B.I.E.T (An autonomous Institute) Jhansi U.P

Syllabus

2nd , 3rd and 4th Year

[Effective from session 2009-10]

B.TECH. CHEMICAL ENGINEERING

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

B.I.E.T (An autonomous Institute) Jhansi U.P

Study and Evaluation Scheme

[Effective from the Session 2009-10]

B. Tech. (Chem. Engg)   **Year 2nd, Semester -III**

S.No.	Course Code	Subject	Periods			Evaluation Scheme				Subject Total	Credits
						Sessional Exam.			ESE		
			L	T	P	CT	TA	Total			
Theory Subject s											
1	ECY 301	Applied Engineering Chemistry	3	1	0	30	20	50	100	150	4
2	EAS301/ EOE031-EOE038	Mathematics III/Science Based Open Elective**	3	1	0	30	20	50	100	150	4
3	EHU301/ EHU302	Industrial Psychology/ Industrial Sociology	2	0	0	15	10	25	50	75	2
4	ECH301	Process Calculations	3	1	0	30	20	50	100	150	4
5	ECH302	Mechanical Operations	2	1	0	15	10	25	50	75	3
6	ECH303	Fluid Flow Operation	3	1	0	30	20	50	100	150	4
7	EHU111	*Human Values & Professional Ethics	2	2	0	15	10	25	50	75	-
Practical/Design											
8	ECY 351	Applied Chemistry Lab	0	0	3	10	10	20	30	50	1
9	ECH351	Mechanical Operations Lab	0	0	3	10	10	20	30	50	1
10	ECH352	Fluid Flow Operation Lab	0	0	3	10	10	20	30	50	1
11	ECH353	Group discussion & Seminar	0	0	2	-	-	50	-	50	1
12	GP301	General Proficiency	-	-	-	-	-	50	-	50	1
		Total	16	5	11	-	-	410	590	1000	26

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

**Science Based Open Elective

EOE031/EOE041: Introduction to Soft Computing (Neural Networks, Fuzzy Logic and Genetic Algorithm)

EOE032/EOE042: Nano Sciences

EOE033/EOE043: Laser Systems and Applications EOE034/EOE044: Space Sciences

EOE035/EOE045: Polymer Science & Technology

EOE036/EOE046: Nuclear Science

EOE037/EOE047: Material Science
EOE038/EOE048: Discrete Mathematics

B.I.E.T (An autonomous Institute) Jhansi U.P
Study and Evaluation Scheme
[Effective from the Session 2009-10]

B. Tech. (Chem. Engg)   **Year 2nd, Semester -IV**

S.No.	Course Code	Subject	Periods			Evaluation Scheme				Subject Total	Credits
						Sessional Exam.			ESE		
			L	T	P	CT	TA	Total			
Theory Subjects											
1	EHU402/ EHU401	Industrial Sociology / Industrial Psychology	2	0	0	15	10	25	50	75	2
2	EOE041-EOE048/ EAS401	Science Based Open Elective/ Mathematics III	3	1	0	30	20	50	100	150	4
3	ECH401	Chemical Engineering Thermodynamics	3	1	0	30	20	50	100	150	4
4	ECH402	Heat Transfer	3	1	0	30	20	50	100	150	4
5	ECH403	Chemical Reaction Engineering- I	3	1	0	30	20	50	100	150	4
6	ECH404	Chemical Technology -I	3	0	0	15	10	25	50	75	2
7	EHU111	*Human Values & Professional Ethics	2	2	0	15	10	25	50	75	-
Pra ctical/Design											
8	ECH451	Chemical Reaction Engineering Lab	0	0	3	15	10	25	30	75	2
9	ECH452	Heat Transfer Lab	0	0	3	15	10	25	50	75	2
11	ECH453	Chemical Technology Lab	0	0	3	10	10	20	30	50	1
12	GP 401	General Proficiency	-	-	-	-	-	50	-	50	1
		Total	17	4	9	-	-	370	630	1000	26

B. Tech. (Chem. Engg)   **Year 3rd, Semester -V**

S. No.	Course Code	Subject	Periods			Evaluation Scheme				Subject Total	Credits
						Sessional Exam.			ESE		
			L	T	P	CT	TA	Total			
The ory Subjects											
1	EHU501	Engineering and Managerial Economics	3	1	0	30	20	50	100	150	3
2	EAS501	Computer based Numerical Methods	3	1	0	30	20	50	100	150	4
3	ECH501	Mass Transfer Operations-I	3	1	0	30	20	50	100	150	4
4	ECH502	Chemical Reaction Engineering- II	3	1	0	30	20	50	100	150	4
5	ECH503	Chemical Technology - II	3	0	0	15	10	25	50	75	3
6	ECH504	Process Instrumentation	2	0	0	15	10	25	50	75	3
7	EHU111	*Human Values & Professional Ethics	2	2	0	15	10	25	50	75	-
Practical/Design											
8	EAS551	Computer Based Numerical Methods	0	0	3	10	10	20	30	50	1
9	ECH551	Mass Transfer Operations-I Lab	0	0	3	10	10	20	30	50	1
10	ECH552	Process Instrumentation lab	0	0	3	10	10	20	30	50	1
11	ECH553	Group discussion & Seminar	0	0	2	-	-	50	-	50	1
12	GP 501	General Proficiency	-	-	-	-	-	50	-	50	1
			17	4	11	-	-	410	590	1000	26

Study and Evaluation Scheme
[Effective from the Session 2010-11]

B. Tech. (Chem. Engg)   **Year 3rd, Semester VI**

S. No.	Course Code	Subject	Periods			Evaluation Scheme				Subject Total	Credits
						Sessional Exam.			ESE		
			L	T	P	CT	TA	Total			
Theory Subjects											
1	EHU-601	Industrial Management	3	0	0	30	20	50	100	150	3
2	ECH 011ECH 013	Departmental Elective -I	3	1	0	30	20	50	100	150	4
3	ECH 021ECH 024	Departmental Elective -II	2	1	0	15	10	25	50	75	3
4	ECH-601	Mass Transfer Operations-II	2	1	0	15	10	25	50	75	3
5	ECH-602	Process Dynamics & Control	3	1	0	30	20	50	100	150	4
6	ECH-603	Process Equipment Design	3	1	0	30	20	50	100	150	4
7	EHU-111	*Human Values & Professional Ethics	2	0	0	15	10	25	50	75	-
Practical/Design											
8	ECH-651	Mass Transfer Operations – II Lab	0	0	3	10	10	20	30	50	1
9	ECH-652	Process Dynamics & Control Lab	0	0	3	10	10	20	30	50	1
10	ECH-653	Energy Lab	0	0	2	10	10	20	30	50	1
11	ECH-654	Equipment Design	0	0	2	10	10	20	30	50	1
12	GP-601	General Proficiency	-	-	-	-	-	50	-	50	1
			16	5	10	-	-	410	590	1000	26

Departmental Elective I
ECH-011: Energy Resources & Utilization
ECH-012: Energy Management

ECH-013: Energy Efficiency & Energy Conservation
Departmental Elective-II
ECH-021: Optimization Technique in Chemical Engineering
ECH-022: Computational Fluid Dynamics
ECH-023: Statistical Design of Experiments
ECH-024: Process Flow Sheet Simulation

B. Tech. (Chem. Engg)   **Year 4th, Semester -VII**

S. No.	Course Code	Subject	Periods			Evaluation Scheme				Subject Total	Credits
						Sessional Exam.			ESE		
			L	T	P	CT	TA	Total			
Theory Subjects											
1	EOE071-EOE074	Open Elective- I	3	1	0	30	20	50	100	150	4
2	EOE031-EOE034	Departmental Elective -III	3	1	0	30	20	50	100	150	4
3	EOE041-EOE044	Departmental Elective -IV	3	1	0	30	20	50	100	150	4
4	ECH 701	Process Modeling & Simulation	3	1	0	30	20	50	100	150	4
5	ECH 702	Plant Design & Economics	3	1	0	30	20	50	100	150	4
6	EHU-111	*Human Values & Professional Ethics	2	0	0	15	10	25	50	75	-
Practical/Design											
7	ECH 751	C A D Lab	0	0	3	10	10	20	30	50	1
8	ECH 752	Project	0	0	3	-	50	50	-	50	2
9	ECH 753	Group discussion & Seminar	0	0	2	-	50	50	-	50	1
10	ECH 754	Industrial Training VivaVoce**	0	0	2	-	50	50	-	50	1
11	GP 701	General Proficiency	-	-	-	-	-	50	-	50	1
			15	5	10	160	260	470	530	1000	26

Note-**Practical Training (4-6weeks) done after 6th Semesters would be evaluated in 7th semester through Report and viva voce etc.

Open Electives-I
   EOE 071: Entrepreneurship Development
   EOE 072: Quality Management
   EOE 073: Operations Research
   EOE 074: Introduction to Biotechnology
Departmental Elective –III
   ECH 031: Air Pollution and Control Equipments

ECH 032: Industrial Pollution Abatement & Waste Management
ECH 033: Environmental Pollution Monitoring & Control
ECH 034: Hazardous Waste Management

Departmental Elective –IV

ECH 041: Process Utility & Safety in Chemical Plants
ECH 042: Corrosion Science & Engineering
ECH 043: Project Engineering & Management ECH
044: Industrial Safety & Hazard Management

Study and Evaluation Scheme
[Effective from the Session 2011-12]

B. Tech. (Chem. Engg)   **Year 4th, Semester -VIII**

S. No.	Course Code	Subject	Periods			Evaluation Scheme				Subject Total	Credits
						Sessional Exam.			ESE		
			L	T	P	CT	TA	Total			
Theory Subjects											
1	EOE 081EOE 084	Open Elective- II	3	1	0	30	20	50	100	150	4
2	ECH 051ECH 054	Departmental Elective -V	3	1	0	30	20	50	100	150	4
3	ECH 061ECH 063	Departmental Elective -VI	3	1	0	30	20	50	100	150	4
4	ECH- 801	Transport Phenomena	3	1	0	30	20	50	100	150	3
5	EHU-111	*Human Values & Professional Ethics	2	0	0	15	10	25	50	75	-
Pra ctical/Design											
6	ECH-851	Project **	0	0	12	-	100	100	250	350	8
7	GP 801	General Proficiency	-	-	-	-	-	50	-	50	1
			15	5	10	160	260	470	530	1000	24

Note. ** Project should be initiated in 7th semester beginning, and should be completed by the end of 8th semester with good Report and power-point Presentation etc

Open Elective- II

EOE 081: Non Conventional Energy Resources
EOE 082: Nonlinear Dynamic Systems
EOE 083: Product Development
EOE 084: Automation and Robotics

Departmental Elective –V

ECH 051: Advance Separation Technology
ECH 052: Design of Piping Systems
ECH 053: Fluidization Engineering
ECH 054: Multiphase Reactor Design

Departmental Elective –VI
ECH 061: Fertilizer Technology
ECH 062: Petroleum Refining Technology
ECH 063: Petrochemical Technology

ECY 301: APPLIED ENGINEERING 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-Schimdt 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)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"*

EAS 301/EAS 401: 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 and **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

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 II

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

Unit III

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 IV

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 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 (1988)

ECH 302: 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

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 IV

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]**

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)
8. Brown,G.G. and associates "Unit operations" Wiley ,New york,(1950).

ECH 303: 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, (1984)

ECY 351: APPLIED ENGINEERING 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.

ECH 351: 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

ECH 352: 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 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 tofind 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

ECH 401: CHEMICAL ENGINEERING THERMODYNAMICS 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).

ECH 402: 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

ECH 403: 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).

ECH 404: CHEMICAL TECHNOLOGY I (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).

ECH 451: 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 separate Organic Compounds by Paper Chromatography.
3. To study the effect of temperature, concentration of the reactants and a catalyst on the rate of chemical reaction
4. To study the activity results or oxidation-reduction replacement reaction.
5. To purify water by ion -exchange.
6. To determine the order and rate constant of esterification reaction at room temperature.
7. To determine the order and rate constant of saponification reaction at room temperature.
8. To study the residence time distribution (R.T.D.) in a stirred tank reactor.
9. To study the residence time distribution (R.T.D.) in a plug flow reactor.
10. To study the decomposition of calcium carbonate
11. To determine the energy of activation of a given chemical reaction.

ECH 452: 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.
2. To find out the thermal conductivity of insulating powder.
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.

ECH 453: 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

EAS-501: 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.

ECH 501: 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)

ECH 502: 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).

ECH 503: CHEMICAL TECHNOLOGY – II (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
Industrial Gases: Oxygen, Nitrogen, Hydrogen Inert gases, Syngas, 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.

ECH 504: 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.

EAS 551: 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.

ECH 551: 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.

ECH 552: PROCESS INSTRUMENTATION LAB   0 0 3

1. Calibration of thermocouple/Bimetallic thermocouple/Resistance thermocouple.
2. Calibration of Pressure gauge/ Pnuematic pressure recorder/ Differential pressure recorder.
3. Calibration of Orificemeter/   Venturimeter / Rotameter/ Gas flow meter.
4. Estimation of viscosity by Redwood/ Saybolt/ Ostwald viscometer.
5. Calibration of pH meter.
6. Calibration of Conductivity meter.

ECH 011: ENERGY RESOURCES AND UTILIZATION 3 1 0
Unit I
Energy Scenario
Indian and global, energy crisis, Classification of various energy sources, Renewable and non-renewable energy sources, Remedial measures to some energy crisis.
Energy Conservation
Energy: Biogas plants and their operation, Biomass and its conversion routes to gaseous and liquid fuels. Wind energy, its potential and generation by wind mills, [8]
Unit II
Alternative Sources of Energy
Fuel cell ,Solar Energy : Photo thermal and photovoltaic conversion and utilisation methods , solar water heating , cooking , drying and its use for other industrial processes , solar cells their material and mode of operation . direct and indirect methods solar energy storage , sensible heat and latent heat storage materials Solar ponds .
Bio energy, biogas plants and their operation , biomass and its conversion roots to gaseous and liquid fuels ,wind energy , its potential and generation by wind mills [8]
Unit III
Hydroelectric potential, its utilization & production, Geothermal energy its potential status and production, Nuclear energy : Status, nuclear raw materials, nuclear reactors and other classification, Generation of Nuclear power, Nuclear installations in India and their capacity of generation, Limitations of nuclear energy, Reprocessing of spent nuclear fuel, Cogeneration of fuel and power, Energy from tidal and ocean thermal sources, MHD systems. [8]

Unit IV
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. [8]
Unit V
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), Biodisel. [8]
Text Books
1. Brame J.S.S. and King J.G., Edward Arnold "Fuel Solid, Liquid and Gases" Edward Arnold (1967).
2. Sukhatme S.P, "Solar Energy - Principles of Thermal Collection and Storage",2nd Ed., Tata McGraw- Hill.,(1996).

ECH 012: ENERGY MANAGEMENT   3 1 0
Unit I
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 II
Energy Management & Energy Planing
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 planing, 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 III
Energy Audit & Energy Monitoring, Targeting and Conservation
Introduction, need, types & procedure of energy audits, modern techniques and instruments for energy audit.
Defining monitoring & targeting, element of monitoring & targeting, data & information analysis, techniques- energy consumption, production & cumulative sum of differences (CUSUM).
Energy conservation opportunity, electrical & thermodynamic ECOs, ECOs in chemical process industries, waste management & recycling of discard material and energy. [8]
Unit IV
Advancement In Technologies & Future Energy Alternatives

Recent advancement in energy technology towards 21st century, transport of energy, ethanol as a fuel.

Fusion – introduction potential, condition for fusion, magnetic confinement fusion reactor, cold fusion laser induced fusion.

Biomass –introduction, municipal waste, biomass conversion, wood combustion

Geothermal energy – introduction, origin, nature, resources and exploration, environment impact, low temperature geothermal resources. [8]

Unit V Case Studies

Energy conservation in alcohol industry.

Energy conservation in fertilizer industry and pulps & paper industry.

Energy conservation in different units of refinery likes FCCU, HCU & ADU. [8]

Text Books

1. Murphy W.R. and Mckay G., Energy Management(BH)
2. Hinrich & Kleinbach "Energy : its use and the environment" III ed. Harcourt.
3. Boyle "Renewable Energy : Power for a sustainable future" Oxford.
4. Rao S. & Parulckar B.B. "Energy technology" khhanna publisher
5. Capenart & Turner " Guide to energy management " 6 ed. Keinnedu fairmant press.

ECH 013 : ENERGY EFFICIENCY AND ENERGY CONSERVATION 3 1 0

Unit I

Energy scenario, Classification of energy sources, Need for conserving energy, Government initiative for conserving energy (Role of Bureau of Energy Efficiency, Energy conservation bill 2001), Energy efficiency based on first and second laws of thermodynamics.

Unit II

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.

Unit III

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.

Unit IV

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.

Unit V

Energy conservation opportunities in chemical process utilities - Steam systems, Compressed air systems, Insulation

Cogeneration, Cogeneration systems

Text Books

1. Hinrich & Kleinbach "Energy : its use and the environment" III ed. Harcourt.
2. Boyle "Renewable Energy : Power for a sustainable future" Oxford.
3. Rao S. & Parulckar B.B. "Energy technology" khhanna publisher
4. Capenart & Turner " Guide to energy management " 6 ed. Keinnedu fairmant press.

ECH 021: 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)

ECH 022: 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

ECH 023: STATISTICAL DESIGN OF EXPERIMENTS 2 1 0

Unit I

Introduction: Strategy of experimentation, basic principles, guidelines for designing experiments;
Simple Comparative Experiments: Basic statistical concepts, sampling and sampling distribution, inferences about the differences in means, randomized and paired comparison design.
Experiments with Single Factor: Analysis of variance, Covariance and analysis of covariance, analysis of fixed effects model, model adequacy analysis, non-parametric methods. [8]

Unit II

Design of Experiments: Fundamental and types of Design of Experiment, Randomized blocks, latin squares, and related design, factorial design, two-factor factorial design, blocking in a factorial design, the 2^2 & 2^3 factorial design, the general 2^k factorial design, blocking and compounding in the 2^k factorial design, two-level, three level and mixed level factorial and fractional factorial designs. [6]

Unit III

Parameter Estimation: Linear regression models, estimation of the parameters in linear regression models, hypothesis testing in multiple regression, non-linear regression, logistic and weighted regression, Chi-squared tests, confidence intervals in multiple regression, prediction of new response observations, regression model diagnostics, testing for lack of fit. [8]

Unit IV

Response Surface Methods: Central composite and Box-Behnken designs, method of steepest ascent, analysis of a second-order response surface, experimental designs for fitting response surfaces, mixture experiments, Simultaneous optimization of several responses, Simplex method, evolutionary operation, robust design.
Experiments with Random Factors: Random effect model, two factor factorial with random factors, two-factor mixed model, sample size determination with random effects, approximate F tests.
Design and Analysis: Nested and split-plot design, non-normal responses and transformations, unbalanced data in a factorial design.[8]

Suggested Books:

1. Lazic Z. R., "Design of Experiments in Chemical Engineering: A Practical Guide", Wiley,2005.
2. Antony J.," Design of Experiments for Engineers and Scientists," Butterworth Heinemann, 2004,
3. Montgomery D. C., "Design and Analysis of Experiments", 5th Ed., Wiley, 2004.

ECH 024: 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 (CO_2 and H_2S 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

ECH 601: 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)

ECH 602: 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.

ECH 603: PROCESS EQUIPMENT DESIGN 2 1 0

Unit I

Introduction to various mechanical properties of materials to be used as material of construction, resistance of metals to corrosion under varying conditions of temperature and pressure etc. Application and use of various codes and standards in design. [6]

Unit II

Design of non-pressure storage vessel, tall vertical vessels, unfired pressure vessels with internal pressure ,Design of unfired pressure vessels with external pressures, end closures, flat plates, domed ends, torispherical, ellipsoidal, hemispherical and conical ends. Design of nozzles,openings and reinforcements, Bolts, flanges, gaskets . [10]

Unit III

Bolted flanges, pipe line design and process design of a few equipments like heat exchangers,Evaporators, Distillation columns, Absorbers, Reactors and Dryers . [8]

Unit IV

Mechanical design of selected process equipments such as heat exchangers, Evaporators,

Distillation columns, Absorbers, Reactors and Dryers and Crystallizers; Use of softwares for design of equipments. [6]

Text Books

1. Peters Max. S., Timmerhaus Klaus D.and Ronald E West "Plant Design
and Economics for Chemical Engineers".2003 V Edition McGraw Hill.
2. Coulson, J. M. and Richardson J. F. "Chemical Engineering", vol. 6 Pargamon
Press. (1989).
3. Brownel and Young, "Process Equipment Design ".Wiley (1968).

Reference Books

1. Indian and American Codes Used in Designing of equipments (TEMA and IS Codes)
2. Evans, F. L., "Equipment Design Handbook", Gulf Publishing Company.(1979).

ECH 651: 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.

ECH 652: 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

ECH 653: 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

ECH- 654: EQUIPMENT DESIGN   0 0 2
Practice to design various equipments with 'to scale' drawing and use of softwares for the design.

ECH 031: Air pollution and control equipment 3 1 0
Unit I

Air Pollutant Sources, Effects and Clean Air Acts: Pollution of air: Sources and effects of air pollutants on physical environment and living systems, Monitoring of air pollution, Air pollution Laws and national standards [5]

Unit II

Air Pollutant Formation, Dipersion, Analysis: Formation of pollutants through large-scale combustion of fossil fuels, mineral processing, automobiles in urban areas and at source minimisation of release - Meteorological aspects of air pollutant dispersion. Chemical reactions in a contaminated atmosphere, urban air pollution, acid rain, Air sampling and measurement, Analysis of air pollutants. [8]

Unit III

Air Pollution Control Methods for Particulates Removal: Control Methods – Source Correction methods - Particulate emission control: Dry techniques: Design of industrial dust collectors, gravity settling chambers, cyclone and multiclone separators, fabric & Fibrous filters, electrostatic precipitators, relative merits and demerits, overall selection of gas cleaning equipment, economics. Wet techniques: Design of wet dust collection, wet cyclone, empty scrubber, column (packed) scrubber, ventury scrubber, suitability, merits and demerits, economics. [10]

Unit IV

Control of Specific Gaseous Pollutants: Cleaning of Gaseous effluents - Control of sulphur dioxide emission by various methods - Control of nitrogen oxides in combustion products - Control of release of carbon monoxide and hydrocarbons to the atmosphere; **Case studies**: Role of APC techniques in coal fired thermal power plants,cement plant and petroleum refinery [10]

Unit V

Noise Pollution and Control: Sound pressure, Power and Intensity - Measures of Noise-Outdoor noise propagation- Indoor Noise propagation- Noise Control [7]

Suggested Books:

1. B.G. Verma, H. Brauer," Air Pollution Control Equipments", Springer, Verlag Berlin, 1981
2. M.N. Rao and H.V.N. Rao, "Air Pollution", Tata McGraw Hill, New Delhi, 1993
3. Rao C .S. "Environmental Pollution Control Engineering," 2nd Edition, New Age International Publishers, 2006
4. A. P. Sincero and G.A. Sincero Environmental Engineering: A Design Approach, Prentice Hall of India Pvt Ltd, N.Delhi, 1996
5. Air Pollution Control Equipment: Selection, Design, Operation and Maintenance, Louis Theodore (Editor), Anthony J. Buonicore (Editor), Springer-Verlag Telos, 1994

ECH 032: INDUSTRIAL POLLUTION ABATEMENT & WASTE MANAGEMENT 3 1 0

Unit I

Introduction: Environment and environmental pollution from chemical process industries, characterization of emission and effluents, environmental Laws and rules, standards for ambient air, noise emission and effluents.[7]

Unit II

Pollution Prevention: Process modification, alternative raw material, recovery of by co-product from industrial emission effluents, recycle and reuse of waste, energy recovery and waste utilization. Material and energy balance for pollution minimization. Water use minimization, Fugitive emission/effluents and leakages and their control-housekeeping and maintenance.[8]

Unit III

Air Pollution Control: Particulate emission control by mechanical separation and electrostatic precipitation, wet gas scrubbing, gaseous emission control by adsorption and adsorption, Design of cyclones, ESP, fabric filters and absorbers.

Water Pollution Control: Physical treatment, pre-treatment, solids removal by setting and sedimentation, filtration centrifugation, coagulation and flocculation.[12]

Unit IV

Chemical Treatment: Anaerobic and aerobic treatment biochemical kinetics, trickling filter, activated sludge and lagoons, aeration systems, sludge separation and drying[5]

Unit V

Waste management: Characterization of wastes-hazardous and non-hazardous wastes. Waste disposal and management laws and guidelines. Non-hazardous industrial wastes-treatment, disposal, utilization and management. Value-extraction from the wastes. **H**andling, storage and disposal of hazardous wastes. Case studies of a few real scenarios of waste management – sugar, pulp and paper, and fertilizer units [8]

Suggested Books:

1. Pollution Control Acts, Rules and Notifications, CPCB, Delhi. 1995
2. Vallero D., "Fundamentals of Air Pollution", 4th Ed., Academic Press, 2007
3. Eckenfelder W. W., "Industrial Water Pollution Control", 2nd Ed., Mc Graw Hill, 1999
4. Kreith F. and Tchobanoglous G., "Handbook of Solid Waste Management", 2nd Ed., Mc Graw Hill, 2002
5. Pichtel J., "Waste Management Practices: Municipal, Hazardous and Industrial", CRC, 2005
6. Conway R.A. & Ross R.D., "Handbook of Industrial Waste Disposal", Van-Nostrand Reinhold, 1980
7. Tchobanoglous G., Theisen H. & Vigil S.A., "Integrated Solid Waste Management : Engineering Principles and Management Issues", McGraw Hill, 1993

ECH 033: ENVIRONMENTAL POLLUTION MONITORING AND CONTROL 3 1 0

Unit I

Introduction

Ecology & Environment, Biodiversity, Interaction of man and environment, Overall picture of Environmental pollution, Ambient air and water quality criteria, Standards and Acts-Indian, EPA& EURO, Effects and control of noise, thermal and radioactive pollution. [8]

Unit II

Air Pollution

Types of pollutants – Natural and man made air pollutants, Dispersion of pollutant in the atmosphere, Gaussian dispersion model, Meteorological factors, Stability and inversion of atmosphere, Plume Behaviour, Control of air pollution from stationary and mobile sources, Methods of measuring and sampling of gaseous and particulate pollutants in ambient air and industrial waste gases, measurement of smoke density and visibility .Control of gaseous pollutants-SOx,NOx,H2S,VOCS,Auto exhaust. Stack design, Classification, selection and design of equipment's like cyclones, electrostatic precipitators, bag filters, wet scrubbers, settling chambers. [8]

Unit III

Water Pollution

Waste water characteristics – Physical and chemical composition, Biochemical oxygen demand (BOD), Pathogenic bacteria and chemical toxicity. Types of pollutants in waste water of chemical industries,

Methods of sampling, preservation of samples and analysis. Methods for the treatment of liquid wastes to control pollution, Classification viz. physical, chemical and biological methods, Selection and design of equipment like hydrocyclone, settling tanks, filters, ion- exchange. [8]

Unit IV

Solid Wastes Management

Characterisation of solid wastes, Problems of collection and handling, Various processing techniques used in solid waste management such as compaction ,incineration, Composting, landfills and biological Processing, Solid waste as resource material. [8]

Unit V

Pollution abatement in important chemical industries like fertiliser, petroleum refineries and etrochemicals, Pulp and Paper, Pharmaceuticals, Tannery, Sugar, Distillery, food processing , cement and electroplating. [8]

Text Books

1. Howard S. Peavy, D. R. Rowe & C. Tchobonoglous "Environmental Engineering", McGraw Hill (1984).
2. Metcalf & Eddy, "Waste Water Engineering Treatment, Disposal & Reuse", Tata McGraw Hill(2003).

Reference Books

1. Werner Strauss, 'Air Pollution Control: Measuring and monitoring air pollutant' Wiley (1978).
2. Werner Strauss, 'Air Pollution Control part -II " Wiley (1978).'
3. Pandey G. N. and Carney G. C., "Environmental Engineering ". Tata McGraw Hill (1991).

ECH 034: HAZARDOUS WASTE MANAGEMENT   3 1 0

Unit1

Characterization: Introduction to Hazardous wastes, Definition of Hazardous waste, The magnitude of the problem. Characterization of industrial wastes-hazardous and non-hazardous wastes. Waste disposal and management laws and guidelines.[8]

Unit2

Non-hazardous Waste Management: Non-hazardous industrial wastes-treatment, disposal, utilization and management. Thermal gasification, combustion and landfill..[8]

Unit3

Hazardous Waste Management: Hazardous wastes – handling, storage. Treatment and disposal methods: Physico-chemical and biological, stabilization and solidification, thermal methods, land disposal, Waste site remediation and clean-up technologies. Wastes from electroplating, lead batteries/cells, soldering and electro winning operations, wastes from refineries and petrochemical units. [8]

Unit4

Risk assessment, Environmental legislation, Dose-response assessment, exposure assement, Waste minimisation and Value-extraction from the wastes. Medical/biomedical and infectious waste management; Transportation of hazardous waste; Ground water contamination, [8]

Unit5

Case Studies: Case studies of a few real scenarios of hazardous waste management in industries. [8]

Suggested Books:

1. Tedder D. W. & Pohland F. G. (Editors), "Emerging Technologies in Hazardous Waste Management", ACS.1990

2. Conway R. A. & Ross R. D., "Handbook of Industrial Waste Disposal", Van-Nostrand Reinhold.1980
3. Shah K. L., "Basics of Solid and Hazardous Waste Management Techniques",Prentice Hall.1999
4. Side G. W., "Hazardous Materials and Hazardous Waste Management", John Wiley.1993
5. Pichtel J., "Waste Management Practices: Municipal, Hazardous and Industrial", CRC.2005

ECH 041:PROCESS UTILITIES AND SAFETY IN CHEMICAL PLANTS 3 1 0
Unit I

Various process utilities, their role and importance in chemical plants.Water Sources
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
utilisation ;Design of efficient steam heating systems; steam economy, Steam
condensers and condensate utilisation Expansion joints ,flash tank design, steam traps
their characteristics, selection and application, waste heat utilisation.; 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.

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

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).

ECH 042: 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 $Fe-H_2O$ 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

ECH 043: PROJECT ENGINEERING AND MANAGEMENT   3 1 0
Unit I
Role of project engineering in project organisation ;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**:Organisation 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 labour
relations, Construction labours distribution, Labour 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.
Programme 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

ECH 044: INDUSTRIAL SAFETY AND HAZARD MANAGEMENT   3 1 0
Unit I
Industrial safety, Industrial hygiene and safety aspects related to toxicity, noise, pressure, temperature, vibrations, radiation etc. Explosions including dust , vapor, cloud and mist explosion.[06]
Unit II
Elements of safety, safety aspects related to site, plant layout, process development and design stages, identification of hazards and its estimation, risk, risk analysis and assessment methods; fault free method, event free method, scope of risk assessment, controlling toxic chemicals and flammable materials. [10]
Unit III
Toxic substances and degree of toxicity, its estimation, their entry routes into human system, their doses and responses, control techniques for toxic substances exposure, use of respirators, ventilation systems [08]
Unit IV
Prevention of losses, pressure relief, provision for fire fighting, release of hazardous materials from tanks, pipes through holes and cracks , relief systems : types and location of reliefs. [08]
Unit V
Handling, transportation and storage of of flammable liquids, gases, and toxic materials and wastes, regulation and legislation, government role, risk management routines, emergency preparedness, disaster planning and management. [08]

Books Recommended
1. D. A. Crowl and J.F. Louvar – Chemical Process Safety (Fundamentals   with Applications), Prentice Hall (1990)
2. H.H. Fawcett and W.S. Wood – Safety and Accident prevention in   Chemical Operations, 2nd Edition, John Wiley &Sons,New York, 1982.
3. Coulson & Richardson's Chemical Engineering – Vol. 6 – R.K. Sinnott,   Butterworth – Heinmann Ltd., 1996.
4. Sanjoy Banerjee, Industrial Hazards & Plant Safety, Taylor & Francis   Group

ECH 701: 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)

ECH 702: PLANT DESIGN AND ECONOMICS
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
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 capitalised 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 optimisation, 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 semicyclic operation, Sensitivity and response analysis. [8]

Unit V

Optimisation 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

ECH 751: 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).

ECH 752: PROJECT   0 0 3
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.

ECH 051: 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, 4[tn] 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

ECH 052: 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 1I
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 1II

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).

ECH 053: FLUIDIZATION ENGINEERING 3 1 0

UnitI

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]

UnitII

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]

UnitIV

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

UnitV

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.

ECH 054: 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.

ECH 061: FERTILIZER TECHNOLOGY   3 1 0
Unit I
Introduction of Indian fertilizer industries, types of fertilizers process details. [8]
Unit II
Manufacture of Nitrogeneous, Phosphatic, potassic, complex, NPK, mixed, Dio and
other fertilizers. [8]
Unit III
Discussion of existing Indian plants pollution and its control, abetment and disposal
of waste of fertilizer units. [8]
UnitIV
Retrofits and modernization, computer control and Instrumentation, Energy
conservation and diversification. [8]
UnitV
Design of Ammonia converters and other reactors, cooling water, expansion,
capacity utilization and other problem of fertilizers industry. [8]
Books:
1.Mortvedt J.J.,Murphy L.S.& Follett R.H., Fertilizer Technology & Application, Meister Publishing
Company
 2. Shreves Chemical Process Industries, McGraw Hill
 3. Drydens Outlines of Chemical Technology, East West Press

ECH 062: 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 Bitumens

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

ECH 063: PETROCHEMICAL TECHNOLOGY Unit-I

Production and consumption pattern of petrochemicals in India, Feedstocks for petrochemicals-Natural gas, LPG, Refinery off-gases, Hydroforming of petroleum stocks, Naphtha and fuel oils, Petroleum coke

Unit-II

Steam reforming and partial oxidation processes for syngas, Manufacture of Methanol, Formaldehyde, Chloromethanes, Trichloroethylene, Perchloroethylene, Acetic acid, adipic acid

Unit-III

Ethylene and acetylene via steam cracking of hydrocarbons, Manufacture of Ethylene dichloride, Vinyl chloride, Ethylene oxide, Ethanolamines, Acetaldehyde, Vinyl acetate, Ethyl acetate, Ethylene glycol

Unit-IV

Manufacture of Isopropanol, Acetone, Methyl ethyl ketone, Methyl isobutyl ketone, Cumene, Acrylonitrile, Propylene oxide, Butadiene, Oxo process

Unit-V

Manufacture of Benzene, Toluene, Xylenes, Phenol, Styrene, Phthalic anhydride, Maleic anhydride, Nitrobenzene, Aniline, Bisphenol-A, Caprolactum

Books Recommended

1.Mall, I D ,Petrochemical Process Technology, McMillan India
2.Bhaskar Rao, Modern Petroleum Refining Processes, Oxford & IBH Publishing
3. Speight J., Chemistry & Technology of Petroleum, Marcel Dekker Inc.
4.Robert Mayer,Handbook of Petroleum Refining Processing, McGraw Hill

ECH 801: 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).

5. **Theodere, L**. "*Transport Phenomena for Engineers*", International Textbook Co. (1971).

ECH 851: PROJECT   0 0 12

This project course is in continuation of project course (ECH 752) 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.