

Department of Chemical Engineering

Curriculum of B. Tech (Chemical Engineering)

FIRST SEMESTER

(COMMON TO ALL BRANCHES)

Sl. No	Sub. Code	Subjects	L-T-P	Credits
1	MA 101	Mathematics – I	3-1-0	4
2	PH 101	Physics – I	3-1-0	4
3	CY 101	Chemistry	3-1-0	4
4	EE 100 EC 100	Basic Electrical Technology Basic Electronics Engineering	OR 3-1-0	4
5	EC 110 CE 130	Engineering Mechanics Environmental and Safety Engineering	OR 3-1-0	4
6	PH 170 CY 170	Physics Laboratory Chemistry Laboratory	OR 0-0-3	2
7	CS 171	Computing Laboratory – I	0-0-3	2
8	CE 171	Engineering Drawing	0-0-3	2
9	WS 171	Workshop Practice – I	0-0-3	2
10		Extra Academic Activity – I	0-0-3	2
TOTAL			15-5-15	30

SECOND SEMESTER

(COMMON TO ALL BRANCHES)

Sl. No	Sub. Code	Subjects	L-T-P	Credits
1	MA 102	Mathematics – II	3-1-0	4
2	PH 102	Physics – II	3-1-0	4
3	CS 102	Data Structures and Algorithm	3-1-0	4
4	EC 100 EE 100	Basic Electronics Engineering Basic Electrical Technology	OR 3-1-0	4
5	CE 130 EC 110	Environmental and Safety Engineering Engineering Mechanics	OR 3-1-0	4
6	CY 170 PH 170	Chemistry Laboratory Physics Laboratory	OR 0-0-3	2
7	CS 172	Computing Laboratory – II	0-0-3	2
8	ME 170	Machine Drawing and Solid Modeling	0-0-3	2
9	WS 172	Workshop Practice – II	0-0-3	2
10		Extra Academic Activity	0-0-3	2
TOTAL			15-5-15	30

THIRD SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credits
1	MA 201	Mathematics – III	3-1-0	4
2	CH 211	Processing and Handling of Materials	3-0-0	3
3	CH 223	Chemical Process Technology	3-0-0	3
4	CH 225	Chemical Process Calculations	3-1-0	4
5		HS & Open Elective – I	3-0-0	3
6	CH 271	Process Technology Laboratory	0-0-3	2
7	CH 273	Fuels and Combustion Laboratory	0-0-3	2
8	EE 270 EC 270	Basic Electrical Engineering Laboratory Basic Electronics Laboratory	OR 0-0-3	2
9	MA 273 HS 270	Mathematics – III Laboratory Language Laboratory	OR 0-0-3	2
TOTAL				26

FOURTH SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credits
1	MA 202	Mathematics – IV	3-1-0	4
2	CH 212	Fluid Dynamics	3-1-0	4
3	CH 220	Chemical Engg. Thermodynamics	3-1-0	4
4		Professional Elective – I		3/4
5		HS & Open Elective – II	3-0-0	3
6	CH 270	Materials Handling Laboratory	0-0-3	2
7	CH 272	Fluid Dynamics Fundamentals Laboratory	0-0-3	2
8	EE 270 EC 270	Basic Electrical Engineering Laboratory Basic Electronics Laboratory	OR 0-0-3	2
9	HS 270	Language Laboratory	0-0-3	2
TOTAL				26

FIFTH SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credits
1	CH 311	Heat Transfer Operations	3-1-0	4
2	CH 315	Mass Transfer Operations	3-1-0	4
3	CH 337	Equipment Design (Mech. Aspects)	3-1-0	4
4		Professional Elective – II		3
5		HS & Open Elective – III		3
6	CH 371	Heat Transfer Fundamentals Laboratory	0-0-3	2
7	CH 373	Mass Transfer Fundamentals Laboratory	0-0-3	2
8	CH 375	Biotechnology Laboratory	0-0-3	2
9	CH 377	Fluid Dynamics Applications Laboratory	0-0-3	2
TOTAL				26

SIXTH SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credits
1	CH 332	Process Equipment Design	3-1-0	4
2	CH 334	Process Dynamics and Control	3-1-0	4
3		Professional Elective – III		3/4
4		Professional Elective – IV		3
5		HS & Open Elective – IV		3
6	CH 370	Computer Aided Design Laboratory – I	0-0-3	2
7	CH 372	Heat Transfer Design Laboratory	0-0-3	2
8	CH 374	Mass Transfer Design Laboratory	0-0-3	2
9	CH 376	Process Instrumentation Laboratory	0-0-3	2
TOTAL				25/26

SEVENTH SEMESTER

Sl.No	Sub. Code	Subject	L-T-P	Credits
1	CH 421	Reaction Kinetics and Catalysis	3-1-0	4
2		Professional Elective – V		3
3		Professional Elective – VI		3
4		HS & Open Elective – V		3
5	CH 471	Chemical Reaction Engg. Laboratory	0-0-3	2
6	CH 473	Computer Aided Design Laboratory – II	0-0-3	2
7	CH 475	Process Dynamics and Control Laboratory	0-0-3	2
8	CH 491	Research Project – I	0-0-6	4
9	CH 493	Seminar & Technical Writing – I	0-0-3	2
10	CH 495	Short term Industrial/Research Experience	0-0-0	2
TOTAL				25

EIGHTH SEMESTER

Sl.No	Sub. Code	Subject	L-T-P	Credits
1	CH 422	Simulation, Modeling and Optimisation of Chemical Process	3-1-0	4
2		Professional Elective – VII		3
3		Professional Elective –VIII		3
4		HS & Open Elective – VI		3
5	CH 470	Process Simulation Laboratory	0-0-3	2
6	CH 492	Research Project – II	0-0-9	6
7	CH 494	Seminar & Technical Writing – II	0-0-3	2
8	CH 496	Comprehensive Viva Voce	0-0-0	2
TOTAL				25

LIST OF PROFESSIONAL ELECTIVES

<u>Sl. No</u>	<u>Sub. Code</u>	<u>Subject</u>	<u>L-T-P</u>	<u>Credits</u>
1.	CH 224	Polymer Science and Technology	3-0-0	3
2.	CH 226	Fuels and Combustion	3-0-0	4
3.	CH 227	Fertilizer Technology	3-0-0	3
4.	CH 312	Transport Phenomena	3-1-0	4
5.	CH 321	Fundamentals of Biochemical Engg.	3-0-0	3
6.	CH 322	Environmental Biotechnology	3-0-0	3
7.	CH 323	Energy Conservation and Renewable sources of Energy	3-0-0	3
8.	CH 324	Particulate Science and Technology	3-0-0	3
9.	CH 330	Petroleum Refinery Engineering and Petrochemicals	3-0-0	3
10.	CH 331	Process Instrumentation	3-0-0	3
11.	CH 335	Applied Statistics for Chemical Engineers	3-0-0	3
12.	CH 336	Chemical Engg. Mathematics	3-1-0	4
13.	CH 391	Special Topic in Chemical Engineering – I		03/04
14.	CH 392	Special Topic in Chemical Engineering – II		03/04
15.	CH 393	Special Laboratory in Chemical Engg – I	0-0-3	2
16.	CH 394	Special Laboratory in Chemical Engg – II	0-0-3	2
17.	CH 395	Engineering Product Development Project – I	0-0-6	4
18.	CH 396	Engineering Product Development Project – II	0-0-6	4
19.	CH 414	Nanotechnology in Catalysis	3-0-0	3
20.	CH 415	Fluidization Engineering	3-1-0	4
21.	CH 417	Modern Separation Processes in Chemical Engineering	3-0-0	3
22.	CH 419	Computational Fluid Dynamics	3-1-0	4
23.	CH 425	Environmental Engineering	3-0-0	3
24.	CH 426	Coal Processing Technology	3-0-0	3
25.	CH 427	Colloid and Interfacial Engineering	3-0-0	3
26.	CH 428	Disaster Management in Chemical Industries	3-0-0	3
27.	CH 432	Optimization Techniques in Process Design	3-0-0	3
28.	CH 434	Project Engineering	3-0-0	3
29.	BM 221	Biomaterials	3-1-0	04
30.	BM 386	Bioreactor Analysis & Design	3-0-0	03
31.	CE 318	Finite Element method	3-1-0	04
32.	CR 245	Introduction to Engineering Materials	3-0-0	03
33.	CR 305	Instrumental Characterization	3-1-0	04
34.	CY 551	Polymer Chemistry	3-1-0	04
35.	EE 427	Artificial Neural Network	3-0-0	03
36.	ME 356	Solar Energy	3-0-0	03
37.	MM 357	Corrosion & Degradation of Materials & Prevention	3-1-0	04
38.	MN 438	Solid Waste Management	3-0-0	03

Department of Chemical Engineering

SUMMARY OF COURSES

Sub Discipline: Transfer Operation

CH 211	Processing and Handling of Materials	3-0-0	3
CH 212	Fluid Dynamics	3-1-0	4
CH 311	Heat Transfer Operations	3-1-0	4
CH 312	Transport Phenomena	3-1-0	4
CH 315	Mass Transfer Operations	3-1-0	4
CH 323	Energy Conservation and Renewable sources of Energy	3-0-0	3
CH 415	Fluidization Engineering	3-1-0	4
CH 417	Modern Separation Processes in Chemical Engg.	3-1-0	4
CH 418	Recent Separation Technologies	3-0-0	3
CH 419	Computational Fluid Dynamics	3-1-0	4
CH 427	Colloid and Interfacial Engineering	3-0-0	3

Sub Discipline: Process Engineering & Technology

CH 220	Chemical Engg. Thermodynamics	3-1-0	4
CH 221	Fundamentals of Biochemical Engg	3-0-0	3
CH 223	Chemical Process Technology	3-0-0	3
CH 224	Polymer Science and Technology	3-0-0	3
CH 225	Chemical Process Calculations	3-1-0	4
CH 226	Fuels and Combustion	3-0-0	3
CH 227	Fertilizer Technology	3-0-0	3
CH 228	Treatment of Industrial Effluents	3-0-0	3
CH 229	Basic Chemical Engineering	3-0-0	3
CH 322	Environmental Biotechnology	3-0-0	3
CH 324	Particulate Science and Technology	3-0-0	3
CH 329	Process Plant Safety	3-0-0	3
CH 330	Petroleum Refinery Engg. and Petrochemicals	3-0-0	3
CH 414	Nanotechnology in Catalysis	3-0-0	3
CH 421	Reaction Kinetics and Catalysis	3-1-0	4
CH 422	Simulation, Modeling and Optimisation of Chemical Process	3-1-0	4
CH 425	Environmental Engineering	3-0-0	3
CH 426	Coal Processing Technology	3-0-0	3
CH 428	Disaster Management in Chemical Industries	3-0-0	3

Sub Discipline: Design and Simulation.

CH 331	Process Instrumentation	3-0-0	3
CH 332	Process Equipment Design	3-1-0	4
CH 334	Process Dynamics and Control	3-1-0	4

CH 335	Applied Statistics for Chemical Engineers	3-0-0	3
CH 336	Chemical Engg. Mathematics	3-1-0	4
CH 337	Equipment Design (Mech. Aspects)	3-1-0	4
CH 338	Industrial Instrumentation and Process Control	3-0-0	3
CH 432	Optimization Techniques in Process Design	3-0-0	3
CH 434	Project Engineering	3-0-0	3
CH 439	Non-Traditional Optimization Techniques	3-0-0	3

Sub Discipline: Laboratory Courses

CH 270	Materials Handling Laboratory	0-0-3	2
CH 271	Process Technology Laboratory	0-0-3	2
CH 272	Fluid Dynamics Fundamentals Laboratory	0-0-3	2
CH 273	Fuels and Combustion Laboratory	0-0-3	2
CH 370	Computer Aided Design Laboratory – I	0-0-3	2
CH 371	Heat Transfer Fundamentals Laboratory	0-0-3	2
CH 372	Heat Transfer Design Laboratory	0-0-3	2
CH 373	Mass Transfer Fundamentals Laboratory	0-0-3	2
CH 374	Mass Transfer Design Laboratory	0-0-3	2
CH 375	Biotechnology Laboratory	0-0-3	2
CH 376	Process Instrumentation Laboratory	0-0-3	2
CH 377	Fluid Dynamics Applications Laboratory	0-0-3	2
CH 470	Process Simulation Laboratory.	0-0-3	2
CH 471	Chemical Reaction Engg. Laboratory	0-0-3	2
CH 473	Computer Aided Design Laboratory – II	0-0-3	2
CH 475	Process Dynamics and Control Laboratory	0-0-3	2

Sub Discipline: Project, Seminar and Special Courses

CH 391	Special Topic in Chemical Engineering – I		
CH 392	Special Topic in Chemical Engineering – II		
CH 393	Special Laboratory in Chemical Engineering – I	0-0-3	2
CH 394	Special Laboratory in Chemical Engineering – II	0-0-3	2
CH 395	Engineering Product Development Project - I	0-0-6	4
CH 396	Engineering Product Development Project - II	0-0-6	4
CH 491	Research Project – I	0-0-6	4
CH 492	Research Project – II	0-0-9	6
CH 493	Seminar and Technical Writing – I	0-0-3	2
CH 494	Seminar and Technical Writing – II	0-0-3	2
CH 495	Short term Industrial/Research Experience	0-0-0	2
CH 496	Comprehensive Viva Voce	0-0-0	2

COURSES OFFERED AS OPEN ELECTIVE

(Normally not offered to students of Chemical Engineering)

<u>Sl. No</u>	<u>Sub. Code</u>	<u>Subject</u>	<u>L-T-P</u>	<u>Credits</u>
1.	CH 228	Treatment of Industrial Effluents	3-0-0	3
2.	CH 229	Basic Chemical Engineering	3-0-0	3
3.	CH 329	Process Plant Safety	3-0-0	3
4.	CH 338	Industrial Instrumentation and Process Control	3-0-0	3
5.	CH 418	Recent Separation Technologies	3-0-0	3
6.	CH 439	Non-Traditional Optimization Techniques	3-0-0	3

DETAILED CONTENT OF SYLLABI OF COURSES

CH 211	Processing and Handling of Materials	3-0-0	3
CH 212	Fluid Dynamics	3-1-0	4
CH 220	Chemical Engg. Thermodynamics	3-1-0	4
CH 221	Fundamentals of Biochemical Engg	3-0-0	3
CH 223	Chemical Process Technology	3-0-0	3
CH 224	Polymer Science and Technology	3-0-0	3
CH 225	Chemical Process Calculations	3-1-0	4
CH 226	Fuels and Combustion	3-0-0	4
CH 227	Fertilizer Technology	3-0-0	3
CH 228	Treatment of Industrial Effluents	3-0-0	3
CH 229	Basic Chemical Engineering	3-0-0	3
CH 270	Materials Handling Laboratory	0-0-3	2
CH 271	Process Technology Laboratory	0-0-3	2
CH 272	Fluid Dynamics Fundamentals Laboratory	0-0-3	2
CH 273	Fuels and Combustion Laboratory	0-0-3	2
CH 311	Heat Transfer Operations	3-1-0	4
CH 312	Transport Phenomena	3-1-0	4
CH 315	Mass Transfer Operations	3-1-0	4
CH 321	Fundamentals of Biochemical Engg.	3-0-0	3
CH 322	Environmental Biotechnology	3-0-0	3
CH 323	Energy Conservation and Renewable sources of Energy	3-0-0	3
CH 324	Particulate Science and Technology	3-0-0	3
CH 329	Process Plant Safety	3-0-0	3
CH 330	Petroleum Refinery Engineering and Petrochemicals	3-0-0	3
CH 331	Process Instrumentation	3-0-0	3
CH 332	Process Equipment Design	3-1-0	4
CH 334	Process Dynamics and Control	3-1-0	4
CH 335	Applied Statistics for Chemical Engineers	3-0-0	3

CH 336	Chemical Engg. Mathematics	3-1-0	4
CH 337	Equipment Design (Mech. Aspects)	3-1-0	4
CH 338	Industrial Instrumentation and Process Control	3-0-0	3
CH 370	Computer Aided Design Laboratory – I	0-0-3	2
CH 371	Heat Transfer Fundamentals Laboratory	0-0-3	2
CH 372	Heat Transfer Design Laboratory	0-0-3	2
CH 373	Mass Transfer Fundamentals Laboratory	0-0-3	2
CH 374	Mass Transfer Design Laboratory	0-0-3	2
CH 375	Biotechnology Laboratory	0-0-3	2
CH 376	Process Instrumentation Laboratory	0-0-3	2
CH 377	Fluid Dynamics Applications Laboratory	0-0-3	2
CH 391	Special Topic in Chemical Engineering – I		03/04
CH 392	Special Topic in Chemical Engineering – II		03/04
CH 393	Special Laboratory in Chemical Engineering – I	0-0-3	2
CH 394	Special Laboratory in Chemical Engineering – II	0-0-3	2
CH 395	Engineering Product Development Project – I	0-0-6	4
CH 396	Engineering Product Development Project – II	0-0-6	4
CH 414	Nanotechnology in Catalysis	3-0-0	3
CH 415	Fluidization Engineering	3-1-0	4
CH 417	Modern Separation Processes in Chemical Engineering	3-0-0	3
CH 418	Recent Separation Technologies	3-0-0	3
CH 419	Computational Fluid Dynamics	3-1-0	4
CH 421	Reaction Kinetics and Catalysis	3-1-0	4
CH 422	Simulation, Modeling and Optimisation of Chemical Process	3-1-0	4
CH 425	Environmental Engineering	3-0-0	3
CH 426	Coal Processing Technology	3-0-0	3
CH 427	Colloid and Interfacial Engineering	3-0-0	3
CH 428	Disaster Management in Chemical Industries	3-0-0	3
CH 432	Optimization Techniques in Process Design	3-0-0	3
CH 434	Project Engineering	3-0-0	3
CH 439	Non-Traditional Optimization Techniques	3-0-0	3
CH 470	Process Simulation Laboratory.	0-0-3	2
CH 471	Chemical Reaction Engg. Laboratory	0-0-3	2
CH 473	Computer Aided Design Laboratory – II	0-0-3	2
CH 475	Process Dynamics and Control Laboratory	0-0-3	2
CH 491	Research Project – I	0-0-6	4
CH 492	Research Project – II	0-0-9	6
CH 493	Seminar and Technical Writing – I	0-0-3	2
CH 494	Seminar and Technical Writing – II	0-0-3	2
CH 495	Short term Industrial/Research Experience	0-0-0	2
CH 496	Comprehensive Viva Voce	0-0-0	2

CH 211**PROCESSING AND HANDLING OF MATERIAL****3 credits [3-0-0]**

Characteristics of a single particle: Size, shape, surface area, volume, Properties of solids. ; Characteristics of a collection of particles: Particle Size Distribution: Specific surface of mixture, average particle size, Number of particles, Screen analysis: Effectiveness of screen, Industrial screening equipments, Size reduction: Factors affecting comminution, Laws of comminution, Industrial equipments ; Particle Dynamics: Single Particle: Settling velocity, Effect of shape, Wall effect, Mixture of Particles: hindered settling ; Separation of particles: Solid-solid separation: Classification, Jigging, Magnetic and Electrostatic separations, Liquid-solid separation: Sedimentation, Filtration, Hydro-Cyclones, Gas-solid separation: Flotation ; Mixing and Agitation: Phenomena of mixing and agitation, Circulation, velocities and power consumption in agitated vessels, Solid-liquid mixing, solid-solid mixing ; Particle transport and storage: Storage of solids: Hopper, Bins & Silos, Mechanical conveyers, Gas-solid: Pneumatic transport in horizontal and vertical pipelines, Liquid-solid: Hydraulic transport Beneficiation circuits of Minerals: Chalcopyrites, Sphalerites, Galena and Bauxite.

Essential Reading:

1. C.M. Narayanan & B.C. Bhattacharyya, *Mechanical Operation for Chemical Engineers (Incorporating Computer Aided Analysis)*, Khanna Publisher, Third Edition, 2005.
2. W I McCabe & J C Smith, P. Harriot, *Unit Operations of Chemical Engineering*, McGraw-Hill publication, 2005

Suggested Reading:

1. M. C. Fuerstenau and K. N. Han, *Principles of Mineral Processing*, John Wiley, N.Y, 2003
2. J. F. Richardson, J. H. Harker & J. Backhurst, *Chemical Engineering Volume 2*, Butterworth-Heinemann, 1st edn, 2002.

CH 212**FLUID DYNAMICS****4 credits [3-1-0]**

Fluid mechanics: Nature of fluid, Pressure concept & various pressure measuring devices. ; Fluid dynamics : Fluid flow phenomena, Nature and classification of flow, Dynamic properties of fluid, Boundary layer formation in straight tube, Universal velocity profile, Haugon and Poiseulle equation, Measurement of viscosity, Dimensional analysis applied to fluid flow problems, Buckingham's theorem, Physical significance of Reynold's number. ; Transportation of fluids: Bernoulli's equation for friction less flow and correction for frictional flow; Pumps: Types, Selection, Applications, Performance characteristics of centrifugal and reciprocating pumps; Flow past immersed bodies: Flow through packed beds, kozney Carman equation, Filtration and Centrifugation, Motion of particles through fluids, Terminal settling velocity, Hydraulic and Pneumatic classification; Fluidization: Types of fluidization, Prediction of minimum fluidization velocity and bed pressure drop, bubbling, slugging and distributors; Introduction to Non-Newtonian fluids.

Essential Reading:

1. W.L. McCabe, J.C. Smith, P. Harriot, *Unit Operations of Chemical Engineering*, McGraw-Hill Publication, 2005.

Suggested Reading:

1. G.K. Batchelor, *Introduction to Fluid Dynamics*, Oxford University Press, 2000.

Pre-requisite: Knowledge in under graduate "Fluid Mechanics"

CH 220**CHEMICAL ENGINEERING THERMODYNAMICS****4 credits [3-1-0]**

First law: Evaluation of PVT properties of fluids, Law of corresponding states, Residual volume, Compressibility factor, Equations of state; Heat effect – Clausius Clapeyron equation; Second law: Entropy, Work function, Free energy; Phase rule: Theoretical and experimental aspects of phase rule and its use in study of multi-component system; Refrigeration: Thermodynamic efficiency, production of work from heat. Partial molal properties, Chemical potential, Fugacity. Gibbs-Duhem equation. Determination of activity coefficients from van Laar equation; Chemical reaction equilibria, Introduction to third law. ; VLE and LLE calculations.

Essential Reading:

1. J. M. Smith & H.C.V Ness and M. M. Abbot, *Introduction to Chemical Engineering Thermodynamics*, Mc Graw and Hills Publication, 2005

Suggested Reading:

1. K. Denbigh, *The principles of Chemical equilibria with applications in Chemistry and Chemical Engineering*, 1981
2. S. I. Sandler, *Chemical and Engineering Thermodynamics*. John Wiley publication, 3rd edition, 2003

CH 223**CHEMICAL PROCESS TECHNOLOGY****3 credits [3-0-0]**

Introduction of CPT with reference to Indian resources, industries, trade and export potential, small scale industries and rural development. Preparation of process flow diagrams, Instrumentation diagrams and Process symbols. ; Introduction to the following industries lying emphasis on process flow sheet, material requirements, process conditions, material of construction and design aspects.

- Chlor-Alkali Industries: Manufacture of Soda ash, Caustic soda and Chlorine.
- Acids; Manufacture of Sulphuric acid, Hydrochloric acid and Nitric acid.
- Electro thermal Industries: Manufacture of Silicon Carbide and Calcium Carbide.
- Extraction and Refining of edible oil, Fat splitting and Hydrogenation of oil.
- Soaps and Detergents, recovery of Glycerin.
- Production of Pulp, Paper and Rayon.
- Fermentation Industries: Manufacture of Industrial alcohol, Absolute alcohol and allied products.
- Manufacture of Sugar, Starch and its derivatives.
- Coal based Chemical Industries.

Essential Reading:

1. C.E. Dryden, *Dryden's outlines of Chemical Technology for the 21st century*, (Edited & revised by M. G. Rao and M Sitting) 2006
2. G.T. Austin, *Shreve's Chemical Process Industries*, 5th edition, McGraw Hill Book Co., New York, 1984

Suggested Reading:

1. S.D. Shukla & G.N. Pandey, *A Text Book of Chemical Technology, Vol. II*, Sangam Books, 2000.
2. W.V. Mark edited by S.C. Bhatia, *Chemical Process Industries Vol. I & Vol. II* 2nd edition, CBS Publisher and Distributor, 2007.

3. R.E. Kirk and D.F. Othmer, *Encyclopedia of Chemical Technology*, 4th edition, Interscience, New York, 1991 (In our library).

CH 224 POLYMER SCIENCE AND TECHNOLOGY 3 credits [3-0-0]

Historical Background, Classification and forms of Polymers, Tacticity, Functionality, Degree of Polymerization, identification of Polymers and end uses; Chemistry of Polymerization: Chain and Step Polymerization and their Kinetics Techniques of Polymerization: Bulk, Solution, Suspension and Emulsion Polymerization; Molecular Weight and its determination by Viscometry, Light-scattering and Osmometric methods; Crystallization in Polymers; Polymer Degradation; Manufacture and Uses of PF, UF, Vinyl Resins, Acrylic Resins, PS and PE; Polymer additives, Blends and Alloys; Polymer Processing; Plastics as materials of construction in chemical equipments.

Essential Reading:

1. R. Mann, *Introductory Polymer Science*, Dhanpat Rai Publications.

Suggested Reading:

1. S. K. Bhasin and J. R. Fried, *Polymer Science and Technology*, Prentice-Hall.
2. F. W. Billmeyer, *Textbook of Polymer Science*, John Willey & Sons
3. R. Sinha, *Outlines of Polymer Technology-I, II*, Prentice-Hall.

Pre-requisite: Knowledge in under graduate “Basic chemistry”

CH 225 CHEMICAL PROCESS CALCULATIONS 4 credits [3-1-0]

Chemical reactions: Excess reactant, Degree of completion, Composition of mixtures and solutions; Material balance: Calculations for (a) unit operations like mixing evaporation, crystallization and distillation, (b) Chemical reactions and (c) Recycling; Behaviour of ideal gases: Various equations of state, Law of Dalton and Amagat, Densities of gaseous mixture. ; Vapour pressures: Liquefaction, Vaporisation, Boiling point, Vapour pressures of solids and liquids, Roul't's law, Polar and non-polar compounds; Energy balance: Heat capacity of gases, liquids, solids and solutions, Kopp's rule, Heats of fusion and vaporisation, Trouton's rule and Kistia Kowaky equation, calculation of heat of reaction, combustion, formation and neutralisation, enthalpy concentration charts, Flame temperatures; Material and energy balance in industrial processes: Simple material and energy balance calculations for the following manufacturing processes – (a) Sulphuric acid, (b) Nitric acid, (c) Phosphoric acid, (d) Lime and Alkali; Numerical techniques for solving material and energy balance equations ; Vapour – liquid equilibrium calculations.

Essential Reading:

1. O.A. Hougen et. al, *Chemical Process Principles (Vol.1)*.
2. R. M. Felder and R. W. Rousseau, *Elementary Principles of Chemical processes*, John Wiley, 2004

Suggested Reading:

1. R.K. Dave, *Chemical Reactions and Stoichiometry*, Campus books International, 2000
2. M. Sylvin, *Problems in stoichiometry*, Sarup & Sons, 2003

Pre-requisite: Knowledge in under graduate “Basic chemistry & Mathematics”

CH 226**FUELS AND COMBUSTION****3 credits [3-0-0]**

Solid fuels: Coal origin, Chemical composition, Calorific value, Classifications, Characteristics and Distribution of Indian coals, Storage and spontaneous combustion of coal, Coal washing and blending, Petrographic constituents of coal, Carbonization of coal, Manufacture and properties of metallurgical coke, Recovery of byproducts; Liquid fuels: Origin and composition of crude oil, Crude oil distillation and its products with special reference to gasoline, kerosene and diesel oil, Cracking and reforming, Coal tar distillation products, Shale oil; Gaseous fuels: Natural gas, Coal gas, Coke oven and blast furnace gas, Manufacture of water gas and producer gas, Carbureted water gas; Synthetic fuels: Hydrogenation of coal, Fischer – Tropsch synthesis; Introduction to nuclear fuels and nuclear reactors, fuels, Moderators and structural materials, Combustion: Combustion of solid fuels, Pulverized coal, Calculation of volumes and weights of air necessary for combustion of fuels, Gas analysis.

Essential Reading:

1. S. Sarkar, *Fuels and Combustion*. Sangam books Ltd (Imported)

Suggested Reading:

1. Himus, *Elements of Fuel technology*.
2. J. Brame and King, *Fuels: Solid, liquid and gaseous fuels*, Kessinger Publishing, LLC, 2007.
3. O. P. Gupta, *Elements of Fuels, Furnaces and Refractories*.

CH 227**FERTILIZER TECHNOLOGY****3 credits [3-0-0]**

Fertilizers: Chemical fertilizers, Types of chemical fertilizers, Fertilizer applications and agronomical details; Nitrogenous fertilizers: Feedstock for production of Ammonia gas, Associated gas, Coke oven gas, Naphtha, Fuel oil, Petroleum heavy stock, Coal, Lignite, Water, Coke, methods of production, Characteristics, Specification and storage of ammonium sulphate, nitrate, urea, calcium ammonium nitrate and ammonium chloride; Phosphatic fertilizers: Raw materials – Phosphate rock, Sulphur, Pyrites. Methods of production, Characteristics, Specification and storage of single super phosphate, triple super phosphate; Potassic fertilizers: Methods of production, Characteristics, Specification and storage of potassium chloride, potassium sulphate and potassium schoenite; Complex and NPK fertilizers: Methods of production, Characteristics, Specification and storage of ammonium phosphate sulphate, Diammonium phosphate, Nitrophosphates, Urea ammonium phosphate, Mono ammonium phosphate and various grades of NPK fertilizers; Others: Secondary nutrients, Micro nutrients, Fluid fertilizers, Controlled release fertilizers; Technology of compound fertilizers, Nitrogenous fertilizers, Phosphate fertilizers, Potash and mixed fertilizers, Fertilizer applications and agronomical details, Technology of ammonia manufacture, Fertilizer raw materials and availability.

Essential Reading:**Supplementary Reading:**

1. Nielsson, *Manual for Fertilizer Technology Series*
2. S. Lee, J. G. Speight, and S. K. Loyalka, *Handbook of Alternative Fuel Technology*, CRC, 2007

CH 228**TREATMENT OF INDUSTRIAL EFFLUENTS****3 credits [3-0-0]**

Characterisation of waste waters - quality of various industrial effluents; permissible limits ; Fundamentals of waste water treatment technologies; water treatment equipments ; Biological waste water treatment:- completely mixed aerated lagoons, oxidation ditches and waste stabilisation ponds - activated sludge - microbial community in activated sludge - aerobic digestion, trickling filters - rotating biological contactors - nitrification - biological fluidised bed reactors for treatment of sewage and industrial effluents - anaerobic digestion and anaerobic contact process - denitrification - fluidised bed anaerobic reactors - anaerobic down flow stationary fixed film reactors. ; Case studies of waste water treatment and disposal of tannery-dye factory-sugar industry-paper and pulp industry -viscose industry - agro chemical industries-fertilizer industries - petro chemical industry and pharmaceutical industries. ; Treatment of gaseous pollutants: Ambient air sampling, analysis methods and measuring devices; air pollution standards, air pollution control equipments ; Case studies of gaseous effluent treatment in typical industries: steel plants, power plants etc.

Essential Reading:

1. N. W. Jern, *Industrial waste water Treatment*, Imperial College Press, 2006.

Suggested Reading:

1. R.S. Ramalho.1983. *Introduction to Waste Water Treatment Process*. Academic press. New York.
2. S. D. Lin and C. C. Lee, *Water and Waste Water Calculation Manual*, McGraw-Hill, 2001.

CH 229**BASIC CHEMICAL ENGINEERING****3 credits [3-0-0]**

Introduction: Units and dimensions, basic laws, unit operations and unit processes; Physico-chemical calculations: Material and energy balance for different unit operations; nit processes. ; Fluid flow and flow measurement: Nature of fluid, viscosity, friction factor, flow through; porous media, fluidization, flow measuring devices; Heat transfer: Modes of heat transfer, calculation of heat transfer coefficient, heat exchangers and evaporators. ; Mass transfer: Transfer mechanism, mass transfer coefficient, introduction to mass transfer operations viz.gas absorption, distillation, leaching and drying, stage and continuous contactors. ; Chemical kinetics: Rate equation, catalysis, tyre of reactors ; Natural resources and their utilization: Important chemical industries based on natural resources viz. paper (wood),soap and detergents(oil seeds),cement(minerals),fertilizers ; (water, coal and minerals)and petroleum refinery(crude oil). ; Chemical process instrumentation: Elements of instruments, static and dynamic characteristics, dynamic response of process instruments, recording, indicating and signaling instruments. ; Pollution from chemical industries and its abatement: Solid, liquid and gaseous effluents from chemical industries and their abatement.

Essential Reading:

1. W.L. McCabe, J.C. Smith and P. Harriott, *Unit Operations of chemical Engineering*, McGraw-Hill, Inc., Sixth Edition, 2005

Suggested Reading:

1. J.M. Coulson, J.F. Richardson, J.R. Backhurst and J.H. Harker, *Chemical Engineering, Vol. 1 and 2*, Pergamon Press, Fourth Edition,1990.
2. G.T. Austin, *Shreve's Chemical Process Industries*, McGraw Hill Book Co., Fifth Edition,(Latest)

CH 270 MATERIAL HANDLING LABORATORY**2 credits [0-0-3]**

1. Determination of average particle size of a mixture of particles by sieve analysis.
2. Study and operation of Jaw crusher and thereby verification of Rittinger's constant.
3. Determination of reduction ratio, maximum feed size and theoretical capacity of crushing rolls.
4. Determination of the effect of no. of balls on grinding in a Ball mill and comparison of its critical speed with the operating speed.
5. To find out the effect of time on grinding and amount of undersize at zero time of grinding in a ball mill and to compare its operating speed with the critical speed.
6. To find out enrichment of the coal sample using a froth flotation cell.
7. Determination of the effectiveness of a vibrating screen.
8. To find the efficiency of Wilfley Table and the effect of water flow rate on efficiency of separation.
9. Study and operation of a Hammer mill thereby finding its reduction ratio.
10. Study and operation of a Pulverizer and thereby finding its reduction ratio.
11. Study and operation of a cyclone separator and thereby finding its efficiency of separation.
12. Study and operation of a Magnetic separator and thereby finding its efficiency of separation.
13. Study and operation of a Gyratory Crusher and thereby finding its reduction ratio

CH 271 PROCESS TECHNOLOGY LABORATORY**2 credits [0-0-3]**

1. Preparation of soap from oil and Determination of alkali content in the soap
 - Commercial soap
 - Prepared soap
2. Determination of saponification value of oil.
3. Determination of fat content in the food stuff using Soxhlet apparatus.
4. Preparation of activated carbon.
5. Determination of Total organic carbon in the water sample.
6. Determination of surface area using BET apparatus.
7. Determination of Bromine no of oil sample.
8. Distribution Coefficient determination for iodine in organic solvent and water.
9. Determination of iron content in a given salt solution.
10. Determination of lime% in a Portland cement.
11. Determination of COD in the water sample.
12. Determination of dye concentrates using spectrophotometric analysis.

CH 272 FLUID DYNAMICS FUNDAMENTAL LABORATORY**2 credits [0-0-3]**

1. To find the cake and filter medium resistance of Plate and Frame Filter press.
2. To find the filter medium resistance of a Vacuum Leaf Filters.
3. To find the flow rate using a V notch
4. To find the friction losses in a Straight pipe
5. To find the friction losses in a Bend pipe
6. Study of Pipe fittings and Valves
7. To study the principle of a hydro-cyclone and find out the efficiency of separation.
8. To study the Reynold's apparatus and verify experimentally

9. To study the working principle of a reciprocating pump and to determine the percentage of slip.
10. To study the working principle of a centrifugal pump and determine its efficiency experimentally.
11. To determine the cake resistance of a batch basket centrifuge
12. To find out the flow profile of water from hook's gauge and determination of coefficient of velocity, coefficient of discharge, coefficient of resistance, coefficient of contraction.

CH 273

FUELS AND COMBUSTION LABORATORY

2 credits [0-0-3]

1. Determination of composting of the supplied sample of Coal by Proximate Analysis.
2. Determination of Caking Index of the supplied sample of Coal by Grey – campredon method.
3. To determine the washability characteristics of the supplied sample of Coal using Float and Sink test.
4. To find the effect of temperature on viscosity of the supplied samples of liquid fuel using Red wood viscometer.
5. To find the effect of temperature on viscosity of the supplied samples of lubricating oil using Engler's viscometer.
6. To find the Flash and Fire point of the supplied samples of liquid fuel using
 - (i.) Penslery Martein closed cup apparatus
 - (ii.) Abel open cup apparatus.
7. To find the Aniline point of the supplied samples of liquid fuels using Aniline point apparatus and hence find out the Diesel Index Number of the Diesel oil.
8. To find the Carbon Residue of the supplied sample of lubricating oil / oil mixture using Conradson apparatus.
9. To find the moisture content of the supplied samples of liquid fuel / Crude oil using Dean and Stark apparatus.
10. To find the Pour point and Solidification point of the supplied samples of liquid fuels.
11. To find the Calorific value of LPG using
 - (i.) Boy.s Gas calorimeter
 - (ii.) Junker's Gas calorimeter.
12. To find the composition of the gas using Gas Chromatograph and hence determine the percent of excess air used for combustion of the fuel used.
13. To determine the ultimate analysis of the supplied sample of coal and hence find the theoretical GCU of given coal.
14. To determine the Swelling Index of the supplied sample of coal and ascertain the agglomerating characteristics of the coal sample.
15. To determine the Gross calorific value of the supplied sample of coal using Bomb Calorimeter (on ash free basis).
16. To determine the Smoke Point of kerosene oil using Smoke Point Apparatus.

CH 311

HEAT TRANSFER OPERATIONS

4 credits [3-1-0]

Mechanism of heat transfer: Conduction – Fourier's law, Steady state conduction of heat through plane, cylindrical and Spherical solids - single and in series. Convection – Steady state heating and cooling of fluids without phase change, Heat transfer from condensing vapours and to boiling liquids – filmwise and dropwise condensation, boiling coefficients. Radiation – Kirchhoff's law, Stefan-Boltzman law, Simple case of radiation heat transfer between surfaces; Applications of heat transfer: Evaporation – Effect of liquid characteristics, Single and multi-effect evaporation, Types of evaporation and their attachments, Performance of single effect

evaporation, Boiling point rise, Multiple effect evaporation – forward, backward, mixed and parallel feed, Performance of multiple effect evaporation in comparison to that of single effect evaporation, Vapour compression evaporation, Calculations for single effect evaporators; Different types of Heat Exchangers; Heat transfer augmentation.

Essential Reading:

1. D. Q. Kern, *Process Heat Transfer*, Mc Graw & Hills, 1982
2. F. P. Incropera, *Fundamentals of Heat and Mass Transfer*, John Wiley & Sons, 2007

Suggested Reading:

1. W. L. McCabe and J. C. Smith, *Unit Operations of Chemical Engineering*, Mc Graw & Hills, 2005.
2. R. W. Serth, *Process Heat Transfer: Principle and Applications*, Academic press, 2007.

CH 312

TRANSPORT PHENOMENA

4 credits [3-1-0]

Momentum transport: Viscosity and mechanism, Newton's law and viscosity, Non-Newtonian fluids, Temperature and pressure dependence of viscosity (gases at low density); Velocity distributions in laminar flow, Shell momentum balances, Flow of falling film, Flow through circular tube and annulus as adjacent flow of two immiscible fluids and creeping flow around a solid sphere, Equations of changes for isothermal system (compressible), Unsteady state viscous flow, Interphase transportations in isothermal system, Friction factor; Energy transport: Thermal conductivity in solids, Fouriers law of heat conduction, Temperature and heat dependence of thermal conductivity in gases and liquids; Temperature distributions in solids and in laminar flow, Shell energy balances, Heat conduction with electrical, viscous and chemical sources, Heat conduction through composite walls and in cooling fin forced and free convection; Equations of change for non-isothermal systems, Equations for energy in rectangular coordinates. Unsteady state heat conduction in solids; Mass transport: Diffusivity and mechanism, Temperature and pressure dependence of mass diffusivity; Concentration distributions in solids and in laminar flow, Shell mass balances, diffusion through a stagnate gas film, Diffusion with homogeneous and heterogeneous chemical reactions, diffusion into a falling liquid film, Diffusion and chemical reaction inside a porous catalyst. Equations of continuity for a binary mixture in rectangular coordinates; Inter-phase transport in multi-component system, Definition of binary mass transfer coefficients in one phase, Correlations of binary mass transfer coefficients in one phase at low mass transfer coefficients and in two phase at low and high mass transfer rates.

Essential Reading:

1. R. B. Bird, W. E. Stewart, and E. N. Lightfoot *Transport phenomena*, John Wiley & Sons; Revised 2nd Edition edition, 2007

Suggested Reading:

2. Bennett and Myers, *Mass, Heat and Momentum transport*.
3. J. Welty, C. E. Wicks, G. L. Rorrer, and R. E. Wilson *Fundamentals of Momentum Heat and Mass Transfer*, John Wiley & Sons; 5th Edition edition, 2008
4. R. S. Brodkey & H. C. Hershey, *Transport Phenomena*.

Pre-requisite: Knowledge in under graduate "Basics of Heat & Mass transfer & Fluid Dynamics"

CH 315 MASS TRANSFER OPERATIONS**4 credits [3-1-0]**

Mechanism of Transfer; Diffusion in gases and liquids. Analogy between mass momentum and heat transfer, Theories of Interphase Mass transfer, Coefficients and their correlations; Gas – Liquid Operations; Absorption: Choice of packings & solvent, M.I.R., N.T.U., H.T.U. and H.E.T.P.: calculation of height and diameter for packed towers. ; Distillation: Boiling point diagram, Flash, Differential, vacuum steam, azeotropic and extractive distillation, Rectification and stripping, calculation of number of ideal stages by McCabeThiele and Ponchan - Savarit methods; Liquid – liquid operation; Extraction: batch and continuous, calculation of number of ideal stages, multistage extraction, equipment and their design principles; Gas – Solid Operation; Humidification and Drying: Wet and dry bulb hygrometry, spray chamber, cooling towers. Theory, mechanism and rate of drying, design and working principles a few types of dryers viz. shelf dryer, drum dryer, rotary dryer and fluidized bed dryer; Crystallization: Theory and applications, Various types of crystallizers

Essential Reading:

1. R. E. Treybal, *Mass Transfer Operations*, Mc Graw and Hills, 1980.
2. W. L. McCabe & J.C. Smith, *Unit Operation of Chemical Engineering*, Mc Graw & Hills, 2005.
3. B. K. Dutta, *Principles of Mass Transfer and Separation Processes*, Prentice Hall, 2005.

Suggested Reading:

1. T.K. Sherwood and R.L. Pigford, *Absorption and Extraction*.
2. V. Winkle; *Distillation*.
3. Sherwood, Pigford and Wilke; *Mass Transfer*.
4. J. Benitez, *Principle and Modern Application of Mass Transfer Operation*, Wiley and Interscience, 2002
5. A. F. Mills, *Mass Transfer*, Prentice Hall, 2001

**CH 321 FUNDAMENTALS OF BIOCHEMICAL
ENGINEERING****3 credits [3-0-0]**

Introduction to Microbiology: Structure of cells, types of cells; Introduction to Biochemical process industries: Industrial alcohols, anti biotic, enzymes, vitamins, single cell process; Fermentation mechanisms and kinetics: Kinetic models of microbial growth and product formation; Fermentation types: Batch and continuous fermentation; Bioreactors: Types of bioreactor and design; Sterilization; Sterilization of media and air, equipment, batch and continuous sterilizer design; Biochemical product separation and recovery: Membrane separation process, chromatographic method; Application to waste water treatment: Activated sludge process, aerobic and anaerobic processes.

Essential Reading:

1. G. Najafpour, *Biochemical Engineering & Biotechnology*, Elsevier Science, 2006.
2. J E Bailey and D F Ollis; *Biochemical Engineering Fundamentals*, Mc Graw & Hills Publication, 1986.

Suggested Reading:

1. M. L. Shuler and F. Kargi, *Bioprocess Engineering: Basic Concepts*, Prentice Hall of India, 2001.
2. R. Dutta, *Fundamentals of Biochemical Engineering*, Springer, 2008.

CH 322**ENVIRONMENTAL BIOTECHNOLOGY****3 credits [3-0-0]**

General effluent treatment – nature of sewers, sewage; Methods adopted in effluent treatment; Legal Consideration – Royal Commissions. Current situation in laying of charging ownership, regulations, legislation; Activated sludge process equipment, plant kinetics, CSTR modeling. PFR modeling, recycle stability, washout; Advanced Process – Trickle filter, moving medium system; Biology of effluent treatment process: Roles of bacteria, fungi and protozoa. Extracellular Polymers, films, flocs, Analysis of effluent; Nutrition, Carbon removal, influences of loading ratio, retention times, season on kinetics and performance, Nitrogen and Phosphorous requirement for adequate plant performance. Nitrification and De-nitrification Anoxic process, extended aeration, high rate process; Sludge disposal methods; Anaerobic processes. Sludge digestion (contact digester), Management of digester sludge. Aerobic effluent treatment. Gas production and utilization, related problem.

Essential Reading:

1. M. J. Waites, N. L. Morgan, J. S. Rockey, and G. Higton , *Industrial Microbiology*, Wiley Blackwell, 2001.

Suggested Reading:

1. W. Grueger and A. Crueger, *Biotechnology a Text book of Industrial Microbiology*, Mc Graw Hill, 1990.
2. J. E. Bailey and D. F. Ollis, *Biochemical Engineering Fundamentals*, Mc Graw-Hill, 2005.

CH 323**ENERGY CONSERVATION & RENEWABLE
SOURCES OF ENERGY****3 credits [3-0-0]**

Introduction to Energy Science and Energy Technology; Energy Science and Energy Technology, world energy future, Energy sources and their availability. Renewable energy sources. Prospects of Renewable energy sources; Solar energy fundamentals and application; Geothermal energy: Introduction, Utilization of Geothermal energy, Geothermal energy resources, geothermal gradient, Different types of Geothermal Electric power plant and their operations for Geothermal Energy systems in India; Wind energy: Fundamentals and application, Basic principles of Wind Energy Conversion, Wind Energy conversion system, Performance of wind machines, Electric generation for wind; Biomass Energy Resources: Introduction, Biomass Conversion Process. Biogas from plant wastes, communities bio-gas plants. Biochemical conversion, Fermentation, liquid fuels for biomass; Urban Waste: A source of Energy. Urban solid waste, waste incineration process. Environmental consideration, Fluidized bed combustion boilers for burning solid waste and fossil fuels; Energy from the oceans: Introduction Ocean Energy conversion Technologies. Types of Ocean Thermal Electric Power Generation system and their operation. Tidal power plant; Hydro Energy: Introduction, types hydro-electric plants and energy conversion scheme, Impulse turbine and Reaction turbine. Classification of Hydro-Energy plants; Energy Conservation: Principle of energy conservation and Energy Audit. Energy conservation Technologies. Co-generation, waste heat utilization, Heat recuperates, Heat regenerators, Heat pipes, Heat pumps, Energy storage.

Essential Reading:

1. S. Rao and Dr. B.B. Parulekar, *Energy Technology, Non conventional, Renewable and Conventional*, Khanna Publishers.

Suggested Reading:

1. G.D. Rai, *Non-conventional Energy Sources*, Khanna Publishers.

2. D.S. Chauhan and S.K. Srivastava, *Non- Conventional Energy Resources*, New Age International Pvt Ltd.
3. G.N. Tiwari, *Fundamentals of Renewable Energy Sources*, Narosa Publishing House.

CH 324 PARTICULATE SCIENCE & TECHNOLOGY 3 credits [3-0-0]

Study of particles: Definition of a particle, Qualities of particles, The industrial revolutions: explosion of particle related advances (from advanced mining techniques to abrasives, cutting tools, and mass production of chemicals and agricultural products). Modern scientific advances in paints and coatings and other particles in various base solvents, Particles in fluids. ; Composite materials, the design and manipulation of matter on the nanoscale and into nanostructures. ; Particle Science as an enabling technology to create new energy sources, clean our air and water and build stronger and lighter materials. Advances in particle sciences in particular in the area of human healthcare.

Essential Readings:

1. J.K. Beddow, *Particulate Science and Technology*
2. R. B. Bird, W. E. Stewart, and E. N. Lightfoot *Transport phenomena*, John Wiley & Sons; Revised 2nd Edition Edition, 2007
3. M. Leva, *Fluidization*.

CH 330 PETROLEUM REFINERY ENGINEERING AND 3 credits [3-0-0]
PETROCHEMICALS

Origin of Petroleum: Mendeleev and Englers' theories, Composition of petroleum, Indian oil fields, Composition of Indian crudes, Properties of crude and products; Evaluation of oil stocks: Base of crude oil, Characterisation factor – TBP apparatus, Gravity and mid-percent curve, Yield curve, Equilibrium flash vaporisation curve, ASTM distillation characteristics of products, ASTM end points and TBP cut point; Crude oil processing: Desalting and dehydration of crude, Topping, Atmospheric and vacuum distillation; Cracking and Reforming: Important cracking and reforming reactions, Thermal cracking, Fixed bed, Moving bed and Fluidized bed catalytic cracking, Catalytic reforming, Processes like Polyforming and hydroforming; Conversion of petroleum gases into motor fuels with special references to Alkylation, Polymerisation and Isomerisation; Chemical treatment: Sulphuric acid treatment, Sweetening treatment like Solutizer process, Doctor's treatment and Catalytic desulphurization; Solvent extraction: Selection of solvents, Eldeleanu process, Furfural processes; Characteristics of important products like gasoline, kerosene, diesel, jet fuels and lubricating oils.

Essential Reading:

1. W. L. Nelson, *Petroleum Refinery Engineering*.

Suggested Reading:

1. J. H. Gary, H. Hanwerk and M.J.Kaiser, *Petroleum Refining Technology and Economics*, CRC, 2007
2. R. J. Hengstebeck, *Petroleum Processing*.
3. B. Rao, *Petroleum Refinery Engineering*.

CH 331**PROCESS INSTRUMENTATION****3 credits [3-0-0]**

Basic principles: Elements of instruments, Static characteristics, Dynamic characteristics, Applications of Laplace transforms in instruments, Responses of first & second order instruments and capacitance; Temperature measuring instruments like Bimetallic, Vapour pressure, Thermocouples, Automatic Potential Recorders, Resistance thermometers, Radiation pyrometers, Optical Pyrometers, Photo-electric Pyrometers, Thermistors, Responses of these instruments; Composition measuring instruments: Spectroscopic methods, Thermal conductivity cells, Carbon dioxide analyser, Humidity measurement, Moisture in paper and lumber, pH meter, Oxygen analyser, polarograph, Refractometer, Chromatography, Colorimetry, Combustible gas analysers; Measurement of pressure and vacuum: Manometers, Pressure spring, McLeod gauge, Pirani Gauge, Ionization Gauge, Thermocouple Gauge, Responses of these instruments; Measurement of flow properties: Viscosity and specific gravity measurement, Level measuring devices, Flow measuring devices, measurement of displacement; Biosensors and its applications; Process instrumentation diagram, Circular chart, Strip chart recorders, Electric transmission, Pneumatic transmission with examples, Basic idea of automatic control and Instrumentation diagrams for equipments like distillation columns, evaporators, crystallisers, dryers and chemical reactors.

Essential Reading:

1. K. Krishnaswamy, *Industrial Instrumentation*, New Age Publishers, 2003

Suggested Readings:

1. A. Suryanarayana, *Outline of Chemical Instrumentation and Process Control*, Khanna Publisher, 1995, upcoming ed. 2008
2. J. Curtis, *Process Control Instrumentation Technology*, Prentice-Hall of India, 2005.
3. R. S. Sirohi, H. C. Radha Krishna, *Mechanical Measurements*, New Age Publishers, 1991.
4. N. A. Anderson, *Instrumentation for Process Measurement and Control*, CRC Press, 1997.
5. W. Dunn, *Fundamentals of Industrial instrumentation and control system*, McGraw-Hill Professional, 2005.

Pre-requisite: Knowledge in under graduate “Basic electronics & Mathematics”

CH 332**PROCESS EQUIPMENT DESIGN****4 credits [3-1-0]**

Detailed process design of the following equipments; Heat exchangers – concentric tube, shell and tube types, Condensers – condenser coolers and superheater condensers for single vapour only, Evaporators – single and multi effects, Absorbers – for binary systems without reactions, Distillation columns – for binary mixtures along with tray hydraulics, Rotary dryers; Multi-component Distillation Column Design.

Essential Reading:

1. D. Q. Kern, *Process Heat Transfer*.

Suggested Reading:

1. J. H. Perry, *Chemical Engineers Handbook*.
2. R. E. Treybal, *Mass Transfer Operations*.

CH 334**PROCESS DYNAMICS AND CONTROL****4 credits [3-1-0]**

Process modeling, Process variables and process degrees of freedom, writing block diagrams, Signal flow diagrams and their algebra, Process dynamics of simple equipment like heat exchanger, chemical reactors and their transfer function; Linear open loop systems: Analysis of first order systems in series and second order system with respect to liquid level, flow, thermal systems and simple chemical processes, Transportation lag; Linear closed loop system: Feedback control, Closed loop transfer functions, Transient response of simple control system, Cascade control, Ratio control, Feed forward and Adaptive control; Frequency response analysis: Introduction, Control system design. Stability of control systems: Ruth, Nyquist, Milkhalov, Bode and Root locus methods; Optimum controller settings: Ziegler Nicholas methods, Continuous cycling, Damped oscillation and Reaction curve method; Controller instruments: Self operated, Pneumatic, Hydraulic, Simple electronic controllers and their uses in level, temperature control, etc; Control valves: Various types of valves, sizing and characteristics of control valves. Basic idea on state equations and state variables and their use in process control. Digital computer control loops and control works, Application – Z transforms, transmitters, sensors. MIMO systems, Digital control.

Essential Readings:

1. G. Stephanopoulos, *Chemical Process Control—An Introduction to Theory & Practice*, Prentice-Hall India, 2002.
2. D.R. Coughanowr, *Process Systems Analysis and Control*, McGraw-Hill International, 1991, upcoming ed. Oct. 2008.

Suggested Readings:

1. B. B. Wayne, *Process Control: Modeling, Design, and Simulation*, Prentice-Hall India, 2006.
2. C. A. Smith, A. B. Corripio, *Principles and Practice of Automatic Process Control*, Wiley, 2005.
3. S. K. Singh, *Computer Aided Process Control*, Prentice-Hall India, 2004.
4. M. L. Luyben, W. L. Luyben, *Essentials of Process Control*, McGraw-Hill, 1996

CH 335**APPLIED STATISTICS FOR CHEMICAL ENGINEERS****3 credits [3-0-0]**

Introduction to probability, distributions, moments, statistical inference estimation, variance and regression analysis. Statistical Process Control and Reliability, error analysis, point estimation and confidence intervals, design of experiments, process monitoring based on statistical quality control techniques. Taguchi Approach, Case studies and use of Microsoft Excel.

Essential Readings:

1. R. M. Bethea, B. S. Duran, *Statistical Methods for Engineers and Scientists*, Marcel Dekker, New York, 3rd Edition, 1995.
2. Z. R. Ladic, *Design of Experiments in Chemical Engineering: A Practical Guide*, ISBN: 978-3-527-31142-2, Wiley Publisher, 2005.

Pre-requisite: Knowledge in under graduate “Mathematics”

CH 336**CHEMICAL ENGINEERING MATHEMATICS****4 credits [3-1-0]**

Treatment of engineering data: Numerical integration (Simpson, Trapezoidal and Gauss methods), Interpolation (Newton, Lagrange, Stirling), Empirical equations and least squares; Ordinary differential equations: Formulation of the physical problems for mass, energy, rate equations and flow systems. Solutions using analytical and numerical methods; Partial differential equations: Formulation of chemical engineering problems, Coordinate transformation, Solutions of partial differential equations using separation variable method and Fourier series and limited to two dimensional cases; Laplace transforms: Applications to Laplace transforms to simple chem. engg. problems.

Essential Reading:

1. H. S. Mickley, T. S. Sherwood, C. E. Reid, *Applied Mathematics in Chemical Engg.*

Suggested Reading:

1. V. G. Jenson and G. V. Jeffrey, *Mathematical Methods in Chemical Engg.*
2. S. Pushpavanam, *Mathematical Methods in Chemical Engineering*, Prentice Halls, 2004.

Pre-requisite: Knowledge in under graduate “Mathematics”**CH 337****EQUIPMENT DESIGN (MECHANICAL ASPECTS)****4 credits [3-1-0]**

Storage tank and pressure vessel: Design of storage tanks, pressure vessels and auxiliaries along with important accessories viz. joints, flanges, heads and nozzles; Supports: Guy wire and saddle supports, Design of bearing plate and anchor bolts; Piping: Various types of pipes and pipe fittings, Pipe supports and expansion joints, Design of pipe line; Materials of construction of process equipments; Introduction to various design codes.

Essential Reading:

1. S. Kenneth and J. N. Harb, *Introduction to Chemical Process: Fundamentals and Design*, Mc Graw and Hills, 2005.
2. B. C. Bhattacharya, *Introduction to Chemical Engineering Process Design*.

Suggested Reading:

1. B. E. Brownell & E M Young, *Process Equipment Design*.
2. M. V. Joshi, *Process Equipment Design*.
3. H. C. Hesse and J H Ruston, *Process Equipment Design*.
4. J. H. Perry, *Chemical Engineers Handbook*.
5. P. C. Sharma & D. K. Agarwal, *Machine Design*.
6. Relevant Indian Standard Codes.

Pre-requisite: Knowledge in under graduate “Mechanics”**CH 338****INDUSTRIAL INSTRUMENTATION AND PROCESS CONTROL****3 credits [3-0-0]**

Basic principles, Elements of instruments, Static characteristics, Dynamic characteristics, Errors, Laplace transforms, Responses of first & second order instruments and capacitance; Transducers, Temperature measuring instruments and there responses. Composition

measuring instruments, Measurement of pressure and vacuum: Instruments and their responses. Measurement of flow properties: Measurement of displacement; Measurement of Head and Level, Biosensors and its applications; Signal conditioning, Transmission, Display and recording devices. ; Fundamentals of automatic control, Time delay, Feedback control, Stability (Routh array & root locus), Frequency response analysis (Bode and Nyquist plots), Design of feedback controllers, Digital control.

Essential Reading:

1. A. K. Ghosh, *Introduction to Instrumentation and Control*, Prentice-Hall of India, 2005.
2. J. Curtis, *Process Control Instrumentation Technology*, Prentice-Hall of India, 2005

Suggested Readings:

1. K. Krishnaswamy, *Industrial Instrumentation*, New Age Publishers, 2003.
2. G. Stephanopoulos, *Chemical Process Control—An Introduction to Theory & Practice*, Prentice-Hall India, 2002.
3. N. A. Anderson, *Instrumentation for Process Measurement and Control*, CRC Press, 1997.
4. W. Dunn, *Fundamentals of Industrial instrumentation and control system*, McGraw-Hill Professional, 2005.

CH 370 COMPUTER AIDED DESIGN LABORATORY-I 2 credits [0-0-3]

1. Application of Gauss elimination Technique to solve coupled linear algebraic equations.
2. Application of Newton Raphson Technique to solve coupled non-linear algebraic equations.
3. Finding out the roots of an algebraic equation using “Interval-having”
4. Integration of ordinary differential equation using “Explicit Euler integration” algorithm.
5. Integration of ordinary differential equation using “Runga-kutta(forth-order)” algorithm.
6. Finding out the Eigen values of a matrix
7. Finding out the Rank of a matrix
8. Finding out the Inverse of a matrix
9. Bubble point calculation using “Interval-having” algorithm. Bubble point calculation using “Newton-Raphson” Technique.
10. Parameter estimation using least-square technique.

Note: The aforesaid problems have to be solved by writing codes in ‘C’ language.

CH 371 HEAT TRANSFER FUNDAMENTAL LABORATORY 2 credits [0-0-3]

1. To find out the thermal conductivity of liquids.
2. To find out the thermal conductivity of a metal rod.
3. Find out the Heat Transfer Coefficient during drop wise and film wise condensation.
4. Find out the Heat Transfer Coefficient in a vertical and a horizontal condenser.
5. To find out the emissivity of a surface.
6. To find out the overall thermal conductance and plot the temperature distribution in case of a composite wall.
7. To find out the average heat transfer co-efficient of vertical cylinder in natural convection.
8. To find out the Stefan Boltzman’s constant and compare with the theoretical value.
9. To find out the relation between insulation thickness and heat loss.

10. To find out the overall heat transfer co-efficient of a double pipe heat exchanger.
11. To find out the overall heat transfer co-efficient of 1-2 shell & tube heat exchanger.
12. Study and operation of a long tube evaporator.

CH 372 HEAT TRANSFER DESIGN LABORATORY 2 credits [0-0-3]

1. Design of heat exchangers
2. Shell and Tube
3. Plate type
4. Fin tube
5. Optimization of shell & tube heat exchanger using ASPEN PLUS
6. Optimization of double pipe heat exchanger using ASPEN PLUS
7. Design and optimization of condenser using ASPEN PLUS
8. Design of multiple effect evaporator system
9. Design of 1-2 shell & tube condenser
10. Design of jacketed vessel for unsteady state heating state heating of water
11. Design of stirred tank for unsteady state heating and cooling of water
12. Design of insulation
13. Study the effect of heat transfer augmentation on the heat transfer surface

CH 373 MASS TRANSFER FUNDAMENTAL LABORATORY 2 credits [0-0-3]

1. (a) Determination of diffusivity of acetone in air.
(b) Determination of mass transfer coefficient in an agitated vessel.
2. (a) Determination of mass transfer coefficient for steady state surface evaporation of water at different temperature.
(b) Determination of mass transfer coefficient in a wetted wall column.
3. Determination of T-x-y diagram for a binary batch distillation.
4. Verification of *Rayleigh equation* in a binary batch distillation process.
5. Verification of steam distillation equations.
6. Determination of ternary curve for the system acetic acid-water-carbontetrachloride.
7. Determination of distribution coefficient of a solute in two immiscible liquids.
8. Solid-Liquid extraction – Soxhlet's experiment.
9. Liquid - liquid extraction in packed bed.
10. Determination of adsorption kinetics and isotherm at solid-liquid interface.
11. Determination of the rate of drying in a tray dryer.
12. Estimation of efficiency of the fluidized bed dryer

CH 374 MASS TRANSFER DESIGN LABORATORY 2 credits [0-0-3]

Scope: The course includes process design and mechanical equipment design aspects of a few mass transfer equipments.

1. Design of mass transfer equipments
 - (i) Continuous contractors
 - (ii) Stage contractors for various mass transfer operations viz absorption, leaching and Liquid-Liquid extraction.
2. Design of equipments for combined heat and mass transfer operations viz. distillation, drying and humidification.
3. Acquaintance with software in the design of various mass transfer equipments.

CH 375**BIOTECHNOLOGY LABORATORY****2 credits [0-0-3]**

1. Different sterilization and inoculation techniques.
2. Preparation of various types of media.
3. Effect of pH, Substrate conc. on cell growth.
4. Effect of temperature on cell growth.
5. Determination of volumetric mass transfer co efficient (K_{la})
6. Determination of mixing time.
7. Determination of size and density of the microbial cells.
8. Determination of thermal death rate constant.
9. Preparation of immobilized whole cell system.
10. Substrate degradation, cell growth and product formation kinetics using free cells and whole cell immobilization.
11. Treatment of sample waste water in a bioreactor
12. Production of Acetic acid using fermentor.

CH 376**PROCESS INSTRUMENTATION LABORATORY****2 credits [0-0-3]**

1. (a) To study the operation of Flow well magnetic level switch to keep constant level in a tank.
(b) Operation & working of ROTOLARM.
2. (a) Study the principle, Calibration & measurement of P⁺¹ of unknown sample using digital p^H meter.
(b) Circular chart recorder.
3. Study the operation of a turbidity meter & to find out the turbidity of a unknown chalk powder from calibration plot.
4. Study the operation of conductivity meter, measuring specific conductance of solutions & determining the compositions of unknown solution from calibrated plot.
5. (a) Study the operation of potentiometric recorder.
(b) Study the operation of a temperature recorder, with strip chart.
6. To study the static & dynamic characteristics of bimetallic, vapor pressure, thermometer, optical pyrometer & radiation pyrometer.
7. Study of the characteristics of different thermocouples & RTD sensors.
8. Determination of transient response of a vapor pressure & bimetallic thermometer. (With & without cover).
9. (a) Determination of Dissolved oxygen using DO meter.
(b) Determination of gas-fraction in gas-liquid mixture using conducting probe.
10. Concentration analysis of hydrogen using gas-liquid chromatograph.
11. Concentration analysis using U-V-visible spectrophotometer & to study its principle of action.
12. Particle-size analysis using Malvern-Particle size analyzer & to study its principle of operation.
13. (a) Composition analysis using digital refractometer & to study the principle of operation.
(b) Determination of moisture content using IR-moisture balance.
14. (a) Determination of viscosity of slurry using Brook-field viscometer & to study its principle of operation.
(b) Measurement of Humidity using hair hygrometer & to study its principle.
15. Pressure measurement using different pressure gauges, U-tube manometer, pressure transducer and study their characteristics.

CH 377**FLUID DYNAMICS APPLICATION LABORATORY****2 credits [0-0-3]**

1. To determine the pressure drop in a packed bed by Leva's and Ergun's equation and verify experimentally.
2. To determine the minimum fluidization velocity in a fluidized bed and verify experimentally.
3. To determine the minimum fluidization velocity and pressure drop in a tapered fluidized bed.
4. Determination of discharge coefficient with Reynold's Number in case of an orifice meter and a venturi meter.
5. Determination of the minimum fluidization velocity and pressure drop in a square bed.
6. Study of D'e laval Centrifuge and to find out its efficiency using it as a Clarifier and Purifier.
7. Study and verification of the flow pattern in a Bernoulli's apparatus.
8. Determination of the mixing and segregation index of the given sample of bed materials in a fluidized bed.
9. Determination of the fluidization index of the given sample of bed materials in a fluidized bed.
10. Acquaintance of Fluent Soft Ware (Part-I)
11. Acquaintance of Gambit Soft Ware
12. Acquaintance of Fluent Soft Ware for the cylindrical tube.

CH 414**NANOTECHNOLOGY IN CATALYSIS****3 credits [3-0-0]**

Introduction to nanotechnology, definition, history. What makes the nanoscale so different from the other lengthscales by considering the underpinning science (i.e. nanoscience) and some key examples of nanotechnology. Methods of synthesis of nanomaterials fabrication-“Top-down” vs. “bottom-up” approaches. Equipment and processes needed to fabricate nanodevices and structures. Fundamental understanding of catalysis at nano-scale. Wet chemical synthesis, preparation and properties of iron, platinum, gold, cadmium, silver, copper and nickel nano-particles. Synthesis and properties of composite nano-particles and coated nano-particles. Characterization of nano particles by Scanning probe microscopes (Atomic Force Microscopy, Scanning Tunneling Microscopy), Transmission Electron Microscopy, Scanning Electron Microscopy.

Essential Reading:

1. S. K. Kulkarni, *Nanotechnology: Principles and Practices*, Capital Publishing Co. 2007.

Suggested Reading:

1. Tang, Zikang and Sheng, Ping, Taylor and Francis, *Nano science and technology: novel structures and phenomena*, 2003.
2. B. Rogers, S. Pennathur, J. Adams, Taylor and Francis, *Nanotechnology: Understanding small systems*, 2008.

CH 415**FLUIDIZATION ENGINEERING****3 credits [3-0-0]**

Introduction to fluidization, Types of fluidization; Gross behavior of fluidized beds: Minimum fluidization velocity, pressure drops in fluidized beds, Bed voidage, TDH, Viscosity and fluidity of beds, Bubble behavior, Bed expansion, Distributor design, Simple mathematical treatment;

Solid transport: Flow and fluidized solids, Solids transfer, Terminal velocity, Particle entrainment and elutriation, Simple calculations; Heat and mass transfer in fluidized beds : Heat transfer mechanism, Principles of gas-solid and bed surface transfer, Heat transfer to liquid fluidized systems, Generalised correlation for fluidized bed mass transfer and its limitations; Semifluidization: Principles, production of various bed parameters, Industrial applications; Design of fluidized bed reactors: Concept of RTD, Basic design principles for fluidized bed reactors.

Essential Reading:

1. D. Kunii and O. Levenspiel, *Fluidization Engineering*.

Suggested Reading:

1. M. Leva, *Fluidization*.
2. J S M Botterill, *Fluid bed heat transfer*.
3. *Current literature*.

Pre-requisite: Knowledge in under graduate “Fluid Dynamics”

CH 417 MODERN SEPARATION PROCESS IN CHEMICAL 3 credits [3-0-0]
ENGINEERING

An overview: Separation techniques, separation from liquids, separation from gasses and vapors, separation from solids and separation methods in bioprocessing: aqueous two-phase separation, Reverse micelle extraction; Membrane separations: Definition of a membrane and membrane process such as microfiltration, reverse osmosis, ultrafiltration, dialysis, electrodialysis, gas permeation, pervaporation Characterization of membrane such as colloidal morphology, permeability and permeselectivity. Membrane modules such as plate and frame device, spiral wound, tubular and hollow-fiber; Membrane technology in gas separation, biotechnology and in food and biochemical industry; Ion Exchange: Ion exchange mechanism, ion exchange media, equilibrium, equipment and design procedure and industrial applications; Adsorption as a separation process: Thermodynamics of adsorption: basic relationship, Representation, correlation and prediction of single component adsorption equilibrium data and extension to multi-component adsorption equilibrium calculation: Isotherm expression of gas adsorption; Adsorption with chemical reaction and adsorption with biological growth; Chromatography separation: Fundamentals of HPLC, Chromatographic column, Development of gradient-elution separations. Basic principles of capillary electro chromatography, mobile phase composition, Stationery phases used in CEC; Solid separation processes: Physical properties of solids, classification of powders, particle size distributions, particle density, bulk density and porosity, forces of adhesion. Separation of particulates and powders. Wet separation process: Protein recovery, Soya processing and other applications.

Essential Reading:

1. J. D. Seader, and E.J. Henley, *Separation process principles*, John Wiley & Sons Inc, 1998.

Suggested Reading:

1. Ruthern, M. Douglas, *Encyclopedia of separation technology*, Wiley-Interscience, 1st edition, 1997.
2. J.S. Weston, *Separation methods for waste and environment*, Marcel Dekker, 2000.
3. N. D. Richard, and T. Patricia, *Principle of Chemical separations with environmental applications*, 2004.

4. S. Ahija, *Handbook of Bioseparations*, Academic Press, 2000.
5. Hunter, J. Robert, *Foundation of Colloid Science*, Vol II 2000.

CH 418 RECENT SEPARATION TECHNOLOGY

3 credits [3-0-0]

Adsorption: Concepts and definitions; adsorbents and their preparation and properties; adsorption isotherms and their importance; adsorption types; equipments; adsorption in fixed bed; methods regenerations of adsorbents and basic mathematical modeling. **Chromatography separation:** Basic principal; different types of chromatographic separation techniques and their application. **Membrane separation technique:** membrane classification, chemistry, structure and characteristics and preparation; various membrane separations technology such as microfiltration, ultrafiltration, reverse osmosis, dialysis, electrodialysis, gas permeation, pervaporation, liquid membrane and their applications in chemical, biotechnology, food, and biochemical industry. **Reactive Distillation:** Concept, modeling and design aspects and applications. **Supercritical Fluid Extraction:** Concept, modeling and design aspects and applications. **Biofiltration:** Concept, modeling and design aspects and applications.

Essential Reading:

1. B. K. Dutta, *Principles of Mass Transfer and Separation Processes*, Prentice Hall of India Private Limited, 2007.
2. R. W. Baker, *Membrane Technology and Applications*, John Wiley & Sons Ltd, 2004.

Suggested Reading:

1. M. C. Porter, *Handbook of Industrial Membrane Technology*, Crest Publishing House, 2005.
2. M. Mukhopadhyay, *Natural extracts using supercritical carbon dioxide*, CRC Press, LLC, Boca Raton, Florida, USA, 2000.
3. R. G. Harrison, P. W. Todd, R. Scott, *Bioseparations Science and Engineering*, Oxford University Press.
4. J. E. Bailey and D.V. Ollis, *Biochemical Engineering Fundamentals*, Mc-Graw Hill, 1986
5. J. G. S. Marcano and T. T. Tsotsis, *Catalytic membranes and membrane reactor*, John Wiley, 2002.

CH 419 COMPUTATIONAL FLUID DYNAMICS

4 credits [3-1-0]

Introduction to CFD; Basic Concepts and Equations of Fluid Dynamics; Basic Concepts, Continuum model of a fluid, Kinematics, Steady and unsteady flow, Description of fluid motion by Lagrangian method, Eulerian method. Acceleration of a fluid particle, Forces acting on a fluid particle, Laws governing fluid motion, derivation of governing equation, continuity equation, Navier Stokes equation and its derivation, Energy equation, Chemical reacting flows. Equations of motion in conservation and vector forms. Non-dimensional form of equations, equations in orthogonal and curvilinear coordinates; Simplified forms of equations: Euler's equation, Velocity potential equation; Reynold's equation for turbulent flow: Averaging procedure, Mass weighted averaging, Reynold's form of continuity equation, Reynold's form of momentum equation, Reynold's form of energy equation, Boundary layer equations; Momentum integral equations, Vorticity transport equations, Conservative and body force fields; Turbulence Modeling Large Eddy Simulation; Governing equations, Models of turbulence, Large eddy simulation and detached eddy simulation; Mathematical behaviour of Governing equations in CFD; Mathematical preliminaries; Finite difference method, Finite volume method; Simulation of Incompressible Flow using Lattice-Boltzmann Method; Introduction; Lattice Gas method; Lattice-

Boltzmann Method; CFD for Process Equipment Application; Modeling of some physical phenomena encountered in CPI; Examples of application of CFD to CPI, Review of status of CFD for CPI applications.

Essential Reading:

1. C. A. J. Fletcher and C. A. Fletcher, *Computational Techniques for Fluid Dynamics – I*, Springer, 2nd edition, 1996.

Suggested Reading:

1. R. Lohner, *Applied computational fluid dynamic Technique*, John Wiley & Sons, 2001
2. D. A. Handerson, *Computational Fluid Mechanics and Heat Transfer*.
3. T. K. Bose, *Numerical Fluid Dynamics*.

Pre-requisite: Knowledge in under graduate “Fluid dynamics”

Pre-requisite: Knowledge in under graduate “Basic chemistry”

CH 421 REACTION KINETICS AND CATALYSIS 4 credits [3-1-0]

Homogeneous Reactions: Classifications of reactions, definition of reaction rate, variables affecting the rate, order of reaction and its determination, theoretical study of reaction rates-The Arrhenious relationship, Collision theory and activated complex theory, molecularity; interpretation of kinetic data for batch and flow systems, integral and differential methods of analysis; design of batch, semi-batch and flow (Tubular & Tank) reactors for single ideal reactions, reactions in series and parallel and mixed reactions under isothermal operations; design of adiabatic and non-isothermal reactors; introduction to enzyme kinetics. Heterogeneous reactions: examples; classification of catalysts, general procedure for manufacture of catalysts, catalytic promoters and poisons, reactions catalyzed by solid catalysts; engineering properties of catalysts and their determination, general mechanism of catalytic reactions, adsorption isotherms; transport processes in reactions catalyzed by solids; design of heterogeneous catalytic reactors.

Essential Reading:

1. O. Levenspiel, *Chemical Reaction Engineering*, John Wiley & Sons, 1999.
2. H. S. Fogler, *Elements of Chemical Reaction Engineering*, Prentice Hall of India Private Limited, 1999

Suggested Reading:

1. G. F. Froment and K. B. Bischoff, *Chemical Reactor Analysis and Design*, John Wiley, 2001.
2. J M Smith, *Chemical Engineering Kinetics*, Mcgraw & Hills, 1981.

CH 422 SIMULATION, MODELLING AND OPTIMISATION 4 credits [3-1-0]
OF CHEMICAL PROCESS

Simulation: Techniques of digital simulation – Information flow, from process to information flow diagram, From information flow diagram to numerical form, Recycles, Calculation of a recycle set, etc; Digital simulation of C.S.T.R.s in series, non-isothermal C.S.T.R, Binary distillation column, Batch reactor, Computer aided design ; Modeling: Fundamentals of mathematical

models and formulation – Continuity equation, Equation of motion, Transport equations, Energy equation, Equations of state, Equilibrium, Chemical kinetics and their applications; Lumped and distributed parameter models – Fluid systems, C.S.T.R. (single, series, isothermal, constant hold up, variable hold up, gas phase pressurized and non-isothermal), Single component vaporizer, Multi-component flash drum, Batch reactor, Reactor with mass transfer, Ideal binary distillation column, Batch distillation, Heat exchanger, etc; Optimization: Single variable optimization (analytical, dichotomous search, fibonacci, golden section, regula falsi), Multivariable optimization (analytical, geometric programming, linear programming), Convergence methods (Newton's methods, direct substitution, Wegstein's method).

Essential Reading:

1. W. L. Luyben, *Process Modelling, Simulation and Control for Chemical Engineers*, McGraw Hill, 1990.

Suggested Readings:

1. B. V. Babu, *Process Plant Simulation*, Oxford University Press, 2004.
2. S. S. Rao, *Engineering Optimization: Theory and practice*, New Age Publishers, 1999.
3. A. Hussain and K. Gangaiah, *Optimisation Techniques for Chemical Engineers*, Macmillan, 2001.
4. B. W. Bequette, *Process Control: Modeling, Design and Simulation*. Prentice-Hall India, 2006.

CH 425 ENVIRONMENTAL ENGINEERING

3 credits [3-0-0]

Importance of environment for mankind, Damages due to environmental pollution; Air pollution: Introduction, Composition of air and nature of air pollution, Classification of pollutants and their nature, Sources of air pollutants and their effects; Meteorological factors influencing air pollution, Methods of estimation of various types of pollutants in air, Air pollution problem in few typical chemical industries, Approaches to air pollution control, Control equipment for particulate emissions and gaseous pollutants, Pollution from mobile sources, Air quality criteria and standards; Water pollution: Waste water treatment – evaluation, classification of wastes, Control of water pollution, Characterisation of waste waters; Methods and equipment – preliminary treatment and disposal, Treatment of industrial wastes from a few typical chemical industries, Standards.

Essential Reading:

1. M. L. Davis and D. A. Cornwell, *Introduction to Environmental Engineering*, Tata McGraw & Hills, 2007

Suggested Reading:

1. L. K. Wang, *Air pollution control Engineering*, Humana Press Inc., U.S.; 2Rev Ed edition, 2004
2. R. Weiner and R. Matthews, *Environmental Engineering*, Butterworth-Heinemann, 2003.

CH 426 COAL PROCESSING TECHNOLOGY

3 credits [3-0-0]

Role of coal in the overall energy situation; Recent advances in coal preparation methods including fine coal treatment; Simulation and modeling of coal beneficiation circuits ; Thermodynamics and kinetics of coal gasification reactions; Fluidized bed coal gasification processes; Combined cycle power generation; Coal liquefaction: Various methods, kinetics of solvent extraction, catalytic hydrogenation and other liquefaction processes; Concept of coal

refinery and coalplex; Environmental impact analysis of coal utilization methods such as carbonization, gasification, etc.

Essential Reading:

1. H.L. Lowary, *Chemistry of Coal Utilization, Vol. I & Vol. II.*

Suggested Reading:

1. Mangold, *Liquefaction and Gasefication of Coal.*
2. Wilson and Wales, *Coal, Coke and Coal Chemicals.*

CH 427 COLLOID AND INTERFACIAL ENGINEERING 3 credits [3-0-0]

General introduction of colloids, interfaces, surfactants, and micellization.; Intermolecular forces, Van der Waals forces (Keesom, Debye, and London interactions), Colloidal systems and colloidal stability (van der Waals attraction and potential energy curves), Brownian motion and Brownian flocculation. Surface and interfacial tension and surface free energy, Surface tension for curved interfaces, Surface excess and Gibbs equation. Theory of surface tension and contact angle, and wetting. Thermodynamics of interfaces, thermodynamics of micelle and mixed micellar formation. Electrical phenomena at interfaces (Electrokinetic phenomena, Electrical double layer). Emulsion and micro-emulsion.; Application: General applications, Enhanced petroleum recovery, super hydrophobic and self cleaning surfaces, novel fabrication of nanostructured particles. Measurement techniques of surface tension, Contact angle, Zetapotential, Particle size.

Essential Reading:

1. P.C. Hiemenz, and R. Rajagopalan, *Principle of colloid and surface chemistry*, 3rd edition, Merce Dekher, N.Y. 1997.
2. D. J. Shaw, *Colloid & Surface Chemistry*, Butterworth Heinemann, Oxford, 1992.

Suggested Reading:

1. M. J. Rosen, *Surfactants and Interfacial Phenomena*, Wiley-Interscience Publication, New York, 2004.
2. Adamson, A. W. Gast, *A. P. Physical Chemistry of Surfaces*, Wiley-Interscience, New York, 1997.
3. J. Israelachvili, *Intermolecular and Surface Forces*, Academic Press, New York, 1992.

Pre-requisite: Knowledge in under graduate “Basic chemistry”

CH 428 DISASTER MANAGEMENT IN CHEMICAL INDUSTRIES 3 credits [3-0-0]

General aspects of industrial disaster: Due to fire, explosion, toxicity and radiation; Chemical hazards: Classification of chemical hazards, Chemical as cause of occupational diseases – dust, fumes, gases and vapours; Hazard analysis and health management; Engineering control of chemical plant hazards – Plant layout, ventilation and lighting, Pressure vessels, Storage, Handling, Transportation, Electrical systems, Instrumentation; Emergency planning, Personal protective devices, Maintenance procedure; Emergency safety and laboratory safety; Legal aspects of safety, Management information system and its application in monitoring disaster, safety and health; Hazop Analysis.

Essential Reading:

1. H. H. Tawcatt & W S Wood, *Safety and Accident Prevention in Chemical Operations*.

Suggested Reading:

2. R. V. Betrabet and T. P. S. Rajan in CHEMTECH-I, *Safety in Chemical Industry*, Chemical Engineering Development Centre, Madras, 1975.
3. Wells, *Safety in Process Plant Design*.
4. Less, P. Frank, *Loss Prevention in Process Industries*.
5. J. Lolb & S. Roy Sterm, *Product Safety and Liability*.

CH 432 OPTIMIZATION TECHNIQUES IN PROCESS DESIGN

3 credits [3-0-0]

Optimal problem formulation, Single variable optimization algorithms including interval halving; golden section search; Newton-Raphson method; bisection method; root finding using optimization techniques, Multi variable optimization algorithms including simplex search method; Cauchy's steepest descent method; Levenberg Marquardt's method, constrained optimization algorithms including Khun-Tucker conditions, transformation methods; direct search methods; liberalized search techniques; feasible direction method, Specialized algorithms including Integer programming; geometric programming. Nontraditional optimization technique like simulated annealing. Application of the aforesaid techniques in Chemical Engineering designs, like optimum insulation thickness, shell and tube heat exchanger design. ; **Scope & Objective:** Optimization has become a part of computer aided design activities where the goal is not only to achieve a feasible design but also a design objective. The course provides basic knowledge of deterministic algorithms as well as algorithms which are stochastic in nature with probabilistic transition rules, new methods in computational intelligence or 'soft computing' inspired by evolutionary processes in nature, such as genetic algorithms. The course consists of lectures and a project component, which includes both model building and programming. This course also provides an opportunity to get conversant with optimization toolbox of MATLAB by the Mathworks, Inc.

Essential Readings:

1. T. F. Edgar, D. M. Himmelblau, *Optimization of Chemical Processes*, Mcgraw-Hill College Division, 1987.

Suggested Readings:

1. B. V. Babu, *Process Plant Simulation*, OUP, India, 2004.
2. S. S. Rao, *Engineering Optimization Theory & Practice*, John Wiley & Sons Inc, 1996.

CH 434 PROJECT ENGINEERING

3 credits [3-0-0]

Introduction to the subject; **Development and implementation of the project in the following steps:** Initial conception; Preliminary design ideas and rough evaluation of market and economics; Procuring data for final design; Final economic evaluation and decision set up the project; Detailed design; Procurement; Construction work; Start up and trial runs; Commercial production; Safety consideration; **Process Design;** Selection of process cycle; Chemical process considerations; Qualitative block type process flow sheet; Material balance and energy balance; Selection of process equipment and its computer aided design using Fortran language to various engineering problems; Plant layout: Planning layout and methods of layout planning; **Economic evaluation of the project;** Capital Cost; Plant cost estimating; **Total product cost:** Manufacturing cost; Raw material cost; Miscellaneous cost (labour cost, repair cost and

maintenance cost); Depreciation; Economic Analysis: Net earning profitability analysis; Introduction to optimization.

Essential Reading:

1. Peters – Timmerham (International Editions), *Plant Design and Economics for Chemical Engineers*, McGraw Hill Book Co.

Suggested Reading:

2. F. C. Viberandt and C. E. Dryden (International Students Editions), *Chemical Engineering Plant Design*, McGraw Hill Book Co.
3. B. S. Golfried, *Theory and Problems of Programming with Fortran: Schaum's Outline Series*, Tata McGraw Hill.

CH 439 NON-TRADITIONAL AND TRADITIONAL 3 credits [3-0-0]
OPTIMIZATION TECHNIQUES

Optimal problem formulation, Single variable optimization algorithms, Multi variable optimization algorithms including simplex search method; Cauchy's steepest descent method; Levenberg Marquardt's method, constrained optimization algorithms including Khun-Tucker conditions, transformation methods; direct search methods; liberalized search techniques; feasible direction method, Specialized algorithms including Integer programming; geometric programming. Nontraditional optimization techniques including simulated annealing, genetic algorithms (GA), introduction to multi objective optimization problems. Application of all the aforesaid techniques with the help of the frequently used benchmark functions for engineering design. ; Scope & Objective: ; Optimization has become a part of computer aided design activities where the goal is not only to achieve a feasible design but also a design objective. The course provides basic knowledge of deterministic algorithms as well as algorithms which are stochastic in nature with probabilistic transition rules, new methods in computational intelligence or 'soft computing' inspired by evolutionary processes in nature, such as genetic algorithms. The course consists of lectures and a project component, which includes both model building and programming. This course also provides an opportunity to get conversant with optimization toolbox of MATLAB by the Mathworks, Inc.

Essential Reading:

1. S. S. Rao, *Engineering Optimization Theory & Practice*, John Wiley & Sons Inc, 1996.

Suggested Reading:

1. K. Deb, *Multi-Objective Optimization Using Evolutionary Algorithms*, John Wiley Sons, 2001.
2. B.V. Babu, *Process Plant Simulation*, OUP, India, 2004.
3. T. F. Edgar, D. M. Himmelblau, *Optimization of Chemical Processes*, Mcgraw-Hill College Division, 1987.

CH 470 PROCESS SIMULATION LABORATORY 2 credits [0-0-3]

1. Steady state simulation of Heat Exchanger using ASPEN PLUS/ HYSYS
2. Steady state simulation of a CSTR using ASPEN PLUS/ HYSYS
3. Steady state simulation of Flash vessel using ASPEN PLUS/ HYSYS

4. Steady state simulation of Distillation Column using ASPEN PLUS/ HYSYS
5. Steady state simulation of an Absorption column using ASPEN PLUS/ HYSYS
6. Dynamic simulation of Heat Exchanger using ASPEN PLUS/ HYSYS
7. Dynamic simulation of a CSTR using ASPEN PLUS/ HYSYS
8. Dynamic simulation of Flash vessel using ASPEN PLUS/ HYSYS
9. Dynamic simulation of Distillation Column using ASPEN PLUS/ HYSYS
10. Dynamic simulation of an Absorption column using ASPEN PLUS/ HYSYS

CH 471 CHEMICAL REACTION ENGINEERING 2 credits [0-0-3]
LABORATORY

1. Study and operation of a packed bed reactor
2. Study and operation of a batch reactor
3. Study and operation of a CSTR
4. Study and operation of a plug flow reactor
5. Study and operation of a cascade CSTR
6. Study and operation of an adiabatic batch reactor
7. Study and operation Trickle bed reactor
8. Study and operation Condensation polymerization reactor
9. Study and operation Emulsion polymerization reactor
10. RTD study in a CSTR
11. RTD study in a plug flow reactor
12. Study and operation of a coiled tubular reactor

CH 473 COMPUTER AIDED DESIGN LABORATORY-II 2 credits [0-0-3]

1. Finding out matrix addition, multiplication, inversion, rank, Eigen values using MATLAB simulator.
2. Plotting set of data using MATLAB
3. Parameter estimation using least-square technique using MATLAB
4. Writing 'm' files in MATLAB platform to solve coupled linear algebraic equations using Gauss elimination method.
5. Writing 'm' files in MATLAB platform to solve non-linear algebraic equations using Newton Raphson Technique.
6. Writing 'm' files in MATLAB platform to control level in a tank using P/PI/PID controller.
7. Finding out response of a first and second order system (transfer function) using 'simulink'
8. Simulation of a stirred tank reactor (both open loop and closed loop) using 'simulink'.
9. Simulation of steady Flow of air through a cylindrical tube using GAMBIT and FLUENT.
10. Simulation of steady state fluid flow and heat transfer processes using GAMBIT and FLUENT when liquid water flows through a cylindrical tube.
11. Simulation of steady Flow of air through a 'T' joint using GAMBIT and FLUENT.

CH 475 PROCESS DYNAMICS & CONTROL LABORATORY 2 credits [0-0-3]

1. Transient response to single tank system with storage & Flow to (a) step change (b) impulse change in put.
2. Transient response of non interacting system in series.
3. Transient response of interacting system in series.

4. Study the operation of ON-OFF electronic temperature controller & determination of its performance to control the temperature of a system having capacity to store thermal energy.
5. Study the principle of operation & working of pneumatic servo system with various input functions.
6. Transient response of a CSTR System to step change.
7. Controlling a batch reactor using digital PID controller.
8. Study the dynamics of parallel & counter flow shell & tube heat exchanger.
9. Controlling of Parallel Flow & counter flow STHE using digital PI controller to have desired output.
10. Dynamics characteristics of mercury & water manometers.
11. Study of control valve characteristics.
12. Study the performance of cascade control system & to maintain desired level in a tank, with flow.
13. Study the dynamics of bubble cap distillation column.
14. Control of a bubble cap distillation column using digital PID controller.
15. Study of effect of PID controller on pressure process trainer.