GIET UNIVERSITY, GUNUPUR, ODISHA
CHEMICAL ENGINEERING DEPARTMENT
SCHOOL OF ENGINEERING AND TECHNOLOGY
Incorporated by Act 23 of Govt. of Odisha and under approval of UGC & AICTE
Accredited by NAAC with a CGPA of 3.28/4 at *A Grade*
Five UG Programs CSE, ME, CHE, AEIE & EEE Accredited by NBA
Gunupur - 765022 , Dist.- Rayagada, Odisha, INDIA
www.giet.edu

SUBJECT STRUCTURE

For

POST GRADUATE DEGREE COURSES

IN

CHEMICAL ENGINEERING

2019-20

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

PEO 1: Acquire the fundamental principles of science and chemical engineering with modern experimental and computational skills.

PEO 2: Face current technical challenges in the society by maintaining a professional and ethical attitude towards the society and also considering impacts on safety, health and environment.

PEO 3: Excel their career as Chemical Engineers or researchers in both traditional and emerging fields of Chemical Engineering such as environmental, material, food, pharmaceutical and energy applications.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO1: To correlate theoretical concepts with real time experimental and field data through application of process simulation and analytical techniques.

PSO2: To develop cutting edge chemical processes, equipment and products for the benefit of the human kind using innovative research and development skills and continuous learning efforts.

PROGRAMME OUTCOMES (POs)

PO-1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.

PO-2. Problem Analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO-3. Design / Development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO- 4. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO- 5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO- 6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO- 7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO- 8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO- 9. Individual and team work: Function effectively as an individual and as a member or leader in diverse teams, and in multidisciplinary settings.

PO-10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO-11. Project management and finance: Demonstrate knowledge and understanding of the engineering management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO-12. Life-long learning: Recognize the need for and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change.

SEMESTER WISE COURSE STRUCTURE

M.TECH (CHEMICAL ENGINEERING)

I SEMESTER [FIRST YEAR]

Sl. No.	Course Category	Course Code	Course Title	L	T	P	Credits
THEORY							
1	PC		Applied Mathematics for Chemical Engineering	3	0	0	3
2	PC		Advanced Mass transfer	3	0	0	3
3	PC		Advance Heat Transfer	2	0	0	2
4	PE		Chemical Process Design Enhanced Oil Recovery Catalytic Reaction Engineering Process Modelling and Simulation	3	0	0	3
5	PE		Solvent Extraction Safety and Hazard Control Multicomponent distillation Safety in Chemical industries	3	0	0	3
6	AUDIT		Audit Coarse	2	0	0	0
PRACTICAL / SESSIONAL							
7	PC		Laboratory-I (Instrumental method of analysis Laboratory)	0	0	4	2
8	AUDIT		Laboratory-II (Advanced Chemical Engineering Laboratory)	0	0	4	2
TOTAL				**16**	**0**	**8**	**18**

II SEMESTER [FIRST YEAR]

Sl. No.	Course Category	Course Code	Course Title	L	T	P	Credits
THEORY							
1	PC		Advanced Transport Phenomena.	3	0	0	3
2	PC		Advanced Reaction Engineering and Reactor Design	3	0	0	3
3	PE		Advanced Thermodynamics	3	0	0	3
			Membrane Technologies for Water and Wastewater Treatment				
			Industrial Pollution Prevention				
			Fuel Cell Technology				
4	PE		Advance Process control	3	0	0	3
			Polymer Technology				
			Industrial Instrumentation				
			Waste Water Engineering				
5	AUDIT		Audit Coarse	2	0	0	0
PRACTICAL / SESSIONAL							
6	ES		Chemical Process Simulation laboratory	0	0	8	4
7	PC		Mini-Project with Seminar	2	0	4	2
TOTAL				**16**	**0**	**12**	**18**

III SEMESTER [SECOND YEAR]

Sl. No.	Course Category	Course Code	Course Title	L	T	P	Credits
THEORY							
1	OE		Operations Research	3	0	0	3
			Total Quality Management				
			Intellectual Property Rights				
			Green Technology & Engineering				
			Research Methodology				
2	PE		Nano Science and Technology	3	0	0	3
			Resource Recovery From Waste				
			Advanced Fluidization Engineering				
			Advanced Separation Processes				
PRACTICAL / SESSIONAL							
3	PC		Dissertation Phase-I	0	0	20	10
TOTAL				**6**	**0**	**20**	**16**

IV SEMESTER [SECOND YEAR]

Sl. No.	Course Category	Course Code	Course Title	L	T	P	Credits
PRACTICAL / SESSIONAL							
1	PC		Dissertation Phase-II	0	0	32	16
TOTAL				**0**	**0**	**32**	**16**

Total Credits for the programme = 18 + 18 +16 +16 = 68

Audit course 1 & 2

1. English for Research Paper Writing
2. Disaster Management
3. Sanskrit for Technical Knowledge
4. Value Education
5. Constitution of India
6. Pedagogy Studies
7. Stress Management by Yoga
8. Personality Development through Life Enlightenment Skills.

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I SEMESTER

SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	APPLIED MATHEMATICS FOR CHEMICAL ENGINEERING	3	0	0	3	A

Course Educational Objectives

CEO1	
CEO2	
CEO3	
CEO4	

Course Outcomes: ***Upon successful completion of this course, students should be able to:***

CO1	
CO2	
CO3	
CO4	

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1														
CO2														
CO3														
CO4														

SYLLABUS

UNIT I: ALGEBRAIC EQUATIONS

Systems of linear equations – Jacabi, Gauss Seidel, Successive over Relaxation methods, Thomas algorithm for tridiagonal systems; Systems of non-linear equations – Sucessive approximation method, methods for improved convergence convergence, Muller method, Chebyshev third order method, Newton method and its variants, Continuation methods for multiple solutions

UNIT II : ORDINARY DIFFERENTIAL EQUATIONS

RungeKutta methods, stip size control and estimates of error, stability of the steady state of a linear system, solution of stiff ODEs, ODE-IVPs coupled with algebraic equations.

UNIT III: ORDINARY DIFFERENTIAL EQUATIONS

Finite difference method, orthogonal collocation method, orthogonal collocation with finite element method, Galerkin finite element method, stability analysis, shooting methods.

UNIT IV : PARTIAL DIFFERENTIAL EQUATIONS – FINITE DIFFERENCE METHOD

Parabolic equations – Explicit and implicit methods – Alternating direction explicit and implicit methods; Chemical reaction and diffusion in a spherical catalyst pellet – Elliptic equations – Point iterative methods – Finite difference solution of a Poisson BVP – First order hyperbolic equations – methods of characteristics – explicit and implicit methods – numerical stability analysis, method of lines.

Partial differential equations – Finite element method – Orthogonal collocation method, Orthogonal collocation with finite element metho, Galerkin finite element method – Function approximation.

Teaching Methods: Chalk& Board

Ref. Books

1.Numerical methods for Chemical Engineering by Kenneth J. Beers, Cambridge University Press, New York, 2007.
2. Gupta S.K.Numerical methods for Engineers, New age publishers 2003.
3. M.K.Jain. S.R.K.Iyengar, R.K.Jain Numerical methods: Problems and solutions, Wiley Eastern Limited, 2008

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SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	ADVANCED MASS TRANSFER	3	0	0	3	A

Course Educational Objectives

CEO1	
CEO2	
CEO3	
CEO4	

Course Outcomes: ***Upon successful completion of this course, students should be able to:***

CO1	
CO2	
CO3	
CO4	

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1														
CO2														
CO3														
CO4														

SYLLABUS

UNIT I:
Characteristic of Equilibrium stage and Flash calculations, Study of different types of equilibrium cascade configurations and its degrees of freedom analysis, Algebraic method to determine the number of equilibrium stages, Calculation of stage efficiency, tray diameter, pressure drop and mass transfer, Rate based method to design a packed column, Scale up of a column from laboratory data,

UNIT II:
Estimation of distillation column efficiency using performance data and to develop its empirical correlation, Scale up of distillation column, Rate based method for packed distillation column, Approximate methods for Multicomponent, multistage separations, Use of residue curve for the conceptual design of distillation columns, Pressure swing and azeotropic distillation, Rate based models for distillation.

UNIT III:
Modeling of batch distillation, Modeling and simulation of absorption and leaching processes.

UNIT IV:
Diffusion in non-ideal system and development of generalized Maxwell-Stefan formulation, Study of Generalized Fick's law, Estimation of binary and multicomponent Diffusion Coefficients, Study of interphase mass along with energy transfer.

TEXT BOOKS

1. J. D Seader, E. J. Henly, *Separation Processes and principles*, John Willey , 2nd edition, 2006
2. Ross Taylor and R. Krishna, *Multicomponent Mass Transfer*, John Wiley, New York , 1993

REFERENCES

1. J. Bendaitez, *Principles and Modern Applications of Mass Transfer Operations*, Willey , 2002
2. Nakajima H., *Mass Transfer: Advanced Aspects*, Intech , 2014

SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	ADVANCED HEAT TRANSFER	3	0	0	3	A

Course Educational Objectives

CEO1	
CEO2	
CEO3	
CEO4	

Course Outcomes: ***Upon successful completion of this course, students should be able to:***

CO1	
CO2	
CO3	
CO4	

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES											PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1														
CO2														
CO3														
CO4														

SYLLABUS

UNIT I:
Derivation of energy equation for conduction in three dimensions. Transient conduction- Concept of Biot number – Lumped capacitance formulation unsteady conduction from a semi-infinite solid solution by similarity transformation method. Solution of the general 1D unsteady problem by separation of variables, Laplace equation – solution by variable separable method – concept of superposition and homogeneous boundary conditions.

UNIT II:
Numerical solution of conduction problems-Basic ideas of finite difference method –forward, backward and central differences – Discretization for the unsteady heat equation.

UNIT III:
Derivation of governing equation for convection. 2D laminar coquette flow and non-dimensional numbers. Concept of Adiabatic wall temperature. Integral methods for momentum and thermal boundary layers. Pipe flow – concept of developed temperature profile and solutions for constant wall flux and constant wall temperature boundary conditions. Solution of entry length problem for constant wall and constant wall flux boundary conditions. Natural convection – governing equation, integral solution for flat surface.

UNIT IV:
Derivation of black body radiation laws from first principles Need for view factors, concept of view factors, mathematical definition. Shape factor calculations. Radiosity, Irradiation method for gray diffuse enclosures. Gas Radiation.

TEXT BOOKS

1. J.P. Holman, Heat Transfer, McGraw-Hill Science/Engineering/Math , 2001
2. C.P. Gupta and R. Prakash, Engineering Heat Transfer, Nem Chand & Bros., Roorkee , 6th Edn, 1994

REFERENCES

1. S.K. Das and A.R. Balakrishan, Process Heat Transfer, Alpha Science International Ltd. , 2005
2. Frank P. Incropera and David P. DeWitt, Fundamentals of Heat and Mass Transfer, Wiley , 1996

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SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	CHEMICAL PROCESS DESIGN	3	0	0	3	A

Course Educational Objectives

CEO1	
CEO2	
CEO3	
CEO4	

Course Outcomes: ***Upon successful completion of this course, students should be able to:***

CO1	
CO2	
CO3	
CO4	

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES											PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1														
CO2														
CO3														
CO4														

SYLLABUS

UNIT I: INTRODUCTION
The Hierarchy of Chemical process Design- Overall process Design, approaches to design. SYNTHESIS OF REACTION – SEPARATION SYSTEMS :Process recycle, Batch processes, Reaction path, reactor performance,

UNIT II: DISTILLATION SEQUENCING
Using simple columns, using columns with more than two products, homogeneous fluid mixtures, Separation of Heterogeneous mixtures, Thermally coupled columns.

UNIT III : HEAT EXCHANGER NETWORK & UTILITIES – ENERGY TARGETS
Heat recovery pinch, The Problem table Algorithm, Utilities Selection, Energy targets capital & total Cost targets.

UNIT IV HEAT EXCHANGER NETWORK & UTILITIES – CAPITAL AND TOTAL COST TARGETS
Number of Heat Exchanger Units, Area Targets, Number of Shells Targets, Capital Cost Targets, Total Cost Targets.

Teaching Methods: Chalk& Board

REFERENCES
1. Smith, R., “Chemical Process Design”, McGraw Hill, New York, 2005.
2. Douglas, J.M., “Conceptual Design of Chemical Process”, McGraw Hill, New York, 1988.

SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	ENHANCED OIL RECOVERY	3	0	0	3	A

Course Educational Objectives

CEO1	
CEO2	
CEO3	
CEO4	

Course Outcomes: ***Upon successful completion of this course, students should be able to:***

CO1	
CO2	
CO3	
CO4	

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1														
CO2														
CO3														
CO4														

SYLLABUS

UNIT I: FUNDAMENTALS OF ENHANCED OIL RECOVERY

Pore Geometry, Microscopic aspects of displacement. Residual oil magnitude and mobilization. Buoyancy forces and prevention of trapping, Wettability, Residual oil and Oil recovery. Macroscopic aspect of displacement

UNIT II: ENHANCED OIL RECOVERY OPERATIONS

Flooding – miscible, CO2, polymer, alkaline, surfactants, steam;

UNIT III: ENHANCED OIL RECOVERY OPERATIONS-

Gas injection, in-situ combustion technology, microbial method.

UNIT IV: PROBLEMS IN ENHANCED OIL RECOVERY

Precipitation and deposition of Asphaltenes and Paraffins, Scaling problems, Formation of damage due to migration of fines, Environmental factors.

Teaching Methods: Chalk& Board

REFERENCES

1. Donaldson, E.C. and G. V. Chilingarian, T. F. Yen, "Enhanced oil Recovery – I & II", Fundamentals and Analysis, Elsevier Science Publishers, New York, 1985.
2. Lake, L.W., "Enhanced oil recovery", Prentice Hall, 1989.
3. Schumacher, M.M., "Enhanced oil recovery: Secondary and tertiary methods", Noyes Data Corp., 1978.
4. Van Poollen, H.K. "Fundamentals of enhanced oil recovery", PennWell Books, 1980.

SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	CATALYTIC REACTION ENGINEERING	3	0	0	3	A

Course Educational Objectives

CEO1	
CEO2	
CEO3	
CEO4	

Course Outcomes: ***Upon successful completion of this course, students should be able to:***

CO1	
CO2	
CO3	
CO4	

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1														
CO2														
CO3														
CO4														

SYLLABUS

UNIT I: CATALYST AND ITS CHARACTERIZATION

General definition of catalysts, illustration of a catalytic a process, Design for catalysts – Primary constitutents, secondary constituents; Catalyst supports. Methods of determining catalysts activity – static methods, flow (dynamic) method; Study of structure – adsorption for determining catalsyst surface and pore radii; Mercury porosimetry, determination of true and apparent densities of catalysts; Structural study of electron microscopy, determination of mechanical strength of catalysts-static methods, dynamic methods; Methods of thermal analysis.

UNIT II: KINETICS OF HETEROGENEOUS CATALYTIC REACTIONS.

Adsorption on Solid Catalysts. Rate Equations. Complex Catalytic Reactions. Experimental Reactors. Model Discrimination and Parameter Estimation. Sequential Design of Experiments. Physicochemical tests

UNIT III: TRANSPORT PROCESSES WITH REACTIONS CATALYZED BY SOLIDS.

Reaction of a component of a fluid at the surface of a solid. Mass and heat transfer resistances. Concentration or partial pressure and temperature differences. Molecular-, Knudsen-, and surface diffusion in pores. Diffusion in a catalyst particle. Diffusion and reaction in a catalyst particle. A continuum model. Falsification of rate coefficient andactivation energy by diffusion limitations. Influence of diffusion limitations on the selectivities of coupled reactions. Criteria for the importance of intraparticle diffusion limitations. Multiplicity of steady states in catalyst particles. Combination of external and internal diffusion limitations. Diagnostic experimental criteria for the absence of internal and external mass transfer limitations. Nonisothermal particles.

UNIT IV :CATALYST DEACTIVATION 5

Types of Catalyst Deactivation. Kinetics of Catalyst Poisoning. Kinetics of Catalyst Deactivation by Coke Formation

TEXT BOOKS

1. Chemical Reactor Analysis and Design, Gilbert F. Froment and Kenneth B. Bischoff, John Wiley & Sons, 2nd Edition, 1990.
2. Elements of Chemical Reaction Engineering, H. Scott Fogler, Prentice Hall
International Series, 3rd Edition, 2000.

Ref. Books

1. Chemical Reaction Engineering, Octave Levenspiel, John Wiley & Sons, 3rd Edition, 1999.
2. Fundamentals of Chemical Reaction Engineering, Mark E. Davis and Robert J.Davis, McGrawHill, 2003

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SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	PROCESS MODELING AND SIMULATION	3	0	0	3	A

Course Educational Objectives

CEO1	
CEO2	
CEO3	
CEO4	

Course Outcomes: ***Upon successful completion of this course, students should be able to:***

CO1	
CO2	
CO3	
CO4	

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES											PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1														
CO2														
CO3														
CO4														

SYLLABUS

UNIT I: STEADY STATE LUMPED SYSTEMS

Introduction to modeling and simulation, classification of mathematical models, conservation equations and auxiliary relations, Degree of freedom analysis, single and network of process units, systems yielding linear and non-linear algebraic equations, flowsheeting – sequential modular and equation oriented approach, tearing, partitioning and precedence ordering, solution of linear and non-linear algebraic equations

UNIT II : UNSTEADY STATE LUMPED SYSTEMS

Acharacteristics for through pipesnalysis of liquid level tank, gravity flow tank, jacketed stirred tank heater, reactors, flash and distillation column, solution of ODE initial value problems, matrix differential equations, simulation of closed loop systems.

UNIT III : STEADY STATE DISTRIBUTED SYSTEM

Analysis of compressible flow, heat exchanger, packed columns, plug flow reactor, solution of ODE boundary value problems.

UNIT IV UNSTEADY STATE DISTRIBUTED SYSTEM

Analysis laminar flow in pipe, sedimentation, boundary layer flow, conduction, heat exchanger, heat transfer in packed bed, diffusion, packed bed adsorption, plug flow reactor, hierarchy in model development, classification and solution of partial differential equations.

Teaching Methods: Chalk& Board

REFERENCES

1. Ramirez, W., "Computational Methods in Process Simulation", 2ndEdn., Butterworths, New York, 2000.
2. Luyben, W.L., "Process Modelling Simulation and Control", McGraw-Hill Book Co., 1990.
3. Felder, R. M. and Rousseau, R. W., "Elementary Principles of Chemical Processes", John Wiley, 2005.
4. Franks, R. G. E., "Mathematical Modelling in Chemical Engineering", John Wiley, 1967.

SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	SOLVENT EXTRACTION	3	0	0	3	A

Course Educational Objectives

CEO1	
CEO2	
CEO3	
CEO4	

Course Outcomes: ***Upon successful completion of this course, students should be able to:***

CO1	
CO2	
CO3	
CO4	

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES											PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1														
CO2														
CO3														
CO4														

SYLLABUS

UNIT I EQUILIBRIUM IN LIQUID-LIQUID SYSTEM :
Binary and ternary liquid equilibria, Tie-lines, Critical solution temperature, Tie linecorrelations ,Contour/prism diagrams, Binary / Ternary prediction methods of activity coefficient, Theory and Prediction of diffusivity in liquids, Theory of inter phase mass transport, Estimation and prediction of mass transport coefficients.

UNIT II :DIFFERENTIAL / STAGE-WISE EQUILIBRIUM CONTACT OPERATIONS
Equilibrium stage-wise contact, Single and multiple contacts with co-current and counter current flow of phases for immiscible and partially miscible solvent phases , Calculation methods, Fractional extraction with reflux of raffinate and extract. Differential contact, HETS, NETS, HTU, NTU concepts and Estimation of these parameters, Mass transfer efficiency, Axial mixing and Residence time distribution in extractors and their estimation.

UNIT III :DISPERSION AND COALESCENCE IN EXTRACTORS
Characteristics of dispersion involving single and multiple nozzle distributors, Drop size and formation and coalescence, Mean drop size at dispersion and their settling velocities/relative characteristics velocities. Effect of drop oscillation wobbling and Internal circulation, Effect of surface active agents, Prediction of drop size and characteristics velocity in spray , packed and mechanically agitated contactors as in RDC, pulsed columns, solute transfer effects on drop dynamics

UNIT IV:DESIGN OF LIQUID EXTRACTION COLUMNS 14
Design of extractor height and diameter, Prediction of flow capacities in terms of flooding rates, Regime of operating envelops, Hydrodynamic design variables such as hold up, characteristic velocities, pressure drop, Effect of direction of solute transfer on these variables and their prediction methods, Correction of mass transfer data, Axial mixing ,correction for column height, Interfacial area estimations, using slow, fast and instantaneous reactions and their application with models for mass transfer coefficients

REFERENCES
1. Laddha, G. S. and Degaleesan, T. E., ”Transport Phenomena in Liquid Extraction”, Tata McGraw Hill, New Delhi, 1976.
2. Hanson, C., Baird, M. H. I. and Lo, T. C., “Hand Book of Solvent Extraction”, Wiley – International, New York, 1983.
3. Hanson, C., “Recent Advances in Liquid Extraction”, Pergamon Press, London, 1972.
4. Treybal, R. E., “Liquid Extraction”, McGraw Hill, New York, 1963.

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SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	SAFETY AND HAZARD CONTROL	3	0	0	3	A

Course Educational Objectives

CEO1	
CEO2	
CEO3	
CEO4	

Course Outcomes: ***Upon successful completion of this course, students should be able to:***

CO1	
CO2	
CO3	
CO4	

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1														
CO2														
CO3														
CO4														

SYLLABUS

UNIT I : Conventional and modern concepts of safety, Basic Principles and concepts in hazardidentification, Chemical hazards, Process and operation hazard, Hazards from utilities like air, water, steam etc., Occupational health hazards, Hazard and operability Studies, Safety Audits.

UNIT II : Past Accident Analysis, Consequence Analysis of fire, gas/vapour, Dispersions and explosion, Vulnerability models, Fault and Event Tree Analysis.

UNIT III
Safety in plant design and layout. Risk Assessment

UNIT IV
Safety measures in handling and storage of chemicals, Process plant, personnel Protection, First Aid. Disaster mitigation, Emergency Preparedness plans.

REFERENCES

1. Well, G.S Safety Process Plants Design, George Godwin Ltd., London, John Wilelys and Sons, New York, 1980.
2. Safety in Chemical and Petrochemical Industries, Report of the Inter Ministry Group, Dept. of Chemicals and Petrochemicals, Govt.of India, ICMA Publications. 1986.
3. Major Hazard Control, Manual by International Labour Organization, Geneva, 1990.
4. Frank P.Less, Loss Prevention in Process Industries, Vol. I and Vol II Butterworth, London, 1980.
5. Marshal, V.C Major Chemical Hazards, Ellis Harwood Ltd. Chichester, U.K. 1987.
6. Guidelines for Chemical Process Quantitative Risk Analysis, Published by Centre for Chemical Process Safety of the AICh.E., New York, USA. 1989.
7. Raghavan, K.V and A.A Khan, Methodologies in Hazard Identification and Risk Assessment, Manual by CLRI., Dec, 1990.

SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	MULTICOMPONENT DISTILLATION	3	0	0	3	A

Course Educational Objectives

CEO1	
CEO2	
CEO3	
CEO4	

Course Outcomes: ***Upon successful completion of this course, students should be able to:***

CO1	
CO2	
CO3	
CO4	

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES											PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1														
CO2														
CO3														
CO4														

SYLLABUS

UNIT I HERMODYNAMIC PRINCIPLES

Fundamental Thermodynamic principles involved in the calculation of vapor – liquid equilibria and enthalpies of multi component mixtures – Use of multiple equation of state for the calculation of K values – Estimation of the fugacity coefficients for the vapor phase of polar gas mixtures – calculation of liquid – phase activity coefficients

UNIT IITHERMODYNAMIC PROPERTY EVALUATION

Fundamental principles involved in the separation of multi component mixtures – Determination of bubble-point and Dew Point Temperatures for multi component mixtures – equilibrium flash distillation calculations for multi component mixtures –separation of multi component mixtures at total reflux.

UNIT III MINIMUM REFLUX RATIO FOR MCD SYSTEM

General considerations in the design of columns – Column sequencing – Heuristics for column sequencing – Key components – Distributed components – Non-Distributed components – Adjacent keys. Definition of minimum reflux ratio – calculation of Rm for multi component distillation – Underwood method – Colburn method.

UNIT IV VARIOUS METHODS OF MCD COLUMN DESIGN

Theta method of convergence – Kb method and the constant composition method – Application of the Theta method to complex columns and to system of columns – Lewis Matheson method – Stage and reflux requirements – Short cut methods and Simplified graphical procedures Design of sieve, bubble cap, valve trays and structured packing columns for multi component distillation – computation of plate efficiencies.

TEXT BOOK

1. Holland, C.D., “Fundamentals of Multi Component Distillation”, McGraw Hill Book Company,1981
2. Van Winkle, “Distillation Operations”, McGraw Hill Publications, 1987. Book House Pvt. Ltd., New Delhi. 1998

SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	Safety in Chemical industries	**3**	**0**	**0**	**3**	**A**

Course Educational Objectives

CEO1	To provide the knowledge about the different types of fire extinguisher.
CEO2	To provide the knowledge about the calculation of material loss in chemical industries
CEO3	To provide the information about the design of the safety-relief valve for liquid and gas/vapour

Course Outcomes: ***Upon successful completion of this course, students should be able to:***

CO1	Inflammable, combustible and explosive materials, and various types of fire
CO2	Application of firefighting equipment
CO3	Controlling of fire and explosion based on blast wave generation
CO4	Loss prevention calculations in chemical industries

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES											PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1														
CO2														
CO3														
CO4														

SYLLABUS

UNIT I

Sources of ignition – fire triangle – principles of fire extinguishing – active and passive fire protection systems – various classes of fires – A, B, C, D, E – types of fire extinguishers – fire stoppers – hydrant pipes – hoses – monitors – fire watchers – lay out of stand pipes – fire station-fire alarms and sirens – maintenance of fire trucks – foam generators – escape from fire rescue operations – fire drills – notice-first aid for burns

UNIT II

Inherently safer design chemical reactor, types, batch reactors, reaction hazard evaluation, assessment, reactor safety. Pressure system, pressure vessel design, standards and codes- pipe works and valves- heat exchangers- process machinery- over pressure protection, pressure relief devices and design, fire relief, vacuum and thermal relief, special situations, disposal- flare and vent systems- failures in pressure system.

UNIT III

General consideration, petroleum product storages, storage tanks and vessel- storages layout- segregation, separating distance, secondary containment- venting and relief, atmospheric vent, pressure, vacuum valves, flame arrestors, fire relief- fire prevention and protection- LPG storages, pressure storages, layout, instrumentation, vapourizer, refrigerated storages- LNG storages, hydrogen storages, toxic storages, chlorine storages, ammonia storages, other chemical storages- underground storages- loading and unloading facilities- drum and cylinder storage- ware house, storage hazard assessment of LPG and LNG Hazards during transportation – pipeline transport. Cascaded N-capacities – Hybrid tank system for level control and temperature control

TEXT BOOKS

1. Lees, F.P, *Loss Prevention in Process Industries*, Butterworths and Company , 1996
2. Derek, James, *Fire Prevention Hand Book*, Butterworths and Company, London , 1986

REFERENCES

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SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	INSTRUMENTAL METHODS OF ANALYSIS LAB	0	0	2	2	A

Course Educational Objectives	
CEO1	
CEO2	
CEO3	
CEO4	

Course Outcomes: ***Upon successful completion of this course, students should be able to:***

CO1	
CO2	
CO3	
CO4	

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES											PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1														
CO2														
CO3														
CO4														

SYLLABUS

LIST OF EXPERIMENTS

1. UV-Visible spectrophotometer
2. Laser particle size diffraction analyzer
3. Gas chromatography
4. High performance liquid chromatography
5. Atomic absorption spectrophotometer.
6. Halogen moisture analyzer
7. Thermo gravimetric analyzer
8. Automated capillary microflow porometer
9. Electrochemical workstation

SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	Advanced Chemical Engineering Laboratory	**0**	**0**	**2**	**2**	**A**

Course Educational Objectives	
CEO1	
CEO2	
CEO3	
CEO4	

Course Outcomes: ***Upon successful completion of this course, students should be able to:***

CO1	
CO2	
CO3	
CO4	

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1														
CO2														
CO3														
CO4														

SYLLABUS

LIST OF EXPERIMENTS

List of experiments

1. Dropwise and filmewise condensation
2. Radiative Heat Transfer and emissivity
3.Hydraullic permeate and pore size of polymeric membrane
4. Hollow fibre membrane pore size and permeate
5.Power curve for paddle mixer
6. Efficiency of Delaval Centrifuge
7.Effect of parameters on drying rate using sfluidized bed dryer
8. Effect of parameters on minimum fluidization velocity for a gas-solid fluidization system
9. Hydrodynamic studies for Inverse fluidization
10. Kinetic studies of Cascade reactor (a series of 3-CSTR) for saponification of ethyle acetate with NaOH
11. Reaction Kinetic studies for CSTR followed by PF

II SEMESTER

SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	ADVANCED TRANSPORT PHENOMENA	3	0	0	3	A

Course Educational Objectives

CEO1	
CEO2	
CEO3	
CEO4	

Course Outcomes: ***Upon successful completion of this course, students should be able to:***

CO1	
CO2	
CO3	
CO4	

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES											PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1														
CO2														
CO3														
CO4														

SYLLABUS

UNIT I INTERPHASE TRANSPORT IN ISOTHERMAL SYSTEMS

Definition of Friction Factors, Friction Factors for Flow in Tubes, Pressure Drop Required for a Given Flow, Flow Rate for a Given Pressure Drop, Friction Factors for Flow around Spheres Determination of the Diameter of a Falling Sphere, Friction Factors for Packed Columns. Case studies

UNIT II MACROSCOPIC BALANCES FOR ISOTHERMAL FLOW SYSTEMS AND POLYMERIC LIQUIDS

The Macroscopic Mass Balance , The Macroscopic Momentum Balance , The Macroscopic Mechanical Energy Balance , Estimation of the Viscous Loss , Power Requirement for Pipeline Flow , Use of the Macroscopic Balances for Steady-State,

Pressure Rise and Friction Loss in a Sudden Enlargement , Isothermal Flow of a Liquid through an Orifice.

Examples of the Behavior of Polymeric Liquids, Rheometry and Material Functions, Non-Newtonian Viscosity and the Generalized Newtonian Models , , Laminar Flow of an compressible Power-Law Fluid in a Circular Tube , Flow of a Power-Law Fluid in a Narrow Slit , Tangential Annular Flow of a Power- Law Fluid , Elasticity and the Linear Viscoelastic Models, Molecular Theories for Polymeric Liquids. Practical applications. Case studies

UNIT III INTERPHASE TRANSPORT IN NONISOTHERMAL SYSTEMS

Definitions of Heat Transfer Coefficients, Calculation of Heat Transfer Coefficients from Experimental Data **,** Analytical Calculations of Heat Transfer Coefficients for Forced Convection through Tubes and Slits **,** Heat Transfer Coefficients for Forced Convection in Tubes **,** Design of a Tubular Heater **,** Heat Transfer Coefficients for Forced Convection

around Submerged Objects **,** Heat Transfer Coefficients for Forced Convection through Packed Beds **,** Heat Transfer Coefficients for Free and Mixed Convection, Heat Loss by Free Convection from a Horizontal Pipe , Heat Transfer Coefficients for Condensation of Pure Vapors on Solid Surfaces. Case studies

UNIT IV MACROSCOPIC BALANCES FOR NONISOTHERMAL SYSTEMS

The Macroscopic Energy Balance, The Macroscopic Mechanical Energy Balance, Use of the Macroscopic Balances to Solve Steady-State Problems with Flat Velocity Profiles, The Cooling of an Ideal Gas , Mixing of Two Ideal Gas Streams, Parallel- or Counter- Flow Heat Exchangers, Flow of Compressible Fluids through Head Meters. Case studies

TEXT BOOK

1. Bird R.B., Stewart, W. E. and Lightfoot, E. N., “Transport Phenomena”, 2nd Edn.,John Wiley and Sons, 2007.

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SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	ADVANCED REACTION ENGINEERING AND REACTOR DESIGN	3	0	0	3	A

Course Educational Objectives

CEO1	
CEO2	
CEO3	
CEO4	

Course Outcomes: ***Upon successful completion of this course, students should be able to:***

CO1	
CO2	
CO3	
CO4	

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES											PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1														
CO2														
CO3														
CO4														

SYLLABUS

UNIT I

Homogeneous reactor design and analysis-I: Ideal reactors, Review of isothermal design for batch, semi-batch and flow reactors, multiple reactions and reaction networks: Yield-selectivity concepts, Wei-Prater analysis for first order networks, reaction networks of general order, Reactor energy balance and its applications to reactor design and analysis

UNIT II

Homogeneous reactor design and analysis-II: Non-ideal reactors- Review of the basic concepts of residence time distributions, single parameter models for real reactor behavior, macromixing and micromixing, segregated flow model and Zweitering's analysis of maximum mixedness, IEM and other models for micromixing.

UNIT III

Heterogeneous reactors-I: Gas-solid systems- Review of kinetics of gas-solid catalytic reactions with and without diffusion limitations, Reactor design for fixed and fluidized bed reactors, Selected case studies, Non-catalytic gas-solid reactions: review of kinetics reactor design case studies.

UNIT IV

Heterogeneous reactors-II: Gas-liquid systems- Basic theories of mass transfer with chemical reaction model systems and model reactors, Reactor design for mechanically agitated and bubble column reactors. Selectedcase studies.

TEXT BOOK

1. H. S. Fogler, *Elements of Chemical Reaction Engineering*, Prentice Hall , 2016
2. J.B. Rawlings, and J.G. Ekerdt, *Chemical Reactor Analysis and Design Fundamentals*, Nob Hill , 2002

REFERENCES

1. O. Levenspiel, Chemical Reaction Engineering, John Wiley & Sons , 1999
2. G. F. Froment, K. B. Bischoff and J. D. Wilde, Chemical Reactor Analysis and Design, John Wiley , 2010

SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	ADVANCED THERMODYNAMICS	**3**	**0**	**0**	**3**	**A**

Course Educational Objectives

CEO1	
CEO2	
CEO3	
CEO4	

Course Outcomes: ***Upon successful completion of this course, students should be able to:***

CO1	
CO2	
CO3	
CO4	

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES											PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1														
CO2														
CO3														
CO4														

SYLLABUS

UNIT I BASIC CONCEPTS

Energy and first Law; Reversibility and second Law; Review of Basic Postulates, equilibrium criteria, Legendre Transformation and Maxwell's relations

STABILITY AND PHASE TRANSITION. Stability of thermodynamic systems, first order phase transitions and critical phenomenon, phase rule, single component phase diagrams, thermodynamic properties from volumetric and thermal data

UNIT II MULTICOMPONENT MIXTURES

Partial molar properties, fugacities in gas and liquid mixtures, activity coefficients, Ideal and Non-ideal solutions, Gibbs-Duhem equation, Wilson, NRTL, and UNIQUAC equations, UNIFAC method.

UNIT III PHASE EQUILIBRIUM

VLE - Equations of state, corresponding states, Henry's Law, lattice theory, criticality, high pressure VLE. Other phase equilibriums- SLE/LLE/VLLE.

UNIT IV CHEMICAL EQUILIBRIUM

Homogeneous gas and liquid phase reactions, heterogeneous reactions – phase and chemical equilibrium

REFERENCES

1. Rao., Y.V.C., Chemical Engineering Thermodynamics, University Press, Hyderabad, 2005
2. Tester, J. W. and M. Modell, Thermodynamics and Its Applications. 3rd Edn. Prentice Hall, New Jersey, 1997.
3. Prausnitz, J.M., Lichtenthaler R.M. and Azevedo, E.G., Molecular thermodynamics of fluid-phase Equilibria, 3rd Edn, Prentice Hall Inc., New Jersey, 1999

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SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	MEMBRANE TECHNOLOGIES FOR WATER AND WASTEWATER TREATMENT	3	0	0	3	A

Course Educational Objectives

CEO1	
CEO2	
CEO3	
CEO4	

Course Outcomes: ***Upon successful completion of this course, students should be able to:***

CO1	
CO2	
CO3	
CO4	

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES											PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1														
CO2														
CO3														
CO4														

SYLLABUS

UNIT I INTRODUCTION
Solid Liquid separation systems-Filtration systems- Theory of Membrane separation – mass Transport Characteristics Cross Flow filtration-Membarne Filtration- Types and choice of membranes, porous, non porous, symmetric and assymmetric – Plate and Frame, spiral wound and hollow fibre membranes – Liquid Membranes

UNIT II MEMBRANE PROCESSES AND SYSTEMS
Microfiltration – Ultrafiltration- Nano Filtration – Reverse Osmosis – Electro dialysis- Pervaporation -Membrane manufactures – Membrane Module/Element designs – Membrane System components – Design of Membrane systems - pump types and Pump selection – Plant operations – Economics of Membrane systems

UNIT III MEMBRANE BIOREACTORS 9
Introduction and Historical Perspective of MBRs, Biotreatment Fundamentals, Biomass Separation MBR Principles, Fouling and Fouling Control, MBR Design Principles, Design Assignment, Alternative MBR Configurations, Commercial Technologies, Case Studies

UNIT IV PRETREATMENT SYSTEMS 8
Membrane Fouling – Pretreatment methods and strategies – monitoring of Pretreatment – Langlier Index, Silt Density Index, Chemical cleaning, Biofoulant control

TEXT BOOKS:
1. Water Environment Federation (WEF), Membrane Systems for Wastewater Treatment, McGraw-Hill, USA, 2005
2. Symon Jud, MBR Book – Principles and application of MBR in water and wastewater treatment,Elservier, 2006

REFERENCES
1.K. Yamamoto and Urase T, Membrane Technology in Environmental management, special issue, Water Science and technology, Vol.41, IWA Publishing, 2000
2. Jorgen Wagner, Membrane Filtration handbook, Practical Tips and Hints, Second Edition, Revision2, Osmonics Inc., 2001
3. Mulder, M., Basic Principle of Membrane Technology, Kluwer Academic Publishers, 1996
4. Noble, R.D. and Stern, S.A., Membrane Separations Technology: Principles and Applications, Elservier, 1995

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SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	INDUSTRIAL POLLUTION PREVENTION	3	0	0	3	A

Course Educational Objectives

CEO1	
CEO2	
CEO3	
CEO4	

Course Outcomes: ***Upon successful completion of this course, students should be able to:***

CO1	
CO2	
CO3	
CO4	

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1														
CO2														
CO3														
CO4														

SYLLABUS

UNIT I

Basics of Jurisprudence-Environmental law relation with other disciplines-Criminal law- Common Law-Relevant sections of the code of civil procedure, criminal procedure code -Indian Penal code.

UNIT II

Fundamental Rights-Directive principles of state policy-Article 48(A) and 51-A (g) Judicial enforcibility-Constitution and resources management and pollution control-Indian forest policy (1990) –Indian Environmental policy (1992).

UNIT III

Administration regulations-constitution of pollution control Boards Powers, functions, Accounts, Audit etc.-Formal Justice Delivery Mechanism Higher and Lower of judiciary- Constitutional remedies writ jurisdiction Article 32,226,136 special reference to madamus and certiorori for pollution abatement-Equitable remedies for pollution control.

UNIT IV 9

Administrative regulation under recent legislations in water pollution control, Water (prevention and control of pollution)Act 1974 as Amended by amendment act 1988 .Water(prevention of control and pollution)Rules1975 Water (prevention and pollution) Cess Act.1977 as amended by amendment act1991.Air(prevention and control of pollution)Act 1981 as amended by Amendment act 1987 and relevant notifications.

REFERENCES

1. Constitution of India Eastern Book Company Lucknow 12th Edition.1997
2. Pandey, J.N., Constitutional Law of India, (31st Edition) Central Law of Agency, Allahabad, 1997
3. Kesari, U.P.D, Administrative Law, Universal Book Trade, Delhi, 1998.
4. Tiwari, H.N., Environmental Law, Allahabad Law.Agency 1997.
5. Shyam Divan and Armin Roseneranz “Environmental law and policy in India “Oxford University Press, New Delhi, 2001..

SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	Fuel Cell Technology	**3**	**0**	**0**	**3**	**A**

Course Educational Objectives

CEO1	1. To know essential material for the hydrogen economy.
CEO2	2. To know details of fuel cell technology, in particular the opportunities for using hydrogen

Course Outcomes: ***Upon successful completion of this course, students should be able to:***

CO1	1. The students will have the general knowledge of Fuel Cells as a promising technology in the context of clean power sustainability and alternative fuels for shipping.
CO2	The students will know different specific developments on Fuel Cells which are available today.
CO3	The students will have the knowledge of how to produce electricity cleanly and efficiently from water and heat as the only products by using fuel cell.

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1														
CO2														
CO3														
CO4														

SYLLABUS

UNIT I

Overview of Hydrogen Energy and Fuel Cells, low and high temperature fuel cells. Fuel Cell performance , Polymer electrolyte fuel cells, Alkaline fuel cells, Phosphoric fuel cells, Molten carbonate fuel cells, Solid oxide fuel cells, Fuel cell systems and Sample calculations.
Fuel cell thermodynamics - heat, work potentials, prediction of reversible voltage, fuel cell efficiency.

UNIT II

Fuel cell reaction kinetics - electrode kinetics, overvoltages, Tafel equation, charge transfer reaction, exchange currents, electrocatalyses - design, activation kinetics, Fuel cell charge and mass transport - flow field, transport in electrode and electrolyte. Fuel cell characterization: - in-situ and ex-situ characterization techniques, i-V curve, frequency response analyses Process Safety and Process Design, Materials Science and Engineering

UNIT III

General consideration, petroleum product storages, storage tanks and vessel- storages layout- segregation, separating distance, secondary containment- venting and relief, atmospheric vent, pressure, vacuum valves, flame arrestors, fire relief- fire prevention and protection- LPG storages, pressure storages, layout, instrumentation, vapourizer, refrigerated storages- LNG storages, hydrogen storages, toxic storages, chlorine storages, ammonia storages, other chemical storages- underground storages- loading and unloading facilities- drum and cylinder storage- ware house, storage hazard assessment of LPG and LNG Hazards during transportation – pipeline transport. Cascaded N-capacities – Hybrid tank system for level control and temperature control

TEXT BOOKS

1. EG&G Technical Services, *Fuel Cell Handbook*, Morgantown, West Virginia, USA, 2004
2. Peter Hoffman, *omorrows Energy: Hydrogen, Fuel cells and the prospects for a cleaner planet*, MIT Press, Cambridge, London, England , 2001

REFERENCES

1. Chris Rayment and Scott Sherwin,, *Introduction to Fuel Cell Technology*, Notre Dame, U.S.A , 2003
2. abcd, *abcd*, abcd

SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	ADVANCED PROCESS CONTROL	3	0	0	3	A

Course Educational Objectives

CEO1	
CEO2	
CEO3	
CEO4	

Course Outcomes: ***Upon successful completion of this course, students should be able to:***

CO1	
CO2	
CO3	
CO4	

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES											PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1														
CO2														
CO3														
CO4														

SYLLABUS

UNIT I

ADVANCED CONTROL STRATEGIES 9

Feed forward, cascade, dead time compensation, split range, selective and override control; automatic tuning and gain scheduling

UNIT II

INTERNAL MODEL CONTROL 9

Model based control – IMC structure – development and design; IMC based PID control,MPC

UNIT III

MULTIVARIABLE CONTROL 9

Control loop interaction – general pairing problem, relative gain array and application, sensitivity. Multivariable control – zeros and performance limitations, directional sensitivity and operability, decoupling

UNIT IV

DISCRETE SYSTEMS 9

Z – Transform and inverse Z – transform properties, Discrete – Time Response of dynamic system, Pulse Transfer Function, Closed Loop System Stability.

TEXT BOOKS:

REFERENCES

1. Bequette, B. W., Process Control: Modeling, Design, and Simulation, Prentice Hall, 2003
2. Stephanopolous, G., "Chemical Process Control", Prentice Hall of India, New Delhi, 1985.
3. Kannan M. Moudgalya, Digital Process Control, John Wiley & Sons Ltd, 2007

SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	POLYMER TECHNOLOGY	3	0	0	3	A

Course Educational Objectives

CEO1	
CEO2	
CEO3	
CEO4	

Course Outcomes: ***Upon successful completion of this course, students should be able to:***

CO1	
CO2	
CO3	
CO4	

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES											PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1														
CO2														
CO3														
CO4														

SYLLABUS

UNIT I GENERAL ASPECTS OF POLYMERS 9

Classification, mechanisms and methods of polymerization, properties-molecular weight, glass transition temperature, crystallinity, thermal, electrical and mechanical properties.

UNIT II APPLICATION ORIENTED POLYMERS 9

Resins-PVC-Silicon oil and resin, fibrous polymers-nylon 66, polyacrylonitrile, adhesivesepoxides, phenol formaldehyde, urea formaldehyde.

UNIT III ELASTOMERS 9

Natural rubber, styrene-butadiene, poly isopropane-neoprene, silicon rubber, thermoplastic elastomer.

UNIT IV PROCESSING OF POLYMERS 9

Processing additives, plasticzer, antiaging additives, surface and optical properties, modifiers, fire retardants, additives for rubber and elastomer, various molding techniques

TEXT BOOKS:

REFERENCES

1. Miles, D.C & Briston, J.H. Polymer Technology, Chemical publishing Co: Inc: NY: 1979
2. Maturine Morton, “Rubber Technology”, 3rd Edition, Van Nostrand Re Inhold, NY: 1987
3. Masic, L. “Thermoplastics Materials Engineering”, Applied science publishers Ltd, NY: 1986
4. Raymond E.Seymour, “Engineering Polymer Source Book”, Mc Graw Hill

SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	INDUSTRIAL INSTRUMENTATION	3	0	0	3	A

Course Educational Objectives

CEO1	
CEO2	
CEO3	
CEO4	

Course Outcomes: ***Upon successful completion of this course, students should be able to:***

CO1	
CO2	
CO3	
CO4	

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES											PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1														
CO2														
CO3														
CO4														

SYLLABUS

UNIT I

Introduction – Variables, Units & standards of measurement, Measurement terms – characteristic. Data Analysis. Sensors,

UNIT II

Process Variables Measurement–Temperature systems– Thermocouples, Thermo resistive system, Filled-system thermometers, Radiation thermometry, Location of temperature measuring devices in equipments, Pressure system – Mechanical pressure elements Pressure Transducers and Transmitters, Vacuum measurement, Resonant wire pressure Transducer, Flow system – Differential producers, Variable area flow meters, Velocity, vortex, mass, ultrasonic & other flow meters, positive displacement flow meters, Open – channel flow measurements, Force systems, Strain gauges Humidity Moisture system, Humidity Measurement, Moisture measurement system, Rheological system, Viscosity measurement, Radiation system, Nuclear radiation instrumentation.

UNIT II

Fundamentals of Automatic process control – Control algorithms-Automatic controllers – Electronic controllers -Electric controllers (Traditional) - Hydraulic controllers – Fluidics - Programmable controllers

UNIT IV

Transmitters and control valves - Pressure, Flow, Level, Temperature and Composition sensors, Transmitters, Pneumatic and electronic control valves, Types, Actuator, accessories, Instrumentation symbols and Labels

REFERENCES

1. Fribance, “Industrial Instrumentation Fundamentals” ,Mc Graw Hill Co. Inc. New York 1985
2. Eckman D.P. “Industrial Instrumentation”, Wiley Eastern Ltd., 1989.
3. Considine D M and Considine G D “Process Instruments Controls” Handbook 3rd Edition , McGraw – Hill Book Co., NY, 1990.
4. Scborg D E,.Edgar T.F and Mellichamp D.A, “Process Dynamics and Control” John Wiley 1989

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SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	WASTE WATER ENGINEERING	**3**	**0**	**0**	**3**	**A**

Course Educational Objectives	
CEO1	
CEO2	
CEO3	
CEO4	

Course Outcomes: ***Upon successful completion of this course, students should be able to:***

CO1	
CO2	
CO3	
CO4	

CO-PO & PSO Mapping

COs	**PROGRAMME OUTCOMES**												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1														
CO2														
CO3														
CO4														

SYLLABUS

UNIT I
INTRODUCTION
Industrial scenario - Uses of Water by industry - Sources and types of industrial wastewater – Industrial wastewater disposal and environmental impacts - Reasons for treatment of industrial wastewater – Regulatory requirements - Industrial waste survey - Industrial wastewater generation rates, characterization and variables – Population equivalent - Toxicity of industrial effluents and Bioassay tests - Preventing and minimizing wastes at the source - Individual and Common Effluent Treatment Plants - Joint treatment of industrial wastewater.

UNIT II
INDUSTRIAL WASTEWATER TREATMENT 10
Equalisation - Neutralisation - Oil separation - Flotation - Precipitation - Heavy metal Removal – Refractory organics separation by adsorption - Aerobic and anaerobic biological treatment - Sequencing batch reactors – High Rate reactors

UNIT III
ADVANCED WASTEWATER TREATMENT AND REUSE 8
Chemical oxidation - Ozonation - Photocatalysis - Wet Air Oxidation - Evaporation – Ion Exchange – Membrane Technologies - Nutrient removal - Land Treatment.

UNIT IV
RESIDUALS MANAGEMENT 5
Residuals of industrial wastewater treatment - Quantification and characteristics of Sludge -Thickening, digestion, conditioning, dewatering and disposal of sludge - Management of RO rejects.

REFERENCES
1. Eckenfelder, W. W., "Industrial Water Pollution Control", Mc-Graw Hill, 1999.
2. Arceivala, S. J., "Wastewater Treatment for Pollution Control", Tata McGraw Hill, 1998.
3. "Pollution Prevention and Abatement Handbook – Towards Cleaner Production ", World Bank and UNEP, Washington, 1998.
4. Nelson Leonard Nemerow, Industrial waste treatment - Contemporary practice and vision for the future. Elsevier, Singapore 2007.

SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	CHEMICAL PROCESS SIMULATION LABORATORY	3	0	0	3	A

Course Educational Objectives	
CEO1	
CEO2	
CEO3	
CEO4	

Course Outcomes: *Upon successful completion of this course, students should be able to:*	
CO1	
CO2	
CO3	
CO4	

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES											PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1														
CO2														
CO3														
CO4														

SYLLABUS

Matlab - Introduction of Matlab;Numerical Integration; Polynomial Curve fitting; simultaneous algebraic equations ; Matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs written in other languages, including C, C++.

ASPEN- Introduction of Aspen Plus**;** Physical and thermodynamic property estimations; Mass and Energy balances; Simulation and design of reactors, distillation column, heat exchangers, absorbers; Simulation of flow in pipes, performing sensitivity analysis; analysis of pipeline hydraulics using Aspen Hysys Pipesys

CFD - Introduction of CFD**,** Construction of geometry and grid generation ; Implementation of boundary conditions ;Fluid flow modeling; convection and diffusion problems ; pressure , velocity, temperature profile; Turbulence modeling; multiphase flow; Unsteady state simulations.

REFERENCES

1. Edgar, T.F. and Himmelblau, D.M.; “Optimization of Chemical Processes”, McGraw- Hill Book Co. 2008.
2. Jana A.K., “Chemical Process Modelling and ComputerSimulation” Prentice Hall.2008
3. Jana A.K., “Process Simulation and Control using ASPEN” Prentice Hall.2009
4. Versteeg, H.K. and Malalasekera, W., “ An Introduction to Computational Fluid Dynamics:
5. The Finite Volume Method”, Prentice-Hall Inc.2008

SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	OPERATIONS RESEARCH	3	0	0	3	A

Course Educational Objectives

CEO1	
CEO2	
CEO3	
CEO4	

Course Outcomes: ***Upon successful completion of this course, students should be able to:***

CO1	
CO2	
CO3	
CO4	

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES											PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1														
CO2														
CO3														
CO4														

SYLLABUS

UNIT I MATHEMATICAL PROGRAMMING 12

Introduction, Linear Programming, Solution by simplex method, Duality, Sensitivity analysis, Dual simplex method, Integer Programming, Branch and bound method, Geometric programming and its application.

UNIT II DYNAMIC PROGRAMMING 10

Elements of DP models, Bellman's optimality criteria, Recursion formula, Solution of multistage decision problem by DP method. Application is Heat Exchange Extraction systems

UNIT III PERT, CPM and GERT 9

Network representation of projects, Critical path calculation, construction of the timechart and resource leveling, Probability and cost consideration in project scheduling, Project control. Graphical Evaluation and Review Techniques.

UNIT IV ELEMENTS OF QUEUING THEORY 7

Basic elements of the Queuing model, M/M/1 and M/M/C Queues.

UNIT V ELEMENTS OF RELIABILITY THEORY 7

General failure distribution, for components, Exponential failure distributions, General model, Maintained and Non-maintained systems, Safety Analysis.

REFERENCES

1. Carter, M. W. and Price, C. C., Operations Research: A Practical Introduction Contributor, CRC Press, 2001.
2. Edgar, T. F., Himmelblau, D. M. and Ladson, L. S., "Optimization of Chemical Processes", 2nd Ed., McGraw Hill, New York, 2003.
3. Hillier, F. S., and Lieberman, G. J., Introduction to Operations Research, McGraw- Hill, 2005
4. Taha, H. A., "Operations Research, An introduction", 6th Ed., Prentice Hall of India, New Delhi, 2006.

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SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	TOTAL QUALITY MANAGEMENT	3	0	0	3	A

Course Educational Objectives

CEO1	
CEO2	
CEO3	
CEO4	

Course Outcomes: ***Upon successful completion of this course, students should be able to:***

CO1	
CO2	
CO3	
CO4	

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1														
CO2														
CO3														
CO4														

SYLLABUS

UNIT I CONCEPTS OF TQM
Philosophy of TQM, Customer focus, organization, top management commitment, team work, quality philosophies of Deming, Crosby and Muller.

UNIT II TQM PROCESS
QC Tools, Problem solving methodologies, new management tools, work habits, quality circles, bench marking, strategic quality planning.

UNIT III TQM SYSTEMS 8
Quality policy deployment, quality function deployment, Standardization, designing for quality, manufacturing for quality.

UNIT IV QUALITY SYSTEM 10
Need for ISO 9000 system, Advantages, clauses of ISO 9000, Implementation of ISO 9000, quality costs, quality, auditing, case studies.

UNIT V IMPLEMENTATION OF TQM 10
Steps, KAIZEN, 5s, JIT, POKAYOKE, Taguchi methods, case studies.

. **REFERENCES**

1. Rose J. E., “Total quality Management”, Kogan Page Ltd, 1999.
2. Bank, J., “The essence of Total Quality Management”, Prentice Hall of India, 1993.
3. Bonds, G., “Beyond Total Quality Management”, McGraw Hill, 1994.
4. Osada, T., “The 5S’s, The Asian Productivity Organisation”, 1991.

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SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	INTELLECTUAL PROPERTY RIGHTS	3	0	0	3	A

Course Educational Objectives	
CEO1	
CEO2	
CEO3	
CEO4	

Course Outcomes: ***Upon successful completion of this course, students should be able to:***

CO1	
CO2	
CO3	
CO4	

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1														
CO2														
CO3														
CO4														

SYLLABUS

UNIT I 5

Introduction – Invention and Creativity – Intellectual Property (IP) – Importance – Protection of IPR – Basic types of property (i). Movable Property ii. Immovable Property and iii. Intellectual Property.

UNIT II 10

IP – Patents – Copyrights and related rights – Trade Marks and rights arising from Trademark registration – Definitions – Industrial Designs and Integrated circuits – Protection of Geographical Indications at national and International levels – Application Procedures..

UNIT III 10

International convention relating to Intellectual Property – Establishment of WIPO – Mission and Activities – History – General Agreement on Trade and Tariff (GATT).

UNIT IV 10

Indian Position Vs WTO and Strategies – Indian IPR legislations – commitments to WTO-Patent Ordinance and the Bill – Draft of a national Intellectual Property Policy – Present against unfair competition.

UNIT V 10

Case Studies on – Patents (Basumati rice, turmeric, Neem, etc.) – Copyright and related rights – Trade Marks – Industrial design and Integrated circuits – Geographic indications – Protection against unfair competition.

TEXT BOOKS

1. Subbaram N.R. “Handbook of Indian Patent Law and Practice “, S. Viswanathan Printers and Publishers Pvt. Ltd., 1998

SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	Green Technology and Engineering	**3**	**0**	**0**	**3**	**A**

Course Educational Objectives

CEO1	Successful students will be able to communicate with other engineers on topics of pollution prevention and waste minimization.
CEO2	Students will be able to use the problem solving skills developed in this course to identify, describe, and solve green engineering problems in other courses, such as plant design.
CEO3	Students will be exposed to topics of safety and environmental regulation and will learn appropriate terminology for green engineering.
CEO4	Students will recognize that modern green engineering problems exist and that the science of pollution prevention and waste minimization is progressing

Course Outcomes: ***Upon successful completion of this course, students should be able to:***

CO1	Gaining basic knowledge of sustainable and eco-friendly product development in the field of chemical and other manufacturing processes.
CO2	Learning design Processes which are benign and environmentally viable.
CO3	Developing materials and generating energy via non-toxic products or processes.
CO4	Learning to modify processes and products to make them green safe and economically acceptable.

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1														
CO2														
CO3														
CO4														

SYLLABUS

UNIT I

Green technology and engineering for sustainability: Principles of Green Technology and Engineering Atom/mass economy E-factor and other metrics to analyze synthetic methods. Waste – sources of waste, different types of waste, chemical, physical and biochemical methods of waste minimization and recycling.

UNIT II

Pollution – types, causes, effects and abatement.

UNIT III

Designing greener, safer chemical synthesis: Solvent free Microwave-assisted synthesis, synthesis using sonication, synthesis using green catalyst and green solvents: ionic liquid, PEG, zeolite, photocatalyst, nano-catalyst, Biocatalyst, polymer supported agent, synthesis involving supercritical solvents, catalysis involving fluorous phase, synthesis in aqueous and non-aqueous solvents.

UNIT IV

Designing greener safer more sustainable manufacturing processes: scale up effect, reactors and separations, Process synthesis Mass and energy integration, process intensification. Emerging green materials and Technologies: bioconversion of renewable Industrial ecology.

TEXT BOOKS

1. M. Charter and U. Tischner, *Sustainable Solutions: Developing Products and Services for the Future*, Greenleaf, 2001
2. D. T. Allen and D. R. Shonnard, *Green Engineering: Environmentally Conscious Design of Chemical processes*, Prentice Hall, 2001

REFERENCES

1. M. C. Cann and M. E. Connelly, *Real-World Cases in Green Chemistry*, American Chemical Society , 2000
2. J. H. Clark and D. J. MacQuarri, *Handbook of Green Chemistry and Technology*, Wiley-Blackwell , 2002

SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	Research Methodology	**3**	**0**	**0**	**3**	**A**

Course Educational Objectives	
CEO1	At the end of this course, the students should be able to understand some basic concepts of research and its methodologies
CEO2	The students are expected to select and define appropriate research problem and parameters
CEO3	The students are expected to organize and conduct research in a more appropriate manner
CEO4	The students are expected to write a research report and thesis
Course Outcomes: ***Upon successful completion of this course, students should be able to:***	
CO1	Developing ideas on research methods, ethics and policies to carry out research in right
CO2	Learning systematic in literature survey or methodology needed for proper direction in research.
CO3	Learning ethics to represent the data or analyze them properly
CO4	

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1														
CO2														
CO3														
CO4														

SYLLABUS

UNIT I

Principles of Research ethics: Research misconduct, Objectives and unbiased approach, Accuracy and Authenticity of Results, Plagiarism, Copyright, Honest usage of software, Repetitive reporting of Research outcome, Authorship, Informed Consent, Legality and Decency, Supervisor-student relationship, supervisor-supervisor relationship Research code of conduct responsibilities of administrative bodies.

UNIT II

Research policy: Principles Concerning research Openness in research Academic Freedom Research Support Responsibility towards fellow researcher Dissemination of Research results Academic Authorship Interdisciplinary research collaborative work with other institutions Conflict of interest. Maintenance of Research data and records: Motivation for instituting the practice of retaining Research Data Purpose behind retaining data Laboratory notebook Guidelines of recording Laboratory data and Maintaining Records Responsibility distribution.

UNIT III

Research Method: Objectives, Types, and Approaches Identification of Research, Problem Research Design: Exploratory, Descriptive, Experimental, Observational Studies & Survey Literature Review Hypotheses Sampling Data Sources Data Collection Tools Data analysis Reliability and Validity Introduction to Qualitative Research Methods Interpretation and Report Writing Writing papers for journals, conference paper, Writing Project proposals.

TEXT BOOKS

1. Dane, Francis C, *Research methods*, Pacific Grove: Brooks /Cole, 1990
2. Devlin, Ann Sloan, *Research methods: Planning, Conducting and Presenting Research*, Belmont, Calif.: Thomson / Wadsworth, 2006

REFERENCES

1. Patrick F. Dunn, *Measurement and Data Analysis for Engineering and Science*, 2/e, CRC Press, 2010
2. Ranjit Kumar, *Research Methodology: A Step-By-Step Guide for Beginners*, Sage Publications, 2010

SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	Nano Science and Technology	**3**	**0**	**0**	**3**	**A**

Course Educational Objectives

CEO1	It's a relatively new area of science and engineering that has generated excitement worldwide due to its interdisciplinary nature and wide range of applications.
CEO2	The nanoscale materials are important because those have different properties at the nanoscale than the bulk or micro scale.
CEO3	So, the objective of this course is to focus on the nanoscale properties and to give an overview of the exciting advancement in this area.
CEO4	

Course Outcomes: ***Upon successful completion of this course, students should be able to:***

CO1	Understanding of the basic science behind the properties of materials at the nanometre scale.
CO2	Understanding of the several important nanoscale materials for chemical engineering applications.
CO3	Understanding of the differences between the properties of micro and nano levels.
CO4	Understanding of the characterization techniques of nanoscale materials.

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1														
CO2														
CO3														
CO4														

SYLLABUS

UNIT I

Introduction to nanotechnology, definition, history. What makes the nanoscale so different from the other length scales by considering the underpinning science (i.e. nanoscience) and some key examples of nanotechnology.

UNIT II

Properties in nanoscale: Extensive and Intensive properties, change in physical properties like color, melting point, electrical, magnetic, and mechanical. Quantum mechanical approach to explain the properties change in nanoscale. Theory of size dependent melting point, effect of grain size and grain boundary on mechanical properties of nanomaterials.

UNIT III

Methods of synthesis of nanometerials fabrication-"Top-down" vs. "bottom-up" approaches. Equipment and processes needed to fabricate nanodevices and structures.

Focus on different nanomaterials: Carbon nanotubes (discovery, preparation, properties, applications), Inorganic nanowires, Biological and bio-inspired materials, Metallic nanomaterials, Different shape nanomaterials.

UNIT IV

Nanomaterial based biosensors: biofunctionalization of nanomaterials, advantages over other sensors, Field effect transistor based biosensors. Application in cholesterol, blood sugar, single virus detection.

UNIT V

Semiconductor nanoparticles, and Quantum dots. Application of quantum dots. Application of nanoparticles in catalysis. Characterization of nano particles by Scanning probe microscopes (Atomic Force Microscopy, Scanning Tunneling Microscopy), Transmission Electron Microscopy, Scanning Electron Microscopy.

TEXT BOOKS

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

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SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	Resource Recovery From Waste	**3**	**0**	**0**	**3**	**A**

Course Educational Objectives

CEO1	At the end of the course the students are expected to be able to define and describe waste, its categories, the waste chain, the situation in flanders, hazardous waste, the waste hierarchy.
CEO2	At the end of the course the students are expected to be able to describe, explain the principles, and other relevant aspects of waste recycling, recovery and reuse
CEO3	At the end of the course the students are expected to be able to select the best treatment option for a given waste/rest stream
CEO4	At the end of the course the students are expected to be able to explain the environmental implications of each treatment.

Course Outcomes: ***Upon successful completion of this course, students should be able to:***

CO1	Economically and environmentally sustainable processes for resource recovery from primary and secondary raw materials.
CO2	Comprehend and apply key tools/methodologies and specialised engineering knowledge for assessing resource recovery from waste/circular economy to effectively analyse related systems and sound support making

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1														
CO2														
CO3														
CO4														

SYLLABUS

UNIT I

Introduction to waste production in different sectors such as domestic, industrial and agriculture etc. What is Waste? Waste Management Hierarchy and 3R Principle of Reduce, Reuse and Recycle. Waste minimization –reducing waste generation at source. Principles of Waste Utilization and introduction waste as a resource and recovery of this resource from waste. Types of waste (organic, inorganic, hazardous, infectious etc.).

UNIT II

Characterization & Classification of waste –agrobased, forest residues, industrial waste (hazardous and non-hazardous), municipal solid waste, plastic waste, biomedical waste, e-waste etc. Concept of–Zero Waste–Zero Pollution–Zero Landfill Three general methods of attaining zero pollution. Economics of zero pollution.

UNIT III

Technologies for Waste Utilization and cleaner production processes–aerobic digestion and anaerobic digestion composting, vermin-composting, briquetting/pelletization. Waste-to-Energy –combustion, gasification, pyrolysis, biomethanation, bio-refineries. Landfill gas generation, collection conversion to fuels for useful energy applications-engine, compressors, burners, lamps etc. Waste recycling to recover resources –Value added chemicals from acid gas, novel adsorbents from fly-ash, red mud etc. Clean Technologies and their applications in production processes.

UNIT IV

Case studies & Success Stories of waste utilization in different industrial sectors: Manufacturing process, pollution sources, waste characterization, waste reduction/reuse/recovery and final treatment methods for–Pulp and Paper, Sugar, Distillery, Tannery, Dairy, Textile, Cement Manufacture, Thermal Power Plant, Dye and Dye Intermediates, pharmaceuticals and any other industry of importance.

TEXT BOOKS

1. Nelson L. Nemerow, *Zero Pollution for Industry: Waste minimization through industrial complexes*, John Wiley & Sons, New York , 1995
2. W Eckenfelder, *Industrial Water pollution control*, McGraw Hill , 1999

SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	Advanced Fluidization Engineering	**3**	**0**	**0**	**3**	**A**

Course Educational Objectives

CEO1	1. To have better understanding of fluidization phenomena to develop generic fluidized bed reactor models
CEO2	2. To investigate new diagnostic methods and analysis techniques to enable more reliable design and operation of industrial-scale fluidized bed reactors
CEO3	
CEO4	

Course Outcomes: ***Upon successful completion of this course, students should be able to:***

CO1	better understanding of fluidization phenomena
CO2	develop generic fluidized bed reactor models
CO3	investigate new diagnostic methods and analysis techniques to enable more reliable design and operation of industrial-scale fluidized bed reactors.
CO4	learn technique of Beneficiation of Low grade Minerals and high ash coals, Energy Winning and Treatment of Wastes

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES											PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1														
CO2														
CO3														
CO4														

SYLLABUS

UNIT I

Introduction to fluidization, types of fluidization, Gross behaviour of fluidized beds, Minimum fluidizing velocity and pressure drops, Distributor design, Voidage, transport disengaging height.

UNIT II

Bubbles in dense beds, Davidson Model, stream of bubbles, bubbling bed models, Emulsion phase, Turn-over rate of solids, residence time distribution diffusion model of solids movement, interchange coefficient into and out of wake.

UNIT III

Diffusion model for gas flow two region models, evaluation of interchange coefficients. Mass and heat transfer between fluids and solid from bubbling bed model Catalytic conversion from bubbling bed model contacting efficiency application to successive reactions Theories and bed-wall heat transfer comparison of theories.

UNIT IV

Entrainment and elutrition, application of entrainment model Residence time distribution and size distribution of solids in fluidized beds, particles of changing size Circulation rates of solids, flow of high and low bulk density mixtures.
Design for catalytic reactors Design for noncatalytic gas-solid reactors

TEXT BOOKS

1. D. Kunii and O. Levenspiel, *Fluidization Engineering*, 2nd edition, Butterworth-Heinemann , 1991.
2. J.F. Davidson and D. Harrison, *Fluidization*, , Academic Press, , 1971

REFERENCES

1. C. K. Gupta, D. Sathiyamoorth, *Fluid Bed Technology in Materials Processing*,, CRC Press, 1st edition. , 1998
2. F.A. Zenz and D.F. Othmer, *Fludization and Fluid Particles Systems*, Reinhold Publishing , 1960

SUBJECT CODE	TITLE OF THE SUBJECT	L	T	P	C	QP
	ADVANCED SEPARATION PROCESSES	3	0	0	3	A

Course Educational Objectives

CEO1	
CEO2	
CEO3	
CEO4	

Course Outcomes: ***Upon successful completion of this course, students should be able to:***

CO1	
CO2	
CO3	
CO4	

CO-PO & PSO Mapping

COs	PROGRAMME OUTCOMES											PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1														
CO2														
CO3														
CO4														

SYLLABUS

UNIT IGENERAL

Review of conventional processes, recent advances in separation techniques based on size, surface properties, ionic properties and other special characteristics of substances. process concept, theory and equipment used in cross flow filtration, cross flow electrofiltration, dual functional filter, surface based solid-liquid separations involving a second liquid, sirofloc filter.

UNIT IIMEMBRANE SEPARATIONS

Types and choice of membranes, plate and frame, tubular, spiral wound and hollow fibre membrane reactors and their relative merits, commercial, pilot plant and laboratory membrane pemeators involving dialysis, reverse osmosis, nanofiltration, ultrafiltration, microfiltration and Donnan dialysis, economics of membrane operations, ceramic membranes.

UNIT III SEPARATION BY ADSORPTION TECHNIQUES

Mechanism, types and choice of adsorbents, normal adsorption techniques, affinity chromatography and immuno chromatography, types of equipment and commercial processes, recent advances and process economics

UNIT IV IONIC SEPARATIONS Controlling factors, Types of equipment employed for electrophoresis, dielectrophoresis, Ion Exchange chromatography and electrodialysis, Commercial processes and applications

REFERENCES

1. King, C. J., “Separation Processes”, Tata McGraw Hill Co., Ltd., 1982.
2. Nakagawal, O. V., “Membrane Science and Technology”, Marcel Dekker, 1992.
3. Rousseau, R. W., “Handbook of Separation Process Technology”, John Wiley, New York, 2009.
4. Humphrey, J and G. Keller, Separation Process Technology, McGraw-Hill, 1997
5. Phillip C. Wankat , Separation Process Engineering (2nd Edition),Printice Hall,2007