling.

MODULE IV (12 hours)

Characterization of porous membranes, ionic membranes,non – ionic membranes. polarization phenomena and fouling concentration polarization, characteristic flux behavior in pressure driven membrane operation, various models, temperature polarization, membrane fouling, methods to reduce fouling. modules and process design: plate and frame, spiral wound, tubular, capillary, hollow fiber modules and their comparison, system design.

MODULE V (12 hours)

Foam separation: surface adsorption, nature of foams, apparatus, applications, and controlling factors. Parametric pumping: thermal parametric pumping, batch, continuous pumping, multicomponent separation, pH-parametric pumping, heatless parametric pumping. ionic separation: controlling factors, applications, equipments for electrophoresis, dielectrophoresis, electro dialysis and ion - exchange, commercial processes. adductive crystallization: molecular addition compounds, clathrate compounds and adducts, equipments, applications,

economics and commercial processes. adsorptive chromatographic separations processes, hybrid separation Technologies-membrane chromatography and electrochromatography. extractive separation, aqueous two-phase extraction, supercritical extraction.

TEXTBOOKS:

1. H. M. Schoen, "New Chemical Engineering Separation Techniques", Inter Science Publications, New York, 1972.
2. Wankat PC , Rate Controlled separations , Elsevier, 1990
3. Asenjo JM, Separation processes in Biotechnology, 1993, Marcel Dekker Inc
4. Basic Principles Of Membrane Technology, Marcel Mulder, Kluwer Academic Publishers, 1997

REFERENCES:

1. King J. – Separation Process – McGraw Hill Lim.
2. Kaup EC – Design Factors In reverse osmosis – Chemical Engineering 80 (1973).
3. Arden TV – Water Purification by ION Exchange – Butterworth, London, 1968
4. Sirkar K. & Winston H.O. "Membrane Hand Book" Van Nostrand Reinhold, New
5. D. M. Ruthven, "Principles of adsorption and adsorption processes", John Wiley & sons,1984
6. Belter PA and Cussler *E, Bioseparations*, Wiley 1985
7. The McCabe WL and Smith JC-Unit Operation of Chemical Engineer Tata McGraw – Hill Lim

***UNIVERSITY EXAMINATION PATTERN*:** Question Paper consists of Part A, Part B and Part C. Part A is for 15 marks and comprises of 5 compulsory short answer questions, each carrying 3marks, covering the entire syllabus. Part B is for 25 marks, comprises of 5 compulsory questions from each module. And Part C is for 60 marks candidate has to answer one full question of 12 marks from each module**.**

CH010 706L04 FOOD TECHNOLOGY AND ENGINEERING

Teaching Scheme **Credits: 3**

2 hours lecture and 1 hour tutorial per week

Objectives

- *To impart the knowledge of preservation and production of food products.*

MODULE I (12 hours)

Food process engineering -Fundamentals of food process engineering, application of quantitative methods of material and energy balances in food engineering practices. unit operations in food industries: fluid flow, thermal process calculations, refrigeration, evaporation and dehydration operations in food processing. food Canning technology: fundamentals of food canning technology.

MODULE II (12 hours)

Heat sterilization of canned food, containers - metal, glass and flexible packaging- canning procedures for fruits, vegetables, meats, poultry, marine products. mechanical operations in food processing: conversion operations, size reduction and screening of solids, mixing and emulsification, filtration and membrane separation, centrifugation, crystallization, extraction. rice: harvesting, threshing and drying, milling of paddy, parboiling, ageing and curing, utilization of by-products of rice milling, processed rice products, storage of Paddy. Wheat: production and marketing, handling and storage, chemical composition, quality criteria, milling, milled products and their utilization, Indian Standards for wheat and wheat products. Pulses Milling: traditional milling of pulses, modern method and machinery for dhal milling, puffing of pulses, manufacture of gum from guar seeds. Fruits and Vegetables.

MODULE III (12 hours)

Present status of industry, raw materials, preservation of fresh fruits and vegetables, manufacturing methods, Fruit and vegetable processing machinery and equipment, regulation of manufacturing practices and standards. Cashew nut: cashew industry, processing of cashew nuts, by products. Spices: spice production and export, production and processing of individual spices, spice products. Starch: introduction, starch manufacture, properties of starch, starch conversion products, standards for starch and starch products. Bread and Biscuits: importance of baking industry in India, Raw materials for bread manufacture, manufacture of bread, biscuits.

MODULE IV (12 hours)

Confectionery: raw materials, manufacture of sugar confectionery, typical confectionery products, chocolate confectionery, indian confectionery. Vegetable protein products: vegetable protein availability in India, vegetable raw materials and their processing, vegetable protein products. soft beverage industry: synthetic soft drinks, coffee, processing of coffee beans, tea, tea processing, cacao, processing of cacao fruit, processing of cacao nibs. Alcoholic beverages: fermented beverages, distilled beverages, by products, ISI Specifications for alcoholic beverages.

MODULE V (12 hours)

Dairy Products: milk management, fluid milk processing, manufacture of dairy Products, new process innovations. Meat: production, slaughtering and dressing, cold storages, meat and poultry products, byproducts. fish and fish products: Marine fish production, fresh Fish, frozen fish, canned fish, cured fish, fish products and byproducts, fish processing machinery. Infestation Control: Post harvest practices, techniques of infestation control in tropical urban and rural storages, pesticide formulations, equipment and appliances. Food preservation: Drying, freeze drying, pre cooling, freezing, storage of food products.

TEXT BOOKS:

1. R. T. Toledo, "Fundamentals of Food Process Engineering", AVI Publishing Co., 1980.

2. R. Angold, G.Beech and J.Taggart, “Food Biotechnology", Cambridge University Press, 1989.
3. Lidsay, Willis Biotechnology, Challenges for the flavor and food industries, Elsevier Applied Science

REFERENCES

1. J. M. Jackson and B. M. Shinn, "Fundamentals of Food Canning Technology", AVI Publishing Co.,
2. J. G. Bernnan, J. R. Butters, N. D. Cowell and A.E.V.Lilley, "Food Engineering Operations", 2nd Edn. Applied Science, 1976.

***UNIVERSITY EXAMINATION PATTERN*:** Question Paper consists of Part A, Part B and Part C. Part A is for 15 marks and comprises of 5 compulsory short answer questions, each carrying 3marks, covering the entire syllabus. Part B is for 25 marks, comprises of 5 compulsory questions from each module. And Part C is for 60 marks candidate has to answer one full question of 12 marks from each module**.**

CH010 706L05 BIOCHEMICAL ENGINEERING

Teaching Scheme **Credits: 3**

2 hours lecture and 1 hour tutorial per week

Objectives

- *To expose students to different areas of biochemical engineering*

MODULE I (12 hours)

Microbiology*:* cell theory, structure of cells: – procaryotic and eucaryotic cells, cell fractionation, classification of microbes, protist kingdom. important cell types (animal and plant cell) and their distinguishing characteristics. Chemicals of life*:* cell polymeric chemicals - repetitive and non repetitive bio polymers - lipids, sugars and polysaccharides, nucleotides - RNA and DNA, amino acids and proteins. protein structure, hybrid bio-chemicals, hierarchy of cellular organization. Kinetics of enzyme catalyzed reactions: simple enzyme kinetics with one or two substrates, Michaelis - Menten kinetics, evaluation of parameters in Michaelis - Menten equation, kinetics of two substrate reactions.

MODULE II (12 hours)

Substrate concentration dependence of enzyme catalyzed reactions: substrate activation and inhibition, multiple substrates reacting on a single enzyme. modulation and regulation of enzyme activity - competitive and uncompetitive inhibition, other influences on enzyme activity. Enzyme specificity and enzyme specificity hypotheses. Applied enzyme catalysis: enzymes of industrial importance. Isolation of crude enzyme - Koji technique

MODULE III (12 hours)

Enzyme purification. Immobilized Enzyme technology: enzyme immobilization - industrial process using immobilized enzymes-medical and analytical applications of immobilized enzymes. applications of hydrolytic enzymes: esterases, carbohydrases, proteolytic enzymes, enzyme mixtures, pectic enzymes and additional applications. medical application of enzymes, non hydrolytic enzymes in current and developing industrial technology.

MODULE IV (12 hours)

Metabolic pathways and energetic of the cell: metabolic reaction coupling: ATP, ADP and NAD. oxidation and reduction- coupling via NAD. Embden-Meyerhof pathway (EMP), pentose phosphate cycle - Entner Doudorff (ED) pathway, respiration - TCA cycle, Kreb cycle, Photo synthesis. transport across cell membranes - passive transport, active transport and facilitated diffusion. kinetics of substrate utilization - product formation and biomass production, measuring and monitoring of growth process (hemacytometer, colony count and turbidity methods).

MODULE V (12 hours)

Batch cultivation - growth cycle (lag, exponential, stationary and death phase). fermentation schemes - Gaden's classification (type I, II and type III) and Deindoerfer classification. transport phenomena in bio process system-gas-liquid mass transfer in cellular system - basic mass transfer and concepts - rates of metabolic oxygen utilization - determination of oxygen transfer rates-mass transfer across free falling or raising bubble and free surface with or without agitation in heat transfer. microbial heat generation and correlation, bio-chemical reactors, types of reactors for sterilization, fermentation and biomass production.

TEXT BOOKS:

1. James E. Baileay and David F. Ollis., “Bio-chemical Engineering Fundamentals”. Mc Graw Hill International Editions.
2. Michael L Shuler and Frikret Khargi., “Bioprocess Engineering Basic Concepts” Phi Publications

REFERENCES:

1. D G Rao., “Introduction to Biochemical Engineering”, Tata Mc Graw Hill.
2. Rajiv Dutta., “Fundamentals of Biochemical Engineering”. Anu books.

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CH 010 707 CHEMICAL ENGINEERING DESIGN SOFTWARE LAB

Teaching scheme **Credits: 2**

3 hours practical per week

Use of software packages:

- MATLAB
- CHEM CAD
- Aspen Plus
- Hysis
- CFD tools

In the process design, modeling and simulation.

50%-Laboratory practical and record
30%- Test/s
20%- Regularity in the class

Note: Exercise in practicing chemical engineering design problems.

End Semester Examination *(Maximum Marks-100)*

70% - modeling steps, results
30% - Viva voce

CH010 708 MASS TRANSFER OPERATIONS LAB

Teaching Scheme **Credits: 2**

3 hour practical per week

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1. Diffusion coefficient measurement: Wetted wall column, measurement of mass transfer coefficient.
2. Distillation:
    i. Determination of VLE,
    ii. Steam distillation
    iii. Verification of Rayleigh's equation for simple distillation,
    iv. Distillation in packed columns, HETP.
3. Absorption: Verification of design equation for height of packing in packed tower absorption of ethanol in water, absorption of carbon dioxide in sodium carbonate solution.
4. Surface evaporation: Free convection mass transfer.
5. Liquid extraction: Determination of ternary liquid - liquid equilibria.
6. Leaching: simple leaching; cross current leaching and counter current leaching.
7. Adsorption: Determination of absorption isotherm.

8. Drying: Determination of drying rate curve and mass transfer coefficient for atmospheric batch drying.

CH010 709 SEMINAR

Teaching Scheme **Credits: 2**

2 hour practical per week

The seminar should be on fundamental and advanced topics in the appropriate branch of Engineering and should be taken by the students as a Power point presentation. A brief report of the topic should be made by the students in consultation with respective guides, and are encouraged to be sent to National and International Conferences. The paper should be relevant to the present day Engineering and should be referenced with a minimum of 7 Journals. Each presentation shall be planned for a duration of 25 minutes, which includes a minimum of 5 minutes for discussion. The internal Marks for seminar will be out of 50. The marks will be awarded based on the presentation of the seminar by the students in front of an evaluation committee, which includes a minimum of 4 faculty members. Apportioning of marks towards various aspects of seminar (extent of literature survey, presentation skill, communication skill etc.) may be decided by the seminar evaluation committee.

A bonafide report of the seminar should be submitted at the end of the semester. This report shall include in addition to the presentation materials, all relevant supplementary materials along with detailed answers to all the questions asked/ clarifications sought during the presentation. All references must be given towards the end of the report. The seminar report should also be submitted for the viva voce examination at the end of the 8th semester.

For seminar, the minimum pass mark shall be 50% of the total marks assigned towards the seminar.

CH010 710 PROJECT

Teaching Scheme **Credits: 2**

2 hour practical per week

At the beginning of the seventh semester, students must submit an abstract of their undergraduate project. The project work will be a design project – experimental project – computer oriented one on any of the topics of Chemical Engineering interest. The assessment of the project will be done at the end of the semester by a committee consisting of three or four faculty members specialized in various fields of chemical engineering. The students will present their project work before the committee. They must submit a preliminary report at the end of the semester. They will complete the project in the eighth semester**.**

EIGHTH SEMESTER

CH010 801 CHEMICAL ENGINEERING DESIGN & DRAWING II

Teaching scheme **Credits:4**

2 hours lecture, 1hour tutorial & 2 hours drawing per week

Objectives

- *To impart the basic concepts of process design of evaporators, distillation, absorption and stripping columns, extraction columns, dryers and cooling towers.*

MODULE I (20 hours)

Process design and detailed drawing of: Evaporators- Standard short tube, Standard long tube and forced circulation evaporators. Multiple effect evaporators. Process design of Cooling Towers.

MODULE II (23 hours)

Process design of steady state isothermal binary component distillation columns. Detailed drawing of distillation column and its accessories. Process design of steady state isothermal absorption and stripping column.

MODULE III (22 hours)

Process design and drawing of: tray and packed Extraction columns; Rotary Dryers and tray dryers.

TEXT BOOKS:

1. B.C Bhattacharya, Introduction to Chemical Equipment Design, CBS Publishers & Distributors, New Delhi.
2. M.V Joshi & Mahajan V.V., Process Equipment Design, 3rd Edn, Mac-Milan & Co. India.
3. Perry. R.H & Green.D.W., Chemical Engineers Handbook, 7th Edn, McGraw hill.

REFERENCES:

1. R.E.Treybal, Mass Transfer Operations, McGraw hill.
2. J.M.Coulson & J.F.Richardson, Chemical Engineering, Vol.6, 3rd Edn, Butterworth-Heinemann, (Indian print)
3. E. Ludwig, Applied Process Design for Chemical & Petrochemical Plants, Vol I, II, II, Gulf Publication, London.
4. IS Codes.
5. D.Q.Kern, Process Heat Transfer, Tata Mc-GRAWHILL.
6. Badger & Bancharo, Introduction to Chemical Engineering, McGraw Hill
7. Rase & Barrow, Project Engineering of Process Plants, John Wiley
8. McCabe W.L., Smith J.C., & Harriot P., Unit Operations In Chemical Engineering, McGraw Hill.

Internal Continuous Assessment *(Maximum Marks-50)*

60% - Tests (minimum 2)
30% - Assignments (minimum 2) such as home work, problem solving, group discussions, quiz, literature survey, seminar, term-project, software exercises, etc.
10% - Regularity in the class

University Examination Pattern

Part A - *Analytical/Problem solving questions with drawing 1 x 30marks=30 marks*
2 question of 30 marks from first module with choice to answer one.
Part B - *Analytical/Problem solving questions with drawing 1 x 35 marks=35 marks*
2 question of 25 marks from second module with choice to answer one.
Part C - *Analytical/Problem solving questions with drawing 1 x 35 marks=35 marks*
2 question of 35 marks from third module with choice to answer one.
Maximum Total Marks: 100

Note: Text book no. 3 References 4 are permitted for exam

CH010 802: NANO-TECHNOLOGY

Teaching Scheme **Credits: 4**

2 hours lecture and 2 hour tutorial per week

Objectives

- *To impart the basic concepts of nano technology and its application in chemical engineering*

MODULE- I (10 Hours)

Introduction to nanotechnology, nanoscale, electromagnetic spectrum, top down and bottom up approach, particle size, chemistry and physics of nanomaterials, electronic phenomenon in nanostructures, optical absorption in solids, quantum effects.

MODULE-II (13 Hours)

Nanomaterials, preparation and properties of nanomaterials like gold, silver, different types of nano-oxides,Al_2O_3, TiO_2, ZnO etc. Sol-gel methods, chemical vapour deposition, ball milling etc. Carbonnanotubes, preparation properties and applications like field emission displays. Different types of characterization techniques like SEM, AFM, TEM & STM.

MODULE-III (10 Hours)

Nanocomposites, nanofillers, high performance materials, polymer nanocomposites, nanoclays, nanowires, nanotubes, nanoclusters etc. smart materials, self assembly of materials, safety issues with nanoscale powders.

MODULE IV (13 Hours)

Nanomanipulation, micro and nanofabrication techniques, photolithography, E-beam, FIB etc. nanolithography., softlithography, photoresist materials. Introduction to MEMS, NEMS and nanoelectronics

MODULE V (10 Hours)

Introduction to bionanotechnology and nanomedicines. basic biological concepts and principles Molecular Motors, Nano particles for Molecular Diagnostics, Nano biosensors, Nano pharmaceuticals, Nanoparticle based Drug Delivery, Nanostructures for TissueEngineering /Regenerative. Medicine, Ethical Safety, and Regulatory issues of Nanomedicine.

TEXT BOOKS:

1. Jean-Marie Lehn, Supramolecular Chemistry, Wiley VCH, 1995
2. Jonathan Steed & Jerry Atwood, Supramolecular Chemistry, John Wiley & Sons, 2004
3. Jacob Israelachvil, Intermolecular and Surface Forces, Academic Press, London, 1992.

REFERENCES

1. Rao C.N.R., Muller A., Chutham A.K, The Chemistry of Nanoparticles Synthesis, Properties and Applications, Vol 1 and Vol 2, WILEY-VCH
2. Challa Kumar, Tissue, Cell And Organ Engineering, Vol 9, WILEY-VCH, 2006
3. Challa Kumar, Nano materials for Medical Diagnosis and Therapy, Vol 10, WILEY VCH,
4. William A. Goddard III, Donald W Brenner, Sergey E. Lyshevski, Gerald J. Iafrate, Handbook of Nanoscience, Engineering, and Technology, CRC Press Taylor and Francis Group, 2007
5. Bhushan, Handbook of Nanotechnology, Springer–Springer,2007
6. Gero Decher and Joseph B. Schlenoff, Multilayer Thin Films, Wiley-VCH Verlag GmbH and Co. KGaA, 2003
7. David S. Goodsell, Bionanotechnolog, Lessons from Nature, Wiley-Liss, 2004.
8. Kenneth J. Klabunde, Nanoscale Materials in Chemistry, John Wiley & Sons, Inc., 2001
9. Christof M. Niemeyer and Chad A. Mirkin, Nanobiotechnology: Concepts, Applications and Perspectives by Wiley-VCH; 1 edition, 2004
10. Guozhong A.O, Nano structure and nano-materials, Imperial College Press, London
11. Poole P, Jr and Frauk J. Owens, Introduction to Nano technology, Charles P, Wiley Interscience, New Jersey, 2003.
12. Carl C. Koch. Noyes, Nano-structured materials: Processing, properties and Potential Applications, William Andrew Publishing New York.
13. David S. Goodsell, Bionanotechnology: Lessons from Nature, Wiley
14. Pradeep.T, Nano: The Essentials, Tata McGraw-Hill Publishing Company Ltd, 2007.
15. Nicholas A.Kotov , Nanoparticles Assemblies and Superstructures, 2006, CRC.
16. Ralph et al, (Eds), Nanoscale Technology in Biological Systems, 2005, CRC.
17. Fujita H, Micromachines as Tools for Nanotechnology, Springer Verlag, 2003
18. Niemeyer C.M and Mirkin C.A, Nanobiotechnology Concepts, Applications and Perspectives 2004, Wiley VCH Verlag GMBH and Co.

19. Mark J. Schulz, Mannur J. Sundaresan, Ajit D. Kelkar, Nanoengineering of Structural, Functional and Smart Materials, CRC Press

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CH010 803 CHEMICAL PROCESS OPTIMISATION

Teaching Scheme **Credits: 4**

2 hours lecture and 2 hour tutorial per week

Objectives

- *To impart the knowledge of various optimization techniques.*

MODULE I (12 hours)

Nature and organization of optimization problems - scope and hierarchy of optimization - typical applications of optimization - essential features of optimization problems – objective function - investment costs and operating costs in objective function - optimizing profitability - constraints - internal and external constraints - formulation of optimization problems – typical examples - nature of functions and their representation

MODULE II (12 hours)

Continuous functions - discrete functions - unimodal functions - convex and concave functions - necessary and sufficient conditions for optimum of unconstrained functions. numerical methods for unconstrained functions - one dimensional search - gradient-free search with fixed step size - gradient search with acceleration - Newton's method - Quasi- Newton method.

MODULE III (12 hours)

Dichotomous search -Fibonacci search - golden-section method - quadratic interpolation - numerical methods for unconstrained multivariable optimization - univariate search - simplex method - Powell's method - method of steepest descent - Fletcher-Reeves Conjugate - gradient method - Newton's method

MODULE IV (12 hours)

Linear programming - basic concepts in linear programming - graphical interpretation - simplex method - apparent difficulties in the simplex method - two-phase simplex method - nonlinear programming with constraints - equality constraints - method of direct substitution - Lagrange multiplier method - use of Lagrange multipliers for inequality constraints – kuhntucker Conditions

MODULE V (12 hours)

Zoutendijk's method - Rosen's gradient projection method - some typical applications (numerical solution not expected) - Optimizing recovery of waste heat - optimization of evaporator design - optimum diameter for pipe for transportation of fluid - optimization of liquid - liquid extraction process - optimal design and operation of staged distillation columns - optimum residence time for isothermal batch reactor - linear programming to optimize reactor operations

TEXT BOOK:

1. Edgar T.F. & Himmelblau D.M., Optimization of Chemical Processes, McGraw Hill
2. Rao S.S., Optimization: Theory and Applications, Wiley Eastern.

REFERENCES:

1. Beveridge G.S.G. & Schechter R.S., Optimization: Theory & Practice, McGraw Hill
2. Beightler C.S., Phillips D.T. & Wilde D.J., Foundations of Optimization, Prentice Hall of India

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ELECTIVE III
CH010 804L01: BIOPROCESS ENGINEERING

Teaching Scheme **Credits: 4**

2 hours lecture and 2 hour tutorial per week

Objectives

- *To impart the knowledge of kinetics of bio chemical reactions and its application.*

MODULE I (12 hours)

Overview of bioprocess engineering: Engineering perspective of fermentation processes – role of bioprocess engineers- integrated bioprocessing-- comparison of bioprocess engineering with Biochemical engineering.

Kinetics of microbial growth and product formation: Microbial growth as an autocatalytic Reaction- specific growth rate- Malthus' law-quantification of cell concentration-determination of cell number density and biomass concentration- direct and indirect methods- Key determinants of cell population kinetics- growth patterns and kinetics in batch cultures- batch growth curve kinetics of exponential growth- implications of endogenous and maintenance metabolism- death Phase kinetics- yield and maintenance coefficients- classification of microbial products - growth associated, non-growth associated and mixed growth associated product formation- classification of fermentation processes- Gaden's scheme and Deindoerfer's scheme- Batch, fed-batch and continuous fermentations ideal Reactors for kinetics measurements- Ideal

batch reactor, Ideal chemo stat, fed-batch reactors, Ideal plug-flow tubular reactors- design equations based on biochemical reactions.

MODULE II (12 hours)

Thermal death kinetics of cells and spores: Survival curve- decimal reduction factor, Extinction probability-sterilization of culture medium- batch and continuous sterilization- design Aspectsair sterilization- design of fibrous type filters. Kinetic modeling of cell growth: Model structure and complexity- different perspectives for Kinetic representations using models- prediction of specific growth rate using unstructured Un-segregated models-Monod equation- Monod chemo stat model- Models with growth inhibitors (Substrate inhibition, product inhibition and inhibition by toxic compounds)- logistic equation growth Models for filamentous organisms-structured kinetic models- compartment models, Metabolic models, cybernetic models.

MODULE III (12 hours)

Bioreactor engineering: Comparison of bioreactors with chemical reactors- Analysis of non ideal Behavior in bioreactors- reasons for non ideality-importance of RTD studies- stimulus response Experiment-circulation time distribution, exit age distribution, F-curve and C-curve mean and variance of residence time-diagnosis of ills of flow reactors- models for non-ideal reactors- zero, one and two parameter models (with emphasis on the tanks in series model and dispersion model)- estimation of biochemical conversion using these models- application of dispersion model to design of continuous sterilizers – design of novel bioreactors- packed bed Bioreactors, Bubble-column bioreactors, fluidized bed bioreactors, trickle bed bioreactors, airlift Loop bioreactors, photo bioreactors,- Key issues in bioreactor design and operation –alternate Bioreactor configurations- bioreactor dynamics- stability analysis in bioreactors- nontrivial and wash out steady states.

MODULE IV (12 hours)

Mass transfer in bioprocessing systems: Gas liquid mass transfer- volumetric oxygen transfer Coefficient- correlations (Cooper correlation, Oldshue correlation, Yamamoto correlation, Yoshida correlation, Richards correlation) – oxygen transfer mechanism- assessment of KLa111 Chemical method, dynamic differential gassing out method, dynamic integral gassing out Method, oxygen balance method, enzymatic method- merits and demerits of each method.

Scale up and scale down of bioprocess systems: Need for scale up and scale down- operating Boundaries for aerated and agitated fermenters- scale up criteria for microbial cell processes constant Power input per unit volume, constant KLa, constant mixing quality, constant Momentum factor, constant impeller tip speed, constant mixing rate number- scale up example With flow chart- scale down procedure.

MODULE V (12 hours)

Measurement analysis: Use of digital computers for data acquisition, interpretation and analysis software systems- data smoothing and interpolation –Fault analysis- state and parameter estimation methods- use of observers or estimators. Process control: Open loop and closed loop control-direct regulatory control, cascade control of Metabolism- programmed controlapplication

of artificial intelligence in bioprocess control knowledge Based expert systems, neural networks (A brief overview of the above is only Required).

TEXT BOOKS:

1. Pauline. M. Doran, *Bioprocess engineering principles*, Academic press.1995.
2. James. E.Bailey, David.F. Ollis *Biochemical engineering fundamentals*, Second Edition, McGraw Hill.1986.
3. Michael. L.Shuler, Fikret Kargi *Bioprocess engineering- Basic concepts, second* Edition, Prentice Hall of India.2002.

REFERENCE:

1. Colin Ratledge and Bjorn Kristiansen *Basic Biotechnology*, Second edition, Cambridge university press.2001.
2. Mukhopadhyay. S.N *Process Biotechnology fundamentals*.
3. Mukesh Doble and Sathyanarayana.N.Gummad, *Biochemical Engineering*, Prentice Hall of India. 2007.
4. D.G.Rao, *Introduction to Biochemical Engineering*, Tata Mcgraw Hill. 2005.
5. Nielsen J and Villadsen J and Liden G, *Bioreaction Engineering Principles*, 2nd Edition, Kluwer Academic. 2003.
6. Irving J. Dunn, Elmar Heinzle, John Ingham and Jiri E. Prenosil, *Biological Reaction Engineering: Dynamic Modeling Fundamentals with Simulation Examples*, 2nd Edition, Wiley- VCH. 2003.
7. Jackson AT, *Bioprocess Engineering in Biotechnology*, Prentice Hall, Engelwood Cliffs, 1991.
8. Aiba S, Humphrey AE and Millis NF, *Biochemical Engineering*, 2nd Edition, University of Tokyo press, Tokyo, 1973.
9. Mansi EMTEL, Bryle CFA. *Fermentation Microbiology and Biotechnology*, 2nd Edition, Taylor and Francis Ltd, UK, 2007.

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CH010 804L02: WATER AND WASTE WATER ENGINEERING

Teaching Scheme **Credits: 4**

2 hours lecture and 2 hour tutorial per week

Objectives

- *To develop the knowledge about characteristics of waste water and its treatment.*

MODULE I (12 hours)

Introduction to water supply and wastewater- water quality parameters and standards- characteristics of water: physical, chemical and biological parameters, standard methods of water analyses, biodegradable waste and agricultural runoff in streams, population forecasting, prediction of water demand and wastewater generation, water and wastewater quality,

MODULE II (12hours)

Water and wastewater treatment plants and systems: physical, chemical and biological systems, primary, secondary and tertiary treatment- Design considerations for sedimentation, coagulation, flocculation, filtration,

MODULE III (12hours)

Adsorption, ammonia removal, aeration, anaerobic and aerobic digestion, activated sludge and trickling filter, ion exchange, lagoons, disinfection, natural treatment systems, sludge treatment and disposal

MODULE IV (12hours)

Industrial wastewater treatment – overview major industries (dairy, distillery, sugar, textile, tannery, pulp & paper, metal finishing, petroleum refining, pharmaceutical and fertilizer; thermal power), their water requirements, and the typical quantities and characteristics of wastewater generated. Environmental consequences of wastewater discharge and the regulatory requirements for treatment and disposal treatment levels and available technologies. Theory and design of waste stabilization ponds and oxidation ditches.

MODULE V (12hours)

Concept of sustainable waste water treatment. management, administration, legal and financial aspects of water and wastewater treatment plants. operational problems encountered in treatment plants: typical problems arising in various units, trouble shooting. operation and maintenance of plant operations. training of operating personnel.

Text book

1. Metcalf & Eddy, “Wastewater Engineering – Treatment and Reuse”, Revised by G.Tchobanoglous, F. L. Burton, and H. D. Stensel, 4th edition. Tata McGraw-Hill, 2003.
2. Casey, T.J., “Unit Processes in Water and Wastewater Engineering”. Wiley Interscience, 1997. ISBN: 0471966932
3. W.W. Eckenfelder, “Industrial Water Pollution Control”, Mc-Graw Hill, 1999

REFERENCES

1. Weber, W.J. and DiGiano, F.A. "Process Dynamics in Environmental Systems". Wiley Interscience. ISBN: 0471017116
2. McCarty, P., and Rittmann, B., "Environmental Biotechnology: Principles and Applications", McGraw Hill, 2000. ISBN: 0072345535

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CH010 804L03: TOTAL QUALITY MANGEMENT

Teaching Scheme **Credits: 4**

2 hours lecture and 2 hour tutorial per week

Objectives

- *To deliver the basic ideas of Total quality management*
- *To impart the of knowledge of different standards available.*

MODULE I (12 hours)

Introduction: Definition of quality, Dimensions of Quality, Quality Planning, Quality Costs – Analysis Techniques for Quality Costs, Basic concepts of Total Quality Management, Historical Review, Principles of TQM, Leadership – Concepts, Role of Senior Management, Quality Council, Quality Statements, Strategic Planning, Deming Philosophy, Barriers to TQM Implementation.

TQM PRINCIPLES: Customer satisfaction – Customer Perception of Quality, Customer Complaints, Service Quality, Customer Retention, Employee Involvement – Motivation, Empowerment, Teams, Recognition and Reward, Performance Appraisal, Benefits.

MODULE II (12 hours)

Process Improvement – Juran Trilogy, PDSA Cycle, 5S, Kaizen, Supplier Partnership Partnering, sourcing, Supplier Selection, Supplier Rating, Relationship Development, Performance Measures – Basic Concepts, Strategy, Performance Measure.

MODULE III (12 hours)

Statistical process control: The seven tools of quality, Statistical Fundamentals – Measures of central tendency and dispersion, population and Sample, Normal Curve, Control Charts for variables and attributes, Process capability, Concept of six sigma, New seven Management tools.

MODULE IV (12 hours)

Tqm tools: Benchmarking – Reasons to Benchmark, Benchmarking Process, Quality Function Deployment (QFD) – House of Quality, QFD Process, Benefits, Taguchi Quality Loss Function, Total Productive Maintenance (TPM) – Concept, Improvement Needs, FMEA – Stages of FMEA.

MODULE V (12 hours)

Quality systems: need for ISO 9000 and Other Quality Systems, ISO 9000:2000 Quality System – Elements, Implementation of Quality System, Documentation, Quality Auditing, QS 9000, ISO 14000 – Concept, Requirements and Benefits. Total Quality Environment Management and EMS 14000: Municipal pollution prevention Programmes – Environment Management System-14000 Systematic, Structured and Documented Response to Environmental Issues - Auditable and Time Targeted Environmental Improvement Programs. Hierarchy of Environment Management Practices**:** Waste-specific pollution prevention: Waste Pre - generation focus on minimization / recycling, Waste-specific pollution control treatment: Pre - generation focus on disposal/ recycling- Waste-specific Post-release-to environment focus: Recycling/ remediation

REFERENCES

1. Dale H.Besterfiled, et al., *Total Quality Management*, Pearson Education Asia, 1999 Indian reprint 2002.
2. James R.Evans & William M.Lidsay, *The Management and Control of Quality*, 5th Edition, South- Western (Thomson Learning), 2002 (ISBN 0-324-06680-5).
3. Feigenbaum.A.V. *Total Quality Management*, McGraw-Hill, 1991.

REFERENCES:

1. Oakland.J.S. *Total Quality Management*, Butterworth Heinemann Ltd., Oxford. 1989.
2. Narayana V. and Sreenivasan, N.S. *Quality Management – Concepts and Tasks*, New Age International 1996.
3. Zeiri, *Total Quality Management for Engineers* Wood Head Publishers, 1991.
4. Bishop P, *Pollution Prevention: Fundamentals and Practice, McGraw-Hill, Singapore,2000*
5. Roy K, *(Editor), Chemical Technology for better Environment,* Allied publishers Ltd, Chennai 1998
6. El Halwagy, M. M, *Pollution Prevention through Process Integration: Systematic Design Tools,* Academic Press, N.Y. (1997)
7. Anastas P.T. and Warner J.C., *Green Chemistry: Theory and Practice.* Oxford University Press. N.Y.1998

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questions from each module. And Part C is for 60 marks candidate has to answer one full question of 12 marks from each module**.**

CH010 804L04 OPERATIONS RESEARCH

Teaching Scheme **Credits: 4**

2 hours lecture and 2 hour tutorial per week

Objectives

- *To impart the basic concepts of operation research*

MODULE I (12 hours)

Origin, nature and impact of Operations Research (OR). Development of OR as a branch of knowledge since World War II. Fields of applications of OR. Steps to be performed when an OR Study is to be carried out. Introduction to Linear Programming (LP). LP model, assumptions of LP, Graphical solution, Simplex method, Revised Simplex Method, Duality Theory and Sensitivity analysis. Economic interpretation of duality and relationship between *primal* and *dual* Problems, Applications. Dual Simplex method, parametric linear programming, upper bound Technique, Transportation problem, Assignment problem, Transshipment problem. Practical Applications and examples.

MODULE II (12 hours)

Network Optimization Models: Terminology of networks, Shortest path problem, Minimum -Spanning -tree problem, Maximal -flow problem, Travelling salesman problem, Minimum cost flow problem. Network Simplex method. Project Management: Use of network concepts to Represent project management problems, Scheduling a project with PERT/CPM. Uncertain Activities, Controlling project costs, Time-cost trade-off

MODULE III (12 hours)

Introduction to dynamic programming, Stochastic programming and Integer programming. Replacement – Replacement in anticipation of failure, Individual and Group replacement. Scheduling on Machines – Two-job Two-machine problem, Johnson's algorithm, Graphical solution.

MODULE IV (12 hours)

Game theory – Practical applications of game theory, Two-person zero-sum games, Solving Simple games, mixed strategy, Graphical solution, Solving by LP. Decision Theory, Statistical Decision theory, Decision making with and without experimentation, Decision Trees, Utility Theory. Stochastic processes, Markov Chains, Chapman- Kolmogorov Equations, Classification of states Of a Markov chain, Long-Run properties of Markov Chains, First passage times, absorbing States, Continuous –time Markov Chains. Queuing theory, Queueing Models, Exponential Distribution, Birth- and- death processes, Basic queuing process, Single server and

multiple server models, Poisson input and exponential service, Limited queue, Priority disciplines,

MODULE V (12 hours)

Applications. Inventory theory, Deterministic continuous- Review models, Deterministic periodic review models, stochastic continuous-review model, model for perishable products Stochastic periodic review models, Large inventory systems in practice.

TEXT BOOKS:

1. Hillier and Lieberman, *Introduction to Operations Research*, Tata McGraw Hill ltd.
2. Paneer Selvam, Operations Research, 2nd edition, Prentice Hall of India,

REFERENCES:

1. Taha, *Operations Research*, MacMillan
2. Naqner and Prandtl Philips and Ravindran, *Introduction to Operations Research*, John Wiley
3. Ackoff and Sasienie, *Fundamentals of Operations Research*, Wiley
4. Churchman, Ackoff and Arneff , *Operations Research*, Wiley

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CH010 804L05 NUMERICAL METHODS FOR PROCESS ENGINEERS

Teaching Scheme **Credits: 4**

2 hours lecture and 2 hour tutorial per week

Objectives

- *To impart the knowledge of application of numerical methods in chemical engineering*

MODULE I (13 hours)

High speed computations using digital computers. Computer arithmetic, Error analysis. Approximation of functions- Chebyshev polynomials Economized power series, Rational functions, Fourier series. Methods of fitting models to data. Empirical relations. Numerical solution of nonlinear, transcendental and polynomial equations. Linear interpolation methods: Bisection method, Secant method, False position method, Birge- Vieta method, Newton Raphson method, Mullers method, Fixed point iteration method, Bairstow's method, QD algorithm, Chebyshev's method, Graeffe's root squaring method, Newton Raphson method for system of nonlinear equations.

MODULE II (12 hours)

Linear Algebraic Equations: Physical problems modeled with set of linear algebraic equations, Solution of sets of linear algebraic equations. Gauss elimination, Gauss- Jordan method, LU decomposition, Crout reduction, Triangular decomposition, Iterative methods, Jacobi method, Gauss- Seidel iteration, Relaxation method, Eigen value problems- Power method, Jacob's method

MODULE 3 (14 hours)

Ordinary Differential Equations (ODE): Physical examples- The spring- mass problem, Initial value problem, Taylor- Series method, Euler's method, Modified Euler's method, Runge- Kutta method, Multi- step methods- Predictor- Corrector methods, Adams- Moulton method, Adams- Bashforth method, Boundary Value Problems:

Partial Differential Equations (PDE): Types of PDE, Physical examples: Temperature distribution in a rod, Temperature distribution in a slab, Solution methods: Shooting method, Alternating direction implicit method. Types of partial differential equations: Solution techniques for the Heat equation and the Wave equation in one and two dimensions- Numerical solution of Lapace equation.

MODULE IV (14 hours)

Finite differences: Forward, backward and central differences. Properties and relations between finite difference operators, Property of difference of a polynomial, factorial polynomial and reciprocal factorial function. Difference equations. Numerical Integration and Differentiation: Derivatives using Newton's forward and backward interpolation formulae. Use of Stirling's formula, Undetermined coefficients and Finite difference. Newton- Cotes Quadrature formula, Trapezoidal rule, Composite Trapezoidal rule, Simpson's rule, Boole's rule, Romberg integration. Gaussian Quadrature, Gauss- Legendre integration. Lobatto integration, Adaptive integration, Double integrals.

MODULE V (17 hours)

Dynamic programming in Chemical Engineering formulation and solution through PC based programmes, developmet of software for Chemical process equipments design distillation column, packed bed, reciprocating plate column. Applications of spreadsheet package in process calculation, estimation of density, molecular weight and percentage composition, empiricical and molecular formula calculations, heat of mixting, gas laws, vapour psressure, chemical kinetic calculations.

TEXT BOOKS

1. Leasely M.E., Computer Aided process plant design, gulf publishing, 1982
2. Hanna O.T., and Scandell O.C., Computational methods in Chemical Engineering, Prentice Hall. 1995.
3. S Pushpavanam, "Mathematical methods in Chemical Engineering", PHI publishers

REFERENCES:

1. Jerry.O and Breneman G.L., Spreadsheet Chemistry, Prentice Hall, Englewood cliffs. 1991
2. Myers, A.L & Seider W.D., Introduction to Chemical Engineering and Computer calculations – 1976.

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ELECTIVE 4
CH010 805 G01: PROJECT ENGINEERING

Teaching Scheme Credits: 4

2 hours lecture and 2 hour tutorial per week

Objectives

- *To impart the basic concepts for developing and executing projects in chemical process industries*

MODULE I (12 hours)

Introduction-Development of project-Research and development: Bench scale of experiments - pilot plant studies- Semi commercial plant Process design and Engineering: Process flow chart Material and energy balance process design and building designs-equipment specifications-Selection of Equipments and materials-Plant layout- Scale modeling- piping design and layout.

MODULE II(12 hours)

Plant location and site selection- preliminary dates construction projects - site development Foundation - Erection and site fabrication –Construction- Alignment and insulation- Startup & Commissioning- Trial runs- Guarantees sums and hand over-

MODULE III (12 hours)

Company formation process license- Technology Transfer- statutory sanctions- contracts and contractors- financing with special reference to financial institutions in India, personnel recruitment and training.

MODULE IV (12 hours)

Economic evaluation of projects- Capital requirements and cost of production-profitability-Break Even analysis and minimum cost analysis- Budgeting and financial control- Depreciation

MODULE V (12 hours)

Taxes- Insurances- Technical advancement and inflation-Financial statements

Project scheduling: Bar chart, CPM, PERT methods

TEXT BOOKS

1. Peters and Timmerhaus - Plant design and economics for chemical engineers 1980.
2. Vilbrent and Dryden-Chemical engineering plant design - TMH, 1975.
3. Bhasin S.D-Project Engineering of process plants

REFERENCES

1. Process engineering economics - G.S. Davies Chemical engineering curriculum developmentCentre, IIT Madras.
2. Anilkumar, Chemical process synthesis and engineering design, TMH 1981

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CH010 805 G02: COMPOSITE TECHNOLOGY

Teaching Scheme **Credits: 4**

2 hours lecture and 2 hour tutorial per week

Objectives

- *To impart the basic knowledge of different composite material, characteristics and application..*

MODULE I (12 hours)

Introduction to composites: General Introduction and Concept of Composite materials, Basic Definitions need and types. Classification- based on Matrix Material: Organic matrix composites Polymer matrix composites (PMC), Carbon matrix Composites or Carbon-Carbon Composites, Metal matrix composites (MMC), Ceramic matrix composites (CMC);

MODULE II (12 hours)

Classification based on reinforcements: Fiber Reinforced Composites, Fiber Reinforced Polymer (FRP) Composites, Laminar Composites and Particulate composites. Comparison of composites with metals, applications of various types of composites, advantageous and limitations of composites.

MODULE III (12 hours)

Polymer matrix composites: Polymer matrix resins – Thermosetting resins, thermoplastic resins, Reinforcement fibres – Rovings Woven fabrics, Non woven random mats, various types of Fibres. PMC processes - Hand lay up processes, Spray up processes, Compression moulding, Reinforced reaction injection moulding, Resin transfer moulding. Pultrusion – Filament winding – Injection moulding. Fibre reinforced plastics (FRP), Glass fibre reinforced plastics (GRP). Metal matrix composites:- Characteristics of MMC, Various types of Metal matrix composites. Alloy vs. MMC, Advantages of MMC, Limitations of MMC, Metal Matrix, Reinforcements – Particles – fibres. Effect of reinforcement - Volume fraction – Rule of mixtures. Processing of MMC – Powder metallurgy process - diffusion bonding – stir casting – squeeze casting.

MODULE IV (12 hours)

Ceramic matrix composites:- Engineering ceramic materials – properties, advantages, Limitations, Monolithic ceramics. Need for CMC Ceramic matrix - Various types of Ceramic Matrix composites- oxide ceramics, non oxide ceramics, aluminum oxide, silicon nitride, Reinforcements – particles, fibres, whiskers. Sintering - Hot pressing, cold isostatic pressing (CIPing), hot isostatic pressing (HIPing).

MODULE V (12 hours)

Advances in composites: - Carbon /carbon composites, Advantages of carbon matrix, limitations of carbon matrix. Carbon fibre, chemical vapour Depositions of carbon on carbon fibre perform. Solgel technique. Composites for aerospace Applications.

TEXT BOOKS

1. Mathews F.L. and Rawlings R.D., "Composite materials: Engineering and Science",Chapman and Hall, London, England, 1st edition, 1994.
2. Chawla K.K., "Composite materials", Springer – Verlag, 1987.
3. T.W. Clyne and P.J. Withers, "Introduction to Metal Matrix Composites", Cambridge University Press, 1993.

REFERENCES:

1. A.B. Strong, "Fundamentals of Composite Manufacturing", SME, 1989.
2. S.C. Sharma, "Composite materials", Narosa Publications, 2000.
3. "Short Term Course on Advances in Composite Materials", Composite Technology Centre, Department of Metallurgy, IIT- Madras, December 2001.

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CH010 805 G03: CORROSION ENGINEERING

Teaching Scheme **Credits: 4**

2 hours lecture and 2 hour tutorial per week

Objectives

- *To understand reasons of corrosion and its prevention in industries.*

MODULE I (12 hours)

Basic concepts: Definition and importance; Electrochemical nature and forms of corrosion; Corrosion rate and its determination. Electrochemical thermodynamics and kinetics: Electrode Potentials; Potential-pH (Pourbiax) diagrams; Reference electrodes and experimental Measurements; Faraday's laws; electrochemical polarization; Mixed potential theory

MODULE II (12 hours)

Experimental polarization curves; Instrumentation and experimental procedure. Galvanic and Concentration cell corrosion: Basic concepts; Experimental measurements, and determination of rates of galvanic corrosion; Concentration cells. Corrosion measurement through polarization techniques: Tafel extrapolation plots; Polarization resistance method; Instrumental methods and Errors in measurement of polarization resistance;

Module III (12 hours)

Commercial corrosion probes; other methods of determining polarization curves. Passivity: Basic concepts of passivity; Properties of passive films; Experimental measurement; Applications of Potentiostatic Anodic Polarization; Anodic protection. Pitting and crevice Corrosion: Basic concepts; Mechanisms of pitting and crevice corrosion; Secondary forms of Crevice corrosion; Localized pitting. Metallurgical features and corrosion: Inter-granular Corrosion; Weldment corrosion; De-alloying and dezincification.

MODULE IV(12 hours)

Environmental induced cracking: Stress corrosion cracking; Corrosion fatigue cracking; Hydrogen induced cracking; some case studies; Methods of prevention and testing; Erosion, Fretting and Wear. Environmental factors and corrosion: Corrosion in water and Aqueous Solutions; Corrosion in sulphur bearing solutions; microbiologically induced corrosion;

MODULE V (12 hours)

Corrosion in soil; Corrosion of concrete; Corrosion in acidic and alkaline process streams. Atmospheric and elevated temperature corrosion: Atmospheric corrosion and its prevention; Oxidation at elevated temperatures; Alloying; oxidizing environments. Prevention and control of Corrosion: Cathodic protection; Coatings and inhibitors; Material selection and design

TEXT BOOKS

1. Fontana, M.G., "Corrosion Engineering", McGraw-Hill.

2. Jones, D.A., "Principal and Protection of Corrosion", Prentice-Hall
3. S.N.Banerjee, "An Introduction to Corrosion Science and Corrosion Inhibition", Oxonian Press P.Ltd. New Delhi, 1985.
4. Zaki Ahmad, "Principles of Corrosion Engineering & Corrosion Control", Butterworth Heinemann, 2006

REFERENCES

1. L. L. Shrier "Corrosion", Butterworth Heinemann, Vol. I & II, 1994
2. H.H.Uhlig and R.W.Revie, "Corrosion and Corrosion Control", A Wiley – Inter Science. Publication John Wiley & Sons, New York, 3rd Edition, 1985
3. C.G. Munger, Vincent, L.D, "Corrosion prevention by protective Coatings," NACE Press, Texas, Houston, USA, 2nd Edition 2002.

***UNIVERSITY EXAMINATION PATTERN*:** Question Paper consists of Part A, Part B and Part C. Part A is for 15 marks and comprises of 5 compulsory short answer questions, each carrying 3marks, covering the entire syllabus. Part B is for 25 marks, comprises of 5 compulsory questions from each module. And Part C is for 60 marks candidate has to answer one full question of 12 marks from each module**.**

CH010 805 G04: SAFETY IN CHEMICAL INDUSTRIES

Teaching Scheme **Credits: 4**

2 hours lecture and 2 hour tutorial per week

Objectives

- *To impart the basic concepts of industrial safety.*
- *To develop understanding about safety practices in industries and emergency Procedures.*

MODULE I (12 hours)

Introduction to safety: Concept and importance of industrial safety. safety in erection and commissioning of chemical plants, Safety in the design process of chemical plants Fundamental safety Tenets. Safety in the site selection and lay out. Location and design parameters for chimney, Flares rupture discs, location of boiler houses, storage of hazardous chemicals etc. Safety in Operations and processes. Work permit system. Confined space safety practices.

MODULE II (12 hours)

Chemical hazards classification, hazards due to fire, explosion, toxic chemicals and radiation. Reduction of Process hazards by plant condition monitoring. Electrical exposures. Guarding Live electrical elements. Electrical wiring switches and fuses. Grounding. Ground Fault Interrupter. Classification of atmospheric contaminants.

MODULE III (12hours)

TLV Contamination reduction or removal methods. Handling and storage of Hazardous chemicals. Pressurized lines and containers (LPG, Compressed air, gases or fluids). Extreme

temperatures – hot and cold.

MODULE IV (12 hours)

Risk assessment - hazard vs risk, techniques for risk assessment, qualitative, reconnoitery, rapid and comprehensive risk assessment techniques: checklists, indices, HAZOP, maximum credible accident analysis, fault tree analysis, past accident analysis, FMEA (Failure mode and effect analysis), quantitative risk assessment, domino effect and its assessment.

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MODULE V (12 hours)

Emergency Preparedness: Fire and Explosion. Fire hazards. Fire pyramid. Types of fires. Types of fire extinguishers and its handling. Types of built in extinguishing systems. Fixed Fire protection systems. Fire fighting techniques. BLEVE and Runaway Reaction. Emergency procedures. Types of alarm systems. Study of fire protection systems and Emergency procedure of a leading chemical industry (preferably refinery/petrochemical)

TEXT BOOKS

1. Lees, F.P., Loss Prevention in Process Industries, Butterworths, NewDelhi, 3rd Edn., 2005. Vol.1 , 2,3

REFERENCE:

1. Accident Prevention Manual for Industrial Operations, NSC, Chicago, 1982.
2. Wells, G. L., Safety in process plant design, George Godwin Ltd, London
3. Encyclopedia of Occupational Health & Safety, International labour Office, Geneva
4. Grialdi, J. V., and Simonds, R.H., Safety Management, AITBS Publishers & Distributors, New Delhi
5. Slote, L., Handbook of occupational safety & Health, John Wiley & Sons, New York.
6. Kumar, A., Chemical Process Synthetics and Engineering Design, Tata McGraw Hill, NewDelhi
7. Buschmann, Loss Prevention and Safety Promotion in the Process Industries, Elsevier Scientific, New York
8. K.V. Raghavan and A.A.Khan: Methodologies in Hazard Identification and AssessmentManual by CLRI, December 1990.
9. V.C Marshal : Major Chemical Hazards – Ellis Harwood Ltd., Chichester, U.K. 1987.
10. Frank P. Leis: Loss Prevention in Process Industries Vol 1 &2: Butterworth – London 1980.
11. Crowl, D.A. and Louvar, J.F., "Chemical Process Safety: Fundamentals with Applications", Prentice Hall, Inc.
12. Safety in Chemical Process Industries: 0. P. Kharbanda

***UNIVERSITY EXAMINATION PATTERN*:** Question Paper consists of Part A, Part B and Part C. Part A is for 15 marks and comprises of 5 compulsory short answer questions, each carrying 3marks, covering the entire syllabus. Part B is for 25 marks, comprises of 5

compulsory questions from each module. And Part C is for 60 marks candidate has to answer one full question of 12 marks from each module**.**

CH010 806 CHEMICAL REACTION ENGINEERING AND PROCESS CONTROL LAB

Teaching Scheme **Credits: 2**

3 hour practical per week

1. Calibration of thermocouple
2. Dynamics of thermocouple
3. Dynamics of thermometer
4. Dynamics of thermometer with thermo well
5. Dynamics of liquid level system - single tank
6. Dynamics of liquid level system - non-interacting tanks in series
7. Dynamics of liquid level system - interacting tanks in series
8. Control of level process systems
9. Dynamics of mixing process
10. Dynamics of manometer
11. Control of temperature process system
12. Comparative study of P, PI and PID controllers for temperature process system
13. Study of Electro-pneumatic converter
14. Control valve characteristics
15. Determination of activation energy
16. Kinetics of hydrolysis of methyl acetate
17. Kinetics of hydrolysis of ethyl acetate
18. Performance study of plug flow reactor
19. Performance study of batch reactor
20. Performance study of CSTR
21. RTD studies

CH010 807 PROJECT

Teaching Scheme **Credits: 4**

6 hour practical per week

Project work is for duration of two semesters and is expected to be completed in the eighth semester. Each student group consisting of not more than five members is expected to design and develop a complete system or make an investigative analysis of a technical problem in the relevant area. The objective of the project is to test the ability of the student to coordinate the entire knowledge of chemical engineering and to judge his/her originality and capacity in the relevant areas of chemical engineering. In the seventh semester student group have to undergo literature review and have to finalize the project topics with their concerned guide. At the end of the seventh semester student groups have to give a project review will be assessed and evaluated

by evaluation committee consisting of two or more faculty members. However the students group has to submit the progress report to the evaluation committee in advance before the commencement of the project review presentation. Project evaluation committee shall study the feasibility of each project work before giving consent. The evaluation committee can accept, accept with modification, and request a resubmission. Students should execute the project work using the facilities of the institute. However, external projects can be taken up in reputed industries, if that work solves a technical problem of the external firm. Prior sanction should be obtained from the head of department before taking up external project work and there must be an internal guide for such projects. Each student is required to prepare a detailed project report. The progress in the project work is to be presented by the middle of eighth semester before the evaluation committee along with the progress report. If the progress of project work is found unsatisfactory by the evaluation committee during the middle of the eighth semester presentation, such students has to present again to the evaluation committee at the end of the semester and if it is also found unsatisfactory an extension of the project work can be given to the students

Project report: To be prepared in proper format decided by the concerned department. The report shall record all aspects of the work, highlighting all the problems faced and the approach/method employed to solve such problems. Members of a project group shall prepare and submit **separate** reports. Report of each member shall give details of the work carried out by him/her.

The student's sessional marks for project will be out of 100, in which 60 marks will be based on day to day performance assessed by the guide. Balance 40 marks will be awarded based on the presentation of the project by the students before an evaluation committee.

For Project, the minimum for a pass shall be 50% of the total marks assigned to the Project work

CH010 808 Viva -Voce

Teaching scheme credits: 2

A comprehensive oral Viva-voce examination will be conducted to assess the student's intellectual achievement, depth of understanding in the specified field of engineering and papers published / accepted for publication etc. At the time of viva-voce, certified bound reports of seminar and project work are to be presented for evaluation. The certified bound report(s) of educational tour/industrial training/ industrial visit shall also be brought during the final Viva-Voce.

An internal and external examiner is appointed by the University for the Conduct of viva voce University examination.

For Viva-voce, the minimum for a pass shall be 50% of the total marks assigned to the Viva-voce.

Note: If a candidate has passed all examinations of B.Tech. course (at the time of publication of results of eighth semester) except Viva-Voce in the eighth semester, a re-examination for the Viva-Voce should be conducted within one month after the publication of results. Each candidate should apply for this 'Save a Semester examination' within one week after the publication of eighth semester results.