ANNA UNIVERSITY:: CHENNAI 600 025
NON-AUTONOMOUS COLLEGES AFFILIATED TO ANNA UNIVERSITY
REGULATIONS 2021
M.TECH. CHEMICAL ENGINEERING
I TO IV SEMESTERS CURRICULA AND I SEMESTER SYLLABUS

SEMESTER I

SL. NO.	COURSE CODE	COURSE TITLE	CATE-GORY	PERIOD PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	MA4154	Advanced Numerical Methods	FC	4	0	0	4	4
2.	CX4101	Advanced Separation Process	PCC	3	0	0	3	3
3.	CX4102	Fluid Phase Equilibria	PCC	3	0	0	3	3
4.	CX4103	Catalytic Reaction Engineering	PCC	3	1	0	4	4
5.	RM4151	Research Methodology and IPR	RMC	2	0	0	2	2
6.		Professional Elective I	PEC	3	0	0	3	3
7.		Audit Course - I *	AC	2	0	0	2	0
PRACTICALS								
8.	CX4111	Computational Programming Laboratory for Chemical Engineers	PCC	0	0	4	4	2
			TOTAL	**20**	**1**	**4**	**25**	**21**

***Audit course is optional**

SEMESTER II

SL. NO.	COURSE CODE	COURSE TITLE	CATE-GORY	PERIOD PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	CX4201	Chemical Process Design	PCC	3	1	0	4	4
2.	CX4202	Advanced Transport Phenomena	PCC	3	1	0	4	4
3.	CX4203	Advanced Process Control	PCC	3	1	0	4	4
4.	CX4204	Multicomponent Distillation	PCC	3	1	0	4	4
5.		Professional Elective II	PEC	3	0	0	3	3
6.		Professional Elective III	RMC	3	0	0	3	3
7.		Audit Course - II *	AC	2	0	0	2	0
PRACTICALS								
8.	CX4211	Separation Techniques Laboratory	PCC	0	0	4	4	2
9.	CX4212	Seminar	EEC	0	0	2	2	1
			TOTAL	**20**	**4**	**6**	**30**	**25**

***Audit course is optional**

SEMESTER III

SL. NO.	COURSE CODE	COURSE TITLE	CATE-GORY	PERIOD PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	CX4301	Process Modelling and Simulation	PCC	3	1	0	4	4
2.		Professional Elective IV	PEC	3	0	0	3	3
3.		Open Elective	OEC	3	0	0	3	3
PRACTICALS								
4.	CX4311	Project Work I	EEC	0	0	12	12	6
5.	CX4312	Internship	EEC	0	0	0	0	1
			TOTAL	**9**	**1**	**12**	**22**	**17**

SEMESTER IV

Sl. No.	COURSE CODE	COURSE TITLE	CATE GORY	PERIOD PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
PRACTICALS								
1.	CX4411	Project Work II	EEC	0	0	24	24	12
			TOTAL	**0**	**0**	**24**	**24**	**12**

TOTAL NO. OF CREDITS: 75

LIST OF PROFESSIONAL ELECTIVES (PEC)

SEMESTER I, ELECTIVES I

Sl. No.	COURSE CODE	COURSE TITLE	CATE-GORY	PERIOD PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	CX4001	Multiphase Flow	PEC	3	0	0	3	3
2.	CX4002	Environmental Risk Assessment	PEC	3	0	0	3	3
3.	CX4003	Design and Analysis of Experiments	PEC	3	0	0	3	3
4.	CX4004	Electrochemical Process	PEC	3	0	0	3	3

SEMESTER II, ELECTIVE II

SL. NO.	COURSE CODE	COURSE TITLE	CATE-GORY	PERIOD PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	CX4005	Fluidization Engineering	PEC	3	0	0	3	3
2.	CX4006	Energy Management	PEC	3	0	0	3	3
3.	CX4007	Pilot Plant and Scale Up Methods	PEC	3	0	0	3	3
4.	CX4008	Fuel Cell Technology	PEC	3	0	0	3	3

SEMESTER II, ELECTIVE III

Sl. No.	COURSE CODE	COURSE TITLE	CATE-GORY	PERIOD PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	CX4009	Computational Fluid Dynamics	PEC	3	0	0	3	3
2.	CX4010	Remote Sensing and GIS Applications in Environmental Management	PEC	3	0	0	3	3
3.	CX4011	Project Engineering of Process Plants	PEC	3	0	0	3	3
4.	CX4012	Process Intensification	PEC	3	0	0	3	3
5.	CX4013	Membrane Technology for Water and Wastewater	PEC	3	0	0	3	3

SEMESTER III, ELECTIVE IV

Sl. No.	COURSE CODE	COURSE TITLE	CATE-GORY	PERIOD PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	CX4014	Gas Transportation	PEC	3	0	0	3	3
2.	CX4015	Green Chemistry and Engineering	PEC	3	0	0	3	3
3.	CX4016	Environmental Sustainability	PEC	3	0	0	3	3
4.	CX4017	Process Optimization	PEC	3	0	0	3	3
5.	CX4018	Polymer Technology	PEC	3	0	0	3	3
6.	CX4019	Nanotechnology	PEC	3	0	0	3	3

AUDIT COURSES - I

REGISTRATION FOR ANY OF THESE COURSES IS OPTIONAL TO STUDENTS

Sl. No.	COURSE CODE	COURSE TITLE	CATE-GORY	PERIOD PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	AX4091	English for Research Paper Writing	AC	2	0	0	0	0
2.	AX4092	Disaster Management	AC	2	0	0	0	0
3.	AX4093	Constitution of India	AC	2	0	0	0	0
4.	AX4094	நற்றமிழ் இலக்கியம்	AC	2	0	0	0	0

MA4154 ADVANCED NUMERICAL METHODS

L	T	P	C
4	0	0	4

COURSE OBJECTIVES :

- To study various numerical techniques to solve linear and non-linear algebraic and transcendental equations.
- To compare ordinary differential equations by finite difference and collocation methods.
- To establish finite difference methods to solve Parabolic and hyperbolic equations.
- To establish finite difference method to solve elliptic partial differential equations.
- To provide basic knowledge in finite elements method in solving partial differential equations.

UNIT I ALGEBRAIC EQUATIONS 12

Systems of linear equations : Gauss elimination method – Pivoting techniques – Thomas algorithm for tri diagonal system – Jacobi, Gauss Seidel, SOR iteration methods – Conditions for convergence - Systems of nonlinear equations : Fixed point iterations, Newton's method, Eigenvalue problems : Power method and Given's method.

UNIT II ORDINARY DIFFERENTIAL EQUATIONS 12

Runge - Kutta methods for system of IVPs – Numerical stability of Runge - Kutta method – Adams - Bashforth multistep method, Shooting method, BVP : Finite difference method, Collocation method and orthogonal collocation method.

UNITIII FINITE DIFFERENCE METHOD FOR TIME DEPENDENT PARTIAL DIFFERENTIAL EQUATIONS 12

Parabolic equations : Explicit and implicit finite difference methods – Weighted average approximation - Dirichlet's and Neumann conditions – Two dimensional parabolic equations – ADI method : First order hyperbolic equations – Method of numerical integration along characteristics – Wave equation : Explicit scheme – Stability.

UNIT IV FINITE DIFFERENCE METHODS FOR ELLIPTIC EQUATIONS 12

Laplace and Poisson's equations in a rectangular region : Five point finite difference schemes, Leibmann's iterative methods, Dirichlet's and Neumann conditions – Laplace equation in polar coordinates : Finite difference schemes – Approximation of derivatives near a curved boundary while using a square mesh.

UNIT V FINITE ELEMENT METHOD 12

Basics of finite element method : Weak formulation, Weighted residual method – Shape functions for linear and triangular element – Finite element method for two point boundary value problems, Laplace and Poisson equations.

TOTAL : 60 PERIODS

COURSE OUTCOMES :

After completing this course, students should demonstrate competency in the following skills:

- Solve an algebraic or transcendental equation, linear system of equations and differential equations using an appropriate numerical method.
- Solving the initial boundary value problems and boundary value problems using finite difference and finite element methods.
- Solving parabolic and hyperbolic partial differential equations by finite difference methods.
- Compute solution of elliptic partial differential equations by finite difference methods.
- Selection of appropriate numerical methods to solve various types of problems in engineering and science in consideration with the minimum number of mathematical operations involved, accuracy requirements and available computational resources.

REFERENCES :

1. Burden, R.L., and Faires, J.D., “Numerical Analysis – Theory and Applications”, 9th Edition, Cengage Learning, New Delhi, 2016.
2. Gupta S.K., “Numerical Methods for Engineers”,4th Edition, New Age Publishers, 2019.
3. Jain M. K., Iyengar S. R., Kanchi M. B., Jain, “Computational Methods for Partial Differential Equations”, New Age Publishers ,1993.
4. Sastry, S.S., “Introductory Methods of Numerical Analysis”, 5th Edition, PHI Learning, 2015.
5. Saumyen Guha and Rajesh Srivastava, “Numerical methods for Engineering and Science”, Oxford Higher Education, New Delhi, 2010.
6. Smith, G. D., "Numerical Solutions of Partial Differential Equations: Finite Difference Methods", Clarendon Press, 1985.

CX4101 ADVANCED SEPARATION PROCESS L T P C
3 0 0 3

COURSE OBJECTIVES:

- To learn about the different separation processes available.
- To make the students understand the fundamental concepts behind the various separation processes.

UNIT I GENERAL 12

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, siroflocfilter.

UNIT II MEMBRANE SEPARATIONS 8

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, nano-filtration, ultrafiltration, microfiltration and Donnan dialysis ,economics of membrane operations ,ceramic membranes.

UNIT III SEPARATION BY ADSORPTION TECHNIQUES 8

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 dielectrophoresis, Ion Exchange chromatography and electrodialysis, Commercial processes

UNIT IV IONIC SEPARATION 8

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

UNIT V OTHER TECHNIQUES 9

Separations involving lyophilization, pervaporation and permeation techniques for solids, liquids and gases, industrial viability and examples, zone melting, addictive crystallization, other separation processes, supercritical fluid extraction, oils pill management, industrial effluent treatment by modern techniques.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

- The students will understand the importance of separation processes and its applications.
- The students will be in a position to select the best separation process for a given problem.

REFERENCES:

1. Humphrey,J and G.Keller, Separation ProcessTechnology,McGraw-Hill,1997
2. King,C.J.,—SeparationProcesses‖,TataMcGrawHillCo.,Ltd.,1982.
3. Nakagawal,O.V.,—Membrane Science and Technology ‖,MarcelDekker,1992.
4. Rousseau, R. W., —Handbook of Separation Process Technology ‖, John Wiley,
5. NewYork,1987.

CX4102 FLUID PHASE EQUILIBRIA L T P C
3 0 0 3

COURSE OBJECTIVES:

- To impart knowledge on equilibrium and transport properties of fluids, solids, and interfaces, physical/ phase and chemical equilibria; fundamental thermodynamic relations; and stability.

UNIT I BASIC CONCEPTS 9

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

UNIT II STABILITY AND PHASE TRANSITION 9

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 MULTICOMPONENT MIXTURES 9

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 PHASE EQUILIBRIUM 9

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

UNITV CHEMICAL EQUILIBRIUM 9

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

TOTAL:45 PERIODS

COURSE OUTCOME:

- Students would have gained knowledge on equilibrium an non equilibrium thermo physical properties of fluids, solids and interfaces.

REFERENCES

1. Prausnitz, J.M., Lichten thaler R.M. and Azevedo, E.G.,Molecular thermo dynamics of fluid-phase Equilibria,3rd Edn, Prentice Hall Inc., New Jersey,1999.
2. Rao., Y.V.C., Chemical Engineering Thermodynamics, University Press, Hyderabad,2005
3. Tester, J. W. and M. Modell, Thermodynamics and Its Applications. 3rd Edn. Prentice Hall, New Jersey,1997.
4. Stanely M. Walas., - Phase Equilibria in Chemical Engineering, Butterworth Publishers., 1985.
5. Mats Hillert.,- Phase Equilibria, Phase Diagrams and Phase transformations., 2nd Edn., Cambridge University Press., 2007

CX4103 CATALYTIC REACTION ENGINEERING L T P C
3 1 0 4

COURSE OBJECTIVE:

- To impart knowledge on different types of chemical reactors, the design of chemical reactors under isothermal and non-isothermal conditions

UNIT I CATALYSTANDITSCHARACTERIZATION 12

General definition of catalysts, Design for catalysts — Primary constituents, secondary constituents; Catalyst supports. Methods of determining catalysts activity — static methods, Study of structure 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 10

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

UNIT III TRANSPORT PROCESSES WITH REACTIONS CATALYZED BY SOLIDS 12

Reaction of a component of a fluid at the surface of a solid. Mass and heat transfer resistances. Molecular-,Knudsen ,and surface diffusion in pores. Diffusion and reaction in a catalyst particle. Influence of diffusion limitations on the selectivity's of coupled reactions. Criteria for the importance of intra-particle diffusion limitations. Multiplicity of steady states in catalyst particles. Diagnostic experimental criteria for the absence of internal and external mass transfer limitations. Non isothermal particles.

UNIT IV CATALYST DEACTIVATION 10

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

UNITV THE MODELING OF CHEMICAL REACTORS. 16

Approach. Aspects of Mass-, Heat- and Momentum Balances. Fixed bed catalytic reactors. Design and Modeling of Fixed Bed Reactors. Pseudo-homogeneous Models-The Basic One-Dimensional Model. One-Dimensional Model with Axial Mixing. Two-Dimensional Pseudo- homogeneous Models.One-Dimensional Model Accounting for Interfacial and Intra-particle Gradients. Two-Dimensional Heterogeneous Models. Fluidized bed and transport reactors- Introduction. Technological Aspects of Fluidized Bed and Riser Reactors. Some Features of the Fluidization and Transport of Solids. Heat Transfer in Fluidized Beds. Modeling of Fluidized Bed Reactors. Modeling of a Transport of Riser Reactor. Catalytic Cracking of Vacuum GasOil.

TOTAL : 60 PERIODS

COURSE OUTCOME:

- Students would have gained knowledge on the selection of the reactor for the reaction and its design

REFERENCES:

1. An Introduction to Chemical Engineering Kinetics& Reactor Design,CharlesG.Hill,Jr.,John Wiley &Sons,177.
2. Chemical Reaction Engineering, Octave Leven Spiel, John Wiley & Sons,3rd Edition,1999.
3. Chemical Reactor Analysis and Design, GilbertF. Froment and Kenneth Bischoff, John Wiley &Sons,2ndEdition, 1990.
4. Elements of Chemical Reaction Engineering, H.Scott Fogler, Prentice Hall International Series,3rdEdition,2000.
5. Fundamentals of Chemical Reaction Engineering, Mark E. Davis and Robert J.Davis,McGrawHill,2003.

RM4151 RESEARCH METHODOLOGY AND IPR L T P C
2 0 0 2

UNIT I RESEARCH DESIGN 6

Overview of research process and design, Use of Secondary and exploratory data to answer the research question, Qualitative research, Observation studies, Experiments and Surveys.

UNIT II DATA COLLECTION AND SOURCES 6

Measurements, Measurement Scales, Questionnaires and Instruments, Sampling and methods. Data - Preparing, Exploring, examining and displaying.

UNIT III DATA ANALYSIS AND REPORTING 6

Overview of Multivariate analysis, Hypotheses testing and Measures of Association. Presenting Insights and findings using written reports and oral presentation.

UNIT IV INTELLECTUAL PROPERTY RIGHTS 6

Intellectual Property – The concept of IPR, Evolution and development of concept of IPR, IPR development process, Trade secrets, utility Models, IPR & Bio diversity, Role of WIPO and WTO in IPR establishments, Right of Property, Common rules of IPR practices, Types and Features of IPR Agreement, Trademark, Functions of UNESCO in IPR maintenance.

UNIT V PATENTS 6

Patents – objectives and benefits of patent, Concept, features of patent, Inventive step, Specification, Types of patent application, process E-filling, Examination of patent, Grant of patent, Revocation, Equitable Assignments, Licences, Licensing of related patents, patent agents, Registration of patent agents.

TOTAL : 30 PERIODS

REFERENCES

1. Cooper Donald R, Schindler Pamela S and Sharma JK, “Business Research Methods”, Tata McGraw Hill Education, 11e (2012).
2. Catherine J. Holland, “Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets”, Entrepreneur Press, 2007.
3. David Hunt, Long Nguyen, Matthew Rodgers, “Patent searching: tools & techniques”, Wiley, 2007.
4. The Institute of Company Secretaries of India, Statutory body under an Act of parliament, “Professional Programme Intellectual Property Rights, Law and practice”, September 2013.

CX4111 COMPUTATIONAL PROGRAMMING LABORATORY FOR CHEMICAL ENGINEERS L T P C
0 0 4 2

COURSE OBJECTIVE:

To give the students an understanding the fundamentals concepts in mathematics, problems solving and computer programming.

SUGGESTEDEXERCISES

1. Equations of state using Newton‘s method
2. Regression for parameter estimation using a set of data points
3. Equilibrium flash distillation(Multicomponent Ideal)
4. Batch Reactor
5. CSTR in Series Stagewise contacting equipment

6. Solving a simple flow sheet by simultaneous approach
7. Simulation of batch Distillation (binary ideal).
8. Gravity Flow Tank
9. Heat Exchanger
10. Plug Flow Reactor
11. Absorber

Specific examples in ASPEN/HYSYS/MATLAB/EXCEL

1. Solving equation of state, regression of parameters using EXCEL/MATLAB
2. CalculationofReynoldsnumber,frictionfactorandpressuredropusingEXCEL/MATLAB
3. Calculation of heat transfer coefficient in a Heat Exchanger using EXCEL/MATLAB
4. CalculationofminimumRefluxratioforbinary/tertiarysysteminafractionatorsusing

EXCEL/ MATLAB

5. Calculation of HTU and NTU in a Absorber using EXCEL/MATLAB
6. Calculation of Antoine‘s coefficient using EXCEL/MATLAB
7. EstimationofsettlingvelocityofsolidsinliquidsusingStoke‘slawusingEXCEL/MATLAB
8. CalculationofminimumnumberofstagesinadistillationcolumnusingEXCEL/MATLAB
9. Solving mass and energy balance problems using EXCEL/MATLAB
10. Calculation of Power in Reciprocating compressor using EXCEL/MATLAB
11. Steady state simulation of Heat Exchanger using ASPENPLUS/ HYSYS
12. Steady state simulation of a CSTR using ASPENPLUS/HYSYS
13. Steady state simulation of Flash vessel using ASPEN PLUS/HYSYS
14. Steady state simulation of Distillation Column using ASPENPLUS/HYSYS
15. Steady state simulation of an Absorption column using ASPENPLUS/HYSYS
16. Dynamic simulation of Heat Exchanger using ASPENPLUS/ HYSYS
17. Dynamic simulation of a CSTR using ASPENPLUS/HYSYS
18. Dynamic simulation of Flash vessel using ASPENPLUS/HYSYS
19. Dynamic simulation of Distillation Column using ASPENPLUS/HYSYS
20. Dynamic simulation of an Absorption column using ASPENPLUS/HYSYS
21. Developing Heat and Mass balance diagram using ASPEN PLUS/ HYSYS

LIST OF EQUIPMENTS FOR A BATCH OF 18 STUDENTS:

- Standalone desktops/serverwithrespectivesimulationsoftwares18Nos.
- Softwares
- MATLAB Single user license
- Open source office
- Open source chemical engineering simulation software.

TOTAL:60 PERIODS

COURSE OUTCOME:

- Students will be equipped with the software applications and the numerical solutions of chemicalengineeringproblems.Minimum10experiments to be offered

REFERENCES:

1. Bequette.B.W,—ProcessDynamics‖:Modelling,AnalysisandSimulation,‖PrenticeHall(1998)
2. Himmelblau.D.M.andBischoff.K.B,—ProcessAnalysisandSimulation‖,Wiley,1988.
3. Strang.G.,‖Introduction to Linear Algebra‖, Cambridge Press, 4th edition, 2009.
4. William. Luyben,—Process Modelling, simulation and control for Chemical Engineers,2nd Edn.,McGra w Hill International Editions, New York, 1990
5. Chapra.S.C. and Canale.R.P. —Numerical Methods for Engineers ‖,McGraw Hill,2001

CX4001 **MULTIPHASE FLOW** **L T P C**
3 0 0 3

COURSE OBJECTIVE:

- To understand the concepts of multiphase flow and particle interaction.

UNIT I CHARACTERISTICS OF MULTIPHASE FLOWS 9

Significance of multiphase flows, important non-dimensional numbers, parameters of characterization, particle size measurement, size distribution and moments, size distribution models

UNIT II PARTICLE FLUID INTERACTION 9

Equation of motion for a single particle, calculation of drag, motion of a particle in two dimensions, effects of unsteady and non-uniform flow fields, effect of acceleration, effect ofcoupling;Interactionbetweenparticles,mechanismofinteraction,interparticle forces, hard sphere model, soft sphere model, discrete element modeling, semi-empirical methods, kinetic theory, force chains.

UNIT III MODELING OF MULTIPHASE FLOWS 9

Flow patterns - identification and classification - flow pattern maps and transition – momentum and energy balance - homogeneous and separated flow models - correlations for use with homogeneous and separated flow models - void fraction and slip ratio correlations - influence of pressure gradient - empirical treatment of two phase flow - drift flux model - correlations for bubble, slug and annular flows

UNIT IV CONSERVATION EQUATIONS 9

Averaging procedures - time, volume, and ensemble averaging, quasi-one-dimensional flow, two-fluid volume-averaged equations of motion, turbulence and two-way coupling.

UNITV MULTIPHASE SYSTEMS 9

Flow regime and hydrodynamic characteristics of packed bed, fluidized bed, pneumatic conveying, bubble column, trickle beds; Conventional and novel measurement techniques formultiphasesystemsincludingCARPT,LaserDoppleranemometry,ParticleImageVelocimetry.

TOTAL: 45 PERIODS

COURSE OUTCOME:

- The students will understand he importance and analysis of multiphase flow.

REFERENCES

1. Clift, R., Weber, M.E. and Grace, J.R., Bubbles, Drops, and Particles, Academic Press, NewYork,2005.
2. Crowe, C. T., Sommerfeld, M. and Tsuji, Y., Multiphase Flows with Droplets and Particles, CRC Press,2011
3. Fan,L.S.and Zhu,C.,Principles of Gas-solid Flows, Cambridge University Press, 2005
4. Govier, G. W. and Aziz. K., ―The Flow of Complex Mixture in Pipes‖, Van Nostrand Reinhold, New York,1972.
5. Kleinstreuer,C.,Two-phaseFlow:TheoryandApplications,Taylor&Francis,2003
6. Rhodes,M.,IntroductiontoParticleTechnology,JohnWiley&Sons,NewYork.2008.
7. Wallis,G.B.,―OneDimensional TwoPhaseFlow‖,McGrawHillBookCo.,NewYork,

CX4002 **ENVIRONMENTAL RISK ASSESMENT** **L T P C**
3 0 0 3

COURSE OBJECTIVE:

- Develop a basic understanding of environmental health and risk assessment and its role within the risk management process.
- To learn about different risk assessment formats and their use in environmental health studies
- To learn about the different models for environmental risk assessment studies.

UNIT I

Risk analysis introduction, quantitative risk assessment, rapid risk analysis – comprehensive risk analysis–identification, evaluation and control of risk

UNIT II

Risk assessment – introduction and available methodologies, Risk assessment steps, Hazard identification, Hazard assessment (consequence analysis), probabilistic hazard assessment(Fault tree analysis)

UNIT III

Overall risk contours for different failure scenarios – disaster management plan –emergency planning – onsite and offsite emergency planning, risk management ISO 14000, EMS models – case studies–marketing terminal gas processing complex.

UNIT IV

Safety measures design in process operations. Accidents modeling–release modeling, toxic release and dispersion modeling, fire and explosion modeling.

UNIT V

Past accident analysis: Flux borough – Mexico – Bhopal analysis. Government policies to manage environmental risk

TOTAL: 45 PERIODS

COURSE OUTCOMES:

- Students will gain the knowledge and understanding of the methods and processes employed inenvironmental health and risk assessment.
- They will use different tools to aid the risk assessment analysis.
- They will gain the knowledge on environmental laws and regulations to develop guidelines,procedures and processes for health and safety issues.
- They will use epidemiological data and to analyze the various methods of risk assessment.

REFERENCES:

1. Crowl, D.A and Louvar, J.F., Chemical process saftery; Fundamentals with applications, prentice hall publication inc.,2002.
2. Houstan,H.B.,Process safety analysis, Gulf publishingcompany,1997
3. Khan, F.I and Abbasi, S.A., Risk assessment of chemical process industries; Emerging Technologies, Discovery publishing house, New Delhi, 1999

CX4003 DESIGN AND ANALYSIS OF EXPERIMENTS L T P C
3 0 0 3

COURSE OBJECTIVES:

- To impart basic knowledge on statistical design of experiments.
- To learn about various methods employed for the design of experiments.

UNIT I CONCEPTS AND TERMINOLOGY 5

Review of hypothesis testing—PValue,– tllVspaired– tlltest, simple comparative experiment, planning of experiment — steps. Terminology - factors, levels, variables, Design principles– replication, randomization, blocking, confounding, Analysis of variance, sum of squares, degrees of freedom.

UNIT II SINGLE FACTOR EXPERIMENTS 10

Completely randomized design, Randomized block design, effect of coding the observations, Latin Square design, orthogonal contrasts, comparison of treatment means — Duncan's multiplerangetest, Newman-Keuel'stest,Fisher's LS Dtest,Tukey'stest.

UNIT III FACTORIAL EXPERIMENTS 10

Main and interaction effects, Rules for sum of squares and expected mean square, two. And three factor full factorial design,2kdesigns with two and three factors, Yate's algorithm, practical applications

UNIT IV SPECIAL EXPERIMENTAL DESIGNS 10

Blocking and confounding in 2k design, nested design, split – plot design, two level fractional factorial design, fitting regression models, introduction to response surface methods- Central composite design.

UNIT V TAGUCHITECHNIQUES 10

Introduction, Orthogonal designs, data analysis using ANOVA and response graph, parameter design– noise factors, objective functions(S/Nratios), multi- level factor OA designs, applications.

TOTAL: 45PERIODS

COURSE OUTCOMES:

- The students will be in a position to solve problems involving many factors.
- Be familiar with statistical tools for environmental applications

REFERENCES:

1. Angela M. Dean and Daniel Voss, Design and Analysis of Experiments, Springer texts in Statistics, 2000.
2. Douglus C. Montgomery, Design and Analysis of Experiments, John Wiley & Sons,2005
3. PhilipJ. Ross, Taguchi Techniques for Quality Engineering, Prentice Hall, 1989.

CX4004 ELECTRO CHEMICAL PROCESS L T P C
3 0 0 3

COURSE OBJECTIVES:

- To make students understand about the principles behind the electro Chemical process In reactors

UNIT I INTRODUCTION OF ELECTROCHEMICAL PROCESS 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, practical cell voltage requirements and polarization, single electrochemical reactions, potentiostatic operations of first order reaction and galvano static operation of first order reactions.

UNIT II ASPECTS OF MASS AND HEAT TRANSFER IN ELECTROLYTIC CELL SYSTEMS 9

Basic aspects of fluid dynamics, mass transfer-mass flux in a fully developed turbulent regime,entranceandexiteffects,obtainingnumericalvaluesofmasstransfercoefficientbycalculationand experiment,mass transfer in two phase flow, energetic and energy balances, CSTR withgeneral order reactions, effect of mass transport and side reaction.

UNIT III RATEPROCESSES ANDREACTIONMODELS 9

Rate processes, kinetics of elementary reactions, reaction mechanism and rate laws, transitionstatetheory,derivationofkineticrelationships,reactionmodels.

UNIT IV REACTORMODELS 9

General considerations, batch reactor and continuous reactor. Fed batch, continuous, cell recycle, plug flowreactor, 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 ELECTROLYTIC REACTOR DESIGN, SELECTION 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

COURSE OUTCOMES:

After completing the course, student should have learnt

- Fundamentals of electrochemical process and types of reactors
- Kinetics and design of electrochemical reactors

REFERENCES:

1. F.Goodridge, K.Scott, Electrochemical Process Engineering. A guide to the design of electrolytic plant,PlenumPress,1995.
2. Bockris, John O'M, Bockris, RalphE. White, B.E.Conway, Modern aspects of electro chemistry, volume 28 ,Plenum Press, New York1985.
3. Newman and Thomas Alyea, Electrochemical systems,3rd edition, Wiley & Sons, Hoboken, 2004.
4. Pletcher. D and Walsh F.C,Industrialelectrochemistry,2nd edition, Chapman and Hall, London,1990.
5. HartmutWendt,GerhardKreysa, Electro chemical engineering, Science and technology in chemical land other industries,Springer,1999.
6. Krishnan Rajeshwar, Jorge G. Ibanez, Environmental Electrochemistry, Fundamentals and applications in Pollution Abatement, Academic Press,Inc,1997

AUDIT COURSES

AX4091 ENGLISH FOR RESEARCH PAPER WRITING L T P C
2 0 0 0

COURSE OBJECTIVES:

- Teach how to improve writing skills and level of readability
- Tell about what to write in each section
- Summarize the skills needed when writing a Title
- Infer the skills needed when writing the Conclusion
- Ensure the quality of paper at very first-time submission

UNIT I INTRODUCTION TO RESEARCH PAPER WRITING 6

Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness

UNIT II PRESENTATION SKILLS 6

Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts, Introduction

UNIT III TITLE WRITING SKILLS 6

Key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check

UNIT IV RESULT WRITING SKILLS 6

Skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions

UNIT V VERIFICATION SKILLS 6

Useful phrases, checking Plagiarism, how to ensure paper is as good as it could possibly be the first- time submission

TOTAL: 30 PERIODS

COURSE OUTCOMES:

CO1 –Understand that how to improve your writing skills and level of readability
CO2 – Learn about what to write in each section
CO3 – Understand the skills needed when writing a Title
CO4 – Understand the skills needed when writing the Conclusion
CO5 – Ensure the good quality of paper at very first-time submission

REFERENCES:

1. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011
2. Day R How to Write and Publish a Scientific Paper, Cambridge University Press 2006
3. Goldbort R Writing for Science, Yale University Press (available on Google Books) 2006
4. Highman N, Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book 1998.

AX4092 **DISASTER MANAGEMENT** **L T P C**
2 0 0 0

COURSE OBJECTIVES:

- Summarize basics of disaster
- Explain a critical understanding of key concepts in disaster risk reduction and humanitarian response.
- Illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
- Describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
- Develop the strengths and weaknesses of disaster management approaches

UNIT I INTRODUCTION 6

Disaster: Definition, Factors and Significance; Difference between Hazard And Disaster; Natural and Manmade Disasters: Difference, Nature, Types and Magnitude.

UNIT II REPERCUSSIONS OF DISASTERS AND HAZARDS 6

Economic Damage, Loss of Human and Animal Life, Destruction Of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts.

UNIT III DISASTER PRONE AREAS IN INDIA 6

Study of Seismic Zones; Areas Prone To Floods and Droughts, Landslides And Avalanches; Areas Prone To Cyclonic and Coastal Hazards with Special Reference To Tsunami; Post-Disaster Diseases and Epidemics

UNIT IV DISASTER PREPAREDNESS AND MANAGEMENT 6

Preparedness: Monitoring Of Phenomena Triggering a Disaster or Hazard; Evaluation of Risk: Application of Remote Sensing, Data from Meteorological And Other Agencies, Media Reports: Governmental and Community Preparedness.

UNIT V RISK ASSESSMENT 6

Disaster Risk: Concept and Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. Techniques of Risk Assessment, Global Co-Operation in Risk Assessment and Warning, People's Participation in Risk Assessment. Strategies for Survival

TOTAL : 30 PERIODS

COURSE OUTCOMES:

CO1: Ability to summarize basics of disaster
CO2: Ability to explain a critical understanding of key concepts in disaster risk reduction and humanitarian response.
CO3: Ability to illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
CO4: Ability to describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
CO5: Ability to develop the strengths and weaknesses of disaster management approaches

REFERENCES:

1. Goel S. L., Disaster Administration And Management Text And Case Studies",Deep & Deep Publication Pvt. Ltd., New Delhi,2009.
2. NishithaRai, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'NewRoyal book Company,2007.
3. Sahni, PardeepEt.Al. ," Disaster Mitigation Experiences And Reflections", Prentice Hall OfIndia, New Delhi,2001.

AX4093 **CONSTITUTION OF INDIA** **L T P C**
2 0 0 0

COURSE OBJECTIVES:

Students will be able to:

- Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.
- To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional
- Role and entitlement to civil and economic rights as well as the emergence nation hood in the early years of Indian nationalism.
- To address the role of socialism in India after the commencement of the Bolshevik Revolutionin1917and its impact on the initial drafting of the Indian Constitution.

UNIT I HISTORY OF MAKING OF THE INDIAN CONSTITUTION

History, Drafting Committee, (Composition & Working)

UNIT II PHILOSOPHY OF THE INDIAN CONSTITUTION

Preamble, Salient Features

UNIT III CONTOURS OF CONSTITUTIONAL RIGHTS AND DUTIES

Fundamental Rights, Right to Equality, Right to Freedom, Right against Exploitation, Right to Freedom of Religion, Cultural and Educational Rights, Right to Constitutional Remedies, Directive Principles of State Policy, Fundamental Duties.

UNIT IV ORGANS OF GOVERNANCE

Parliament, Composition, Qualifications and Disqualifications, Powers and Functions, Executive, President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualifications, Powers and Functions.

UNIT V LOCAL ADMINISTRATION

District's Administration head: Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative, CEO, Municipal Corporation. Pachayati raj: Introduction, PRI: Zila Pachayat. Elected officials and their roles, CEO Zila Pachayat: Position and role. Block level: Organizational Hierarchy(Different departments), Village level:Role of Elected and Appointed officials, Importance of grass root democracy.

UNIT VI ELECTION COMMISSION

Election Commission: Role and Functioning. Chief Election Commissioner and Election Commissioners – Institute and Bodies for the welfare of SC/ST/OBC and women.

TOTAL: 30 PERIODS

COURSE OUTCOMES:

Students will be able to:

- Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
- Discuss the intellectual origins of the framework of argument that informed the conceptualization
- of social reforms leading to revolution in India.
- Discuss the circumstances surrounding the foundation of the Congress Socialist Party[CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
- Discuss the passage of the Hindu Code Bill of 1956.

SUGGESTED READING

1. The Constitution of India,1950(Bare Act),Government Publication.
2. Dr.S.N.Busi, Dr.B. R.Ambedkar framing of Indian Constitution,1st Edition, 2015.
3. M.P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis,2014.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

AX4094	நற்றமிழ்இலக்கியம்	L T P C 2 0 0 0

UNIT I **சங்க இலக்கியம்** **6**

1. தமிழின்துவக்கநூல்தொல்காப்பியம்
   – எழுத்து, சொல், பொருள்
2. அகநானூறு(82)
   - இயற்கைஇன்னிசைஅரங்கம்
3. குறிஞ்சிப்பாட்டின்மலர்க்காட்சி
4. புறநானூறு(95,195)
   - போரைநிறுத்தியஔவையார்

UNIT II **அறநெறித்தமிழ்** **6**

1. அறநெறிவகுத்ததிருவள்ளுவர்
   - அறம்வலியுறுத்தல், அன்புடைமை, ஒப்புறவுஅறிதல், ஈகை, புகழ்
2. பிறஅறநூல்கள்- இலக்கியமருந்து
– ஏலாதி, சிறுபஞ்சமூலம், திரிகடுகம், ஆசாரக்கோவை
(தூய்மையைவலியுறுத்தும்நூல்)

UNIT III **இரட்டைக்காப்பியங்கள்** **6**

1.கண்ணகியின்புரட்சி
- சிலப்பதிகாரவழக்குரைகாதை
2. சமூகசேவைஇலக்கியம்மணிமேகலை
- சிறைக்கோட்டம்அறக்கோட்டமாகியகாதை

UNIT IV **அருள்நெறித்தமிழ்** **6**

1. சிறுபாணாற்றுப்படை
   - பாரிமுல்லைக்குத்தேர்கொடுத்தது, பேகன் மயிலுக்குப் போர்வை கொடுத்தது,
   அதியமான்ஔவைக்குநெல்லிக்கனிகொடுத்தது, அரசர் பண்புகள்
2. நற்றிணை
   - அன்னைக்குரியபுன்னைசிறப்பு
3. திருமந்திரம் (617, 618)
   - இயமம்நியமம்விதிகள்
4. தர்மச்சாலையை நிறுவிய வள்ளலார்
5. புறநானூறு
   - சிறுவனேவள்ளலானான்
6. அகநானூறு (4) - வண்டு
   நற்றிணை (11) - நண்டு
   கலித்தொகை (11) - யானை, புறா
   ஐந்தினை 50 (27) - மான்
   ஆகியவைபற்றியசெய்திகள்

UNIT V **நவீனதமிழ்இலக்கியம்** **6**

1. உரைநடைத்தமிழ்,
   - தமிழின்முதல்புதினம்,
   - தமிழின்முதல்சிறுகதை,
   - கட்டுரைஇலக்கியம்,
   - பயணஇலக்கியம்,
   - நாடகம்,

2. நாட்டுவிடுதலைபோராட்டமும்தமிழ்இலக்கியமும்,
3. சமுதாயவிடுதலையும்தமிழ்இலக்கியமும்,
4. பெண் விடுதலையும் விளிம்பு நிலையினரின் மேம்பாட்டில் தமிழ் இலக்கியமும்,
5. அறிவியல்தமிழ்,
6. இணையத்தில்தமிழ்,
7. சுற்றுச்சூழல் மேம்பாட்டில் தமிழ் இலக்கியம்.

TOTAL: 30 PERIODS

தமிழ்இலக்கியவெளியீடுகள் / புத்தகங்கள்

1. தமிழ்இணையகல்விக்கழகம் (Tamil Virtual University) - www.tamilvu.org
2. தமிழ்விக்கிப்பீடியா (Tamil Wikipedia) -https://ta.wikipedia.org
3. தர்மபுரஆதினவெளியீடு
4. வாழ்வியல்களஞ்சியம் - தமிழ்ப்பல்கலைக்கழகம், தஞ்சாவூர்
5. தமிழ்கலைக்களஞ்சியம் - தமிழ்வளர்ச்சித்துறை (thamilvalarchithurai.com)
6. அறிவியல்களஞ்சியம் - தமிழ்ப்பல்கலைக்கழகம், தஞ்சாவூர்