Name Of Course: B.Tech.(Chemical Engg.)

U.K. TECHNICAL UNIVERSITY, DEHRADUN

Study and Evaluation Scheme

[Effective from the Session 2010-11]

Year 2nd Semester –III

S. NO	COURSE CODE	SUBJECT	PERIODS			EVALUTION SCHEME				SUBJECT TOTAL
						Sessional Exam			ESE	
			L	T	P	CT	TA	Total		
THEORY										
1	ECY-301	Applied Chemistry	3	1	0	30	20	50	100	150
2	EMA-301	Mathematics III	3	1	0	30	20	50	100	150
3	ECH-301	Process Calculations	3	1	0	30	20	50	100	150
4	ECH-302	Mechanical Operation	2	1	0	15	10	25	50	75
5	ECH-303	Fluid Flow Operations	3	1	0	30	20	50	100	150
6	EHV-301	Industrial Psychology	2	0	0	15	10	25	50	75
7.	EHU-111	Human Values & Professional Ethics*	1	2	0	15	10	25	50	75
Practical /Design										
8	ECY-351	Applied Chemistry	0	0	3	10	10	20	30	50
9	ECH-351	Mechanical Operation	0	0	3	10	10	20	30	50
10	ECH-352	Fluid Flow Operations	0	0	3	10	10	20	30	50
11	ECH-353	Group Discussion & Seminars	0	0	2	-	-	50	-	50
12	GP-301	General Proficiency	-	-	-	-	-	50	-	50
		Total								1000

* Human Values & Professional Ethics will be offered as compulsory Audit Course fro which passing marks are 40% in theory & 50% I aggregate. Student will be required to audit it within period of their study. Their will not be carry over facility for this course and a failed student will be required to repeat this course.

Name Of Course: B.Tech.(Chemical Engg.)
U.K. TECHNICAL UNIVERSITY, DEHRADUN
Study and Evaluation Scheme
[Effective from the Session 2010-11]

Year 2nd, Semester –IV

S. NO	COURSE CODE	SUBJECT	PERIODS			EVALUTION SCHEME				SUBJECT TOTAL
						Sessional Exam			ESE	
			L	T	P	CT	TA	Total		
THEORY										
1	EHU-401	Industrial Sociology	2	1	0	10	15	25	50	75
2	ECH-401	Chemical Engineering Thermodynamics I	3	1	0	30	20	50	100	150
3	ECH-402	Heat Transfer	3	1	0	30	20	50	100	150
4	ECH-403	Chemical Reaction Engineering –I	3	1	0	30	20	50	100	150
5	ECH-404	Chemical Technology-I(Inorganic)	3	0	0	30	20	50	100	150
6	EOE-031/037/035	Science Based Open Elective	3	1	0	30	20	50	100	150
7	EHU-111	Human Values & Professional Ethics*	1	2	0	15	10	25	50	75
Practical /Design										
8	ECH-451	Chemical Reaction Engineering –I	0	0	3	10	10	20	30	50
9	ECH-452	Heat Transfer	0	0	3	15	10	25	50	75
10	GP-401	General Proficiency	-	-	-	-	-	-	50	50
		Total								1000

Science Base Open Elective:

EOE-031 1. Introduction to Soft Computing (Neural Network, Fuzzy Logic & Genetic Algorithm)
EOE-035 2. Material Science
EOE-037 3. Polymer Technology

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[Effective from the Session 2010-11]

Year 3rd Semester –V

S. NO	COURSE CODE	SUBJECT	PERIODS			EVALUTION SCHEME				SUBJECT TOTAL
						Sessional Exam			ESE	
			L	T	P	CT	TA	Total		
THEORY										
1	EAS-501	Computer Based Numerical Methods	3	1	0	30	20	50	100	150
2	ECH-501	Mass Transfer I	3	1	0	30	20	50	100	150
3	ECH-502	Chemical Reaction Engineering II	3	1	0	30	20	50	100	150
4	ECH-504	Process Instrumentation	3	0	0	10	15	25	50	75
5	ECH-503	Chemical Technology II (Organic)	3	0	0	10	15	25	50	75
6	EHU-501	Process Economics & Plant Design	3	1	0	30	20	50	100	150
7	EHU-111	Human Values & Professional Ethics*	1	2	0	15	10	25	50	75
Practical /Design										
8	EAS-551	Computer Based Numerical Methods	0	0	3	10	10	20	30	50
9	ECH-551	Mass Transfer I	0	0	3	10	10	20	30	50
10	ECH-552	Chemical Technology	0	0	3	10	10	20	30	50
11	ECH-553	Group Discussion & Seminar	0	0	2	-	50	-	-	50
12	GP-501	General Proficiency	-	-	-	-	-	-	50	50
		TOTAL								1000

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Year 3rd Semester –VI

S. NO	COURSE CODE	SUBJECT	PERIODS			EVALUTION SCHEME				SUBJECT TOTAL
						Sessional Exam			ESE	
			L	T	P	CT	TA	Total		
THEORY										
1	ECH-601	Transport Phenomena	3	1	0	30	20	50	100	150
2	ECH-014	Energy Recourses & Management	3	1	0	30	20	50	100	150
3	ECH-011 ECH-012 ECH-013	Department Elective-I	3	1	0	10	15	25	50	75
4	ECH-602	Mass Transfer II	3	1	0	30	20	50	100	150
5	ECH-603	Process Dynamics & Control	3	1	0	30	20	50	100	150
6	ECH-604	Process Equipment Design	3	1	0	10	15	25	50	75
7	EHU-111	Human Values & Professional Ethics*	1	2	0	15	10	25	50	75
Practical /Design										
8	ECH-651	Mass Transfer II	0	0	3	10	10	20	30	50
9	ECH-652	Process Dynamics & Control	0	0	3	10	10	20	30	50
10	ECH-653	Process Equipment Design	0	0	3	10	10	20	30	50
11	ECH-654	Petroleum Energy Lab	0	0	2	10	10	20	30	50
12	GP-601	General Proficiency	-	-	-	-	-	50	-	50
		TOTAL								1000

Department Elective I:

ECH-011 Optimization Technique in Chemical Engg.

ECH-012 Computational Fluid Dynamics

ECH-013 Process Flow Sheet Simulation

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[Effective from the Session 2010-11]

Year 4th semester –VII

S. NO	COURSE CODE	SUBJECT	PERIODS			EVALUTION SCHEME				SUBJECT TOTAL
						Sessional Exam			ESE	
			L	T	P	CT	TA	Total		
THEORY										
1	ECH-701	Thermodynamics II	3	1	0	30	20	50	100	150
2	EHU-701	Industrial Safety & Hazards Management	3	1	0	30	20	50	100	150
3	ECH-021 ECH-022 ECH-023 ECH-024	Department Elective II	3	1	0	30	20	50	100	150
4	ECH-702	Process Modeling & Simulation	3	1	0	30	20	50	100	150
5	ECH-703	Process Design (Mechanical Aspects)	3	1	0	30	20	50	100	150
6	EHU-111	Human Values & Professional Ethics*	1	2	0	15	10	25	50	75
Practical /Design										
7	ECH-751	C.A.D	0	0	3	10	10	20	30	50
8	ECH-752	Minor Project Report & Viva	0	0	2	30	20	50	50	100
9	ECH-753	Group Discussion	0	0	2	-	-	50	-	50
10	GP-701	General Proficiency	-	-	-	-	50	50	-	50
		TOTAL								1000

Department Elective II:

ECH-021 Process Utility & Safety in Chemical Plants
ECH-022 Corrosion Science & Engineering
ECH-023 Project Engineering & Management
ECH-024 Biochemical Engineering

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Year 4th semester –VIII

S. NO	COURSE CODE	SUBJECT	PERIODS			EVALUTION SCHEME				SUBJECT TOTAL
						Sessional Exam			ESE	
			L	T	P	CT	TA	Total		
THEORY										
1	ECH-801	Petroleum Refining Technology	3	1	0	30	20	50	100	150
2	ECH-802	Plant Design & Economics	3	1	0	30	20	50	100	150
3	ECH-031 ECH-032 ECH-033 ECH-034	Department Elective III	3	1	0	30	20	50	100	150
4	EOE-081	Non Convection Energy Recourse	3	1	0	30	20	50	100	150
5	EHU-111	Human Values & Professional Ethics*	1	2	0	15	10	25	50	75
Practical /Design										
6	ECH-851	Major Project	0	0	12	-	100	100	250	350
7	GP-801	General Proficiency	-	-	-	-	-	50	-	50
		Total								1000

Department Elective III:

ECH-031 Advance Separation Technology
ECH-032 Design Of Piping Systems
ECH-033 Fluidization Engineering
ECH-034 Multiphase Reactor Design

SEMESTER III

APPLIED CHEMISTRY **3 1 0**

Unit I

Organic Chemistry **[8].**

Organic reactions of Industrial Significance.

(i)Alcohols, phenols & ethers : Reactions of alcohols with alkaline earth metals , Iodoform reaction, Oxidation, conversion of alcohols into Mesylates &Tosylates; Crown ethers & epoxides ; Reimer-Tiemann reaction , Kolbes-Schimidt reaction mechanisms

(ii) Aldehydes & Ketones : Oxidation & reduction , Perkin reaction ,Claison-Schmidt reaction, Benzoin condensation, Knovenagel reaction, reformatsky reaction,Wittig reaction.

(iii)carboxylic acids and their derivatives : Hell-Volhartd Zelinsky reaction ,Hoffmann bromide reaction, Curtius and Lorsen Reaction

(iv) Nitrocompounds: Reduction of nitrobenzene under different conditions

(v) Amines : Reactions with nitrous acids , Diazotization and reactions of arenedizonium salts

Unit II **[8]**

(i) Concept of aromaticity in benzoid and non-benzoid compounds, aromatic and non-aromatic compounds

(ii) (ii)Organomettalic compounds : Applications of Grignard Reagent and Lithium aluminum hydride

(iii) Stereochemistry : Conformational analysis : various terms , conformational analysis of cyclohexane and 1,2 –disubstituted cyclohexane . Stereoisomerism of cyclic compounds (cyclohexane), chiral drugs (ibuprofen),the relative and absolute configuration ,stereoselective and stereospecific reactions .

Unit III **[8]**

Surface Chemistry

(i) Catalysis : Acid base catalyzed reaction, enzyme catalyzed reaction and heterogeneous catalyzed reaction

(ii) Surface tension determination and Applications

(iii) Adsorption Isotherms- Freundlich and Langmuir

(iv) Colloids: General methods of preparation and properties, hydrophilic and hydrophobic sols, Electrical Properties of colloids

(v) Colligative Properties: Lowering of Vapor Pressure, Elevation in boiling point, lowering in melting point, Osmotic Pressure and their relation with molecular weight.

Unit IV: **[8]**

Analytical Chemistry

Instrumental methods of chemical analysis: A brief introduction and applications of Conductometry , Potentiometer, GLC, HPLC , mass spectroscopy and atomic absorption Spectroscopy.

Unit V: **[8]**

Natural Organic Molecules Biomolecules: Definition, types of biomolecules-nucleosides & nucleotides (DNA and RNA), saccharides (glucose, fructose, maltose and cellulose), lignin, lipids and amino acids (protein structure of apoenzymes, isoenzymes and vitamins) and their industrial applications.

Text Books

1. **Finar, I.L.** "Organic Chemistry : Vol. I & II".

2. Morrison & Boyd "Organic Chemistry".

3. March, J. "Organic Chemistry".

4. Soloman, T. "Organic Chemistry".

5- Glasstone, S. "Physical Chemistry"

6- Atkin, P. W. "Physical Chemistry"

7- Banwell, C. N. "Fundamentals of Molecular Spectroscopy"

8- Willard Merit & Dean "Instrumental Methods of Chemical Analysis"

9- Skoog & West "Instrumental Methods of Chemical Analysis"

MATHEMATICS –III **3 1 0**

Unit – I : Function of Complex variable

Analytic function, C-R equations, Cauchy's integral theorem, Cauchy's integral formula for derivatives of analytic function, Taylor's and Laurent's series, singularities, Residue theorem, Evaluation of real integrals of the type. **[10]**

Unit – II : Statistical Techniques - I

Moments, Moment generating functions, Skewness, Kurtosis, Curve fitting, Method of least squares, Fitting of straight lines, Polynomials, Exponential curves etc., Correlation, Linear, non –linear and multiple regression analysis, Probability theory. **[08]**

Unit – III : Statistical Techniques - II

Binomial, Poisson and Normal distributions, Sampling theory (small and large), Tests of significations: Chi-square test, t-test, Analysis of variance (one way) , Application to engineering, medicine, agriculture etc. Time series and forecasting (moving and semi-averages), Statistical quality control methods, Control charts, , R, p, np, and c charts. **[08]**

Unit – IV : Numerical Techniques –

I Zeroes of transcendental and polynomial equation using Bisection method, Regula-falsi method and Newton-Raphson method, Rate of convergence of above methods. Interpolation: Finite differences, difference tables, Newton's forward and backward interpolation , Lagrange's and Newton's divided difference formula for unequal intervals. **[08]**

Unit – V : Numerical Techniques –II

Solution of system of linear equations, Gauss- Seidal method, Crout method. Numerical differentiation, Numerical integration , Trapezoidal , Simpson's one third and three-eight rules, Solution of ordinary differential (first order, second order and simultaneous) equations by Euler's, Picard's and forth-order Runge- Kutta mehthods. **[08]**

Test Books :-

1. Peter V. O'Neil, Advance Engineering Mathematics Thomson (Cengage) Learning, 2007.
2. Jain, Iyenger & Jain, Numerical Methods for Scientific and Engineering Computation, New Age International, New Delhi , 2003.
3. J.N. Kapur, Mathematical Statistics, S. Chand & company Ltd.,2000

Reference Books :-

1. R.K. Jain & S.R.K. Iyenger, Advance Engineering Mathematics, Narosa Publication House, 2002.
2. Chandrika Prasad, Advanced Mathematics for Engineers, Prasad Mudralaya, 1996.
3. E. Kreysig, Advanced Engineering Mathematics, John Wiley & Sons, 2005.
4. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 2005.
5. Devi Prasad, An introduction to Numerical Analysis, Narosa Publication house, New Delhi 2006.
6. T. Veerajan & T. Ramchandrandran, Theory & Problems in Numerical Methods, TMH, New Delhi, 2004.
7. S.P.Gupta, Statistical Methods, Sultan and Sons, New Delhi, 2004.
8. Devore, Probability and Statistics, Thomson(Cengage) Learning, 2007.
9. Walpole, Myers, Myers & Ye, Probability and Statistics for Engineers & Scientists, Pearson Education, 2003.

ECH 301: PROCESS CALCUALTIONS 3 1 0

Unit I Stoichiometry & Material Balance

Material balances for systems with and without chemical reactions, species and elemental balance, Analysis of systems with by-pass, recycle and purge. **[8]**

Unit II Energy Balance

Heat capacity of gases, liquids and solutions, Heat of fusion and vaporisation. Steady state energy balance for systems with and without chemical reactions. Calculations and application of heat of reaction, combustion, formation, neutralisation and solution. Enthalpy-concentration charts. Combustion of solids, liquids and gaseous fuels, Calculation of theoretical and actual flame temperatures. **[8]**

Unit III

Units their dimensions and conversions, Mass and volume relations, Stoichiometric and composition relations, Excess reactants, Degree of completion, Conversion, selectivity and yield. Ideal gas law, Dalton's Law, Amagat's Law, and Average molecular weight of gaseous mixtures. Effect of temperature on vapour pressure, Vapour pressure plot (Cox chart), Vapour pressures of miscible and immiscible liquids and solutions, Raoult's Law and Henry's Law.**[10]**

Unit IV

Humidity and saturation

Relative Humidity and percent saturation, Dew point, Dry and Wet bulb temperatures, Use of humidity charts for engineering calculations. **[6]**

Unit V

Degrees of freedom in steady state processes, solution of simultaneous material and energy balance problems using flow sheeting softwares, Unsteady state material and energy balance **[8]**

Text books

1. Himmelblau, D.M. "Basic Principles and Calculations in Chemical Engineering", 6th ed. Prentice Hall (1996).

2. Felder, R.M. & Rousseau, R.W. "Elementary Principles of Chemical Processes ", 3rd edition. John Wiley. (1999).

3. Bhatt., B.I. and Vora S.M. "Stoichiomerty" IInd edition, Tata McGraw Hill (1984)

Reference Books

Hougan D. A., Watson K.M. and Ragatz R. A. "Chemical Process principles" Vol. 1 Asia Publishing House (1962)

Luben W.L. and Wenzel, L.A. "Chemical Process Analysis Mass and Energy Balance" Prentice Hall

MECHANICAL OPERATIONS 2 1 0

Unit I

Introduction to unit operations and their role in Chemical Engineering industries. Types of Mechanical Operations, Characteristics of particulate solids: sampling techniques, specification and screen analysis, particle size distribution, particle size measurement,

Surface area measurements, statistical mean diameters, relevant equations and problems. **[08]**

Unit II

Principles of size reduction: Specific properties of solids for size reduction. Energy required for size reduction. Crushing and grinding efficiency. Laws of crushing, pulverization and ultrafine grinding. Classification of crushing and grinding equipment. Construction and working principle of mostly used equipments, viz., Jaw crushers, gyratory crushers, hammer mill, crushing rolls, ball mills, and fluid energy mills. Mixing of solids, blending, kneading, etc. Size enlargement: scope and applications, size enlargement techniques. **[08]**

Unit III

Classification of separation methods for different types of mixtures like solid-solid, solid-gas, solid-liquid. Screening, classification of screening equipments. Mechanical classification and classifiers. Rare and dense medium separation, magnetic separation, electrostatic separation. Floatation and elutriation. Continuous thickeners, decantation, Phase separation: Centrifugal separation, Electrostatic precipitators. Impingement separators , Gas-solid separation: Gravity settling, Impingement separators, Cyclone separators, bag filters, scrubbers Filtration: classification of filters, theory of filtration, cake resistance **[08]**

Unit IV

Conveying of bulk solids, classification of conveyors, selection of conveyors. Storage of solids in bulk protected and unprotected piles, bines, silos, hoppers, mass flow and funnel flow Bins, Flow assisting devices, feeders. Weighing of bulk solids, batch and continuous weighing techniques.**[06]**

Unit V

Flow through packed Bad: Chartersterstics of packings, flow of a single fluid through a packed ba, Problems of channeling and wetting, counter-current, gas- liquid flow through packed beds, loading and flooding characteristics.

Books Recommended

1. Coulson and Richardson: Chemical Engineering, Vol. 2.Butterworth Heinemann Pub
2. Welty,Wicks,Wilson & Rorrer, Fundamentals of Momentum,Heat,and Mass Transfer, 4th ed. Wiley
3. Narayanan C.M.& Bhattacharya B.C. “Mechanical opeartions for chemical engineers”, Khanna Publishers. 3 rd Ed.1999.

Reference Books

1. Foust A. S. & associates , “Principles of Unit Operations” John Wiley and Sons (1980).
2. McCabe Smith, “Unit Operation in Chemical Engineering” 5th ed. Mc Graw Hill (1985).
3. Perry R.H. & Chilton C.H., “Chemical Engineers Hand Book” , 7th ed.Mc graw hill.
4. Badger and Bencharo, “ Introduction to Chemical Engineering”. Tata mc graw hill.
5. S. K. Gupta, “Momentum Transfer Operation”. Tata Mc Graw Hill (1979)
6. Davidson J.F. &Harrison D.”Fluidization” Academic press (1985)
7. Kunni & Levenspiel “ Fluidization engineering “ Wiley (1962)

FLUID FLOW OPERATIONS 3 1 0

Unit I
Properties of fluids and their classification.,Fluid statics: Forces on fluids, pressure depth relationship for compressible and incompressible fluids, Forces on submerged bodies,Rigid body motion, pressure measurements, Euler's equation. [08]

Unit II
Kinematics of flow, Description of velocity field, Stream functions, Angular velocity, Fluids in circulation, Irrational flow. Dimensional analysis; Buckingham'sΠ.theorem ; Dimensionless numbers and their physical significance; Similitude criteria. Mixing and agitation of fluid, Types of mixers and their selection Power requirement. [08]

Unit III
Fluid flow: Laminar and turbulent flows; Pressure drop in pipes and tubes, pipe fittings and pipe network and friction factor; Conservation of mass ,momentum and energy; Navier-Stokes equation; Mechanical Energy balance and Bernoulli'sTheorem.[08]

Unit IV
Flow measuring devices for chemical plants: Orifice meter, nozzle and venturi meters, rotameter and pitot tube. [06]

Unit V Pumping and compressing of chemicals and gases, reciprocating pumps, rotary pumps, centrifugal pumps and blowers. NPSH and calibration. Mixing and agitation of fluids. Compressible fluid flow , Solution of fluid flow problems using softwares. [10]

Books Recommended
1.McCabe Smith: Unit Operations in Chemical Engineering, McGraw Hill
2.Fox, R.A. & McDonald, A.T. "Introduction to Fluid Mechanics, 5th ed: John Wiley (1998).

Reference Books

1. Kumar D S "fluid Mechanics", S.K, Katria and Sons, Delhi (1998.)
2. Rajput R.K."Text book of Fluid Mechanics" , S.Chand and Co., New Delhi, (1998)
3. Gupta, Vijay and SK Gupta," Fluid Mechanics and its Applications"Wiley Eastern, NewDelhi,

INDUSTRIAL PSYCHOLOGY

Unit I:
Introduction to Industrial Psychology – Definitions & Scope. Major influences on industrial Psychology- Scientific management and human relations schools Hawthorne Experiments.

Unit II:
Individual in Workplace Motivation and Job satisfaction , stress management. Organizational culture, Leadership & group dynamics.

Unit III:
Work Environment & Engineering Psychology-fatigue. Boredom, accidents and safety. Job Analysis, Recruitment and Selection – Reliability & Validity of recruitment tests.

Unit IV:
Performance Management : Training & Development.

Reference Books:

1. Miner J.B. (1992) Industrial/Organizational Psychology. N Y : McGraw Hill.
2. Blum & Naylor (1982) Industrial Psychology. Its Theoretical & Social Foundations CBS Publication.
3. Aamodt, M.G. (2007) Industrial/Organizational Psychology : An Applied Approach (5th edition) Wadsworth/Thompson : Belmont, C.A.
4. Aswathappa K. (2008). Human Resource Management (fifth edition) New Delhi : Tata McGraw Hill**.**

SEMESTER III LABS

APPLIED CHEMISTRY LAB 0 0 3

1. Identification of Organic Compounds in the mixture.
2. Estimation of Glucose, phenol,aniline.
3. Applications of TLC in the organic chemistry.
4. Determination of percentage composition of mixture with the help of viscosity measurements.
5. Freundlich adsorption isotherm verification.
6. Distribution of solute between two immiscible solvents (I2 / water + organic solvent). Distribution law.
7.Conductivity: (i) Conductivity titration strength of strong acid vs. strong base, (ii) Dissociation constant of a weak acid (CH3COOH).
8. Determination of molecular weight of a non volatile substance by (i) elevation in boiling point (ii) depression in freezing point.
9. Determination of Iron by Specrophotometric method.
10. Potentiometric titration.

MECHANICAL OPERATIONS LAB 0 0 3

1. To study the performance of Ball Mill and find out it's crushing efficiency.
2. To study the performance of Jaw Crusher and find out it's crushing efficiency.
3. To study the performance of Crushing Rolls and find out it's crushing efficiency.
4. To study the settling characteristics.(Free & Hindered settling) of a given suspension of particles.
5. To study the filtration characteristics of rotary vacuum filter.
6. To study the filtration characteristics of Plate and frame filter press.
7. To study the filtration characteristics of Leaf and sparkle filter.
8. To carry out differential and cumulative screen analysis of given sample of solid particles.
9. To study the pressure drop characteristics through packed beds.
10. To study the pressure drop and porosity in Air fluidized bed.
11. To study the pressure drop and porosity in Liquid fluidized bed.

FLUID FLOW OPERATIONS LAB 0 0 3

1. To calibrate the venturimeter and to find out its discharge coefficient. Also, to plot a graph between Reynolds number and discharge coefficient.
2. To calibrate the orifice meter and to find out its discharge coefficient. Also, to plot a graph between Reynolds number and discharge coefficient.
3. To calibrate the V-notch and Weirs to determine its discharge coefficient.
4. To find out the equivalent length of various pipe fittings (i) Gate valve, fully open (ii) Globe valve, fully open (iii) Elbow (iv) Reducer (v) Socket and (vi) Bend.
5. To verify Bernoulli's theorem.
6. To study the characteristics of a centrifugal pump (UPSH / NPSH) / compressor
7. To calibrate the Rotameter.
8. To study the flow characteristics using Reynolds' apparatus.
9. To study the flow curves of fluid's for Newtonian and Non-Newtonian fluids flow conditions.
10. To calibrate and to find out discharge coefficient using Nozzle flow meter.
11. To find out the viscosity of a given Liquid sample using Falling Ball Viscometer.
12. To calculate the power requirement of mixing.

SEMESTER IV

CHEMICAL ENGINEERING THERMODYNAMICS-I 3 1 0

Unit I
Basic Concept The firstlaw and conservation of energy. Applications to steady , nonsteady flow and other engineering problems. The second law. Applications to engineering problems relating to equilibrium , maximum and minimum work. **[8]**

Unit II
Properties of Pure Substances Changes in thermodynamic properties and their inter-relationships. The ideal gas. Fugacity and Fugacity coefficients for real gases.**[8]]**

Unit III
Multicomponent System Partial molal properties. Mathematical models for the chemical potential. Ideal and non-ideal solutions. Activity and activity coefficients. The Gibbs Duhem equations. Excess properties of mixtures. **[8]**

Unit IV
Phase Equilibria Criteria for equilibrium between different phases in Multicomponent nonreacting systems. Applications to systems of engineering interest, particularly to vapour – liquid equilibria and solubility. **[8]**

Unit V
Chemical Equilibrium The equilibrium constant and the variation of yield in chemical reactions with pressure, temperature and composition. **[8]**

Text Books

1. Smith, J.M., Van Ness, H.C. & Abbot, M.M. “Intro to Chemical Engineering Thermodynamics “, 5th edition. New York: Mc-Graw Hill (1996)”
2. Daubert T.E., "Chemical Engineering Thermodynamics" McGraw Hill (1986).

Reference Books

1. Y.V.C.Rao,” Chemical Engineering Thermodynamics” University press (1997).

HEAT TRANSFER OPERATIONS **3 1 0**

Unit I
Introduction to heat transfer and general concepts of heat transfer by conduction, convection and radiation. Conduction: Basic concepts of conduction in solids, liquids and gases, steady state temperature fields and one dimensional conduction without heat generation, e.g., through plane walls, cylindrical and spherical surfaces, composite layers, etc. Insulation materials, critical and optimum insulation thickness. Extended surfaces, fins and their practical applications. Introduction to unsteady state heat transfer. **[07]**

Unit II
Convection: Fundamentals of convection, Basic concepts and definitions, natural and forced convection, hydrodynamic and thermal boundary layers, laminar and turbulent heat transfer inside and outside tubes, Dimensional analysis, determination of individual and overall heat transfer coefficients and their temperature dependence, heat transfer in molten metals. **[09]**

Unit III
Radiation: Basic laws of heat transfer by radiation, black body and gray body concepts, view factors, Kirchoff's law, solar radiations, combined heat transfer coefficients by convection and radiation. **[04]**

Unit IV
Heat Transfer with Phase Change: Condensation of pure and mixed vapors, film wise and drop wise condensation, loading in condensers and basic calculation on condensers, heat transfer in boiling liquids, boiling heat transfer coefficients. Evaporation: Elementary principles, types of evaporators. Single and multiple effect evaporators and their calculation, thermocompression. **[10]**

Unit V
Heat Transfer Equipment: Classification, principles and design criteria, types of exchangers, viz., double pipe, shell and tube, plate type, extended surface, Furnaces and their classification and application. **[10]**

Books Recommended
Holman, J.P.: "Heat Transfer" 9 th ed. McGraw Hill (1989).

Reference Books

1. Coulson, J.M. & Richardson, J.F. "Chemical Engineering :Vol-1", 6th ed. Butterworth- Heinemann(1999)
2. McAdams W.H. "Heat Transmission", 3rd ed., McGraw-Hill, (1954)
3. Kern D.Q. "Process Heat Transfer" McGraw Hill Book (1950)
4. Badger W.L. & Bancharo J.T.,"Introduction to chemical engineering" Tata McGraw Hill.

CHEMICAL REACTION ENGINEERING - I 3 1 0

Unit I
Rate of reaction, Elementary and non-elementary homogeneous reactions, Molecularity and order of reaction, Thermodynamic formulations of rates, Mechanism of reaction, Temperature dependency from thermodynamics, Arrhenius collision and activated complex theories. **[8]**

Unit II
Integral and differential methods for analyzing kinetic data, Interpretation of constant volume batch reactor, data for zero, first, second and third order reactions, Half life period, Irreversible reaction in parallel and series, Auto catalytic reaction. **[8]**

Unit III
Interpretation of variable volume batch reactions data for zero, first and second order reactions, Design equations for batch, plug flow, back mix flow and semi batch reactors for isothermal, adiabatic homogeneous reaction. **[8]**

Unit IV
Holding time and space-time for flow system, Design of batch, plug flow and mixed flow reactors for first and second order single reactions.,Optimum reactor size, Plug flow reactors in series/parallel. Equal and different size of mixed reactors in series and finding the best system for the given conversion, Recycle reactor, Design of reactors for multiple reactions, parallel and series reaction, series-parallel reactions. **[8]**

Unit V
Temperature and pressure effects for single reaction, Optimal temperature progression for first order reactions. Residence time distribution of fluid in vessels, E , F and C curve, Dispersion models, Tanks in series model **[8]**

Text Books
1.Levenspiel, O.. "Chemical Reaction Engineering", 3rd ed. New York John Wiley (1998)

Reference Books
1. Fogler, H.S. "Elements of Chemical Reaction Engineering", 4th ed. Prentice Hall (1997).
2. Smith, J. "Chemical Engineering Kinetics ", 3rd edition. McGraw-Hill, . (1990).

CHEMICAL TECHNOLOGY – I (INORGANIC) 3 0 0

A study of the following chemical industries in relation to their current status (Indian and global), Production and consumption pattern, manufacturing process, latest technological developments, Engineering problems viz pollution control, material of construction, corrosion and economic status should be under taken. These industries have been distributed in the following units :-

Unit I
Chlor-alkali industry: Common salt, Caustic soda and Chlorine, Soda Ash, Hydrochloric acid. **[8]**

Unit II
Sulfur Industry: Sulfur and sulfuric acid,Oleum Phosphorus Industry: Phosphorus, Phosphoric acid and super phosphates **[7]**

Unit III
Nitrogen Industry: Ammonia, Nitric acid, Urea and other nitrogen fertilisers, Mixed fertilisers (SSP, TSP, NPK ,KAP ,DAP, Nitrophosphate) Bio fertilizers. **[8]**

Unit IV
Industries : Cement Refractoriness, Ceramics & Cement . **[7]**

Text Books

1. Dryden, C. E. “Outlines of Chemical Technology” (Edited and Revised by M.Gopal Rao and Sittig .M) East West Press. ,New Delhi,3 rd Edition(1997).
2. Austin G. T » Shreve’s Chemical Process Industries”, 5th ed., McGraw Hill.(1984).

Reference Books

1. Faith, W. L., Keyes, D. B. and Clark, R. L., “Industrial Chemicals” John Wiley.(1975).
2. Kirk and Othmer, "Encyclopaedia of Chemical Technology" Wiley (2004).
3. Pandey G.N & Shukla.S.D, “Chemical Technology Vol - I” Vikas publication.

INDUSTRIAL SOCIOLOGY

UNIT I:
Industrial Sociology : Nature and Scope of Industrial Sociology-Development of Industrial Sociology.

UNIT II:
Rise and Development of Industry : Early Industrialism – Types of Productive Systems – The Manorial or Feudal system – The guild system – The domestic or putting-out system – and the factory system – Characteristics of the factory system – causes and Consequences of industrialization.

UNIT III:
Industrialization in India. Industrial Poling Resolutions – 1956.

UNIT IV:
Contemporary Issues : Grievances and Grievance handling Procedure.
Industrial Disputes : courses, strikes & lockouts, Industrial Relations Machinery Bi-partite & Tri-partite Agreement, Labour courts & Industrial Tribunals, Code of Discipline, Standing order.

Reference Books:

1. GISBERT PASCAL, Fundamentals of Industrial sociology, Tata McGraw Hill Publishing Co., New Delhi, 1972.
2. SCHNEIDER ENGNO V., Industrial Sociology 2nd Edition, McGraw Hill Publishing Co., New Delhi, 1979.
3. MAMORIA C.B. And MAMORIA S., Dynamics of Industrial Relations in India.
4. SINHA G.P. and P.R.N. SINHA, Industrial Relations and Labour Legislations, New Delhi, Oxford and IBH Publishing Co., 1977.

A): INTRODUCTION TO SOFT COMPUTING (Neural Networks, Fuzzy Logic and Genetic Algorithm)

L T P
3 1 0

Unit-I

Neural Networks-1(Introduction & Architecture) Neuron, Nerve structure and synapse, Artificial Neuron and its model, activation functions, Neural network architecture: single layer and multilayer feed forward networks, recurrent networks.Various learning techniques; perception and convergence rule, Auto-associative and hetro-associative memory. **8**

Unit-II:

Neural Networks-II (Back propogation networks) Architecture: perceptron model, solution, single layer artificial neural network, multilayer perception model; back propogation learning methods, effect of learning rule co-efficient ;back propagation algorithm, factors affecting backpropagation training, applications. **8**

Unit-III :

Fuzzy Logic-I (Introduction) Basic concepts of fuzzy logic, Fuzzy sets and Crisp sets, Fuzzy set theory and operations, Properties of fuzzy sets, Fuzzy and Crisp relations, Fuzzy to Crisp conversion. **8**

Unit-IV :

Fuzzy Logic –II (Fuzzy Membership, Rules) Membership functions, interference in fuzzy logic, fuzzy if-then rules, Fuzzy implications and Fuzzy algorithms, Fuzzyfications & Defuzzificataions, Fuzzy Controller, Industrial applications. **8**

Unit-V:

Genetic Algorithm(GA) Basic concepts, working principle, procedures of GA, flow chart of GA, Genetic representations, (encoding) Initialization and selection, Genetic operators, Mutation, Generational Cycle, applications. **8**

Text Books:

1. S. Rajsekaran & G.A. Vijayalakshmi Pai, "Neural Networks,Fuzzy Logic and Genetic Algorithm:Synthesis and Applications" Prentice Hall of India.
2. N.P.Padhy,"Artificial Intelligence and Intelligent Systems" Oxford University Press.

Reference Books:

1. Siman Haykin,"Neural Netowrks"Prentice Hall of India
2. Timothy J. Ross, "Fuzzy Logic with Engineering Applications" Wiley India.
3. Kumar Satish, "Neural Networks" Tata Mc Graw Hill

B): POLYMER SCIENCE AND TECHNOLOGY

L T P
3 1 0

UNIT –I & II

POLYMERS: Introduction, chemistry of polymer synthesis, polymer reaction kinetics, physical properties and characterization of polymers, effect of structure on properties of polymers, organic polymers. Introduction to high performance polymers and composites and their processing. **18**

UNIT –III & IV:

POLYMERIZATION: Introduction, step-growth polymerization, free radical chain growth polymerization, emulsion polymerization, ionic and cationic polymerization, chain statistics and rubber elasticity. **13**

UNIT –V & VI:

PREPARATION AND APPLICATIONS: Preparation, properties and technical applications of thermo-plastics (PVC, PVA), thermostats (PF, UF) and elastomers (SBR, GR-N), silicones. Application of polymers in space, ocean, electronics, medical, agriculture, automobile, sports and building construction. **9**

Reference Books:

1. R.J.Young & P.A. Lovell., "Introduction to Polymers" Stanley Thormes.
2. George Odian.," Principles of Polymerizations" Wiely Inter science
3. R.Sinha.," Outline of polymer Technology (Processing Polymers)." Prientice Hall.
4. Anil Kumar & Rakesh k. Gupta.," Fundamentals of Polymers." McGraw –Hill.
5. Dr. S.K. Bhasin & Dr. Rekha Mann.," Introductory Polymer Science.," Dhanpat Rai. Pub.

C): MATERIAL SCIENCE

L T P
3 1 0

UNIT-I

Introduction: Historical perspective, importance of materials, Brief review of modern & atomic concepts in Physics and Chemistry. Atomic models, Periodic table, Chemical bonding. Crystallography and imperfections: Concept of unit cell, space lattice, Bravais lattices, common crystal structures, Atomic packing factor and density. Miller indices. X-ray crystallography techniques, imperfections, Defects & Dislocations in solids. .

UNIT-II:

Mechanical Properties and Testing: Stress strain diagram, Ductile and brittle materials, stress Vs strength, toughness, hardness, fracture, fatigue and creep. Testing, such as Strength testing, Hardness testing, Impact testing, Fatigue testing Creep testing, Non-destructive testing (NDT) Micro Structural Exam: Microscope principle and methods, Preparation of samples and microstructure exam and grain size determination, comparative study of microstructure of various metals and alloys, such as Mild steel, CI, Brass. Phase Diagram and Equilibrium Diagram: Uniary and Binary diagrams, Phase rules, Types of equilibrium diagrams: solid solution type, eutectic type and combination type, Iron-carbon equilibrium diagram.

UNIT-III:

Ferrous materials: Iron and steel manufacture, furnaces, various types of carbon steels, alloy steels and cast irons, its properties and uses.Heat Treatment: various types of heat treatment, such as Annealing, Normalizing, Quenching, Tempering and Case hardening. Time Temperature Transformation (TTT) diagrams. Non-Ferrous metals and alloys: Non-ferrous metals, such as Cu, Al, Zn, Cr, Ni etc. and its applications. Various types of Brass, Bronze bearing materials their properties and uses. Aluminum alloys, such as Duralumin, Other advanced materials/alloys.

UNIT-IV:

Magnetic properties: Concept of magnetism- Dia, para, ferro magnetic materials, Hysteresis, Soft and hard magnetic materials, Magnetic Storages. Electric Properties: Energy band, concept of conductor, insulator and semi conductor. Intrinsic and extrinsic semi-conductors, P-n junction and transistors, Basic devices and their applications. diffusion of Solid Super conductivity and its applications, Messier effect. Type I & II superconductors. High Temp. superconductors.

UNIT-V

Ceramics: Structure, types, properties and applications of ceramics.Mechanical/Electrical behaviour and processing of ceramics. Plastics: Various types of polymers/plastics and their applications. Mechanical behaviour and processing of plastics, Future of plastics. Other Materials: Brief description of other materials, such as optical and thermal materials, concrete, composite materials and their uses. Other Materials: Brief description of other materials, such as optical and thermal materials, concrete, composite materials and their uses. Performance of materials in service: Brief theoretical consideration of fracture, fatigue, and corrosion and its control.

Text / Reference Books:

1. W.D. Callisster Jr. “Material Science & Engineering Addition” - Wesly Publishing Co. 2. Van Vlash, “Elements of Material Science & Engineering”, John Wiley & Sons 3. V. Raghvan, “Material Science”, Prentice Hall of India 4. Narula, “Material Science”, Tata Mc.Graw Hill 5. Srivastava, Srinivasan, “Science of Materials Engineering” New Age International.

SEMESTER IV LABS:

CHEMICAL REACTION ENGINEERING LAB 0 0 3

1.To determine the relative rates of reaction of iodide ion with hydrogen peroxide at room temperature using different concentrations of the iodide ion.
2. To study the effect of temperature, concentration of the reactants and a catalyst on the rate of chemical reaction
3. To study the activity results or oxidation-reduction replacement reaction.
4. To purify water by ion -exchange.
5. To determine the order and rate constant of esterification reaction at room temperature.
6. To determine the order and rate constant of saponification reaction at room temperature.
7. To study the residence time distribution (R.T.D.) in a stirred tank reactor.
8. To study the residence time distribution (R.T.D.) in a plug flow reactor.
9. To study the decomposition of calcium carbonate
10. To determine the energy of activation of a given chemical reaction.

HEAT TRANSFER OPERATIONS LAB 0 0 3

1. To find the thermal conductivity of metallic rod at different temperature and draw the temperature profile for steady and unsteady state conduction.
3. To find the thermal conductivity of liquid / gases.
4. To find the emissivity of grey plate with respect to black plate
5. To study the critical heat flux behaviour of a liquid
6. To find the heat transfer coefficient for parallel and counter current flow condition for a Double pipe heat exchanger
7. To study the shell & Tube heat exchanger and find the heat duty and Over all heat transfer coefficient for parallel flow condition.
8. To study the shell & Tube heat exchanger and find the heat duty and Over all heat transfer coefficient for counter flow condition.
9. Compare the heat duty for parallel &Counter flow And find the energy saving.
10. To study the Plate heat exchanger and find the Over all heat transfer coefficient
11. To study the performance of heat pipe.
12. To find the heat transfer coefficient for open pan evaporator for steady and unsteady state condition.
13. To study Single/Double/Tripple effect Evaporator and find its Steam economy.
14. To study the Cross Flow Exchanger.
15. Newton's cooling cure experiments.

SEMESTER V

COMPUTER BASED NUMERICAL METHODS 3 1 0

Unit I

Problem solving on computer. Algorithms and flow charts. Introduction to numerical computing, approximations and errors in numerical computations. Truncation and round off errors, propagation of errors. Root finding: bisection method, regula falsi method, iteration method, Newton Raphson method, Secant method, systems of nonlinear equations.**[08]**

Unit II

Matrix algebra, Solution of simultaneous linear algebraic equations: Gauss elimination, Gauss Jordan method, LU decomposition, Jacobi method, Gauss Seidel method, SOR method, convergence of iterative methods. Tridiagonal systems and Thomas algorithm, Condition of a system and stability issues. **[06]**

Unit III

Interpolation and Extrapolation: Newton's forward and backward interpolation formula, Lagrange interpolation formula. Divided differences and Newton's general formula. Numerical differentiation, Numerical integration : Trapezoidal and Simpson's rules. Newton-Cotes integration formulas, Romberg integration, Gaussian Quadrature. **[10]**

Unit IV

Numerical solution of O.D.E.: Taylor series method, Euler's method, Runge Kutta methods. Multistep methods: Milne's method, Adams method, accuracy, Convergence criteria, stiffness, systems of equations. **[08]**

Unit V

Boundary Value problems: Finite difference method, solving eigenvalue problems, polynomial method, power method. Numerical solution of Partial Differential equations. Elliptic, Parabolic and hyperbolic PDEs. **[08]**

Books Recommended

E. Balagurusamy: Numerical Methods, Tata McGraw hill.

Reference Books

1. Sastry, S. S. "Introductory Methods of Numerical Analysis", 3rd ed. Prentice- Hall of India, New Delhi (2002).

2. "Schaum's Outlines: Numerical Analysis", 2nd ed. Tata Mc Graw Hill Publishing Co. Limited (1968)

3. Kandasamy, P. Thialagawathy, K. & Gumawathy, K. "Numerical Methods", S. Chand & Company Ltd., New Delhi (1999).

4. Balaguruswamy, E. "Numerical Methods. Tata Mc Graw Hill Publishing Company Limited, New Delhi (2001).

5. V. K. Singh "Numerical and Statistical Methods in Computer" (2005), Paragon International Publishers, New Delhi.

6. Jain, Iyengar and Jain, "Numerical Methods for Scientific and Engineering Computation" (2003), New Age International, New Delhi.

7. Grewal B.S., "Numerical Methods in Engineering and Science", Khanna Publishers, Delhi.

MASS TRANSFER OPERATIONS - I 3 1 0

Unit I
Diffusion :
Molecular and turbulent diffusion, diffusion coefficient, Fick's Law of diffusion, Dependence of diffusion coefficient on temperature, pressure and composition; measurement and estimation of diffusivity. Diffusion in multi-component gas mixtures. Diffusion in Solids: Molecular, Knudsen & surface diffusion; Inter- phase mass transfer: Mass transfer coefficients, Diffusion between phases, Equilibrium solubility of gases in liquids, Mass transfer theories, Mass transfer in fluidized beds, Flow past solids and boundary layers, Simultaneous heat and mass transfer. **[8]**

Unit II
Absorption and Stripping:
Equipments, Gas-liquid equilibria, Henry's law, Selection of solvent, Absorption in tray column, Graphical and analytical methods, Absorption in packed columns, HTU, NTU &HETP concepts, Design equations for packed column, Absorption with chemical reaction and mass transfer. **[8]**

Unit III
Humidification and Dehumidification:
Vapour liquid equilibrium and enthalpy for a pure substance, vapour pressuretemperature curve, Vapour gas mixtures, Definition and derivations of relationships related with humidity Fundamental concept of humidification, Dehumidification and water cooling, Wet bulb temperature, Adiabatic and non-adiabatic operations, Evaporative cooling ,Classification and design of cooling towers. **[8]**

Unit IV
Drying:
Solid-gas equilibria, Different modes of drying operations, Definitions of moisture contents, Types of batch and continuous dryers, Rate of batch drying, Time of drying, Mechanism of batch drying, Continuous drying, Design of continuous dryers. [8] Unit V Crystallisation: Equilibrium yield of crystallization ,Heat and mass transfer rates in crystallization,Theories of crystallization, Factors governing nucleation and crystal growth rates, Controlled growth of crystal., Classification and design of crystallizers. **[8]**

Text Books
1. Treybal, R "Mass Transfer Operations", 3rd ed. New York: McGraw-Hill, (1980).
2. Sherwood T. K., Pigford R. L. and ˜ilke P. "Mass Transfer" McGraw Hill (1975).

Reference Books
1. Foust A. S. et.al., "Principles of Unit Operations" John Wiley (1980).
2. Geankoplis, C.J.. "Transport Processes and Unit Operations", 3rd ed. Prentice Hall. (1993)

CHEMICAL REACTION ENGINEERING - II 3 1 0

Unit I

Reactor Models
Design equations for batch, continuous and semi batch reactors, Selectivity and yield. Non-catalytic heterogeneous reactions ; Rate equations for heterogeneous reactions. **[8]**
Unit II
Heterogeneous Catalysis Nature of catalysis, Adsorption isotherms, Mechanism of catalytic reactions, Physical properties of solid catalysts. Preparation testing and characterization of catalysts, Catalyst selection, Catalyst poisoning. **[8]**

Unit III
External Transport Process Reaction and diffusion within porous catalysts, Effective diffusivity, Thermal conductivity and effectiveness factor. Reactor choice for single and multiple reactor system and recycle reactor Stability of Reactors Non - isothermal design of ideal reactor, Hot spot in tubular reactor, Steady state multiplicity and effect of operating variables on the stability of C.S.T.R. **[8]**

Unit IV
Reactor Design Progressive conversion and un-reacted core model, Determination of rate controlling step, application to design, fluidized bed reactions Design of solid catalytic reactor, batch, CSTR and tubular reactor. Design of fixed bed and fluidized bed reactors. **[8]**

Unit V
Non elementary reactions and reactor design, biochemical reaction system, Enzyme fermentation, Microbial fermentation, polymerization reactors **[8]**

Text Books
1.Levenspiel, O.. "Chemical Reaction Engineering", 3rd ed. New York John Wiley (1998)

Reference Books
1. Fogler, H.S. "Elements of Chemical Reaction Engineering", 4th ed. Prentice Hall (1997).
2. Smith, J. "Chemical Engineering Kinetics ", 3rd edition. McGraw-Hill, . (1990).

CHEMICAL TECHNOLOGY II (ORGANIC) 3 0 0

Note: In the following units, study of the given chemical industries in relation to their current status (Indian and Global),Production and Consumption Pattern ,Manufacturing process and flow sheet, latest technological developments, Engineering problems, viz Pollution control, materials of construction, corrosion, and economical status should be under taken.

Unit I

Importance and Overview of Chemical Process Industries .Unit operations and Unit process concept . Sugar, Glucose, Starch, Fermentation products such as Alcohol , Acetic acid, Citric acid and antibiotics **[8]**

Unit II

Soap and Surfactants, Glycerin, Fatty acids, Hydrogenation of edible oils , paper and pulp **[6]**

Unit III

Synthetic and natural fibers: Nylon, Dacron, Terylyne, Polyester and other new products, Viscose rayon, acetate rayon , synthetic rubber with special reference to manufacture, vulcanization and reclaiming of rubber, SBR, Plastics, Thermosetting and Thermo Plastics(PVC, Polyethylene, Polyurethane, Teflon) **[8]**

Unit IV

Crude oil distillation, Thermal conversion processes(visbreaking ,coking), Catalytic conversion processes(fluid catalytic cracking, catalytic reforming, hydro cracking, alkylation, isomerisation, polymerization) Finishing processes, sulphur removal process, lub oil manufacture; Petrochemicals(ethylene, propylene, formaldehyde, methanol, ethylene oxide , ethanolamine, cumene, ethylene glycol, ethyl benzene) **[8]**

Text Books

1. Dryden, C. E. “Outlines of Chemical Technology” (Edited and Revised by M.Gopal Rao and Sittig .M) East West Press.Pvt Ltd,New Delhi,3 rd Edition(1997).
2. Austin G. T » Shreve’s Chemical Process Industries”, 5th ed., McGraw Hill.(1984).

PROCESS INSTRUMENTATION **3 1 0**

Unit I

Importance of measuring of Instruments in Process Control, Classification of Instruments, Elements of an Instruments, Static & Dynamic Characterization of Instruments, Errors in measurements & Error Analysis, Selection of instrument for a particular Measurement, transducers.**[8]**

Unit II

Measurement of Temperature: Thermocouples, Resistance Thermometer, Expansion Thermometers, Pyrometers. **[6]**

Unit III

Measurement of Pressure & Vacuum, Hydrostatic type, Elastic Element type, Electrical Type and other type of instruments like Neleod Gauge, Thermocouple gauge, Knudson Gauge, Ionization Gauge. **[8]**

Unit IV

Instruments for Measurement of Flow rate, level & Viscosity, Variable Area & variable head flow meters, Volumetric and Mass flow rate meters, Linear velocity measurement systems, Anemometers, Pressure type , Resistance & Capacitance type, Sonic & Ultrasonic, Thermal type Level meters. Viscometers: Redwood, Saybolt, Engler, Cup & Cone type, Rheo & other types of viscometers, **[8]**

Books

1. Eckman, D.P., Industrial Instrumentation, Wiley Eastern Ltd., New York 1990.
2. Jain, R.K., Mechanical and Industrial Measurements, Khanna Publishers.

PROCESS ECONOMICS AND PLANT DESIGN

L T P
3 0 0

Unit I:
Time value of money:
Interest, Compounding and Discounting factors, Loan payment, cash flow, Continuous cash flow.
Unit II:
Methods for calculating Profitability: Method that do not consider the time value of money, methods that consider the time value of money, methods that consider the time value of money, Alternative investment by different profitability methods, effected of inflation on profitability analysis, methods of profitability evaluation fro replacement.
Unit III:
Depreciation: Straight line, Decline balance , Double declining balance, sum of the digit, Sinking- fund, Accelerated cost recovery system, modified accelerated cost recovery system.
Unit IV:
Analysis of cost Estimates: Factors affecting investment and production cost, capital investment, types of capital cost estimates, methods for estimating capital investment, estimation of revenue, Estimation of total product cost, gross profit, net profit and cash flow.
Unit V:
Optimum Design and Design Strategy: Procedure with one, two, and more variables, optimum production rates in plat operation, case studies, linear Programming –Simplex algorithm, Dynamic programming for optimization, application of language multipliers, Methods of steepest Ascent or Descent.
Unit VI:
Plant Location & Layout: Factor for selection of plant location , site selection and preparation, plant layout and installation.
Unit VII:
Scale up: pilot plants and models , principles of similarity, Dimensional analysis, Differential equation, Regime concept , static Regime, dynamic Regime- Fluid system, thermal regime, chemical regime, similarity criteria and scale- equation for important equipment.

Suggested Books:

1. Peters M.s and Timmerhaus K.D.," Plant Design and Economics for Chemcial Engineers", 5th Ed,. Mc Grw Hill, International Ed 2004
2. Towlwer G.and Sinnott R.K., "Chemical Engineering Design : Principles, Practic and Economics of Plant and Process Design", Butterworth- Heinemann.2008
3. Couper J.," Process Engineeing Economics:, CRc Publishers 2003
4. Zlokarnik M., " Scale up in chemical Engineeing:, 2nd Ed., Wiley- VCH 2006

SEMESTER V LABS

COMPUTER BASED NUMERICAL METHODS LAB 0 0 3
Use of following Techniques in C/C++ Language

1. Solution of single non-linear algebraic equations by Newton Raphson method.
2. Solution of single non-linear equations by Regulafalsi method.
3. Solution of system of linear simultaneous by Gauss Elimination method.
4. Solution of system of linear simultaneous equation by gauss seidel method and successive over relaxation method.
5. Solution of single first order ordinary differential equations by fourth order Runge-Kutta method.
6. Solution of Heat equations (Parabolic equations) by finite difference method.
7. Solution of Laplace equations (elliptic equation) by finite difference method.
8. Solution of wave equations (Hyperbolic equation) by finite difference method.
9. Finding Newton's interpolatory polynomial for n points.
10. Finding Newton's interpolatory polynomial based on finite difference table for n points.
11. Simpson's 3/8-rule.

MASS TRANSFER OPERATIONS LAB-I 0 0 3

1. Study the performance and determination of Equilibrium relationships
2. Mass transfer coefficients,
3. Diffusion coefficients,
4. Separation factors of the experiments with differential distillation,
5. Flash vaporization, vapour liquid equilibrium,
6. Liquid – liquid extraction,
7. Solid –liquid extraction,
8. Ion exchange and membrane separation.

CHEMICAL TECHNOLOGY LAB 0 0 3

Preparation and Quality evaluation of following items :-
1. Cement Paint..
2. Dry Distemper.
3. Oil bound Distemper.
4. Plastic Emulsion Paint.
5. Polystyrene by Bulk Polymerization Technique. 6. PMMA by Bulk Polymerization Technique.
7. Transparent Soaps
8. Powdered Detergent.
9. Liquid Detergent
10. Washing Soap.

SEMESTER VI

TRANSPORT PHENOMENA 3 1 0

Unit I

Introduction to Transport Phenomena Similarity between momentum, heat and mass transfer, The continuum hypothesis, Basic laws of fluid motion, Newton's second law of motion, principle of balance between momentum, heat and mass transfer, Principles of conservation of momentum, mass and energy.

Unit II

Momentum Transport Phenomena Momentum transport in laminar flow: Newton's law of viscosity, Science of rheology, Prediction of viscosity and its dependence on temperature, pressure and composition, Boundary conditions, Shell balance approach for stress distribution and velocity profiles. Introduction to time derivatives and vector analysis, Equation of continuity and equation of motion and their applications in fluid flow problems.

Unit III

Unsteady state momentum transport, Flow near a wall suddenly set in motion, Momentum transport phenomena in turbulent flow. Definitions of friction factors, friction factor for flow in tubes, for flow around spheres, for packed bed column.

Unit IV

Energy Transport Phenomena Energy transport in laminar flow: Fourier's law of heat conduction, Prediction of thermal conductivities and its dependence on temperature, pressure and composition, Boundary conditions, shell balance approach. Types of heat sources, Principle of extended surfaces, types of cooling fans, free and forced convection. Unsteady state heat transport, Unsteady state heat conduction in solids, heating of semi-infinite slab, heating of finite slab.

Unit V

Mass Transport Phenomena Definitions of concentration, velocities and mass fluxes, Fick's law of diffusion, Prediction of diffusivity and its dependence on temperature, pressure and composition, Boundary conditions, Shell balance approach for mass transfer problems, Problems of diffusion with homogeneous and heterogeneous chemical reaction, Diffusion and chemical reaction in porous catalyst – the effectiveness factor. The equation of continuity for multicomponent mixtures.

Text Books

1. Bird, R. B., Stewart, W. E. and Lightfoot, E. N., "Transport Phenomena", 2nd edition John Wiley (1960).
2. Bannet, C. O. and Myers J. E., "Momentum Heat and Mass Transfer" Tata McGraw Hill, (1973)..
3. RS Broadkey dan HC Hersey, "Transport Phenomena:AUnified approach", McGraw-Hill Book, (1988).

Reference Books

1. Beck, W. J. and Muttzall, K.M.K., "Transport Phenomena", John Wiley, (1975).
2. Loddha, G. S. and Degaleesan T. E. "Transport Phenomena in Liquid Extraction", Tata McGraw Hill, (1975).
3. Slattery, J. "Momentum, Energy and Mass Transfer in Continua", McGraw Hill, (1972).
4. Scissom, L. E. and Pitts, D. R., "Elements of Transport Phenomena", McGraw Hill, (1972).

ENERGY RESOURCE AND MANAGEMENT

Unit I:

Fossil and Processed Fuel: Coal its origin and formation, Coal analysis, Coal classification, Coal preparation, Coal washing and coal blending, Coal carbonization, Treatment of coal gas and recovery of chemical from coal tar, Coal gasification, liquid fuel synthesis from coal, CBM. Petroleum crude , Types of crude ,emergence of petroleum products as energy, Gaseous Fuels: Natural gas, Water gas, producer gas, L.P.G., bio- gas, coke oven gas, blast furnace gas, LNG ,CNG, Gas hydrates ,GTL Technology (gas to liquid), Biodiesel. **[8]**

Unit II:

Energy Scenario Commercial & Non commercial energy, primary energy resources, commercial energy production, final energy consumption, energy need of growing economy, long term energy scenario, energy pricing, energy sector reform, energy & environment, energy conservation and its importance, re- structuring of the energy supply sector, energy strategy for future, energy conservation act. **[8]**

Unit III:

Management & Energy Planning Definition & significance, energy strategy, energy policy & energy planning, two sides of energy management, sectors of supply side energy management, objective of energy management, hierarchical levels of supply side energy management, trade off b/w energy management, energy strategies & energy planning, energy & economy, essential imperatives & steps in supply side energy planning, energy planning flow for supply side, essential data for supply side energy planning, infrastructure planning, transportation of energy, per capita energy consumption, imperatives & steps in user side energy planning, energy management & control system for demand side, seven principal of energy management, energy policy of a supply organization & demand side organization, organization for energy management, training & human resource development, motivation. **[8]**

Unit IV:

Thermodynamic analysis of chemical processes Energy audit, Objectives of energy audit, Energy audit team, Methodology, Types of energy audit-Preliminary and detailed, Proposed measures for energy conservation with cost-benefit analysis. Equipment-oriented approaches for energy conservation-Fired heater, Boiler, Evaporators, Distillation column, absorption/stripping column, Dryer, Liquid-liquid extraction column Waste heat recovery: Sources of waste heat, Feasibility of waste heat recovery, Types of heat recovery equipments, Applications. Pinch technology, Energy targets, Composite curves, Process pinch, Pinch principles, Grand composite curves and process utility interface, Uses of pinch analysis in chemical process industries. Energy conservation opportunities in chemical process utilities - Steam systems, Compressed air systems, Insulation Cogeneration, Cogeneration systems

Text Books

1. . Rao S. & Parulckar B.B. ”Energy technology” khhanna publisher.
2. Boyle “Renewable Energy : Power for a sustainable future” Oxford.
3. Rao S. & Parulckar B.B. ”Energy technology” khhanna publisher
4. Sukhatme S.P, "Solar Energy - Principles of Thermal Collection and Storage",2nd Ed., Tata McGraw- Hill.,(1996).

MASS TRANSFER OPERATIONS – II **3 1 0**

Unit I
Distillation Pressure-composition, Temperature-concentration, Enthalpy-concentration diagrams for ideal and non-ideal solutions, Raoults law and its application, Maximum and minimum boiling mixtures, concept of relative volatility, Single Stage Distillation Differential distillation, Flash vaporization, Vacuum, molecular and steam distillation. **[8]**

Unit II
Continuous Distillation of Binary Mixtures Multistage contact operations, Characteristics of multistage tower, McCabe Thiele method, Ponchon Savarit method, Reflux, maximum, min. and optimum reflux, Use of open steam, Tray efficiency, Determination of height and column diameter, Multistage batch distillation; Principles of azeotropic and extractive distillation, Introduction to multicomponent distillation system. **[8]**

Unit III
Liquid-Liquid Extraction Ternary liquid equilibria, Triangular graphical representation concept of theoretical or ideal stage, Equipment used for single stage and multistage continuous operation; Analytical and graphical solution of single and multistage operation Super critical fluid extraction. **[8]**

Unit IV
Solid /Liquid Extraction Leaching, Solid liquid equilibrium, Equipment used in solid-liquid extraction,Single and multistage cross current contact and counter current operations. Concept of an ideal stage, Overall stage efficiency, Determination of number of stages. **[8]**

Unit V
Adsorption Description of adsorption processes and their application, Types of adsorption, Nature of adsorbents adsorption equilibria and adsorption hysterises, Stage wise and continuous contact adsorption operations, Determination of number of stages, Equipments; Ion exchange, Equilibrium relationship, Principle of ion-exchange, techniques and applications, Principles and application of dialysis, osmosis reverse osmosis, thermal diffusion, sweep diffusion. **[8]**

Text Books
1. Treybal, R "Mass Transfer Operations", 3rd ed. New York: McGraw-Hill, (1980).
2. Sherwood T. K., Pigford R. L. and Wilke P. "Mass Transfer" McGraw Hill (1975).

Reference Books
1. Foust A. S. et.al., "Principles of Unit Operations" John Wiley (1980).
2. Geankoplis, C.J.. "Transport Processes and Unit Operations", 3rd ed. Prentice Hall. (1993).

PROCESS DYNAMICS & CONTROL 3 1 0

Unit I :
Introduction to Process control systems, Regulator & Servo control, Feed Forward & Feed backward control, Negative & Positive Feed back Control, variables & Physical Elements of a Control system, Physical, Block & Signal Flow Diagram. Use of Laplace & Inverse Laplace Transformation is study of Process Dynamics.

Unit II
Dynamic Modeling of a Process, Dynamic behavior of First order systems and First order systems in series. Dynamic behavior of second & higher order system for various kind of inputs, Linearization of nonlinear system, Transportation & Transfer Lag.

Unit III
Modes of control action, Controllers & Final control Elements, Reduction of Block & Signal Flow Diagrams, Closed loop transfer function and response of closed loop control system for various type of control actions.

Unit IV
Stability analysis, Rouths criterion, Root locus Analysis, Frequency Response Analysis & Design of Controllers for optimum Performance.

Unit V
Advanced control strategies, cascade control, Feed forward control, Tuning Rules for Feed Forward & Feed backward control, Ratio control, optimum controller Tuning, Ziegler Nichol & Cohen Coon settings.

Test Books :
1. Process system Analysis & Control, D.R. Coughanoowr, McGraw Hill Publication.

Reference Books :
1. Process Control. Peter Harriot, Tata McGraw Hill.
2. Process control, Staphno polies, Prentic Hall India Ltd.

DEPARTMENT ELECTIVE-I

A): OPTIMIZATION TECHNIQUES IN CHEMICAL ENGINEERING **2 1 0**

Unit I
Analytical Method Necessary and sufficient conditions for optimum in single and multi variable unconstrained and constrained problems. **[7]**

Unit II
Unconstrained One Dimensional Search Newton, Quasi-Newton and Secant method for unidimensional search, Region elimination methods (Golden Section, Fibonacci, Dichotomous. etc.) **[7]**

Unit III
Linear Programming, Graphical simplex method, revised simplex method, duality and transportation problems. Unconstrained Multi Variable Search, Direct methods, Indirect method. **[8]**

Unit IV
Finite difference approximation, Dynamic Programming, Principle of optimality, Discrete and continuous dynamic programming. **[8]**

Books Recommended

1. T.F. Edgar and D.M. Himmelblau Optimization of Chemical Processes – McGraw Hill (1989)

2. K. Urbanier and C. McDermott - Optimal Design of Process Equipment – John Wiley (1986)

B): COMPUTATIONAL FLUID DYNAMICS **2 1 0**

Unit I

Basic Concepts of Fluid Flow:

Philosophy of computational fluid dynamics, conservation principles of mass, energy, and momentum, simplified flow models such as incompressible, inviscid, potential and creeping flows, classification of flows. Turbulence and its Modelling: Transition from laminar to turbulent flow, Effect of turbulence on time-averaged Navier-Stokes equations, Characteristics of simple turbulent flows, Free turbulent flows, Flat plate boundary layer and pipe flow, Turbulence models, Mixing length model,The k-e model, Reynolds stress equation models, Algebraic stress equation models **[6]**

Unit II

Grid Generation:

Structured and unstructured grids, choice of grid, general transformation of equations, some modern developments in grid generation in solving the engineering problems. Finite Difference Method: Discretization of ordinary and partial differential equations, approximation of first, second and mixed derivatives, implementation of boundary conditions, discretization errors, applications to the engineering problems.**[7]**

Unit III

Finite Volume Method:

Discretisation methods, approximations of surface integrals and volume integrals, interpolation and differentiation practices, implementation of boundary conditions, applications to the engineering problems. Introduction, one-dimensional steady state diffusion, two-dimensional diffusion problems, three-dimensional diffusion problems. The Finite Volume Method for Unsteady Flows and Implementation of Boundary Conditions: One-dimensional unsteady heat conduction, **[10]**

Unit IV

Special Topics:

Flow in a sudden pipe contraction / expansion, flow and heat transfer in a complex tubes and channels, reactive flow, multiphase flow , and turbulent flow processes. **[7]**

Suggested Books:

1. Anderson Jr J. D., “Computational Fluid Dynamics: The Basics with Applications”, McGraw Hill. 1995
2. Muralidhar K. and Sundararajan T., “Computational Fluid Flow and Heat Transfer”, Narosa Publishing House. 2003
3. H. K. Versteeg and W. Malalasekera, An introduction to computational fluid dynamics: the finite volume method , Longman scientific & technical publishers 2007
4. Ferziger J. H. and Peric M., “Computational Methods for Fluid Dynamics”, 3rd Ed., Springer. 2002
5. Ranade V. V, “Computation Flow Modeling for Chemical Reactor Engineering”, Academic Press. 2002

C): PROCESS FLOW SHEET SIMULATION 2 1 0

Unit I

Introduction to Process Simulation: Background and history of process simulation; Steady State and Dynamic Simulation; Different approaches to process simulation; modules and components in a process simulation package, integration of simulation tools, structure and functionality of commercial simulation tools, selection of flowsheet and simulation software. Process Flow sheeting: Approaches to flowsheeting, collection and estimation of thermo-physical properties for the chemical species of the system, thermo-physical properties banks, Flow sheet presentation, manual flow sheet calculations, computer aided flow-sheeting, manual calculations with recycle streams, partitioning and tearing a flowsheet.**[7]**

Unit II

Fundamentals of systems engineering: system definition, system properties, aggregation/decomposition, hierarchies of systems; introduction of canonical modeling concepts: devices, connections, equations, variables; formalizing the modeling process: methods of structuring complex chemical processes, procedures for process modeling; degrees of freedom in a flow sheet. numerical properties of the model equations, numerical methods for steady-state and dynamic systems, Differential Algebraic Equations; Synthesis of reaction systems and synthesis of azeotropic separation systems.**[7]**

Unit III

Processing Simulation with softwares such as: ASPEN PLUS/Hysis/PRO II/Design II/UniSim/OLI Pro/Aspen Custom Modeler/TK-Solver: Introduction to the Simulation Package; Features of simulation packages; Introduction to the simulation package Graphical User Interface; Example-1: Flashing of Light Hydrocarbons; Survey of unit operation models; Example-2: Vinyl chloride monomer (VCM) flowsheet. Flowsheet Calculations and Model Analysis Tools: Sensitivity and case-study runs ; Design specifications and calculator blocks ; Example-3: VCM flowsheet sensitivity run / design-spec run. Inorganic chemicals and electrolyte modeling; Example-4: sour water systems (CO2 and H2S removal for example);**[8],**

Unit IV

Physical Properties: Overview of physical property system ; Property model specifications ; Property data requirements and input; Physical property analysis; Example-1: Introducing a non-databank component. Multistage Separation: RADFRAC: Rigorous rating and design fractionation model; Example-2: Using RADFRAC in the VCM flowsheet. Introduction to ICARUS(an economic evaluation package inside ASPEN PLUS), Flowsheet Convergence: Example-3: VCM flowsheet convergence, Introduction to overall Plant automation through simulation, molecular modeling and how it will compliment standard simulators and dynamic simulation.

Case Study: Design and simulation of some of the inorganic and organic process plants such as sulphuric acid, ammonia.**[8]**

Suggested Books and Resources:

1.Dimian A. C., “Integrated Design and Simulation of Chemical Processes”, Elsevier,2003
2.Westerberg, A. W., Hutchison, H. P., Motard, R. L. & Winter, P., “Process Flowsheeting”, Cambridge University Press,1979.
3.Kumar, A., “Chemical Process Synthesis and Engineering Design”, Tata McGraw Hill,1981.
4.K. M. Hangos and I. T. Cameron, “Process Modelling and Model Analysis”, Academic Press,2001
5.W. F. Ramirez, “Computational Methods for Process Simulation”, 2nd ed., Butterworths,1997
6.A.W. Westerberg, et al, "Process Flow Sheeting", Cambridge University Press,1990
7.Resources:

- SCILAB, available at http://www.scilab.org, is an open-source simulation package, quite similar to MATLAB.
- Netlib online repository for numerical and scientific computing: http://www.netlib.org/
- Numerical Recipes: The art of scientific computing website: http://www.nr.com/
- CANTERA, Object-Oriented Software for Reacting Flows: http://www.cantera.org/
- Practice problems: http://www.che.eng.kmutt.ac.th/cheps/ChE656.htm.

PROCESS EQUIPMENT DESIGN :

Unit I:
Heat Exchangers: Basic design procedure of heat transfer equipment, overall heat transfer coefficient and dirt Factors, shell and tube heat exchanger – construction details, selection algorithm, design codes, mean temperature difference, general design consideration, tube and shell side heat transfer coefficient and pressure drop , CAD of shell and tube heat exchangers, mechanical and fabrication aspects: mechanical drawing of heat exchangers

Unit II:
Condensers: Design of condenser for single vapor, correlation of heat transfer coefficient for condensation inside and outside of tubes of vertical and horizontal condensers, design of desuperheater cum condenser and condenser cum sub cooler, condensation of mixture, pressure drop in condenser.

Unit III:
Evaporators: Reboiler, vaporizers and evaporators- pool boiling, convective boiling, selection of reboilers and vaporizers and evaporators, drawing of evaporators.

Unit IV:
Crystallizers: design of crystallizers, agitated vessels and selection of agitators, design of gas liquid separators and mixing equipment.

Unit V:
Distillation Columns: type of packing, packed bed height, column diameter, column internals, design methods, design of liquid of liquid- liquid extractors and gas –liquid absorber

Text books:

1. Towler G. and Sinnot R.K., "Chemical Engineering Design: Principles, Practice and economics of plnt and process Design.
2. Seader J.D. and Henely E.J., "Sepration Process Principles" 2nd Ed., Wiley- India

SEMESTER VI LABS

MASS TRANSFER LAB-II **0 0 3**

Study the performance and determination of equilibrium relationships, mass transfer coefficient, Separation factors of the experiments with gas diffusion, packed bed absorption, bubble gas absorption, humidification and dehumidification, cooling tower, tray dryers, crystallization and adsorption.

PROCESS DYNAMICS AND CONTROL LAB **0 0 3**

1. To study the response, time constant of thermocouple/ Bimetallic thermometer.
2. To study the response of a liquid level tank system
3. To study the response of a two tank non-interacting system
4. To study the response of a two tank interacting system.
5. To study the response of a stirred tank heater system
6. To study the characteristics of an on-off controller.
7. To study the characteristics of a PI/PID pneumatic / electronic controller.
8. To study the performance of a closed loop control system containing controller, final control element, measuring element.
9. Calibration of temperature and pressure measuring instruments
10. Analysis of solution by UV/VIS spectrophotometer

PETROLEUM ENERGY LAB **0 0 2**

1. Estimation of net & gross calorific value of coal sample using Bomb Calorimeter
2. Estimation of net calorific value of petroleum sample using Bomb Calorimeter
3. Derivation of kinematic viscosity by Saybolt Viscometer (Universal and Furol)
4. Determination of flash and fire points by Penskey Marten apparatus
5. Estimation of carbon residue
6. Efficiency of solar cell
7. Proximate analysis of Coal
8. Performance of solar water pump
9. Performance of solar regenerator.
10. Coal analysis: Smoke point, Flash Point, Fire Point etc.

EQUIPMENT DESIGN **0 0 2**

Practice to design various equipments with 'to scale' drawing and use of software's for the design.

SEMESTER VII

THERMODYNAMICS II

Phase rule –
Single & Multicomponent phase equilibria, Thermodynamics of solutions, electrolytes and non-electrolytes. Ideal - non-ideal solutions. High Pressure vapor liquid equilibrium. Criterion of equilibrium and Gibb's - Duhem equitation. V-L, L-L and V-S equilibrium for ideal and nonideal systems.

Homogeneous, Single & Multiple Reactions. Equilibrium constant and its variation with Temp & Pressure. Minimization of free energy. Heterogeneous Reactions Equilibrium - Single & Multiple Heterogeneous reactions.Duhem's theorem for reacting systems. Compression & Absorption, Refrigeration cycles. Liquefaction of gases.
.
Thermodynamic analysis of the processes.

Reference Books:

1. Introduction to Chemical Engineering thermodynamics:
Mc Graw Hill *Smith, Vanner s& Abbott*
2. Chemical Engineering thermodynamics:
John Wiley & Sons *Sandler*
3. Chemical Engineering thermodynamics
Universities Press, Pune.
4.YVC Rao
Chemical Engineering thermodynamics
Prentice Hall
Narayanan

PROCESS DESIGN (MECHANICAL ASPECT)

Unit I:

Mechanics of Materials: Stress, strain, biaxial stress: Stress- strain relationship for elastic bodies : Membrane stresses in various type of thin pressure vessels.

Unit II:

Pressure Vessels: selection of type of vessels, designing consideration, introduction of codes of pressure vessel design, classification of pressure vessel as per codes, design of cylindrical and spherical shells under internal and external pressure, selection and design of closers and heads: introduction to compensation for opening: design of jacketed portion of vessels:, design of high pressure monoblock and multilayer vessel.

Unit III:

Flanges: selection of gaskets, selection of slandered flanges, optimum selection of bolts for flanges, design of flanges, inspection and testing of vessels using heads and flanges as per code specifications.

Unit IV:

Piping : Pipe thickness calculation under internal and external pressure, introduction to flexibility analysis of piping systems.

Unit V:

Tall Tower Design: Design of shell, skirt, bearing plate and anchor bolts for tall tower used at high wind and seismic conditions..

Unit VI:

Design of lug support and saddle support including bearing plates and anchor bolts.

Unit VII:

Storage Tanks: Introduction to Indian standards, filling and breathing losses:, classification of storage tanks :, Design if liquid and gas storage tanks with and without floating roof.

Text books:

1. Brownell L.E and Young H.E., " process equipment design ", John Wiley and sons. 2004
2. Bhattacharya B.C., "introduction of chemical equipment design "CBS publishers.2003
3. I.S: 803-1962," Code of practice fro design, fabrication and erection of vertical mild steel cylindrical welded oil storage tanks". 1962

INDUSTRIAL SAFETY AND HAZERDS MANAGEMENT

UNIT I:
Introduction: Industrial process and hazards potential, mechanical electrical, thermal and process hazards. Safety and hazards regulation hygiene and the factory act, and environment protection acts and rules.
Unit II:
Toxicology: hazards identification-toxicity, fire, static electricity, noise and dust concentration. Materials safety data sheet, hazards indices- Dow and Mond indices, HAZOP AND HAZAN.
Unit III:
Reliability Engineering and Hazards Assessment: Probabilistic failure distribution, failure of slandered and complex systems, failure data analysis and failure modeling. Event data, fault tree and event tree analysis, scenario development and consequence modeling , risk criteria.
Unit IV:
Fire and Explosion: shock waves propagation, vapor cloud and boiling liquid expanding vapor explosion (VCE and BLEVE), mechanical and chemical explosion, multiphase reaction, transport effects and global rates.
Unit V:
Relief System: Preventive and protective management from fires and explosion inerting, static electricity passivation, ventilation and sprinkling, proofing , relief systems- relief valves, flares, scrubbers.
Unit VI:
Case Studies: Flixborough and Bhopal accidents.

Text Books:

1. Crowl D.A.and Louvar J.F.," chemical process safety: fundamentals with application", 2nd Ed., Prentice Hall. 2001
2. Mannan S.," Lee's Loss preventaion in the process Industries",2nd Ed., Butterworh Heinemann. Vol. I 2004
3. Mannan S.," Lee's Loss preventaion in the process Industries",2nd Ed., Butterworh Heinemann. Vol. II 2004
4. Mannan S.," Lee's Loss preventaion in the process Industries",2nd Ed., Butterworh Heinemann. Vol. III 2004

DEPARTMENT ELECTIVE: II

A): PROCESS UTILITIES AND SAFETY IN CHEMICAL PLANTS 3 1 0

Unit I

Various process utilities, their role and importance in chemical plants. Water Sources of water and their characteristics ;Treatment storage and distribution of water; water for use in boilers, cooling purposes, drinking and process; Reuse and conservation of water; Water resource management. **[8]**

Unit II

Steam Generation and Utilization Steam generation and its application in chemical process plants, distribution and utilization ;Design of efficient steam heating systems; steam economy, Steam condensers and condensate utilization Expansion joints ,flash tank design, steam traps their characteristics, selection and application, waste heat utilization.; Lagging, selection and thickness .Selection and sizing of boilers; waste heat boilers. [8]

Unit III

Compressors, blowers and Vacuum Pumps Compressors, blowers and vacuum pumps and their performance characteristics; Methods of developing vacuum and their limitations, material handling under vacuum, Piping systems; Lubrication and oil removal in compressors and pumps. Air filters, Air and gas leakage. Inert gas systems , compressed air for process, Instrument air.**[8]**

Insulation Importance of insulation for meeting the process requirement, insulation materials and their effect on various material of equipment piping, fitting and valves etc. insulation for high intermediate, low and sub zero temperatures, including cryogenic insulation. **[8]**

Unit IV

Elements of Safety Elements of safety, safety and site selection; Plant layout and unit plot planning; Definition of risk and hazard, Identification and assessment of the hazards, distinction between hazards and risk, Hazard operability (HAZOP) hazard analysis (HAZAN); Assessment of the risk, fault tree, event tree, scope of risk assessment; Control of hazards, controlling toxic chemicals and controlling flammable materials. Prevention of losses Prevention of losses, Pressure relief, Provision of fire fighting equipments, Technology selection and transfer, Choosing the right process. [8]

Unit V

Control of Process Control of process, Prevention of hazardous deviation in process variables, e.g. pressure, temperature flow by provision of automatic control systems-interlocks, alarms, trips together with good operating practices and management. Regulations and legislation, Role of government role, risk management routines and tackling disaster. [8]

Text Books

1. Nordell, Eskel, “Water Treatment for Industrial and Other Uses”, Reinhold Publishing Corporation, New York.(1961).
2. Crowl, D.A. & Louvar, J.F.. “Chemical Process Safety: Fundamentals with Applications”. New Jersey: Prentice-Hall. (1989).
3. Goodall, P. M., “The Efficient Use Of Steam” IPC Science and Technology (1980).

Reference Books

1. Lees, F. P., “Loss Prevention in Process Industries 3 volume set” Butterwort – Heinemann, Oxford (1996).

B): BIO CHEMICAL ENGINEERING:

Unit I:
Introduction: Aspects of microbiology, cell theory, structure of cells, classification of microorganism, influence f environmental parameters on micro organism. Chemical compostion of cell, liquids, carbohydrates, proteins and enzymes.

Unit II:
Metabolism and Energetic: assimilatory and dissimilarity processes, metabolism of cells.

Unit III:
Enzymes and Microbial Kinetics: simple enzyme kinetics with one or two substrates, modulation and regulation of enzymatic activity, enzyme reactions in heterogeneous systems. Cell- growth –cycle phase for batch cultivation, modeling of batch growth, product synthesis kinetics, overall kinetics and thermal death kinetics of cells and spore, kinetics with and without inhibition.

Unit IV:
Unit operation in biochemical Process: Agitation and aeration, gas liquid mass transfer, determination of oxygen rates,' a' and K_L a', scaling of mass transfer equipment. Heat balance and heat transfer correlations for biotechnical systems, sterilization, filtration and drying. Immobilization of cell and enzymes characteristics of different bioreactors, batch and continuous rectors, tubular, CSTR and tower rectors. Aerobic and anaerobic fermentation, process design and operation of typical aerobics and anaerobic fermentation processes, manufacture of microbial product, e.g. antibiotics, alcohol/ wine etc. use of immobilized enzymes and whole cell for industrial processes.

Text Books:

1. Bailey J.E. and Ollis D.F." Biochemical Engineering Fundamentals, 2nd Ed.,McGraw Hill." 1987.
2. Doble M. and Gummadi S.N.,"Biochemical Engineering. "Prenice Hall. 2007.
3. Schuler M.L. and Kargi F.,"Bio process Engineering.," 2nd Ed., Prentice Hall. 2002

C): CORROSION SCIENCE AND ENGINEERING 3 1 0

Unit I

Basic aspects introduction, classification, economics and cost of corrosion. Emf series, Galvanic series, corrosion theories derivation of potential- current relationship of activation controlled and diffusion corrosion processes. Potential- pH diagrams Fe-H2O system, application and limitations. Passivation-definition, anodic Passivation, theory of Passivation, oxidation laws, effects of oxygen and alloying on oxidation rates.

Unit II

Forms of corrosion-definition, factors and control methods of various forms of corrosion such as pitting, inter granular, crevice, stress corrosion, corrosion fatigue, hydrogen embrittlement, corrosion processes and control methods in fertilizers, petrochemical and petroleum refineries

Unit III

Environmental aspects: Atmospheric corrosion- classification, factors influencing atmospheric corrosion, temporary corrosion preventive methods, corrosion in immersed condition, effect of dissolved gases, salts, pH, temperature and flow rates on corrosion, Underground corrosion- corrosion process in the soil, factors influencing soil corrosion.

Unit IV

Corrosion control aspects: Electrochemical methods of protection-theory of cathodic protection, design of cathodic protection, sacrificial anodes, anodic protection. Corrosion inhibitors for acidic, neutral and alkaline media, cooling water system-boiler water system. Organic coating-surface preparation, natural synthetic resin, paint formulation and applications. Design aspects in corrosion prevention, corrosion resistant materials.

Unit V

Corrosion Testing, monitoring and inspection, laboratory corrosion tests, accelerated chemical tests for studying different forms of corrosion. Electrochemical methods of corrosion rate measurements by DC and AC methods, corrosions monitoring methods, chemical and electrochemical removal of corrosion products,

Text Book:

1. S.N. Banerjee, An Introduction to Corrosion and Corrosion Inhibition, Oxonian Press Ltd., New Delhi.

Reference Books:

1. LL Shrier Corrosion Vol. I & II George NownonsLtd., Southhampton Street London Endn. II
2. M.G. Fontana & N.D. Greene,Corrosion Engineering, McGraw Hill, New York (3/e)
3. H.H. Uhlig, Corrosion and Corrosion Control. A Wiley- Inter Science. Publication John Wiley & Sons, New York.
4. C.T.Munger- Organic Coatings
5. Jain & Jain, Engineering Chemistry, Dhanpat Rai & Sons, New Delhi

D): PROJECT ENGINEERING AND MANAGEMENT 3 1 0

Unit I

Role of project engineering in project organization ;Plant location and plant layout; Start up and shut downs of project; Preliminary data for construction projects; Process engineering; Flow diagram, Plot plans, Scheduling the project; Engineering design and drafting. **[8]**

Unit II

Business and legal procedures Procurement operations: Organization and operation of a procurement department, Contract versus Commodity buying; Procurement requiring engineering participation, Procurement of off-the-shelf materials, Expediting and inspection, Procurement procedure, Bid comparisons, The purchase order inspection, Expediting, General purchaser-vendor practices, Project engineering and procurement. Office procedure: Conferences, Technical writing, Filing systems, Contracts and contractors :Engineering and constructors firms, Selecting the contractor, The basis of contract, Type of reimbursement, The contract form, Exhibits, Overtime payments, Typical engineering and construction contracts, Exhibits for engineering and construction contracts, Lump-sump contract form, Contracts and engineers, Ethics and the contract.**[8]**

Unit III

Details of engineering design and equipment selection: Vessels, Heat exchangers, Process pumps, Compressor and Vacuum pumps, Motors and turbines, Other process equipment, Piping design, Thermal insulation, Process instruments, Plant utilities, Foundations, Structures and buildings, Safety and plant design. **[8]**

Unit IV

Construction planning: Construction personnel: Jurisdictional disputes and labor relations, Construction labors distribution, Labor rates. Construction operations: Site preparation, Driving of pile, Temporary buildings, Temporary water supply, Road ways and rail road spurs, Excavation operation, Installation of underground facilities, Electrical conduit, Foundation construction, Erection of guyed derrick, Erection of elevated reinforced concrete structures and structural steel, Erection of major equipment, Installation of piping, pipe identification, insulation, Buildings, final stage of construction. **[8]**

Unit V

Critical path method (cpm): Events and activities; Network diagramming; Earliest start time and earliest finish time ;latest start time and latest finish time; Float, Advantage of CPM ;Cost to finish he projects earlier than normal cost; Precedence diagramming. Programmed evaluation and review technique (pert).PERT network and time estimates; Single versus multiple time estimates; Frequency distribution. [8]

Text Books

1. Rase F. Howard & Barrows M. H.," Project engineering of process plant"Wiley (1957)

Reference books

1. Peter S. Max & Timmerhaus, Plant design and economics for chemical engineers. Mc Graw Hill (2002).
2. Srinath L. S., "PERT AND CPM." affiliated east press pvt. Ltd., new york (1973)
3. Perry J. H.,"Chemical engineering handbook" 7TH ed. Mc Graw Hill (1997).
4. JELLEN F. C., "Cost and optimization in engineering". Mc Graw Hill (1983

PROCESS MODELLING AND SIMULATION **3 1 0**

Unit I
Introduction to mathematical modeling; Advantages and limitations of models and applications of process models of stand-alone unit operations and unit processes; Classification of models – Simple vs. rigorous, Lumped parameter vs. distributed parameter; Steady state vs. dynamic, Transport phenomena based vs. Statistical; Concept of degree of freedom analysis. **[8]**

Unit II
Simple examples of process models; Models giving rise to nonlinear algebraic equation (NAE) systems, - steady state models of flash vessels, equilibrium staged processes distillation columns, absorbers, strippers, CSTR, heat exchangers, etc.; Review of solution procedures and available numerical software libraries. **[8]**

Unit III
Steady state models giving rise to differential algebraic equation (DAE) systems; Rate based approaches for staged processes; Modeling of differential contactors - distributed parameter models of packed beds; Packed bed reactors; Modeling of reactive separation processes; Review of solution strategies for Differential Algebraic Equations (DAEs), Partial Differential Equations (PDEs), and available numerical software libraries. **[8]**

Unit IV
Unsteady state (time dependent) models and their applications; Simple dynamic models of Batch reactors, Adsorption columns, Multistage separation systems; Model reduction through orthogonal collocation; Review of solution techniques and available numerical software libraries. **[8]**

Unit V
Introduction to flow sheet simulation; Sequential modular approach; Equation oriented approach; artitioning and tearing; Recycle convergence methods; Review of thermodynamic procedures and physical property data banks. **[8]**

Text Books
1. Luyben W.L., “Process Modeling, Simulation, and Control for Chemical Engineering”, Wiley.
2. M.M. Denn, “Process Modelling”, Wiley, New York, (1990).

Reference Books
1. Hussain Asghar, “Chemical Process Simulation”, Wiley Eastern Ltd., New Delhi, (1986)
2. C.D. Holland and A.I. Liapis, “Computer Methods for Solving Dynamic Separation Problems”, McGraw Hill, (1983).
3. C.D. Holland, “Fundamentals of Modelling Separation Processes”, Prentice Hall, (1975)
4. S.M. Walas, “Modelling with Differential Equations in Chemical Engineering”, Butterworth, (1991)
5. M.E. Davis, “Numerical Methods and Modelling for Chemical Engineers”, Wiley, New York(1984).

SEMESTER VII LABS:

C.A.D LAB **0 0 3**

Recommended to be done using a commercial simulator
1. Design of a Flow network containing Pumps, fittings and Piping (horizontal, vertical, inclined)
2. Process design of simple reactors (CSTR, Tubular) with or without heat transfer.
3. Process design & Rating of stand alone Multi-component Distillation columns.
4. Process design & Rating of TEMA Type Shell &Tube Heat exchangers.
5. Steady state flow sheeting of acyclic processes.
6. Steady state flow sheeting of Processes with recycles /Purge/Bypass etc.

Recommended to be done using a Simulation Language/Programming Environment
1. Study of dynamic behavior of simple systems such as tank in series, double effect evaporators,etc.
2. Study of coupling of manipulated and controlled variables using relative gain analysis (RTA).

Recommended to be done using a commercial simulator
1. Dynamic simulation of Simple process systems with controllers.
2. Dynamic simulation & controllability analysis of Binary distillation column.

Recommended Software
1. Steady state/Dynamic simulator (such as Hysys. Plant or Aspen Plus/Aspen Dynamic)
2. Simulation Language /Programming Environment (MATLAB).

MINOR PROJECT

0 0 6

The student would be allotted a project in the beginning of the VII semester itself. The project will be based on the industry where he/she has undergone in plant training in industry during summer vacations. He/She would be expected to submit a detailed plant design report later in the (VIII) semester.In this semester he/she will be assessed (out of 50 marks) for the work that he/she does during the seventh semester under the supervision of a faculty of the department..

SEMESTER VIII

PETROLEUM REFINING TECHNOLOGY 3 1 0

Unit I

Petroleum Exploration Production and Refining of Crude oils Crude oils: Chemistry and composition (Characteristics and constituents of crude oils, Classification of crude oils). **[8]**

Unit II

Quality Control of Petroleum Products Classification of laboratory tests, distillation, vapour pressure, flash and fire points, octane number, performance number, cetane number, aniline point, viscosity index, calorific value, smoke point, char value, viscosity, viscosity index, penetration tests, cloud and pour points, drop point of grease, melting and settling points of wax, softening point of Bitumen, induction period of gasoline, thermal stability of jet fuels, gum content, Total Sulphur, Acidity and Alkalinity,, Copper Strip Corrosion Test, Silver – Strip Corrosion Test for ATF, Ash, Carbon Residue (Conradson method, Ramsbottom method) Colour, Density and Specific gravity, Refractive index of hydrocarbon liquids, water separation index (modified) (WSIM), ductility. **[8]**

Unit III

Petroleum Products Composition, Properties & Specification of LPG, Naphthas, motor spirit, Kerosine, Aviation Turbine Fuels, Diesel Fuels, Fuel Oils, Petroleum Hydrocarbon Solvents, Lubricating oils (automotive engine oils, industrial lubricating oils electrical insulating oils, Jute Batching oils, white oils, steam turbine oils, metal working oils, etc.) Petroleum Waxes Bitumens, Petroleum coke. Crude Oil Distillation Desalting of crude oils, Atmospheric distillation of crude oil, Vacuum distillation of atmospheric residue. Thermal Conversion Process Thermal Cracking Reactions, Thermal Cracking, Visbreaking, (Conventional Visbreaking and Soaker Visbreaking) Coking (Delayed Coking, Fluid Coking, Flexicoking), Calcination of Green Coke. **[8]**

Unit IV

Catalytic Converson Process Fluid catalytic cracking; Catalytic reforming; Hydrocracking Catalytic Alkylation, Catalytic Isomerization; Catalytic Polymerization. Finishing Process Hydrogen sulphide removal processes; Sulphur conversion processes; Sweetening processes (Caustic treatment, Solutizer process; Doctor treating process; Copper chloride sweetening,; Hypochlorite sweetening ;Air and inhibitor treating process; Merox processes;Sulphuric acid treatment; Clay treatment); Solvent extraction processes (Edeleanu process, Udex process, Sulfolane process), Hydrotreating processes. **[8]**

Unit V

Lube Oil Manufacturing Process Evaluation of crude oils for lube oil base stocks, Vacuum distillation, Solvent deasphalting Solvent extraction of lube oil fractions (Furfural, NMP and Phenol), Solvent dewaxing, Hydrofinshing, Manufacture of petroleum waxes (Wax sweating, Solvent deoiling) Manufacture of Bitumen's Selection of crude oil, Methods of manufacture of bitumens, (Distillation, Solvent precipitation, Air blowing). **[8]**

Books Recommended

1. Nelson, W.L., Petroleum Refining Engineering, McGraw Hill
2. Mall, I D ,Petrochemical Process Technology, McMillan India
3. Sarkar,G.N., Advance Petroleum Refining, Oscar Publication

PLANT DESIGN AND ECONOMICS **3 1 0**

Unit I

Process Development Process selection, study of alternative processes, pilot plant, Scale up methods, Flow sheet preparation, sketching techniques, Equipment numbering, Stream designation, Material and energy balances. Plant Design basis ,Process selection - Selection of equipment, specification and design of equipment's, material of construction, Plant location, Plant layout and installation, Safety, Start up, Shutdown and Operating guidelines. **[8]**

Unit II

Cost Engineering Time value of money and equivalence, Interest, cost comparisons by present worth, Annual equivalent cost and capitalized cost methods, Uniform gradient and series. Depreciation, Taxes and Insurances Nature of depreciation, Methods of determining depreciation, depreciation rates in current Indian situation, Types of taxes and insurance's, Procedure for cost comparison after taxes. **[8]**

Unit III

Cost Estimation Types of cost estimation, capital investment cost, fixed capital cost, working capital cost, start-up costs, process equipment cost estimation, cost index, Equipment costs due to inflation, Battery limit investments, estimation of plant cost, Estimation of total product cost, Manufacturing cost, General expenses.

Profitability

Criteria of profitability, Payout period, Return on investment, Present value, Cash flow analysis, Alternative investment analysis, Sensitive analysis in project profitability. **[8]**

Unit IV

Economic Optimization and Optimum Design Nature of optimization, Uni-variable and multivariable systems, Analytical, graphical and incremental methods of solution, LaGrange multiplier method, Linear programming and dynamic programming establishing optimum conditions, Break even chart for production schedule, Optimum production rates in plant operation, Optimum conditions in batch, cyclic and semi cyclic operation, Sensitivity and response analysis. **[8]**

Unit V

Optimization of Different Process Equipment Viz., transportation systems, heat exchangers, evaporators, mass transfer equipments and reactors. Determination of height and diameter of different process equipments at conditions of optimum cost .Pinch Technology analysis. Preparation of techno-economic feasibility report. **[8]**

Books Recommended:

1.Peters M., Timmerhaus K. & Ronald W., Plant Design & Economics for Chemical Engineers, McGraw Hill
2.James R Couper, Process Engg. Economics (Chemical Industries) CRC Press
3. Aries & Newton, Chemical Engg. Cost Estimation, McGraw Hill

DEPARTMENT ELECTIVE III

A): ADVANCED SEPARATION TECHNOLOGY 3 1 0

Unit I

Uses and characterization of separation processes, equilibrium and rate governed multistage processes. **[8]**

Unit II

ideal cascades total interstage flows, squared off cascades, seperative duty and potential, energy requirement for separation processes. **[8]**

Unit III

30 Membrane characterization, Gas permeation through polymeric membranes, Liquid membrane separation processes, reverse osmosis , Concentration polarization. **[8]**

Unit IV

Dialysis, Ultra filtration, Electro dialysis. **[8]**

Unit V

Chromatographic separation, molecular sieve separations. **[8]**

Books Recommended

1.Geankoplis, C.J.. "Transport Processes and Unit Operations", 3rd ed. Prentice Hall. (1993)

2. Sun-Tak-Hwang and Karl Kammermeyer – Membranes in Separations – John Wiley & Sons, New York (1975)

3. J.M. Coulson and J.F. Richardson – Chemical Engineering: Particle Technology and Separation Processes, Vol. 2, 4th Edition, Asian Books Pvt. Ltd. New Delhi (1998)

4. Christie J. Geankoplis – Transport Processes and Unit Operations – 3rd Edition, Prentice Hall of India Pvt. Ltd., New Delhi

5. King C.J., Separation Processes, Tata McGraw Hill

B): MULTIPHASE REACTOR DESIGN 3 1 0

Unit I

Basic data and principles for design, Interpretion of data from laboratory. **[8]**

Unit II

Batch, C.S.T.R. and Tubular flow reactors, Accuracy of Kinetic Measurements, Thermodynamic aspect of chemical reactions. **[8]**

Unit III

Summary of catalyst preparation methods, Catalyst characterization. **[8]**

Unit IV

Establishing global rate of reaction, Mass & Energy balance equation for reactors. **[8]**

Unit V

Reactor design using Global rates and actual temperature and connection profile

Books:

1.Peter Harroitt , Chemical Reactor Design, McGraw Hill

2.Trehan M., Catalytic Reactor Design, McGraw Hill

3.Hayes R.E., Chemical Reactor Analysis, Gordon & Breach Science Publisher

4.Cooper A.P.& G.V.Jefferys, Chemical Kinetics & Reactor Design, Prentice Hall

5. Gianetta & Silvertan, Multiphase Chemical Reactor- Theory, Design, Scale up, Hemisphere Publishing Corp.

C):DESIGN OF PIPING SYSTEMS 3 1 0

Unit 1

Analysis of pipe flow Energy losses in pipe lines, concept of equivalent length and equivalent pipes, problems in pipe flow, hydraulic power transmission through a pipe line. **[8]**

Unit II

I Negative pressure in pipe lines, Siphon, Multiple pipe systems, working pressure, design pressure, choice of pipe materials, hydraulic analysis of complex pipe networks. **[8]**

Unit III

Aids in selecting pipe valves and fittings, standards for piping design, Dimensional and mechanical standards for pipe valves and fittings. **[8]**

Unit 1V

Process piping arrangement plant layout and equipment arrangement, criteria for equipment layout, piping layout and arrangement. **[8]**

Unit V

Pipe fabrication, vibration, its prevention and control in piping systems. **[8]**

Books Recommended

1. King, R. C. and Croker, S., "Piping Handbook", McGraw Hill.
2. Kellogg, M. W Company., "Design of Piping Systems", Pullman Power Products, New York (1976).

D): FLUIDIZATION ENGINEERING 3 1 0

Unit I

Introduction: Importance of fluidization in process industry, comparison of fluidized beds with other modes of contacting, advantages and disadvantages, industrial applications. Fluidization: Fixed bed of particles of one and mixed sizes, fluidization with and without carryover of particles, minimum fluidization, terminal velocity of particles, pneumatic transport of solids,**[10]**

Unit II

Bubble Behavior and Bed Properties: Single rising bubble models, wake region and solids within bubbles, interaction and coalescence of bubbles, bubble formation, slug flow.**[8]**

Unit III

Bubbling Fluidized Beds: Emulsion phase, gas flow, bubble properties, physical and flow models. Entrainment and Elutriation From Fluidized Beds: Free boards behavior, gas outlet location, entertainment from tall and short vessels.**[8]**

Unit IV

High Velocity Fluidization: Turbulent fluidized beds, fast fluidization, pressure drop in turbulent and fast fluidization. Spouted Beds: Hydrodynamics and processing in spouted beds.**[6]**

Unit V

Circulation Systems: Circuits for the circulation of solids, pressure balance, flow of gas-solid mixtures in down-comers, flow in pneumatic transport lines. Design for Physical Operations: Design of single stage and multistage systems, heat and mass transfer, fluid bed drier**.[8]**

Books:

1.Kunii D. and Levenspiel O., "Fluidization Engineering", 2nd Ed., Butterworth-Heinemann,1991.
2.Davidson D. and Harrison J. F., "Fluidization Engineering", 2nd Ed., Academic Press,1992.
3.Yang W. C., "Handbook of Fluidization and Fluid Particle Systems", 3rd Ed.

NON-CONVENTIONAL ENERGY RESOURCES **L T P**
3 1 0

UNIT-I

Introduction Various non-conventional energy resources- Introduction, availability, classification, relative merits and demerits. **3**

Solar Cells:

Theory of solar cells. solar cell materials, solar cell array, solar cell power plant, limitations. **4**

UNIT-II

Solar Thermal Energy:

Solar radiation, flat plate collectors and their materials, applications and performance, focussing of collectors and their materials, applications and performance; solar thermal power plants, thermal energy storage for solar heating and cooling, limitations.

UNIT-III

Geothermal Energy:

Resources of geothermal energy, thermodynamics of geo-thermal energy conversion-electrical conversion, non-electrical conversion, environmental considerations.

Magneto-hydrodynamics (MHD):

Principle of working of MHD Power plant, performance and limitations.

Fuel Cells:

Principle of working of various types of fuel cells and their working, performance and limitations.

UNIT-IV

Thermo-electrical and thermionic Conversions:

Principle of working, performance and limitations.

Wind Energy:

Wind power and its sources, site selection, criterion, momentum theory, classification of rotors, concentrations and augments, wind characteristics. performance and limitations of energy conversion systems.

UNIT-V

Bio-mass:

Availability of bio-mass and its conversion theory.

Ocean Thermal Energy Conversion (OTEC):

Availability, theory and working principle, performance and limitations. Wave and Tidal Wave: Principle of working, performance and limitations. Waste Recycling Plants.

Text/References Books:

1. Raja etal, “Introduction to Non-Conventional Energy Resources” Scitech Publications.
2. John Twideu and Tony Weir, “Renewal Energy Resources” BSP Publications, 2006.
3. M.V.R. Koteswara Rao, “ Energy Resources: Conventional & Non-Conventional “ BSP Publications,2006.
4. D.S. Chauhan,”Non-conventional Energy Resources” New Age International.
5. C.S. Solanki, “Renewal Energy Technologies: A Practical Guide for Beginners” PHI Learning.
6. Peter Auer, "Advances in Energy System and Technology". Vol. 1 & II Edited by Academic Press.

MAJOR PROJECT

0 0 12

This project course is in continuation of project course allotted in the beginning of the VII the semester .Here the students are supposed to do the detail work as scheduled in the last semester. Finally he/she will be required to submit a detailed project report on which viva-voce examination will be conducted by a committee having one External Examiner.

A Foundation Course
IN
Human Values & Professional Ethics

Course Code:

Course Objective:

This introductory course input is intended

a. To help the students appreciate the essential complementarily between VALUES and SKILLS to ensure sustained happiness and prosperity which are the core aspirations of all human beings.
b. To facilitate the development of a Holistic perspective among students towards life. Profession and happiness, based on a correct understanding of the Human reality and the rest of Existence. Such a holistic perspective forms the basis of Value based living in a natural way.
c. To highlight plausible implications of such a Holistic understanding in terms of ethical human conduct trustful and mutually satisfying human behavior and mutually enriching interaction with Nature.

Thus, this course is intended to provide a much needed orientation input in Value Education to the young enquiring minds.

Course Methodology

- The methodology of this course is universally adaptable. Involving a systematic and rational study of the human being vis-a vis the rest of existence.
- It is free from any dogma or value prescriptions.
- It is a process of self investigation and self exploration and not of giving sermons whatever is founded as truth of reality is stand as proposal and the students are facilitated to verify it in their own right based on their Natural Acceptance and Experiential Validations.
- This process of Self exploration takes the form of a dialogue between the teacher ans the students to begin with, and within the student himself/herself finally.
- This self –exploration also enables them to evaluate their pre- conditionings and present beliefs.

A Foundation Course
In
Human Values & Professional Ethics
Course Code:

Total no. of Lectures: 28 [L-T-P:2-02]
Total no. of Practice Sessions: 14(of 2 hrs each)

Content for Lectures:

Module 1: Course Introduction- Need, Basic Guidelines, Content and Process for Value Education [6]

1. Understanding the need, basic guidelines, content and process for Value Education.
2. Self Exploration-what is it? – its content and process: 'Natural Acceptance ' and Experiential Validation- as the mechanism for self exploration.
3. Continuous Happiness and Prosperity- A look at basic Human Aspirations.
4. Right understanding, Relationship and Physical Facilities- the basic requirements for fulfillment of aspirations of every human being with their correct priority.
5. Understanding Happiness and Prosperity correctly- A critical appraisal of the current scenario.
6. Method to fulfill the above human aspirations; understanding and living in harmony at various levels.

Module 2: Understanding Harmony in the Human Being- Harmony in Myself! [6]

7. Understanding human being as a co-existence of the sentient 'I' and the material 'Body'.
8. Understanding the needs of Self (I) and 'Body'-Sukh and Suvidha.
9. Understanding the Body as an instrument of 'I' (I being the doer, seer and enjoyer)
10. Understanding the characteristics and activities of 'I' and harmony in 'I'
11. Understanding the harmony of I with the Body: Sanyam and Swasthya: correct appraisal of Physical needs, meaning of Prosperity in detail
12. Programs to ensure Sanyam and Swasthya

Practice Exercise and Case Studies will be taken up in Practice Sessions

Module 3: Understanding Harmony in the Family and Society- Harmony in Human-Human Relationship [6]

13. Understanding harmony in the Family- the basic unit of human interaction
14. Understanding values in human-human relationship: meaning of Nyaya and program for its fulfillment of ensure Ubhay –Tripti.
15. Understanding the meaning of Vishwas; Difference between intention and competence
16. Understanding the meaning of Vishwas; Difference between respect and differentiation: the other salient values in relationship.
17. Understanding the harmony in the society(society being an extension of family): Samadhan, Samridhi, Abhay, Sah-astitva as comprehensive Human Goals.
18. Visualizing a universal harmonious order in society- Undivided Society (Akhand Samaj), Universal Order (Sarabhaum Vyawastha)-from family to world family!

Practice Exercise and Case Studies will be taken up in Practice Sessions.

Module 4: Understanding Harmony in the Nature and Existence – Whole existence as Co-existence [4]

19. Understanding the harmony in the Nature
20. Interconnectedness and mutual fulfillment among the four orders of naturerecyelability and self-regulation in nature.
21. Understanding Existense as Co- existence (Sha- astitva) of mutually interacting units in all- pervasive space.
22. Holistic perception of harmony at all levels of existence

-Practice Exercise and Case Studies will be taken up in Practice Sessions.

Module 5: Implications of the above Holistic Understanding of Harmony On Professionl Ethics [6]

23. Natural acceptance of human values
24. Definitiveness of Ethical Human Conduct
25. Basis for Humanistic Education, Humanistic Constitution and Humanistic Universal Order
26. Competence in professional ethics:
    a) Ability to utilize the professional competence for augmenting universal human order.
    b) Ability to identify the scope and characteristics of people-friendly and eco-friendly production systems.
    c) Ability to identify and develop appropriate technologies and management patterns for above production systems.
27. Case studies of typical holistic technologies. Management models and production systems.
28. Strategy for transaction from the present state to Universal Human Order
    a) At the level of individual: as socially and ecologically responsible engineers technologists and mangers.
    b) At the level of society as mutually enriching institutions and organizations.

Content for Practice Sessions:

Module 1: Course Introduction- Need, Basic Guidelines, Content and Process for Value Education

PS 1: Introduce yourself in detail. What are the goals in your life? How do you set your goals in your life? How do you differentiate between right and wrong? What have been your achievement and shortcomings in your life? Observe and analyze them.
Expected outcome: the student start exploring themselves; get comfortable to each other and to the teacher and start finding the need and relevance for the course.

PS 2: Now-a-days. There is a lot of voice about many techno-genic maladies such as energy and natural resource depletion. Environment pollution, global warming. Ozone depletion, deforestation. Soil degradation etc. all these seem to be man made problems threatening the survival of life of Earth- What is the root cause of these maladies & what is the way out in your opinion ?

On the other hand, there is rapidly growing danger because of nuclear proliferation, arms race, terrorism, criminalization of politics, large scale corruption, scams, breakdown of relationships. Generation gap, depression & suicidal attempts, etc- what do you think, is the root cause of these to human happiness and peace- what could be the way out in your opinion?

Expected outcome: The students start finding that technical education without study of human values can generate more problems than solutions. They also start feeling that lack of understanding of human values is the root cause of all problems and the sustained solution could emerge only through understanding of human values and value based living. Any solution brought out through fear, temptation of dogma will not be sustainable.

PS 3:

1. Observe that each one of us has Natural Acceptance, based on which one can verify right or not right for him. Verify this in case of
i) What is Naturally Acceptable to you in relationship –Feeling of respect or disrespect?
ii) What is Naturally Acceptable to you- to nurture or to exploit others?
Is your living the same as your natural acceptance or different?

2. Out of the three basic requirements for fulfillment of your aspirations- right understanding, relationship and physical facilities, observe how the problems in your family are related to each. Also observe how much time & effort you devote for each in your daily routine.

Expected outcome:

1. The students are able to see that verification on the basis of natural acceptance and experiential validation through living is the only way to verify right or wrong, and referring to any external source like text or instrument or any other person cannot enable them to verify with authenticity; it will only develop assumptions.
2. The students are able to see that their practice in living Is not in harmony with their natural acceptance most of the time and all they need to do is to refer to their natural acceptance to remove this disharmony.
3. The students are able to see that lack of right understanding leading to lack of relationship is the major cause of problems in their family and not eh lack of physical facilities in most of the cases, while they have given higher priority to earning of physical facilities in their life ignoring relationships and not being aware that right understanding is the most important requirement for any human being.

Module 2: Understanding Harmony in the Human Being- Harmony in Myself?

PS 4: List down all your desires. Observe whether the desire is related to Self (I) or Body. If it appears to be related to both, see which part of it is related to Self (I) and which part is related to Body.

Expected outcome: the students are able to see that they can enlist their desires and the desires are not vague. Also they are able to relate their desires to 'I' and 'Body' distinctly. If any desire appears related to both, they are able to see that the feeling is related to I while the physical facility is related to the body. They are also able to see that 'I' and 'Body' are two realities and most of their desires are related to 'I' and not Body, while then efforts are mostly centered on the fulfillment of the needs of the body assuming that it will meet the need of 'I' too.

PS 5:

1. a. Observe that any physical facility you use follows the given sequence with time: Necessary & tasteful –unnecessary & Tasteless-intolerable

acceptable at all, if naturally acceptable, you want if continuously and if not acceptable, you do not want it any moment!

2. List down all your activities. Observe whether the activity is of your attention for different moments (over a period of says 5 to 10 minutes) and draw a line diagram connecting these points, try to observe the link between any two nodes.

Expected outcome:

1. The student are able to see that all physical facilities they use are required for a limited time in a limited quantity. Also they are able to see that in case of feelings. They want continuity of the naturally acceptable feelings and they do not want feelings which are not naturally acceptable even for a single moment.
2. The students are able to see that activities like understanding, desire, through and selection are the activities of 'I' only, the activities like breathing. Palpitation of different parts of the body are fully the activities of the body with the acceptance of 'I' while the activities they do with fully the activities of the body with their sense organs like hearing through ears, seeing through eyes, sensing through touch, tasting through tongue and smelling through nose or the activities they do with their work organs like hands, legs etc. are such activities that require the participation of both 'I' and body.
3. The students become aware of their activities of 'I' and start finding their focus of attention at different moments. Also they are able to see that most of then desires are coming from outside (through preconditioning or sensation) and are not based on their natural acceptance.

PS 6:

1. Chalk out programs to ensure that you are responsible to your body- for the nurturing protection and right utilization of the body.
2. Find out the plants and shrubs growing in and around your campus, Find out their use for curing different disease.

Expected outcome: the students are able to list down activities related to proper upkeep of the body and practice them in their daily routine. They are also able to appreciate plants wildly growing in and around the campus which can be beneficial in curing different disease.

Module 3: Understanding Harmony in the Family and Society- Harmony in Human- Human Relationship

PS 7: Form small groups in the class and in that group initiate dialogue and ask the eight questions related to trust. The eight questions are:

1a. Do I want to make myself happy? 1b. Am I able to make myself always happy?

2a. Do I want to make the other happy? 2b. Am I able to make the other always happy"

3a. Does the other want to make him happy? 3b. Is the other to make him always happy?

4a. Does the other want to make me happy? 4b. Is the other able to make me always happy?

What is the answer? What is the answer?

Intention(Natural Acceptance) Competence

Let each student answer the question for himself and everyone else. Discuss the difference between intention and competence. Observe whether you evaluate your intention & competence as well as the others intention & competence.

Expected outcome: The students are able to see that the first four question are related to our Natural Acceptance i.e. Intention and the next four to our Competence. They are able to note that the intention is always correct. Only competence is lacking! We generally evaluate ourselves on the basis of our intention and others on the basis of their competence! We seldom look at our competence and others intention as a result we conclude that I am a good person and other is a bad person.

PS 8:

1. Observe on how many occasions you are respecting your related ones (by doing the right evaluation) Over –evaluation or otherwise evaluation.
2. Also observe whether your feeling of respect is based on treating the other as yourself or on differentiations based on body, physical facilities or beliefs.

Expected outcome: The students are able to see that respect is right evaluation, and only right evaluation leads to fulfillment in relationship. Many present problems in the society are an outcome of differentiation(lack of understanding of respect), like gender biasness, generation gap, caste , conflicts, class struggle dominations through power play, communal violence, clash of isms, and so on so forth . All these problems can be solved by realizing that the other is like me as he has the same natural acceptance, potential and program to ensure a happy and prosperous life for him and for others though he may have different body, physical facilities or beliefs.

PS 9:

1. Write a note in the form of story, poem, skit, essay, narration, dialogue to educate a child. Evaluate it in a group.
2. Develop three chapters to introduce social science –its need, scope and content in the primary education of children.

Expected outcome: The students are able to use their creativity for educating children. The students are able to see that they can play a role in providing value education for children. They are able to put in simple words the issues that are essential to understand for children and comprehensible to them. The student are able to develop an outline of holistic model for social science and compare it with the existing model.

Module 4: understanding Harmony in the nature and existence – whole existence as co-existence.

PS: 10-list down unit's things around you. Classify then in four others observe and explain the mutual fulfillment of each unit with other subjects.

Expected outcome: The student are able to differentiate between the characteristics and activities of different order and study the manual fulfillment among them. They are also able to see that human being are not fulfilling to order today and need to take appropriate steps to ensure right participation terms of nurturing. Protection and right utilization in the nature

PS 11:

1. Make a chart for the whole existence. List down different course of studies and relate them to different units or levels in the existence.
2. chose any one subject being thought today. Evaluate it and suggest suitable modification to make it appropriate and holistic.

Expected outcome: The student feels confident that they can understand the whole existence; nothing is a mystery in this existence. They are also able to see the interconnectedness in the nature, and point out how different course of study related to the different units and levels. Also they are able to make out how these courses can be made appropriate and holistic.

Module 5: implication of the above holistic understanding of harmony at all levels of existence.

PS 12: Chose any two current problem of different kind in the society and suggested how they can be solved on the basis of natural acceptance of human values. Suggested steps you will take in present condition

Expected outcome: The student are able to present sustainable solution to the problems in society and nature. They are also able to see that these solutions are practicable and draw roadmaps to achieve them.

PS 13:

1. Suggested ways in which you can use your knowledge of technology /engineering management for universal human order, from your family to world family.
2. Suggest one format of humanistic constititution at the level of nation from your side.

Expected outcome: The student is able to grasp the right utilization of their knowledge in their streams of technology /engineering /management to ensure mutually enriching and recyclable production systems.

PS 14: the course is going to be over now. Evaluate your state before ans after the course in terms of

a) Thought b) Behavior c) Work d) Realization.

Do you any plan to participate in the transition of the society after graduating from the institute? Write a brief note on it.

Expected outcome: The students are able to sincerely evaluate the course and share with their friends. They area also able to suggest measure to make the course more effectively and relevant. They are also to make use of their understanding in the course for a happy and prosperous society.

Term paper

Text Book and Reference Material:

a. The text book :

R..R .Gaur ,R Sangal, G.P. Bagaria, 2009, *A foundation course in Human Value and Professional Ethics, Excel Book Private Limited, New Delhi.*

b) Teacher's Manual:

R..R .Gaur ,R Sangal, G.P. Bagaria, 2009, *A foundation course in Human Value and Professional Ethics, Excel Book Private Limited, New Delhi.*

Video CD of teacher's Orientation Workshop will be made available on website.

c) Reference Books:

1. Ivan lllich, 1974, Energy & equity. The Trinity Press,Worcester and Harpercollins, USA.
2. E.F. Schumacher, 1973, small is beautiful: a study of economics as if people mannered. Blond & Briggs, Britain.
3. Sussan George, 1976, How The Other Half dies, Penguin Press, Reprinted1986,1991.
4. Donella H . Meadows, Dennis L. Meadows. Jpgen Randers, William W. Behrens III. 1972, limits to growth –club of Rome's report, universe Books.
5. A Nagraj, 1998, Jeevan Vidhya ek Prichay, Divya Path Sansthan, Amarkantak.
6. P L Dhar, RR Gaur, 1990,Science and Humanism, Commonwealth Publishers.
7. A.N.Tripathy,2003, 2003, Human Values, New Age International Publishers.
8. Subhas Palekar,2000, How to practice Natural Farming, Pracheen (vaidik) Krishi Tntra Shodh, Amaravati.
9. E.G.Seebauer & Robert L Berry,2000,Fundamentals of Ehics for Scientist & Engineers, Oxford University Press.
10. M Govnidrajran, S Natrajan & V.S. Senthils Kumar, Engineering Ethics (including Human Values, Eastern Economy Editon, Prentice Hall of India Ltd.
11. B.P Banerjee, 2005, Foundation of Ehics and Management, Excel Bools.
12. B.L Bajpai, 2004 ,Indian Ehos and Modern Management, New Royal Book Co., Lucknow, Reprited 2008.

d Relevant websites, CD, Movies and Documentaries:

1. Value Educatiion website, http://www.uptu.ac.in.
2. Story of stuff, http://www.storystuff.com
3. Al Gore, An Inconvenient Truth, Paramount Classics, USA.
4. Charlin Chaplin, Modern Times, United Artist, USA.
5. IIIT Delhi, Mordern Technology- the Untold Story.
6. Anaand Gandhi, Right here right now, Cyce;ewala P roduction.