SRI VENKATESWARA COLLEGE OF ENGINEERING,

(An Autonomous Institution, Affiliated to Anna University, Chennai – 600025)

M.Tech, Chemical Engineering

CURRICULUM AND SYLLABUS

REGULATION – 2022

CHOICE BASED CREDIT SYSTEM

Curriculum Revision No:	0	Board of Studies recommendation date :	03.10.2022	Academic Council Approved date:	08.10.2022
Salient Points of the revision					

Note: Times new Roman font and size 12 should be used throughout the document if specific size is not mentioned.

SRI VENKATESWARA COLLEGE OF ENGINEERING,

(An Autonomous Institution, Affiliated to Anna University, Chennai – 600025)
REGULATIONS2022

CHOICEBASEDCREDITSYSTEM

PROGRAMEDUCATIONALOBJECTIVES (PEOs)

I. PEO1: Acquire comprehensive knowledge in Chemical Engineering and research capabilities
II. PEO2: Analyze and solve using Chemical Engineering principles and modern engineering tools to conduct experiments for improving the quality of the chemical processes.
III. PEO3: Design processes within realistic constraints such as economic, social, ethical, environment, health and safety conditions.
IV. PEO4: Provide opportunities to students to engage in professional societies, and help them to acquire new skills to stay connected with today's fast progressing environment.
V. PEO5: Empower students to become entrepreneurs for Chemical industries.

PROGRAMOUTCOMES (POs)

PO GRADUATEATTRIBUTES

1. Independently carry out research /investigation and development work to solve practical problems.
2. Write and present a substantial technical report/document.
3. Demonstrate a degree of proficiency over the area as per the specialization of the program. The proficiency should be at a level higher than the requirements in the appropriate bachelor program
4. Potential to analyze 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.
5. Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
6. Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PROGRAM SPECIFIC OUTCOMES (PSOs)
After the successful completion of the course, the students:
PSO1: Apply the knowledge of science and mathematics in the field of various transport processes to accomplish the contemporary needs of chemical and allied industries.
PSO2: Execute the chemical engineering principles and modern engineering tools to conduct experiments or design a system for developing quality chemical processes by considering the cost, safety and environmental aspects.

PEO’s–PO’s & PSO’s MAPPING: (Example)

POs	PEOs				
	I	II	III	IV	V
1.	✓	✓	✓	✓	✓
2.		✓		✓	✓
3.	✓	✓	✓	✓	✓
4.	✓	✓		✓	✓
5.		✓	✓	✓	✓
6.	✓	✓	✓	✓	✓
PSO 1	✓	✓	✓	✓	✓
PSO 2	✓	✓	✓	✓	✓

SRI VENKATESWARA COLLEGE OF ENGINEERING,

(An Autonomous Institution, Affiliated to Anna University, Chennai – 600025)

REGULATIONS2022
CHOICEBASEDCREDITSYSTEM

CURRICULUMFORSEMESTERSITOVIIIANDSYLLABIFORSEMESTERS IANDII

SEMESTERI

SL. NO.	COURSE CODE	COURSETITLE	CATEGORY#	PERIODSPER WEEK				TOTAL Hours	Prerequisite	Position
				L	T	P	C			
Theory Subjects										
1.	MA22183	Mathematical and Statistical Methods for Chemical Engineering	PC	3	1	0	4	60	Nil	F
2.	CL22101	Advanced Thermodynamics for Chemical Engineers	PC	3	1	0	4	60	Nil	F
3.	CL22102	Advanced Separation Processes	PC	3	0	0	3	45	Nil	F
4.	CL22103	Advanced Chemical Reaction Engineering	PC	3	1	0	4	60	Nil	F
5.		Professional Elective - I	PE	3	0	0	3	45	Nil	F
6.	CL22104	Process Modeling and Simulation(Integrated)	PC	3	1	2	5	90	Nil	F
Practical Subjects										
7.	CL22111	Instrumental Methods of Analysis Laboratory	PC	0	0	4	2	60	Nil	F
			Total	**18**	**4**	**6**	**25**	**420**		

<Foot notes may be given, if any>

Note: Row Height should be 0.8 CM

The Course category may be any one of the following:

- i) Humanities and Social Sciences (HS)
- ii) Management Courses (MG)
- iii) Basic Sciences (BS)
- iv) Engineering Sciences (ES)
- v) Professional Core (PC)
- vi) Professional Elective (PE)
- vii) Open Elective (OE)
- viii) Employability Enhancement (EE)
- ix) Value Added (VA)
- x) General Elective (GE)
- xi) Mandatory Course (MC)
- xii) Audit Course (AC)

SEMESTERII

SL. NO.	COURSE CODE	COURSETITLE	CATEGORY#	PERIODSPER WEEK				TOTAL Hours	Prerequisite	Position
				L	T	P	C			
Theory Subjects										
1.	CL22201	Advanced Transport Phenomena	PC	3	1	0	4	60	Nil	F
2.	CL22202	Advanced Process Control	PC	3	0	0	3	45	Nil	F
3.	GR22251	Introduction to Research Methodology and IPR	MC	3	0	0	3	45	Nil	F
4.		Professional Elective -II	PE	3	0	0	3	45	Nil	F
5.	CL22203	Chemical Process Design	PC	3	0	0	3	45	Nil	F
6.	CL22204	Software applications inChemical industries(Integrated)	PC	3	1	2	5	90	Nil	F
Practical Subjects										
7.	CL22211	Advanced Chemical Engineering Laboratory	PC	0	0	4	2	60	Nil	F
			Total	**18**	**4**	**6**	**23**	**390**		

SEMESTERIII

SL. NO.	COURSE CODE	COURSETITLE	CATEGORY#	PERIODSPER WEEK				TOTAL Hours	Prerequisite	Position
				L	T	P	C			
Theory Subjects										
1.		Professional Elective -III	PE	3	0	0	3	45	Nil	F
2.		Professional Elective -IV	PE	3	0	0	3	45	Nil	F
3.	CL22312	Comprehension and Seminar	EE	0	0	2	1	30	Nil	F
4.	CL22311	Project Work Phase – I	EE	0	0	12	6	180	Nil	F
			Total	**6**	**0**	**14**	**13**	**300**		

SEMESTERIV

SL. NO.	COURSE CODE	COURSETITLE	CATEGORY#	PERIODSPER WEEK				TOTAL Hours	Prerequisite	Position
				L	T	P	C			
Theory Subjects										
1.	CL22411	Project Work Phase – II	EE	0	0	24	12	360	Nil	F
			Total	**0**	**0**	**24**	**12**	**360**		

PROFESSIONAL ELECTIVES (PE)

S. No.	Course code	Course title	Category	Contact hours	L	T	P	C	Pre-Requisite	Fixed/ Movable
ELECTIVE -I										
1		Electrochemical Processes for Clean Technology	PE	3	3	0	0	3		
2		Solar Energy Engineering	PE	3	3	0	0	3		
3		Down Stream Processes in Petroleum Engineering	PE	3	3	0	0	3		
4		Environmental Engineering	PE	3	3	0	0	3		
5		Wastewater Engineering	PE	3	3	0	0	3		
ELECTIVE -II										
1		Electrochemical Processfor Chemical Engineers	PE	3	3	0	0	3		
2		Process Integration	PE	3	3	0	0	3		
3		Gas Transportation	PE	3	3	0	0	3		
4		Environmental Policies and Legislation	PE	3	3	0	0	3		
5		Bioprocess Engineering	PE	3	3	0	0	3		

MA22183 MATHEMATICAL AND STATISTICAL METHODS FOR CHEMICAL ENGINEERING

L	T	P	C
3	1	0	4

COURSE OBJECTIVES:

1. To introduce the basic concepts of PDE for solving standard partial differential equations.
2. To introduce Fourier series analysis which is central to many applications in engineering apart from its use in solving boundary value problems.
3. To acquaint the student with Fourier series techniques in solving heat flow problems used in various situations.
4. To acquaint the student with Fourier, transform techniques used in wide variety of situations.
5. To introduce the effective mathematical tools for the solutions of partial differential equations that model several physical processes and to develop Z transform techniques for discrete time systems.

UNIT I ALGEBRAIC EQUATIONS 12

Systems of linear equations: Gauss Elimination method, LU decomposition method pivoting techniques, Thomas algorithm for tridiagonal system –Gauss Seidel, SOR iteration methods - Systems of nonlinear equations: Fixed point iterations, Newton Raphson Method, Eigen value problems: Power method and Jacobi method.

UNIT II ORDINARY DIFFERENTIAL EQUATIONS 12

Runge Kutta Methods for system of IVPs, numerical stability, Adams-Bashforth multistep method, shooting method, BVP: Finite difference method, orthogonal collocation method, orthogonal collocation with finite element method, Galerkin finite element method.

UNIT III BOUNDARY VALUE PROBLEMS 12

Parabolic equations: explicit and implicit finite difference methods- Laplace and Poisson's equations in a rectangular region: Five-point finite difference schemes, Liebman's iterative methods, Dirichlet and Neumann conditions - different explicit and implicit methods; numerical stability analysis. Wave equation: Explicit scheme- Stability of above schemes.

UNIT IV TESTING OF HYPOTHESIS 12

Sampling distributions and Standard error– Type I and Type II errors – Critical region– Tests based on Normal, t, χ^2 and F distributions for testing of mean, difference between two means, proportion, difference between two proportions, variance, ratio of two variances – Independence of attributes ($r \times c$ contingency table) - Goodness of fit- Non parametric test (concept only).

UNIT V ANALYSIS OF VARIANCE 12

Basic principles of experimentation-Analysis of variance-One-way classification – Completely randomized design - Two-way classifications - Randomised block design, Latin square design-problems-2^2 factorial design (concept only)

.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

Upon successful completion of the course, students should be able to:

1. Solve algebraic or transcendental equation, linear system of equations, IVPs and BVPs and calculate Eigen values and Eigen vectors of matrices using an appropriate numerical method.
2. Acquire the skill to solve ordinary differential equations using single step, multistep methods and finite element method.
3. Construct the methods for the numerical solution of boundary value problems for parabolic, elliptic and hyperbolic PDEs.
4. Perform large sample test and small sample testing of Hypothesis as well as calculate confidence interval for a population parameter for real time data.
5. Classify and apply the related analysis of variance techniques in all fields of scientific experimentation.

TEXT BOOKS:

1. Richard A. Johnson, "Miller and Freund's Probability and Statistics for Engineers, Pearson Education, Asia, 3rd Edition, 2013.
2. Saumyen Guha and Rajesh Srivastava, "Numerical methods for Engineering and Science", Oxford Higher Education, New Delhi, 2015
3. Jain M. K., Iyengar S.R.K, Jain M. K., "Computational Methods for Partial Differential Equations", New Age international Publishers, 2007.

REFERENCES:

1. Gupta S.C. and Kapoor V.K.,"Fundamentals of Mathematical Statistics", Sultan and Sons, New Delhi, 2005.
2. Arora P.N., Sumeet Arora and Arora S., "Comprehensive Statistical Methods", 3rd edition, S. Chand and company Limited, 2010.
3. Burden, R.L., and Faires, J.D., "Numerical Analysis – Theory and Applications", 9th Edition, Cengage Learning, New Delhi, 2011
4. Gupta S.K., "Numerical Methods for Engineers", New Age Publishers, Third Edition 2015.

WEBLINKS:

1. https://nptel.ac.in/courses/111/107/111107105/
2. https://nptel.ac.in/courses/111/107/111107063/
3. https://nptel.ac.in/courses/103/106/103106112/

COURSE ARTICULATION MATRIX

COs	POs														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1.	3	3	2									3			
2.	3	3	2									3			
3.	3	3	2									3			
4.	3	3	2	3								3			
5.	3	3	2	3								3			

CL22101 ADVANCED THERMODYNAMICS FOR CHEMICAL ENGINEERS

L	T	P	C
3	1	0	4

COURSE OBJECTIVES:

1. To introduce the basic concepts of chemical engineering thermodynamics and Maxwell's relations
2. To introduce phase transition and thermodynamic properties from volumetric and thermal data.
3. To acquaint the student with Wilson, NRTL, UNIQUAC equations and UNIFAC methods for ideal and non-ideal solutions.
4. To acquaint the student with pressure on vapor liquid equilibrium used in wide variety of situations.
5. To introduce the chemical equilibrium for the homogenous gas and liquid phase reactions

UNIT I BASICCONCEPTS 12

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

UNIT II STABILITYANDPHASE TRANSITION 12

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 III MULTICOMPONENTMIXTURES 12

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 IV PHASEEQUILIBRIUM 12

VLE-Equationsofstate,correspondingstates,Henry'sLaw,criticality,highpressureVLE.Otherphaseequilibriums-SLE/LLE/VLLE.

UNIT V -CHEMICALEQUILIBRIUM 12

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

TOTAL: 60 PERIODS

OUTCOMES:

Upon successful completion of the course, students should be able to:

1. Analyze the basic concept of fluid phase equilibria and Maxwell's relations.
2. Assess the stability and phase equilibria of the thermodynamic systems.
3. Explain the Wilson, NRTL, UNIQUAC equations and UNIFAC methods for ideal and non-ideal solutions.
4. Develop phase equilibrium based on vapor liquid equilibrium.
5. Identify chemical equilibrium for the homogenous gas and liquid phase reactions.

TEXT BOOKS:

1. Tester,J.W. and M. Modell, Thermodynamics and Its Applications.3rdEdn.Prentice Hall, New Jersey, 1997
2. Rao.,Y.V.C.,ChemicalEngineeringThermodynamics,UniversityPress,Hyderabad, 2005

REFERENCES:

1. Prausnitz, J.M., Lichtenthaler R.M. and Azevedo, E.G., Molecular Thermodynamics of fluid-phaseEquilibria,3rdEdn, Prentice Hall Inc., NewJersey,1999
2. Dodge, B.F., "ChemicalEngineeringThermodynamics", McGraw-Hill, 1960.
3. Smith, J.M., VanNess, H.C., & Abbot M.C, "Introduction to Chemical Engineering Thermodynamics", McGraw Hill VII Edition 2004.
4. NarayananK.V"ATextBookofChemicalEngineeringThermodynamics"53PrenticeHall of India Pvt. Ltd. 2001.

At the end of the course add the Course articulation matrix as per the following format:
COURSE ARTICULATION MATRIX

COs	POs													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1.	3	1	3	2	3	2	2	2							
2.	3	1	3	1	2	3	3	2							
3.	2	1	3	2	3	3	2	2							
4.	3	1	2	3	3	3	2	3							
5.	3	1	3	3	3	2	3	3							

- All the 5 course outcome matches very strongly with the Pos1 and Pos 3.

CL22102 **ADVANCED SEPARATION PROCESSES**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

1. To impart knowledge on advanced separation processes and the selection of separation processes.
2. To enable students to understand the principles and processes of adsorption, membrane separation and chromatography and to design a membrane unit to achieve a specified separation
3. To introduce reactive separation technologies and its applications in Industries

UNIT I SEPARATION PROCESS **9**

Absorption, Adsorption, Distillation, Drying, Extraction, Leaching, Crystallization. Advances in separation techniques based on size, surface properties, ionic properties. Process concept, theory and equipment used in cross flow filtration, cross flow electro-filtration, dual functional filter, surface based solid-liquid separations involving a second liquid, siroflocfilter.

UNIT II MEMBRANE SEPARATIONS **15**

Types and choice of membranes, Plate and frame, spiral wound membranes, Tubular and hollow fiber membrane reactors, Membrane Permeates: Dialysis, Reverse osmosis, Nano filtration, ultra filtration, microfiltration, Donnan dialysis, Ceramic membranes, Membrane fouling, Economics of membrane operations. Characteristics of organic and inorganic membranes, basis of membrane selection, osmotic pressure, partition coefficient and permeability, concentration polarization. Liquid membrane separation, adsorptive separation-pressure, vacuum and thermal swing.

UNIT III IONIC SEPARATION **7**

Controlling factors, applications, types of equipment employed for electrophoresis, di-electrophoresis, ion exchange chromatography and electrodialysis, commercial process

UNIT IV REACTIVE SEPARATION PROCESSES **7**

Reactive distillation, extraction with reaction, absorption with reaction, adsorption with reaction, reactive membrane separation, reactive crystallisation.

UNIT V – OTHER TECHNIQUES **7**

Separations involving lyophilisation, pervaporation and permeation techniques for solids, liquids and gases, industrial viability and examples, zone melting, addictive crystallization, supercritical fluid extraction.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, students should be able to:

1. Assess the recent advances in separation techniques based on the properties of substances.
2. Analyze the mechanism and equipment used in various membrane separation techniques.

3. Identify the mechanism and equipment used in ionic separations.
4. Assess the importance of Reactive separation Process.
5. Identify the importance of advanced separation techniques used in Industry.

TEXT BOOKS:

1. Separation Processes Principles, J.D. Seader, Ernest J. Henley, D. Keith Roper, John Wiley & Sons, 2011, 3rd Edition.
2. Transport Processes and Unit Operations, Geankoplis C. J., Prentice Hall of India Pvt. Ltd., New Delhi, 2004, 4th Edition.
3. KaushikNath, *Membrane Separation processes*, PHI, New Delhi 2008.

REFERENCES:

1. Nakagawal, O. V., "Membrane Science and Technology", Marcel Dekker, 1992
2. Humphrey, J and G. Keller, Separation Process Technology, McGraw-Hill, 1997
3. Phillip C. Wankat , Separation Process Engineering (2nd Edition),Prentice Hall,2007
4. Reactive Separation Processes, Santi Kulprathipanja, Taylor & Francis, 2002.
5. Rousseau, R. W., "Handbook of Separation Process Technology", John Wiley, New York,
6. King C.J., "Separation Processes", Tata McGraw Hill. 1982.

COURSE ARTICULATION MATRIX

COs	**POs**														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
1.	**1**	**1**	**3**	**2**	**3**										
2.	**1**	**1**	**3**	**3**	**3**										
3.	**1**	**1**	**3**	**2**	**3**										
4.	**1**	**1**	**3**	**2**	**3**										
5.	**1**	**1**	**3**	**2**	**3**										

1- Slight (Low), 2- Moderate (Medium) , 3- Substantial (High)

CL22103 ADVANCED CHEMICAL REACTION ENGINEERING

L	T	P	C
3	1	0	4

COURSE OBJECTIVES:

1. To study the design of heterogeneous reactors.
2. To learn the energy balance, temperature and concentration profiles in different reactors.
3. To analyze the advanced design aspects of multiple reactors.
4. To gain insight on the importance of population balance of particles.
5. To understand the role of Reaction Engineering in the mitigation of Global warming.

UNIT I **12**

Non-elementary Kinetics Importance: Approximations for formulations of Rate laws, Formulations of Kinetic model - Effect of flow on conversions in Reactors: Semibatch Reactors: Importance and examples of applications - Material Balance on Semibatch Reactor – Multiple reaction in Semibatch Reactors, Conversion vs. Rate in Reactors.

UNIT II **12**

Multiple Reactor systems with CSTR's: Exothermic and Endothermic Reaction with examples, CSTR with heat effects, multiple reactions in CSTR and PFR with heat effects, Semi batch Reactors with heat exchange. Design of PFR and Packed Bed Tubular Reactors: Volume of reactors calculations for non-isothermal reactors. Optimal Design of Reactors for Reversible exothermic reactions: Heat effects in semi batch unsteady state operation. Auto thermal Plug flow reactors and packed tubular reactors. PFR with inter stage cooling. Examples of optimal design of PFR and Semi batch and CSTR Exothermic Reactions.

UNIT III **12**

Catalytic reactions: theory and modeling: Global rate of reaction, Types of Catalytic Heterogeneous reactions, Different steps in catalytic reactions, Theories of heterogeneous catalysis. Steady State approximation, formulations of rate law Rate laws derived from the PSSH, Rate controlling steps, Eiley-Rideal model, Reforming catalyst example: Finding mechanism consistent with experimental observations Evaluation of rate law parameters, packed beds: Transport and Reactions, Gradients in the reactors: temperature. Porous media reactors:

UNIT IV **12**

Fluidized bed reactor modeling: Fixed bed vs fluidized bed Why fluidized bed, important parameters pressure drop in fixed bed, Class I model Arbitrary Two Region Flow Models, Class II Chemical Reactor: Plug Flow or Mixed Flow Model.

UNIT V **12**

Application of Population Balance Equations for reactor modeling: Particle size distribution, Distribution Functions in Particle Measuring Techniques, Particle distribution model in colloidal particle synthesis in batch reactor, Moments of Distribution, Nucleation rate based on volumetric holdup versus crystal growth rate. Reaction engineering and mitigation of Global warming: CO_2 absorption in high pressure water, different techniques of mitigation of CO_2, methods of separations.

Recent advancements, automotive monolith catalytic converter example, removal and utilization of CO_2 for thermal power plants.

TOTAL: 60 PERIODS

OUTCOMES:

Upon successful completion of the course, students should be able to:

1. Evaluate heterogeneous reactor performance considering mass transfer limitations.
2. Acquire knowledge on energy balance and obtain concentration profiles in multiphase reactors.
3. Estimate the performance of multiphase reactors under non-isothermal conditions.
4. Enumerate modern reactor technologies for mitigation of global warming.
5. Model population balance equations for batch, continuous and catalytic reactor modelling.

TEXT BOOKS:

1. Denbigh K.G. and Turner J.C.R., "Chemical Reactor Theory: An Introduction", 3rd Edition, Cambridge University Press, 1984.
2. Levenspiel O., "Chemical Reaction Engineering", 3rd Edition, Wiley India, 2006.

REFERENCES:

1. Smith J.M., "Chemical Engineering Kinetics", 3rd Edition, McGraw-Hill Education, 1981.
2. Fogler H.S., "Elements of Chemical Reaction Engineering" 4th Edition, Prentice Hall India, 2008.
3. Froment G.F., Bischoff K.B. and Wilde J.D. "Chemical Reactor Design and Analysis" 3rd Edition, Wiley, 2010.

COURSE ARTICULATION MATRIX

COs	**POs**														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
1.	**3**	**3**	**3**	**2**	**2**	**2**									
2.	**3**	**1**	**2**	**2**	**2**	**2**									
3.	**3**	**3**	**3**	**3**	**2**	**2**									
4.	**3**	**2**	**3**	**3**	**2**	**2**									
5.															

CL122104 PROCESS MODELING AND SIMULATION (INTEGRATED)

L	T	P	C
3	1	2	5

COURSE OBJECTIVES:

1. To understand the basics of model construction.
2. To learn about solving model equations and validation of the models.
3. To apply degree of freedom analysis to find out solution of linear and non-linear chemical system
4. To develop mathematical models for chemical processes
5. To analyze and simulate heat exchangers and reactors

UNIT I INTRODUCTION 18

Introduction to modeling and simulation, classification of mathematical models, conservation equations, and auxiliary relations.

Lab Experiments:

1. Simulation studies of various unit operations using Aspen Plus
2. Thermodynamic property estimations using property estimation and property analysis in Aspen.

UNIT II STEADY STATE LUMPED SYSTEMS 18

Degree of freedom analysis, single and network of process units, systems yielding linear and non-linear algebraic equations, flow sheeting – sequential modular and equation-oriented approach, tearing, partitioning and precedence ordering, solution of linear and non-linear algebraic equations.

Lab Experiments:

3. Simulate Mixer, splitter, heat exchangers, and reactive distillation column.
4. Solve linear and non-linear programming problems.

UNIT III UNSTEADY STATE LUMPED SYSTEMS 18

Analysis 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.

Lab Experiments:

5. Simulation of Ideal Binary Distillation Column
6. Apply sensitivity, design specification and case study tools in Aspen

UNIT IV STEADY STATE DISTRIBUTED SYSTEM 18

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

Lab Experiments:

7. Simulation of Heat/Mass Transfer coefficient in 3 phase fluidized bed column
8. Modeling and Simulation of cyclone separator

UNIT V UNSTEADY STATE DISTRIBUTED SYSTEM 18

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 – Empirical modeling, parameter estimation, population balance and stochastic modeling.

Lab Experiments:

9. CFD Simulation of flow over a flat plate
10. CFD Simulation of flow over a sphere.

TOTAL: 90 PERIODS

OUTCOMES:

1. Upon successful completion of the course, students should be able to:
2. To impart knowledge on the fundamentals of modeling and simulation, system analysis and evaluation.
3. Apply degree of freedom analysis to find out solution of linear and non-linear chemical system.
4. Develop mathematical model for Chemical Processes and simulate tank systems.
5. Analyze and simulate heat exchangers and reactors, and identify the solution of boundary value problems.
6. Evaluate the mathematical model and validate with the simulation results obtained in the chemical processes.

TEXT BOOKS:

1. Ramirez, W., "Computational Methods in Process Simulation", 2nd Edn., Butterworths, New York, 2000.
2. Luyben, W.L., "Process Modelling Simulation and Control", McGraw-Hill Book Co.,1973.

REFERENCES:

1. Asghar Husain, “Chemical Process Simulation”, Wiley, 1986
2. Felder, R. M. and Rousseau, R. W., “Elementary Principles of Chemical Processes”, John Wiley, 2000.
3. Franks, R. G. E., “Mathematical Modelling in Chemical Engineering“, John Wiley, 1967.

At the end of the course add the Course articulation matrix as per the following format:

COURSE ARTICULATION MATRIX

COs	POs													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1.	3	3	3	3	2	2	3	3							
2.	3	3	3	3	2	2	3	3							
3.	3	3	3	3	2	2	3	3							
4.	3	3	3	3	2	2	3	3							
5.	3	3	3	3	2	2	3	3							

CL22111 INSTRUMENTALMETHODSOFANALYSIS LABORATORY

L	T	P	C
0	0	4	2

COURSE OBJECTIVES:

1. Introduction of the student to the fundamentals of instrumental methods of spectroscopic and chemical analysis.
2. Development of the capability of choosing the instrumental technique suitable to best solving a specific analytical problem.
3. Introduction of the role of instrumental analytical quality control.
4. Acquire knowledge about the widely used analytical Instruments
5. Train students to perform practical work on real samples to get acquainted with instrumentation and equipment which is needed in monitoring of environmental pollution.

LIST OF EXPERIMENTS:

1. . Analysis of Sample Mixture Using Gas Chromatography
2. . High Performance Liquid Chromatography (HPLC)
3. . Thermo-gravimetric Analysis
4. . Estimation of Amount of Copper and Chromium in the given water sample
5. . Estimation of Iron in the given water sample
6. . Cyclic Voltametry
7. . Tafel Plot
8. Determination of Absorption Curve and Concentration of different dyes using UV-Visible Spectrophotometer
9. Determination of Chromium and Manganese Concentration in solution
10. Determination of Arsenic in solution

TOTAL: 60 PERIODS

COURSE OUTCOMES:

Upon successful completion of the course, students should be able to:

CO1: Estimate the heavy metal quantity present in sample using Atomic Absorption \ Spectroscopy (AAS).
CO2: To impart knowledge on the importance and applications of UV visible spectrophotometer analysis.
CO3: AssesstheskillofoperatingGasChromatographyfortheanalysisoffluidsamples.
CO4: Assess the skill of operating High Performance Liquid Chromatography for the analysis of liquid samples.
CO5: Explore knowledge on determination of standard redox potential and corrosion rate of a given sample.

At the end of the course add the Course articulation matrix as per the following format:
COURSE ARTICULATION MATRIX

COs	POs														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1.	1	2	1	1	2	3	2	3							
2.	3	1	3	1	1	2	3	3							
3.	2	1	3	2	2	1	3	2							
4.	1	3	1	2	2	1	2	2							
5.	2	2	1	3	1	2	1	2							

CL22201 **ADVANCED TRANSPORT PHENOMENA**

L	T	P	C
3	1	0	4

COURSE OBJECTIVES:

1. To familiarize the student with basic concepts of transport phenomena and brief review of mathematics.
2. To enable students to understand the equations of change for isothermal flow and for nonisothermal flow.
3. To introduce them to the equations of change for multi component systems and aspects of dimensional analysis.
4. To equip the students to perform macroscopic balances involving transport properties.

UNIT I EQUATIONS OF CHANGE FOR ISOTHERMAL SYSTEMS **12**

Equation of Continuity, Equation of Motion, Equation of Mechanical Energy, Equations of Change in terms of the Substantial Derivative, Use of the Equations to solve Flow Problems, Dimensional Analysis of the Equations of Change. Velocity Distributions with more than one Independent Variable: Time Dependent Flow of Newtonian Fluids. Time Smoothed equation of velocity, temperature and concentration.

UNIT II EQUATIONS OF CHANGE FOR NON ISOTHERMAL SYSTEMS **12**

The Energy Equation, Special forms of the Energy Equation, The Boussinesq Equation of Motion for Forced and Free Convection, Use of the Equations of change to Solve Steady-State Problems, Dimensional Analysis of the Equations of Change for Non-Isothermal Systems. Temperature Distributions in Solids and in Laminar Flow. Temperature Distributions with more than One Independent Variable - Unsteady Heat Conduction in Solids, Steady Heat Conduction in Laminar, Incompressible Flow and Empirical Expressions for the Turbulent Heat Flux.

UNIT III EQUATIONS OF CHANGE FOR BINARY/MULTI COMPONENT SYSTEMS **12**

Concentration Distributions with more than One Independent Variable: Time-Dependent Diffusion, Steady-State Transport in Binary Boundary Layers, Time-Smoothing of the Equation of Continuity for binary system, Semi-Empirical Expressions for the Turbulent Mass Flux. Interphase Transport in Multi-Component Systems: Definition of Transfer Coefficients in One Phase, Analytical Expressions for Mass Transfer Coefficients, Correlation of Binary Transfer Coefficients in One Phase, Definition of Transfer Coefficients in Two Phases, Mass Transfer and Chemical Reactions

UNIT IV MACROSCOPIC BALANCES – PART I **12**

Macroscopic Balances for Isothermal Systems: The Macroscopic Mass Balance, Momentum Balance, Mechanical Energy Balance, Estimation of the Viscous loss, Use of the Macroscopic Balances for Steady-State Problems, Macroscopic Balances For Non-Isothermal Systems: Macroscopic Energy Balance, Macroscopic Mechanical Energy Balance, Use Of The Macroscopic Balances To Solve Steady State Problems With Flat Velocity Profiles

UNIT V MACROSCOPIC BALANCES – PART II **12**

Macroscopic Balances For Multi-Component Systems: Macroscopic Mass Balances, Macroscopic Momentum, Use of the Macroscopic Balances to solve Steady-State Problems.

TOTAL: 60 PERIODS

OUTCOMES:

Upon successful completion of the course, students should be able to:

1. Remember and apply the fundamental knowledge involving Equations of Change for Isothermal systems.
2. Acquire and apply the fundamental knowledge involving Equations of Change for Non – Isothermal systems.
3. Gain and apply the fundamental knowledge for Interface transport and estimating the concentration distributions among different scenarios
4. Practice the skill of preparing model in macroscopic scale for Isothermal and Non – Isothermal systems.
5. Analyze and/or construct the macroscopic model for any Multi Component systems.

TEXT BOOKS:

1. R.B. Bird, W.E. Stewart and E.W. Lightfoot, "Transport Phenomena", John Wiley, Second Edition 2006.
2. Robert, S Brodkey, Harry C. Hershey, "Transport Phenomena A Unified Approach", Brodkey Publishing 2003.

REFERENCES:

1. J.R. Welty, R.W. Wilson, and C.W.Wicks, Rorer G.E, Wilson R.W. "Fundamentals of Momentum Heat and Mass Transfer", V Edition. John Wiley, New York, 2008
2. W.M.Deen."Analysis of Transport Phenomenon", II Edition, Oxford University Press, 2013.
3. Robert J Kee, Michael E Coltrn, Peter Glarborg, "Chemically Reacting Flow", II Edition, Wiley,2018.

COURSE ARTICULATION MATRIX

COs	**POs**														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
1.	**3**	**2**	**3**	**3**	**2**	**2**	**2**	**1**							
2.	**3**	**2**	**3**	**3**	**2**	**2**	**2**	**2**							
3.	**3**	**2**	**3**	**3**	**2**	**2**	**3**	**2**							
4.	**3**	**3**	**3**	**3**	**3**	**2**	**3**	**3**							
5.	**3**	**3**	**3**	**3**	**3**	**2**	**3**	**3**							

<3 – Strong, 2 – Moderate, 1 – Weak>

CL22202 **ADVANCED PROCESS CONTROL**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

1) To introduce dynamic response of open and closed loop systems, control loop components.
2) To analyze the stability of control systems along with instrumentation.
3) To study multi-variable control strategies.

UNIT I ADVANCED CONTROL STRATEGIES **9**

Introduction to advanced control strategies, Feed forward control, Cascade control, dead time compensator, splitrange control, selective and override control; automatic tuning and gain scheduling.

UNIT II INTERNALMODEL CONTROL **9**

Model based control–internal model control**:** Structure; development and design; internal model control based PID controller design, Case studies.

UNIT III MULTI-VARIABLECONTROL **9**

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

UNIT IV DISCRETESYSTEMS **9**

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

UNIT V DIGITALFEEDBACKCONTROLLERS **9**

Design of digital feedback controllers, digital approximation of classical, effect of sampling, Dahlin's algorithms, Dead–beat algorithm, ringing, IMC algorithm, simplified model predictive algorithm.

TOTAL: 45 PERIODS

OUTCOMES:

1) Describe the dynamic response of advanced control systems.
2) Develop and design Internal Model based PID control system.
3) Enumerate the control loop interaction and multi-variable control strategies.

4) Acquire knowledge on discrete-time response of dynamic system.
5) Design of digital feedback controllers.

TEXT BOOKS:

1) Bequette, B.W., ProcessControl: Modeling, DesignandSimulation, PrenticeHall, 2003.
2) Coughnowr,D.,“ProcessSystemsAnalysisandControl“,3rdEdn.,McGrawHill,New York, 2008.

REFERENCES:

1) Stephanopolous, G., “ChemicalProcessControl”, PrenticeHallofIndia, NewDelhi, 2003.
2) Pradeep B. Deshpande, Raymond H. Ash, Elements of Computer Process Control with Advanced Control Applications, Instrument Society of America,1981.

COURSE ARTICULATION MATRIX

COs	**POs**														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
1.	**2**	**2**	**2**	**2**	**2**	**3**	**3**	**3**							
2.	**3**	**2**	**3**	**2**	**2**	**3**	**3**	**3**							
3.	**3**	**2**	**3**	**2**	**2**	**3**	**3**	**3**							
4.	**2**	**2**	**2**	**2**	**2**	**3**	**3**	**3**							
5.	**3**	**2**	**3**	**3**	**2**	**3**	**3**	**3**							

GR22251 **INTRODUCTION TO RESEARCH METHODOLOGY AND IPR**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:
To impart knowledge on formulation of research problem, research methodology, ethics involved in doing research and importance of IPR protection**.**

UNIT I RESEARCH METHODOLOGY **9**
Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations. Effective literature studies approaches, analysis Plagiarism, Research ethics

UNIT II RESULTS AND ANALYSIS **9**
Importance and scientific methodology in recording results, importance of negative results, different ways of recording, industrial requirement, artifacts versus true results, types of analysis (analytical, objective, subjective) and cross verification, correlation with published results, discussion, outcome as new idea, hypothesis, concept, theory, model etc.

UNIT III TECHNICAL WRITING **9**
Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

UNIT IV INTELLECTUAL PROPERTY RIGHTS **9**
Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

UNIT V PATENT RIGTS AND NEW DEVELOPMENTS IN IPR **9**
Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

TOTAL: 45 PERIODS

OUTCOMES:
Upon successful completion of the course, students should be able to:

1. Critically evaluate any research article based upon research methodology.
2. Correlate the results of any research and develop hypothesis, concept, theory and model.
3. Developing a research proposal, research presentation and review article in the field of engineering.
4. Enumerate the importance of intellectual property right in research.
5. Develop proposal for patent rights and identify the new developments in IPR

TEXT BOOKS:

1. Ranjit Kumar, Research Methodology- A step by step guide for beginners, Pearson Education, Australia, fourth edition, 2014
2. Ann M. Korner, Guide to Publishing a Scientific paper, Bioscript Press 2008
3. T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008

REFERENCES:

1. Kothari, C. R. Research Methodology - Methods and Techniques, New Age International publishers, New Delhi, fourth edition, 2019
2. Stuart Melville and Wayne Goddard, “Research methodology: an introduction for science & engineering students’, Juta & Company, 1996.
3. Robert P. Merges, Peter S. Menell and Mark A. Lemley, “Intellectual Property in New Technological Age”, Aspen Publishers, 2016.

At the end of the course add the Course articulation matrix as per the following format:

COURSE ARTICULATION MATRIX

COs	**POs**														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
1.	3	3	3	2	3	2	2	3	-	2	1	2	3	3	
2.	3	3	3	3	3	1	1	2	2	2	2	2	3	3	
3.	3	3	3	3	3	-	2	3	2	2	3	2	3	3	
4.	2	2	3	2	2	1	-	3	1	2	2	1	2	3	
5.	3	3	3	2	3	2	2	3	2	2	2	2	3	3	

CL22203

CHEMICAL PROCESS DESIGN

L	T	P	C
3	0	0	3

OBJECTIVES:

To impart the knowledge on chemical engineering design of process Equipments

UNIT I DESIGN INFORMATION & FLUID MOVING EQUIPMENTS 10

General sources of physical properties, Accuracy required of engineering data, Prediction of physical properties. Flow of fluids: Properties and units, pipeline networks, optimum pipe diameter, non-Newtonian liquids. Pumps: Type, selection, performance curves, pump efficiency, NPSH, Head calculations, & power calculation. Compressors: Type, selection, performance curves, Head calculations and power calculations.

UNIT II HEAT TRANSFER EQUIPMENTS 10

Process Design of Heat Exchanger: Basic design procedure and theory, Design and sizing of Shell and Tube Heat exchangers with types and arrangements of fluids, plate type heat exchanger.

Mechanical design of heat exchanger: Mechanical design of shell & tube heat exchanger.

Condensers: Heat-transfer fundamentals. Design of vertical and horizontal condensers

Reboilers: Boiling heat-transfer fundamentals, Pool boiling, Convective boiling, Design of forced-circulation reboilers.

UNIT III HEAT TRANSFER EQUIPMENTS 10

Design of evaporator: Introduction, types of evaporators, methods of feeding of evaporators, general design and consideration of evaporator.

UNIT IV PROCESS DESIGN OF MASS TRANSFER COLUMNS 8

Design of driers: Introduction, types driers, design consideration of driers

Design of distillation and absorption column :Packed columns: Types of packing, Packed-bed height, Prediction of the height of a transfer unit (HTU), Column diameter (capacity), Column sizing approximation, Plate contactors and Plate hydraulic design

UNIT V PRESSURE VESSELS 7

Design of Pressure vessels Codes & Standards, selection of material, vessels operating at low temperatures and elevated temperatures, design conditions and stress, design of shell and its components, supports, stress from local loads and thermal gradients, thermal stresses in cylindrical shell.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

1. Impart knowledge on design information and data and Outline the essentials of fluid movers and related items.
2. Instruct the basics of process design of heat transfer equipments.
3. Apply the knowledge on heat transfer equipments.
4. Identify the methods of process design of separation columns.
5. Pertain the mechanical design of Pressure vessels

TEXT BOOKS

1. J.M. Coulson, J. Richardson, "Chemical Engineering", Vol. 6, Asian Books Printers, Fourth edition 2005.
2. M.V. Joshi, V.V. Mahajan, "Design of Process Equipment Design", Third edition, McMillan India, 1996.

REFERENCE BOOKS

1. R.H. Perry, "Chemical Engineers Handbook", Seventh Edition, McGraw Hill, 2004.
2. Brownell and Young, "Process Vessel Design", Wiley Eastern, 2009.
3. Ray Sinnott, Gavin Towler, Chemical Engineering Design - Principles, Practice and Economics of Plant and Process Design, Butterworth-Heinemann, 2007

COs	**POs**														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
1.	**3**	**2**	**3**	**3**	**3**	**2**	**3**	**3**							
2.	**3**	**2**	**3**	**3**	**3**	**2**	**3**	**3**							
3.	**3**	**2**	**3**	**3**	**3**	**2**	**3**	**3**							
4.	**3**	**2**	**3**	**3**	**3**	**2**	**3**	**3**							
5.															

CL22204 SOFTWARE APPLICATIONS IN CHEMICAL INDUSTRIES (INTEGRATED)

L	T	P	C
3	1	2	5

COURSE OBJECTIVES:

1. To introduce the concepts of process plant simulation
2. To familiarize the computer – aided analysis of chemical processes
3. To gain knowledge on the use of Process simulation software
4. To understand the applications of Computational Fluid Dynamics in Chemical Industries
5. To acquaint with the machine learning algorithms and data analytics

UNIT I INTRODUCTION TO PROCESS SIMULATION 18

Introduction to Process Plant Simulation – Applications – Types of Chemical Process Simulators – Information Flow Diagram – Flow Sheeting Approaches – Convergence Analysis – Sensitivity Analysis – Design Specifications

Introduction to simulation software – ASPEN PLUS, HYSYS, MATLAB, ANSYS CFD

UNIT II COMPUTATIONAL FLUID FLOW AND HEAT TRANSFER 18

Governing Equations of Fluid Flow and Heat Transfer – Time Averaged Navier - Stokes Equation - Turbulence models – Finite Difference Approximation – Finite Volume Method – Convection – diffusion problems – Flow field Computation Algorithms – Grid Generations – CFD Simulation of fluid flow and heat transfer using ANSYS

UNIT III PROCESS PLANT SIMULATION USING ASPEN PLUS AND HYSYS 18

Simulation of pumps, compressors, expanders; Heat Exchange equipments – Shortcut and rigorous calculation methods – Process Heat Integration – Energy Analysis – Reactors – Separation columns

UNIT IV DYNAMIC SIMULATION AND OPTIMIZATION 18

Introduction to Dynamic Simulation – Control of distillation columns, pressure relief valves, Flow, level, temperature control

Formulation of Optimization problem – Plant-wide optimization – Non-traditional optimization techniques – Meta - Heuristic Algorithms – simulated annealing – genetic algorithms – differential evolution – Particle Swarm Optimization

UNIT V DATA ANALTYICS AND MACHINE LEARNING 18

Introduction to Machine Learning and Data analytics – Regression Analysis – Classification and Clustering – Support Vector Machines for regression and classification – Application of Artificial Neural Networks in process plant simulation – Neural Network based optimization – Machine Learning algorithms – Industry 4.0

TOTAL: 90 PERIODS

OUTCOMES:

Upon successful completion of the course, students should be able to:

1. Perform computer aided analysis of Chemical Industries
2. Execute steady state and dynamic simulation of process plants
3. Apply Computational Fluid Dynamics software to solve fluid flow and heat transfer problems
4. Formulate and Solve optimization problems using software tools
5. Apply machine learning algorithms in process plant simulation

TEXT BOOKS:

1. I.D. Gil Chaves, "Process Analysis and Simulation in Chemical Engineering", Springer, Switzerland, 2016.
2. Anderson, J. D., "Computational Fluid Dynamics: The Basics with Applications", McGraw Hill, 2012.
3. I.M. Mujtaba and M.A. Hussain, "Application of Neural Networks and other learning technologies in Process Engineering", World Scientific Publishing Company, 2006.
4. T.F. Edgar, D.M. Himmelblau and L.S. Lasdon, **"**Optimization of Chemical Processes", McGraw-Hill, 2001.

REFERENCES:

1. Luyben, W.L., "Process Modelling Simulation and Control", McGraw-Hill Book Co., 1973.
2. Asghar Husain, "Chemical Process Simulation", Wiley, 1986.
3. Juma Haydary, "Chemical Process Design and Simulation: Aspen Plus and Aspen Hysys Applications, Wiley, 2019.
4. B.V. Babu, "Process Plant Simulation", Oxford University Press, 2004.

At the end of the course add the Course articulation matrix as per the following format:

COURSE ARTICULATION MATRIX

COs	POs														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1.	3	2	3	3	2	3	3	3							
2.	3	2	3	3	2	3	3	3							
3.	3	2	3	3	1	3	3	3							
4.	3	2	3	3	2	3	3	3							
5.	3	2	3	3	1	3	3	3							

1-Weak, 2-Medium, 3-strong

CL22211 ADVANCED CHEMICAL ENGINEERING LABORATORY

L	T	P	C
0	0	4	2

COURSE OBJECTIVES:

1. Analyze characteristics of a fluidized bed dryer, compact heat exchangers, electrochemical phenomena such as corrosion.
2. Evaluate the performance of a process intensification in catalytic reactions, ultrasound assisted reactions, reactive distillation column, micro reactor and advanced flow reactor.
3. Design controller for a given process and evaluate the performance of membrane separation process for water purification.

LIST OF LABORATORY EXPERIMENTS

1. Ultrasonic cavitation based reactions
2. Helical Coil heat exchanger
3. Plate Type Heat Exchanger
4. Kinetics for solid catalyzed esterification reaction in a batch reactor
5. Reactive distillation in Packed Column
6. Characteristics of a fluidized bed dryer
7. Advanced Flow Reactor
8. Membrane Separation for water purification
9. Corrosion characteristics of a metal in a given electrolyte
10. Control of liquid level in non-interacting systems.
11. Identification and control of a three tank system.
12. pH control in a process.

TOTAL: 60 PERIODS

OUTCOMES:

Upon successful completion of the course, students should be able to:

1. Evaluate the characteristics of a fluidized bed dryer, compact heat exchangers, electrochemical phenomena such as corrosion.
2. Evaluate the performance of process intensification in various reactors and reactive distillation column.
3. Design controller and determine the performance of membrane separation process for water purification.
4. Identify the use of PID for Control of liquid level in interacting and non-interacting systems
5. Distinguish the corrosion characteristics of a metal in different electrolytes.

COURSE ARTICULATION MATRIX

COs	POs														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1.	3	3	3	3	2	2									
2.	3	3	3	3	2	2									
3.	3	3	3	3	2	2									
4.	3	3	3	3	2	2									
5.	2	3	3	3	2	2									

CLXXXX ELECTROCHEMICAL PROCESSES FOR CLEAN TECHNOLOGY

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

1. To introduce the basic concepts of electrochemical reactor for electrode material synthesis followed by effluent treatment.
2. To enable the students to understand the different types of electrochemical reactor design.
3. To impart knowledge of transport in various membranes and diaphragms.
4. To acquaint the student with the treatment of wastewater containing organic and inorganic compounds using electrochemical processes.
5. To understand the different types of organic electro synthesis, limitations and the scope of electro synthesis.

UNIT I THE ELECTROCHEMICAL CELL AND REACTOR 9

The electrochemical cell, Faraday's Law and current efficiency, Electrode potential and current density, The Electrochemical reactor – Production Capacity, Energy Requirements and Cell Voltage, Temperature Control, Hydrodynamics and mass transport, Reactor Operating Factors. Electrode Materials – Chemical Suitability, Electrode Materials in Synthesis and Effluent treatment.

UNIT II ELECTROCHEMICAL CELL DESIGN AND ENGINEERING 9

Operating Factors in Electrochemical Reactor Design – Modes of Operation, In-cell and Excell Reactions, Recycle Operation, Electrical Power supply, Distribution of Powers in Electrolysers. Cell Design, Design Concepts. Electrochemical Reactor Designs – Parallel Plate. Electrolysers, General Purpose Flow Electrolyser, Other Reactor Design, Reactor Design for Multiphase Reactions. Electrochemical Reactor Analysis, Mass Transport and Reactor Design.

UNIT III ELECTROCHEMICAL MEMBRANE PROCESS 9

Transport in Membranes and Diaphragms- Transport Process in Diaphragms, Membrane and the Transport of Ions. Ion-Selective Membranes in Salt Regeneration, Recycling and Effluent Treatment, Electro hydrolysis, Treatment of Plating Bath Rinse Waters and Waste Streams. Bipolar Membranes, Characteristics of Bipolar Membranes. Electrochemically enhanced Microfiltration and Ultra filtration.

UNIT IV THE TREATMENT OF INDUSTRIAL PROCESS STREAMS AND EFFLUENTS 9

Treatment of Organic Chemicals-Direct Anodic Oxidation, Chlorine and Chlorinated compounds, Indirect Oxidation Process. Treatment of Waste Water Containing Inorganic Compounds- Cyanides and Thiocynates, Chromium Liquors, Sterilisation of Water and Waste. Metal Recovery by Electrode position- Electrode position from Single Metal Ion Solutions, Metal separation from Mixed Metal Ion solutions, Combined Electrochemical Processes.

UNIT V ORGANIC AND INORGANIC ELECTROCHEMICAL SYNTHESIS 9

Types of Organic Electro synthesis, Limitations in Solubility, Indirect electro synthesis, Heterogeneous Redox Catalysis, Electrosorbed hydrogen, Direct electro organic Synthesis, Examples of electro organic Synthesis. Inorganic electrochemical Process- The Electro winning and Refining of Metals, Electrochemical Generation of Arsine, Other Processes, The scope for Inorganic Electro synthesis.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, students should be able to:

1. Understand the basic principles of electrochemistry and electrochemical reactor for electrode material synthesis.
2. Design various electrochemical reactor using various mechanisms and theories of mass transfer.
3. Apply the principles of electrochemistry in mitigating the various membranes and diaphragms.
4. Describe the various electro deposition techniques and electro chemical energy storage systems.
5. Establish the fundamental knowledge of electrodes used in different electrochemical industries and its design.

TEXT BOOKS:

1. Scott. K., "Electrochemical processes for clean technology", Standards media, 1995
2. Goodridge F., Scott K., "Electrochemical Process Engineering. A guide to the design of electrolytic plant", Plenum press, 1995.
3. Cynthia, Zoski. G., "Handbook of electrochemistry", 1st edition, Elsevier science, 2007.
4. Picket, "Electrochemical Engineering", Prentice Hall, 1977.

REFERENCES:

1. Marcel Mulder, "Basic Principles of Membrane Technology", 2nd edition, Kluwer Academic Publishers, 2003.
2. Krishnan Rajeshwar, Jorge G. Ibanez, "Environmental Electrochemistry, Fundamentals and applications in Pollution Abatement", Academic Press, Inc,1997.
3. Scott K., "Electrochemical reaction engineering", London, Academic Press, 1991.

At the end of the course add the Course articulation matrix as per the following format:

COURSE ARTICULATION MATRIX

COs	POs														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1.	3	1	1	2	1	1	3	3							
2.	3	1	2	3	1	1	3	3							
3.	3	0	2	3	2	0	3	3							
4.	2	1	2	3	2	1	3	3							
5.	3	1	2	3	2	0	3	3							

CLXXXX **SOLAR ENERGY ENGINEERING**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

1. To impart knowledge on solar radiation and its measurements.
2. To develop and design an efficient solar energy collector.
3. To design various applications powered by solar energy systems.
4. To understand the basic concept of photo voltaic cell construction.
5. To differentiate the various solar energy storage systems.

UNIT ISOLAR RADIATION AND MEASUREMENTS **9**

Source of radiation – solar constant– solar charts – Measurement of diffuse, global and direct solar radiation: pyrheliometer, pyranometer, pyregeometer, net pyradiometer-sunshine recorder, Solar Energy Industry in India, Advantages of Solar Energy, Solar Energy Potential in Industries.

UNIT IISOLAR ENERGY COLLECTOR SYSTEMS **9**

Solar Non-Concentrating Collectors- Design considerations – Classification air, liquid heating collectors –Derivation of efficiency and testing of flat plate collectors –Analysis of concentric tube collector - Solar green house, Solar space heating and cooling, Solar pumping systems.

UNIT III SOLAR POWERED SYSTEMS **9**

Design – Classification– Concentrator mounting –Focusing solar concentrators Heliostats. Solar powered absorption A/C system, water pump, chimney, drier, dehumidifier, still, cooker, Solar energy applications/solar energy gadgets, Construction details and application of wind mills.

UNIT IV SOLAR PHOTOVOLTAIC SYSTEMS **9**

Photo-voltaic cell – characteristics-cell arrays-power electric circuits for output of solar panels-choppers-inverters-batteries-charge regulators, Construction concepts, Solar photovoltaic systems, solar lantern, solar street lights, solar fencing.

UNIT V ENERGY STORAGE SYSTEMS **9**

Energy Storage -Sensible, latent heat and thermo-chemical storage-pebble bed etc. materials for phase change-Glauber's salt-organic compounds, Solar ponds, Solar grain dryers, solar refrigeration system.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, students should be able to:

1. Gain the knowledge on solar energy radiation, availability, solar energy potential in Industries.
2. Differentiate the design of concentrating and non-concentrating collectors with pumping systems.

3. Design an efficient solar powered gadgets, solar cookers and water heating systems.
4. Perform the calculation, analyse and optimize various parameters associated with the solar energy for a specific geography.
5. Compare the different types of energy storage systems based on transport processes.

TEXT BOOKS:

1. Yogi Goswami D., Frank Kreith, Jan. F. Kreider, "Principles of Solar Engineering", 2nd Edition, Taylor & Francis, 2000, Indian reprint, 2003.
2. Edward E. Anderson, "Fundamentals for solar energy conversion", Addison Wesley Publ. Co., 1983.

REFERENCES:

1. Duffie J. A and Beckman, W. A., "Solar Engineering of Thermal Process", John Wiley, 1991.
2. Tiwari G. N. and Ghosal M. K., "Fundamentals of Renewable energy Sources", Narosa Publishing House, New Delhi, 2007.
3. Shepherd W and Shepherd D. W., "Energy Studies", Second Edition, Imperial College Press, London, 2004.

At the end of the course add the Course articulation matrix as per the following format:

COURSE ARTICULATION MATRIX

COs	POs													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1.	3	1	3	3	3	1	2	2							
2.	3		3	2	3		2	2							
3.	3	1	3	3	3	1	2	2							
4.	2		2	2	3		2	2							
5.	3		3	3	3	1	2	2							

3 – Strong, 2 –Moderate, 1 – Weak

CLXXXX DOWNSTREAM PROCESSES IN PETROLEUM ENGINEERING

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

1. To illustrate the importance of crude oil as source of fuel and the size of refining industry
2. To summarize the various refinery processes and the products along with their specifications
3. To show the challenges involved in refining from viewpoint of economic considerations and environmental regulations.

UNIT I OVERVIEW OF PRODUCTION AND REFINING OF CRUDE OIL 9

Origin, formation, exploration and production of crude oil, Reserves and deposits in the world, Petroleum industry in India, Overall Refinery flow, Petroleum Products.

UNIT II COMPOSITION AND EVALUATION OF CRUDE OIL AND ITS PRODUCTS9

Classification of crude oil, Composition of crude oil, Crude Assay, ASTM/TBP/EFV curves, Specifications and Test methods for: LPG, Naphtha, Gasoline, Kerosene, Diesel, Lube oil, Waxes, Bitumen and Coke.

UNIT III REFINERY PROCESS: DISTILLATION, CRACKING AND CONVERSION9

Desalting of Crude, Preheating Train, Atmospheric Distillation of Crude oil, Vacuum Distillation, Catalytic Cracking, Thermal Cracking - Visbreaking, Fluid Catalytic cracking and Hydrocracking. Hydrocracking, Catalytic Reforming, Alkylation, Isomerization, Hydroprocessing, Hydrotreating, Coking

UNIT IVMANUFACTURE OF LUBE OIL AND BITUMEN 9

Evaluation of crude oils for lube oil base stocks, Lube oil processing, Propane deasphalting, Solvent Extraction, Dewaxing, hydrofining, clay contact process – Production of lubricating oils, Finishing Processes, Lube oil additives, Properties of Bitumen, Methods of Manufacture of Bitumen

UNIT VSUPPORTING PROCESS AND POLLUTION CONTROL IN REFINERIES9

Product Blending, Hydrogen Production, Sulphur Recovery, Control of air and water pollution, solid waste management

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, students should be able to:

1. Demonstrate knowledge on the overall refinery flow and petroleum products.
2. Classify crude oil on the basis of its properties and characterization methods.
3. Identify the specifications required for good quality petroleum product
4. Explain the process of purification and fractionation of lube oil
5. Gain knowledge on the supporting processes and pollution control

TEXT BOOKS:

1. Gary, J.H and Handwerk, G.E., 'Petroleum Refining Technology and Economics', Fourth Edition, Marcel Dekker, Inc. 2001

2. Ram Prasad, ‘Petroleum Refining Technology’, First Edition, Khanna Publishers. 2013

REFERENCES:

1. Bhaskara Rao, B.K, ‘Modern Petroleum Refining Processes’, Fifth Edition, Oxford and IBH Publishing Co. Pvt. Ltd. 2007
2. Fahim, M.A., Alsahhaf, T.A. and Elkilani, A. ‘Fundamentals of Petroleum Refining’, Elsevier, 2010
3. Nelson, N.L. (1985) ‘Petroleum Refinery Engineering’, McGraw Hill Book Co

COURSE ARTICULATION MATRIX

COs	POs														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1.	2	2	2	1	1	1	3	2							
2.	2	2	2	2	1	1	3	2							
3.	2	2	2	2	1	1	3	2							
4.	2	2	2	1	1	1	3	2							
5.	2	2	2	1	1	1	3	2							

CLXXXX **ENVIRONMENTAL ENGINEERING**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

1. To introduce students to Environment friendly chemical processes, unit operations for abatement of water, air and solid pollution.
2. To make students to understand waste recycles methodologies, towards a cleaner environment and also to recover useful products from wastes.

UNIT I ENVIRONMENT AWARENESS **9**

Impact of civilization on Environment, Hazardous Waste Management and Risk Assessment: Types of hazardous Wastes-Health effects -Nuclear fission and radioactive waste treatment and disposal methods. Risk assessment, Environmental Audit.

UNIT II CHEMICAL ENGINEERING PROCESSES **9**

Unit Operations – application of - Abatement of water pollution, Engineered systems for waste water treatment; Current strategies to control air pollution, Control devices for particulate and gaseous contaminants; Solid waste processing techniques and disposal.

UNIT III RECYCLING AND RECOVERYMETHODOLOGY **9**

Economic recovery and recycling of waste; Material Recovery systems, Recovery of biological and thermal conversion products, Energy recovery systems.

UNIT IVCLEAN TECHNOLOGY **9**

Towards Eco- friendly products of chemical industry; Pesticides – Their transfer and Transformation in the environment, Biological and electrochemical technology for effluent treatments, Transport fuel- Bio-fuel for a cleaner environment.

UNIT VPOLLUTION PREVENTION **9**

Mass exchange network synthesis for pollution control and minimization Implications of environmental constraints for process design, policies for regulation of environmental impacts, Concept of common effluent treatment; Environmental legislations, Role of Government and Industries.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, students should be able to:

1. Demonstrate knowledge on the environmental chemical engineering processes.
2. Assess the unit operations required for treatment water, air and solid wastes.
3. Perform hazard and risk analysis and to apply the appropriate recycling methodology.
4. Apply clean technology principles to produce the eco-friendly products from chemical industries.
5. Apply the knowledge to apply the various concepts for the betterment of the environment

TEXT BOOKS:

1. Rao, C.S Environmental Pollution Control Engineering, Wiley- Eastern Ltd. 1991.
2. Peavy H.S. Rowe D.R., and George Environmental Engineering, Mc Graw Hill Book Company, Ny, 1985
3. P. Sincero and G.A. Sincero, Environmental Engineering: A Design Approach Prentice Hall of India Pvt Ltd, New Delhi.1996

REFERENCES:

1. S.P. Mahajan, "Pollution Control in Process Industries", Tata McGraw Hill, New Delhi, 1985 Theodore L and Buomlore A.J Air pollution control equipments. Prentice Hall Inc, NY. 1982.
2. A. K. Shrivastava, “Environment Auditing”, APH Publishing, 2003

COURSE ARTICULATION MATRIX

COs	POs														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1.	2	1	3	1	2	1	1	1							
2.	2	2	3	1	1	2	1	2							
3.	2	2	3	1	2	2	1	2							
4.	2	2	3	1	1	2	1	1							
5.	2	2	3	1	1	2	1	1							

2- Slight (Low), 2- Moderate (Medium) , 3- Substantial (High)

CLXXXX WASTEWATERENGINEERING

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

1. To impart knowledge of waste water source and need for the Treatment
2. To introduce various waste water treatment methods available
3. To acquaint the student with advanced waste water treatment methods
4. To understand the management of residuals from waste water treatment
5. To review different case to mitigate the environmental problems arise in Industries

UNIT I INTRODUCTION 9

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 INDUSTRIALWASTEWATERTREATMENT 9

Equalisation-Neutralisation-Oilseparation-Flotation-Precipitation-HeavymetalRemoval–Refractoryorganicsseparationbyadsorption-Aerobicandanaerobicbiologicaltreatment- Sequencing batch reactors – High Rate reactors.

UNIT III ADVANCEDWASTEWATERTREATMENTANDREUSE 9

Chemicaloxidation-Ozonation-Photocatalysis-WetAirOxidation-Evaporation–Ion Exchange–Membrane Technologies- Nutrient removal - Land Treatment.

UNIT IV RESIDUALSMANAGEMENT 9

Residualsofindustrialwastewatertreatment-QuantificationandcharacteristicsofSludge-Thickening, digestion, conditioning, dewatering and disposal of sludge- Management of RO rejects.

UNIT V CASE STUDIES 9

Industrial manufacturing process description, wastewater characteristics and waste treatment flow sheet for Textiles- Tanneries- Pulp and paper.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, students should be able to:

1. Demonstrate knowledge and understanding of the chemical and biological principles behind unit processes used in wastewater treatment processes.
2. Acquire knowledge on advanced methods of wastewater treatment and to reuse.
3. Design the wastewater treatment plant.
4. Explain the management of residuals from wastewater treatment.
5. Analyze different case studies to mitigate the problems arising in industries

TEXT BOOKS:

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.

REFERENCES:

1. Nelson Leonard Nemerow, Industrial waste treatment-Contemporary practice and vision for the future. Elsevier, Singapore2007
2. Metcalf & Eddy, George Tchobanoglous, Franklin L. Burton& H. David Stensel "Wastewater Engineering: Treatment and Reuse", Fourth Edition, Tata McGraw Hill, 2003.

At the end of the course add the Course articulation matrix as per the following format:

Course Articulation Matrix

COs	**POs**														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
1.	3	2	3	2	1	3	3	3							
2.	3	2	3	2	1	3	3	3							
3.	3	3	3	3	3	3	3	3							
4.	3	2	3	2	1	3	3	3							
5.	3	3	2	3	3	3	3	3							
	3	2.4	2.8	2.4	1.4	3	3	3							

*3 –Strong; 2 – Moderate; 1 - Weak

CLXXXX ELECTROCHEMICALPROCESSFOR CHEMICALENGINEERS

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

1. To acquire the knowledge onfundamentalsofreactionkineticsandthermodynamicsbehaviorofelectrolyticprocesses
2. To understand the basic concept of Heat and Mass Transfer application in Electrochemical Processes
3. To study the rate process to develop the reaction models
4. To understand the reactor dynamics and stability of different reactors.
5. To design and scale up the electrolytic reactor.

UNIT I INTRODUCTIONOFELECTROCHEMICAL ENGINEERING 9

Industrial importance of electrolytic processes, Basic concepts and definitions, Criteria for reactor performance, Electrochemical and catalytic reactions and reactors. Fundamentals of reaction kinetics, rate of electrochemical reaction, electrochemical thermodynamics, practicalcellvoltagerequirementsandpolarization, singleelectrochemicalreactions, potentiostatic operationsoffirstorderreactionandgalvanostaticoperationoffirstorderreactions.

UNIT II MASSAND HEATTRANSFER IN ELECTROLYTICCELL 9

Basic aspects of fluid dynamics, mass transfer- mass flux in a fully developed turbulent regime, entrance and exit effects, obtaining numerical values of mass transfer coefficient by calculation and experiment, mass transfer in two-phase flow, energetic and energy balances, CSTR with general order reactions, effect of mass transport and side reaction.

UNIT III RATEPROCESSESANDREACTIONMODELS 9

Rate processes, kinetics of elementary reactions, reaction mechanism and rate laws, transition state theory, derivation of kinetic relationships, and reaction models.

UNIT IVREACTOR MODELS 9

General considerations, batch reactor and continuous reactor. Fed batch, continuous, cell recycle, plug flow reactor, two stage reactors. Reactor dynamics and stability. Reactors with non-ideal mixing. Other types of reactors- fluidized bed reactors; packed bed reactors, bubble column reactors, trickle bed reactors

UNIT V ELECTROLYTICREACTORDESIGN AND SCALEUP 9

Electrolytic reactor designs, Electrolytic reactor selection, scale up of electrolytic reactors, effect of scale-up on mass transfer, effect of scale-up on current distribution, Multiple electrode models and time factors.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, students should be able to:

1. Illustrate the various reaction kinetics, mass transfer and fluid flow of various electrolytic processes.
2. Infer the concepts in Mass Transfer operations with its applications.
3. Illustrate the different rate processes involved in electrochemical reaction
4. Elaborate the procedure to design and scale up of the electrochemical reactors.
5. Explain the types of fluid flow in electrolytic processes.

TEXT BOOKS:

1. F.Goodridge, K.Scott, Electrochemical process engineering. A guide to the design of electrolytic plant, Plenum Press, 1995.
2. Bockris, John O'M, Bockris, Ralph E. White, B.E. Conway, Modern aspects of electrochemistry,volume28, Plenum Press, New York1985.
3. Newman and Thomas-Alyea, Electrochemical systems, 3rd edition, Wiley & Sons, Hoboken, 2004.

REFERENCES:

1. Pletcher. D and Walsh F.C, Industrial electrochemistry,2nd edition, Chapman and Hall, London, 1990.
2. Hartmut Wendt, Gerhard Kreysa, Electrochemical engineering, Science and technology in Chemical and other industries,Springer,1999.
3. Krishnan Rajeshwar, JORGE G. IBANEZ, Environmental Electrochemistry, Fundamentals

At the end of the course add the Course articulation matrix as per the following format:

Course Articulation Matrix

COs	**POs**														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
1.	3	3	2	2	1	2	3	3							
2.	3	2	2	2	1	1	3	3							
3.	3	3	3	2	2	2	3	3							
4.	3	3	3	3	3	2	3	3							
5.	3	3	2	2	1	1	2	2							

*3 –Strong; 2 – Moderate; 1 - Weak

CLXXXX **PROCESS INTEGRATION**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

1. To introduce to the students, the various opportunities in the process integration in chemical industries.
2. To the make students familiar with the important concepts process integration for heat Recovery/minimization.
3. To get familiarized with case studies.

UNIT I INTRODUCTIONAND APPLICATIONS OF PI **06**

Introduction to process Intensification and Process Integration (PI). Areas of application and techniques available for PI, onion diagram.

UNIT II ONERVIEW OF PINCH TECHNOLOGY **12**

Pinch Technology-an overview: Introduction, Basic concepts, How it is different from energy auditing, Roles of thermodynamic laws, problems addressed by Pinch Technology, Key steps of Pinch Technology: Concept of Tmin , Data Extraction, Targeting, Designing, Optimization Super targeting, Basic Elements of Pinch Technology: Grid Diagram, Composite curve, Problem Table Algorithm, Grand Composite Curve.

UNIT III NETWORK ANALYSIS IN HEAT EXCHNAGER **09**

Heat exchanger networks analysis, Maximum Energy Recovery (MER) networks for multiple utilities and multiple, Chemical Engineering Pre-requisites: Knowledge of basic process design of process equipment. Pinches, design of heat exchanger network.

UNIT IV HEAT INTEGRATION IN UNIT OPERATIONS **09**

Heat integrated distillation columns, evaporators, dryers, and reactors.

UNIT V Z – CASE STUDIES IN PROCESS INTEGRATION **09**

Waste and waste water minimization, flue gas emission targeting, and heat and power Integration. Case studies.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, students should be able to:

1. Compare and contrast the given process for the maximum heat recovery.
2. Explain the opportunities for integration towards high-efficiency energy.
3. Illustrate the various Energy-intensive thermal separation operations (distillation, evaporation) at an industrial process site.
4. Evaluate the process integration measures with respect to energy efficiency, green house gas emissions and economic performance.
5. Identifying the various opportunities for integration of high-efficiency energy

TEXT BOOKS:

1. Shenoy U.V.;"Heat Exchanger Network Synthesis", Gulf Publishing Company, 1995.
2. Smith R.;"Chemical Process Design", McGraw-Hill, New York, 1995

REFERENCES:

1. Linnhoff B., Townsend D. W., Boland D, Hewitt G. F., Thomas B.E.A., Guy A. R., and Marsland R. H.;"A User Guide on Process Integration for the Efficient Uses of Energy", Inst. of Chemical Engineers.

Douglas, J.M., "Conceptual Design of Chemical Process", McGraw Hill, New York, 1988.

At the end of the course add the Course articulation matrix as per the following format:

COURSE ARTICULATION MATRIX

COs	**POs**														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
1.	**3**	**1**	**2**	**1**	**1**	**1**	**2**	**1**							
2.	**3**	**1**	**2**	**2**	**2**	**2**	**1**	**1**							
3.	**3**	**2**	**2**	**2**	**2**	**2**	**2**	**2**							
4.	**3**	**3**	**2**	**2**	**3**	**2**	**1**	**1**							
5.	**3**	**2**	**2**	**2**	**2**	**2**	**2**	**1**							

<Foot Note has to be given about the strength of correlations here>

CLXXXX **GAS TRANSPORTATION**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

Students gain knowledge on

1. Selection of right type of transport
2. Different Types of fluid flow
3. Various types of pipes
4. Pipeline protection techniques and
5. Design of pipeline.

UNIT I **9**

Introduction, widespread use, the various types, the advantages and the special features of pipelines.

UNIT II **9**

The fluid mechanics of various types of pipe flow including incompressible and compressible flows of Newtonian fluids, non-Newtonian fluids, flow of solid/liquid mixture (slurry), flow of solid/air mixture (pneumatic transport), and flow of capsules (capsule pipelines).

UNIT III **9**

Various types of pipes (steel, concrete, PE, PVC, etc.), valves (gate, globe, ball, butterfly, etc.) and pressure regulators in pipelines. Blowers and compressors (for gases). Various kinds of flow meters, sensors, pigs (scrapers) and automatic control systems used in pipelines.

UNIT IV **9**

Various means to protect pipelines against freezing, abrasion and corrosion, such as cathodic protection, Planning, construction and operation of pipelines, including modern use of advanced technologies such as global positioning systems (GPS), directional drillings, automatic control using computers, and pipeline integrity monitoring such as leak detection.

UNIT V **9**

.Structural design of pipelines —load considerations and pipe deformation and failure. Economics of pipelines including life-cycle, Cost analysis and comparison of the cost effectiveness of pipelines with alternative modes of transport such as truck or railroad. Legal, safety and environmental issues about pipelines

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, students should be able to:

1. Choose the right type of transport processes for gases
2. Elaborate the various types of pipes, pipeline protection techniques
3. Design pipeline for gas transportation
4. Enumerate the contribution for field development
5. Illustrate the pipeline integrity and environmental, legal, safety considerations and implications.

TEXT BOOKS:

1. Liu, H., R. L. Gandhi, M. R. Carstens and G. Klinzing, "Freight pipelines: current status and anticipated use,"(Report of American Society of Civil Engineers (ASCE) Task Committee on freight Pipelines), ASCE J. of Transportation Engr., vol. 124, no. 4, pp.300-310, Jul/Aug 1998.
2. Liu, H and T. Marrero, "Pipeline engineering research and education at universitie in the United States," C.D. Proc. of Intl. Conf. on Engr. Education (ICEE-98), Rio de Janeiro Brazil, 15 pages, August 17-20, 1998.

REFERENCES:

1. Oilfield Processing: Crude Oil (Oilfield Processing of Petroleum R. Solvay, Pennwell Books 1995
2. Advances in Environmental Control Technology: Storage Tank Paul Cheremisinoff Gulf Professional Publishing; 1ST edition (May 9, 1996

COURSE ARTICULATION MATRIX

COs	POs													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1.	1	3	1	1	1	3	3	3							
2.	1	3	1	1	1	3	3	3							
3.	3	3	3	2	3	3	3	3							
4.	3	3	3	3	3	3	3	3							
5.	3	3	3	3	3	3	3	3							

CLXXXX ENVIRONMENTALPOLICIES AND LEGISLATION

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

1. To explain the role of law, policy and institutions in the conservation and management of natural resources as well as pollution control.
2. To gain the knowledge about Indian policies and legislations pertaining to prevention and control of water pollution, air pollution and waste management
3. To impart knowledge on Supreme Court judgements in landmark cases of environmental abuse and protection.

UNIT I INTRODUCTION 9

Indian Constitution and Environmental Protection – National Environmental policies- Precautionary Principle and Polluter Pays Principle– Concept of absolute liability–multilateral environmental agreements and Protocols– Montreal Protocol, Kyoto agreement, Rio declaration– Environmental Protection Act, Water (P&CP) Act, Air (P&CP) Act– Institutional framework (SPCB/CPCB/MoEF).

UNIT II WATER (P&CP) ACT, 1974 8

Power & functions of regulatory agencies- responsibilities of Occupier Provision relating to prevention and control Scheme of Consent to establish, Consent to operate–Conditions of the consents– Outlet– Legal sampling procedures, State Water Laboratory–Appellate Authority– Penalties for violation of consent conditions etc. Provisions for closure/directions in apprehended-pollution situation

UNIT III AIR (P&CP) ACT, 1981 8

Power & functions of regulatory agencies-responsibilities of Occupier Provision relating to prevention and control Scheme of Consent to establish, Consent to operate– Conditions of the consents– Outlet– Legal sampling procedures, State Air Laboratory– Appellate Authority– Penalties for violation of consent conditions etc. Provisions for closure/directions in apprehended pollution situation.

UNIT IV ENVIRONMENT (PROTECTION) ACT 1986 13

Genesis of the Act–delegation of powers–Role of Central Government–EIA Notification– Sitting of Industries – Coastal Zone Regulation - Responsibilities of local bodies mitigation scheme etc., for Municipal Solid Waste Management – Responsibilities of Pollution Control Boards under Hazardous Waste rules and that of occupier, authorization– Biomedical waste rules–responsibilities of generators and role of Pollution Control Boards

UNIT V PUBLIC INTEREST AND SUPREME COURT JUDGEMENTS IN LANDMARK CASES 7

Relevant Provisions of Indian Forest Act, Public Liability Insurance Act, CrPC, IPC – Public Interest Litigation - Writ petitions - Supreme Court Judgments in Landmark cases of environmental abuse and protection.

TOTAL: 45 PERIODS

OUTCOMES:

1. To impart the knowledge about the national environmental principles and policies.
2. Elaborate regulatory and legal aspects of Water act and Provisions for closure/directions in apprehended-pollution situation.
3. The importance of regulatory and legal aspects of Air act and Penalties for violation of consent conditions.
4. Explain the environmental protection act and responsibilities of pollution control boards.
5. Compare and contrast the different provisions and judgments towards environmental protection.

TEXT BOOKS:

1. Shyam Divan and Armin Roseneranz “Environmental law and policy in India” Oxford University Press, Second Edition New Delhi, 2002.

REFERENCES:

1. CPCB, “Pollution control acts, Rules and Notifications” issued there under pollution control series-PCL/2/1992, Central Pollution control board, New Delhi, 1997

2. Greger I. McGregor, “Environmental law and enforcement”, First Edition, CRC Press, London, 1994.

COURSE ARTICULATION MATRIX

COs	POs														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
1.	2	2	2	2	2	2	3	3							
2.	3	3	3	3	3	2	3	3							
3.	3	3	3	3	3	2	3	3							
4.	3	3	3	3	3	2	3	3							
5.	2	3	3	2	2	2	3	3							

CLXXXX **BIOPROCESS ENGINEERING**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

1. To learn the principles of bio processing for traditional chemical engineering in the design and development of processes involving biocatalyst.
2. To study engineering principles in the development of products based on living cells or Sub components of such cells.
3. To learn and develop quantitative models and approaches related to bioprocesses.
4. To learn mechanistic models for enzyme catalyzed reactions for large scale production of bioproducts.

UNIT I INTRODUCTION **06**

Biotechnology and bioprocessing. An overview of biological basics. Basics of enzyme and microbial kinetics. Operating considerations for bioreactors: cultivation method, modifying batch and continuous reactors, immobilized cell systems, solid state fermentations.

UNIT II ADVANCE ENZYME KINETICS **10**

Models for complex enzyme kinetics, modeling of effect of pH and temperature, models for insoluble substrate, models for immobilized enzyme systems, diffusion limitations in immobilized enzyme system, electrostatic and steric effects.

UNIT III BIOREACTORS **10**

Selection, scale-up, operation and control of bioreactors: Scale-up and its difficulties, bioreactor instrumentation and control, sterilization of process fluids. Modifications of batch and continuous reactors, chemostat with recycle, multistage chemostat, fed-batch operation, perfusion system, active and passive immobilization of cells, diffusional limitations in the immobilized system, solid state fermenters.

UNIT IV HOMOGENEOUS & HETEROGENEOUS REACTIONS IN BIOPROCESS **10**

Reaction thermodynamics, growth kinetics with Plasmid instability, The Thiele Modulus and effectiveness factor, diffusion and reaction in waste treatment lagoon. Reactors and choice of reactors.

UNIT V RECOVERY & PURIFICATION OF PRODUCTS **09**

Strategies to recover and purify products, separation of insoluble products, cell disruption, separation of soluble products.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, students should be able to:

1. Illustrate the details on different cells and their use in biochemical processes.
2. Identifying the role of enzymes in kinetic analysis of biochemical reaction.
3. Analyze bioreactors, upstream and downstream processes in production of bioproducts

4. Elaborate the mechanistic models for enzyme catalyzed reactions for large scale production of bioproducts.
5. Demonstrate the fermentation process and its products for the latest industrial revolution

TEXT BOOKS:

1. Bailey J.E. and Ollis D.F., “Biochemical Engineering Fundamentals”, McGraw-Hill, 2e, 2017
2. Shuler M.L., Kargi F., ”Bioprocess Engineering”, Prentice –Hall, 1992

REFERENCES:

1. Doran P.M., “Bioprocess Engineering Principles”, Academic Press, 2e, 2012

At the end of the course add the Course articulation matrix as per the following format:

COURSE ARTICULATION MATRIX

COs	**POs**														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
1.	**2**	**1**	**2**	**2**	**2**	**2**	**2**	**2**							
2.	**3**	**1**	**1**	**3**	**2**	**1**	**2**	**2**							
3.	**2**	**1**	**2**	**3**	**2**	**1**	**2**	**2**							
4.	**3**	**2**	**2**	**2**	**2**	**2**	**1**	**2**							
5.	**3**	**2**	**2**	**2**	**1**	**1**	**2**	**2**							

<Foot Note has to be given about the strength of correlations here>