

**PUDUCHERRY TECHNOLOGICAL UNIVERSITY
PILLAICHAVADY, PUDUCHERRY – 605 014.
(A Technological University of Govt.of Puducherry)**



**Curriculum and Syllabi
for
M.Tech. (Chemical Engineering)
(Effective from the Academic Year 2026–27)**

**Recommended in the Second Board of Studies Meeting in Chemical
Engineering held on 13th July 2026
(To be Placed in the Academic Council)**

CURRICULUM

The curriculum of M.Tech.(Chemical Engineering) is designed to fulfill the Programme Educational Objectives (PEO) and Programme Outcomes (PO) listed below:

PROGRAMME EDUCATIONAL OBJECTIVES (PEO)

PEO1	To produce scholarly and competent graduates in the core areas of Chemical Engineering.
PEO2	To inculcate intellectual capacity, research aptitude and independent thinking to inquire, study and explore the frontier areas of the domain.
PEO3	To arouse the interest for application centric learning through intensive laboratory practices towards producing confident and industry ready human resource.
PEO4	To nurture and evoke the spirit of innovation, creativity and entrepreneurship
PEO5	To develop life skills, ethical disposition and sensitivity towards environment and safety.

PROGRAMME OUT COMES (PO)

PO1	Ability to evolve as knowledgeable and competent graduates with a global perspective in the areas of Chemical Engineering.
PO2	Ability to be innovative and develop aptitude for independent research and development.
PO3	Ability to demonstrate a degree of mastery in the areas of Chemical Engineering with appropriate sustainable goals.
PO4	Ability to apply the knowledge of science, mathematics and engineering principles and propose ingenious solutions to practical problems with due considerations for public health and safety, cultural, societal and environmental factors.
PO5	Ability to contribute to the technological advances through quality research.
PO6	Ability to collaborate and work in a multi-disciplinary environment towards higher academic and research objectives. Capacity for applying knowledge, modern techniques and tools to design and conduct experiments as well as to analyze and interpret data to build practical systems.
PO7	Ability to understand and appreciate ethical principles and social responsibilities.
PO8	Understanding of engineering and management principles to lead and manage projects efficiently towards fulfilling the envisaged outcomes.
PO9	Ability to articulate and present the ideas and thought precisely and with clarity.
PO10	Ability to understand and appreciate ethical principles and social responsibilities.
PO11	Ability to engage in life-long learning with commitment to stay relevant and contemporary.

PROGRAMME SPECIFIC OUT COMES (PSO)

PSO1	Ability to identify, formulate, design and solve engineering challenges in separation and transport processes, reactor analysis and design.
PSO2	Explore evolving technologies in nano and bio-process engineering, process intensification and cleaner technologies.
PSO3	Ability to understand and use contemporary tools for process optimization, synthesis, design and analysis.

Distribution of Credits among the subjects grouped under various categories:

Courses are grouped under various categories and the credits to be earned in each category of courses are as follows:

Sl. No.	Category	Credits	Course Category Code (CCC)
1	Programme Core Courses	24	PCC
2	Programme Specific Elective Courses	15	PSE
3	Open Elective Courses	03	OEC
4	Professional Activity Courses (Project Work, Seminar)	28	PAC
5	Mandatory Audit Courses	Non Credit	MAC
	Total	70	

Semester Wise Courses and Credits

Semester I

Course Code	Course	CCC	Periods			Credits
			L	T	P	
CH351	Computational Methods in Chemical Engineering	PCC	3	0	0	3
CH352	Advanced Chemical Reaction Engineering	PCC	3	0	0	3
CH353	Advanced Chemical Engineering Thermodynamics	PCC	3	0	0	3
CHENN	ProgrammeSpecificElective-1	PSE	3	0	0	3
CHENN	ProgrammeSpecificElective-2	PSE	3	0	0	3
CH354	Computational and Simulation Laboratory	PCC	0	0	4	2
CH355	Research Methodology and IPR	PCC	2	0	0	2
AD3NN	Audit Course–I	MAC	2	0	0	0
Total			23			19

Semester II

Course Code	Course	CCC	Periods			Credits
			L	T	P	
CH356	Advanced Transport Phenomena	PCC	3	0	0	3
CH357	Advanced Separation Processes	PCC	3	0	0	3
CH358	Advanced Process Control	PCC	3	0	0	3
CHENN	ProgrammeSpecificElective-3	PSE	3	0	0	3
CHENN	ProgrammeSpecificElective-4	PSE	3	0	0	3
CH359	Advanced Chemical Engineering Laboratory	PCC	0	0	4	2
CH360	Mini Project and Seminar	PAC	0	0	4	2
AD3NN	Audit Course–II	MAC	2	0	0	0
Total			25			19

Semester III

Course Code	Course	CCC	Periods			Credits
			L	T	P	
CHZNN	ProgrammeSpecificElective-5	PSE	3	0	0	3
OE3NN	Open Elective	OEC	3	0	0	3
CH361	Dissertation–Phase I	PAC	0	0	20	10
Total			26			16

Semester IV

Course Code	Course	CCC	Periods			Credits
			L	T	P	
CH362	Dissertation–Phase II	PAC	0	0	32	16
Total			32			16

TotalCredits:70

AuditCourses(MAC)

AD301	English for Research Paper Writing
AD302	Disaster Management
AD303	Value Education
AD304	Constitution of India
AD305	Pedagogy Studies
AD306	Stress Management by Yoga

OpenElectiveCourses(OEC)

OE301	Business Analytics
OE302	Industrial Safety
OE303	Operation Research
OE304	Cost Management and Engineering
OE305	Composite Materials

ProgrammeSpecificElectives (PSE)

I Semester PSE - 1 PSE-2	CHE01	Advanced Downstream Processing
	CHE02	Transport Process in Porous Media
	CHE03	Modern Concepts in Catalysis and Surface Engineering
	CHE04	Membrane Technology and Applications
	CHE05	Process Design and Synthesis
	CHE06	Food Processing Technology
	CHE07	Fluidization Engineering
	CHE08	Design of Experiments and Parameter Estimation
II Semester PSE -3 PSE-4	CHE09	Process Intensification
	CHE10	Process Integration
	CHE11	Process Plant Design and Flow Sheeting
	CHZ12	Bioprocess Engineering
	CHE13	Application of Nanotechnology in Chemical Engineering
	CHE14	Process Modeling and Simulation
	CHE15	Micro and nano-fluidics
	CHE16	Industrial Pollution Control
III Semester PSE-5	CHE17	Optimization of Chemical Processes
	CHE18	Chemical Reactor Analysis
	CHE19	Chemo informatics
	CHE20	Cleaner Production

XX–Department Code; NN–Running double digit number; N–Running single digit number

Department: Chemical Engineering				Programme: M.Tech.(Chemical Engineering)				
Semester: I				Course Category Code: PCC			Semester Exam Type: TY	
Course Code	Course Name	Periods/ Week			Credit	Maximum Marks		
		L	T	P		CA	SE	TM
CH351	Computational Methods in Chemical Engineering	3	-	-	3	40	60	100
Prerequisite								
Course Outcome	On completion of the course, the student will be able to							
	CO1	Formulate and solve problems in chemical engineering represented by Linear Algebraic Equations						
	CO2	Formulate and solve problems in chemical engineering represented by Nonlinear Algebraic Equations						
	CO3	Formulate and solve problems in chemical engineering represented by Ordinary Differential Equations - IVP						
	CO4	Formulate and solve problems in chemical engineering represented by Ordinary Differential Equations - BVP						
	CO5	Formulate and solve problems in chemical engineering represented by Partial Differential Equations						
UNIT I	Linear Algebraic Equations					Periods: 9		
Vector Spaces, Vector Norms, Matrix Norms, Condition Number, Cramer's Rule, Gauss Elimination, LU decomposition, Iterative Methods- Jacobi's method, Gauss-Seidel method, Successive Relaxation method, Case studies - Multi-component Flash, Linear Process Flow Sheet, Polynomial Regression								CO1
UNIT II	Nonlinear Algebraic Equations					Periods: 9		
Bisection method, Secant method, Fixed Point iteration, Picard's method, Newton Raphson method, System of non-linear algebraic equations- Picard's method, Newton Raphson method, Case Studies- Redlich- Kwong and Peng - Robinson EOS, Nonlinear Flash calculations, Bubble Point and Dew Point calculations,								CO2
UNIT III	Ordinary Differential Equations- IVP					Periods: 9		
Explicit Euler method, Implicit Euler method, Predictor-Corrector method, Runge-Kutta methods, Numerical stability, System of ODEs, Stiff systems, Case studies- CSTR with fluctuating inlet, Liquid level dynamics and control, Non-isothermal PFR								CO3
UNIT IV	Ordinary Differential Equations- BVP					Periods: 9		
Boundary conditions - Dirichlet, Neuman and Robin boundary conditions, Finite difference approximations, Shooting method, Method of Orthogonal Collocation, Case study- Reaction-Diffusion in a packed bed, PFR with axial dispersion								CO4
UNIT V	Partial Differential Equations					Periods: 9		
Classification of first order and second order PDEs, Hyperbolic PDEs (Convective Systems) - Finite differences in space and time, Crank - Nicholson method, Method of lines, Case Study - Transient PFR, Parabolic PDEs (Diffusive Systems)- Finite differences in space and time, Crank-Nicholson method, Method of lines, Transient PFR with Axial Dispersion								CO5
Lecture Periods: 45		Tutorial Periods: -		Practical Periods: -		Total Periods: 45		
Reference Books								
1. Numerical Methods with Chemical Engineering Applications, Kevin D Dorfman, Prodromos Daoutidis, Cambridge University Press, 2017								
2. Computational Techniques for Process Simulation and Analysis using MATLAB, Niket S. Kaisare, CRC Press, 2018								
3. Introduction to chemical engineering computing, Bruce A Finlayson, John Wiley and Sons, 2012								
4. Numerical Methods for Engineers, S.K. Gupta, 4 th edition, New Age Publishers, 2019								

Department: Chemical Engineering				Programme: M.Tech.(Chemical Engineering)				
Semester: I				Course Category Code: PCC			Semester Exam Type: TY	
Course Code	Course Name	Periods/ Week			Credit	Maximum Marks		
		L	T	P		CA	S E	TM
CH352	Advanced Chemical Reaction Engineering	3	-	-	3	40	6 0	100
Prerequisite								
Course Outcome		On completion of the course, the student will be able to						
		CO1	Evaluate heterogeneous reactor performance considering mass transfer limitations					
		CO2	Perform the energy balance and obtain concentration profiles in multiphase reactors.					
		CO3	Estimate the performance of multiphase reactors under non-isothermal conditions.					
		CO4	Understand modern reactor technologies					
		CO5	Understand the kinetic Modeling of reactors.					
UNIT I	Kinetics of Non-Elementary Reactions and Non-Isothermal Reaction Modeling					Periods: 9		
Non-elementary Kinetics Importance: Approximations for formulations of Rate laws, Formulations of Kinetic model. Effect of flow on conversions in Reactors: Semi-batch Reactors: Importance and examples of applications , Material Balance on Semi-batch Reactor, Multiple reaction in Semi-batch Reactors, Conversion Vs Rate in Reactors. Non-Isothermal reaction modeling in CSTR & Semi-Batch reactor: Energy Balance equations for CSTR, PFR and Batch reactors, Adiabatic operations Temperature conversion profiles in PFR, CSTR, Steady state tubular reactor with heat exchange.								CO1
UNIT II	Multi-Staging and Optimal Design of Reactors					Periods: 9		
Need for Multi-staging CSTR with multiple stages: 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: Radial and Axial mixing in Tubular reactors, unsteady state in non-isothermal energy balance, CSTR, Energy balance in Batch Reactors, Volume of reactors calculations for non-isothermal reactors. Optimal Design of Reactors for Reversible exothermic reactions: Unsteady state non-isothermal reactor design, adiabatic operation in batch, Heat effects in semi batch unsteady state operation. Auto thermal Plug flow reactors and packed tubular reactors. PFR with inter stage cooling. Shift of Energy and material balance lines for reversible reactions in CSTR, Examples of optimal design of PFR and Semi-batch and CSTR Exothermic Reactions.								CO2
UNIT III	Catalytic Reactions					Periods: 9		
Catalytic reactions: theory and modeling: Global rate of reaction, Types of Heterogeneous reactions Catalysis, 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: Mass transfer coefficients, Flow effects on spheres tube and cylinders, External Mass Transfer pore diffusion, structure and concentration gradients Internal Effectiveness Factor Catalytic wall reactor: limiting steps reactions and mass transfer limiting Porous catalyst on tube wall reactors Design of packed bed porous catalytic reactors: Mass transfer limited reactions in Packed bed.								CO3
UNIT IV	Heterogeneous Reactors					Periods: 9		
Fluidized bed reactor modeling: Geldart Classification of powders, Fixed bed vs fluidized bed Why fluidized bed, important parameters pressure drop in fixed bed, Class I model Arbitrary Two Region Flow								CO4

Models, Class II Chemical Reactor: Plug Flow or Mixed Flow Model. Class III Modeling the Bubbling Fluidized Bed Reactor, BFB, The Kunii-Levenspiel bubbling bed model, Gas Flow Around and Within a Rising Gas Bubble in a Fine particle BFB, Reactor performance of BFB.			
UNIT V	Applications of Chemical Reaction Engineering	Periods: 9	
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. BioChemical Reactors–Modeling and design aspects			CO5
Lecture Periods: 45	Tutorial Periods:-	Practical Periods:-	Total Periods: 45
<u>Reference Books</u>			
1. K.G.Denbigh: Chemical Reactor Theory, 1971. Cambridge University Press, Second Edition, 2. J.M.Smith: Chemical Engineering Kinetics, 1981. McGraw Hill, Third Edition 3. Levenspiel, O, Chemical Reaction Engineering, 1998. Wiley, 4. Foggler, H.S, Elements of Chemical Reaction Engineering, 2008. Prentice Hall of India, 5. Fromment G.F. and Bischoff K.B., Chemical Reactor Analysis and Design, 2010. John Wiley			

Department: Chemical Engineering			Programme: M.Tech.(Chemical Engineering)					
Semester: I			Course Category Code: PCC			Semester Exam Type: TY		
Course Code	Course Name	Periods/ Week			Credit	Maximum Marks		
		L	T	P		CA	SE	TM
CH353	Advanced Chemical Engineering Thermodynamics	3	-	-	3	40	60	100
Prerequisite								
Course Outcome	On completion of the course, the student will be able to							
	CO1	Understand the importance of phase equilibrium						
	CO2	Able to estimate thermodynamic properties from volumetric data						
	CO3	Understand intermolecular forces, corresponding states and osmotic systems						
	CO4	Able to compute fugacity in gases mixtures and liquid mixtures						
	CO5	Understand fundamentals of statistical thermodynamics.						
UNIT I	Phase Equilibrium					Periods:9		
The phase equilibrium Problem: Essence of the problem, Application of thermodynamics to phase equilibrium problems; Classical Thermodynamics of Phase equilibria: Homogenous closed system, homogeneous open system, equilibrium in heterogeneous closed system, the Gibbs-Duhem equation, the phase rule, the chemical potential, fugacity and activity, a simple application to Raoult's law								CO1
UNIT II	Thermodynamic Properties from Volumetric Data and Cubic Equation of State					Periods:9		
Thermodynamic Properties with independent variables P and T, Fugacity of a component in mixture at moderate pressures, fugacity of a pure liquid or solid; Thermodynamic Properties with independent variables V and T, Fugacity of a component in a mixture according to van der Waals equation								CO2
UNIT III	Intermolecular Forces, Corresponding States and Osmotic Systems					Periods:9		
Potential energy functions, electrostatic forces, polarizability and induced dipoles, intermolecular forces between non-polar molecules, Mie's potential energy function for non-polar molecules, structure effects, specific (chemical) forces, hydrogen bond, electron donor-electron acceptor complexes, hydrophobic interaction, molecular interaction in dense fluid media (osmotic pressure, Donnan equilibria, molecular theory of corresponding state theory to more complicated molecules								CO3
UNIT IV	Fugacity in Gases Mixtures and Liquid Mixtures					Periods:9		
The Lewis fugacity rule, the Virial equation of state, extension to mixtures, fugacity from the Virial equation. The Ideal solution, Fundamental relation of excess functions, activity and activity coefficients, Activity coefficient from excess functions in binary mixtures, Wohl's expansion for the Gibbs energy, Wilson, NRTL and UNIQUAC equation								CO4
UNIT V	Introduction to Statistical Thermodynamics					Periods:9		
Thermodynamic states and quantum states of a system, ensembles and basic postulates, the canonical ensemble, the grand canonical ensemble, the semi classical partition function: two basic combinatorial relations, maximum-term method and Stirling's formula								CO5
Lecture Periods:45		Tutorial Periods:-		Practical Periods:-		Total Periods:45		
Reference Books								
- John M Prausnitz, Rudiger N Lichtenthaler, Edmundo Gomes de Azevedo, Molecular Thermodynamics of Fluid-phase equilibria, 3rd edition Prentice Hall PTR (Pearson Education). - Stanley I Sandler, <i>Chemical and Engineering Thermodynamics</i>, Wiley, 2016 - Balzhiser, Samuels and Eliassen, Chemical Engineering Thermodynamics, the study of energy, entropy and equilibrium, Prentice Hall international, 1972. - Leonard K Nash, Elements of statistical thermodynamics, Dover publication 1974. - Terrell L. Hill, An Introduction to Statistical thermodynamics, Dover 1986 J. Rajaram and J. C. Kuriacose, Chemical Thermodynamics: Classical, statistical and irreversible, Pearson education india 1st edition, 2013.								

7. TomasEngelandPhilipReid,Physicalchemistry,PearsonEducationIndia;1stedition(1January 2013)

Department: Chemical Engineering				Programme: M.Tech.(Chemical Engineering)				
Semester: I				Course Category Code: PCC		Semester Exam Type: LB		
Course Code	Course Name	Periods/ Week			Credit	Maximum Marks		
		L	T	P		CA	SE	TM
CH354	Computational and Simulation Laboratory	-	-	4	2	40	60	100
Prerequisite								
Course Outcome		On completion of the course, the student will be able to						
		CO1	Write programs in MATLAB/OCTAVE for solving simple problems					
		CO2	Write programs in MATLAB/OCTAVE for solving linear/nonlinear algebraic equations					
		CO3	Write programs in MATLAB/ OCTAVE for solving ODEs and PDEs					
		CO4	Simulate simple chemical engineering processes using DWSIM/ASPEN					
List of Experiments:								
Programming in MATLAB / GNU OCTAVE - Data structures, Matrix and vector manipulation, Input / output, Logical flow - Conditional statements, If statement and If-else statement, Loops, Functions, General features - Evaluation of an Integral, Interpolation, Solving algebraic equations, Solving ODEs - IVP, Plotting, Import / Export data, Programming GUIs							CO1	
Solution of Linear and Nonlinear Algebraic Equations - Case Studies from Units I and II of CH251 - Equations of State, VLE calculations, Isothermal Flash, Chemical Reaction Equilibria, Mass Balances with Recycle Steams, Multicomponent distillation							CO2	
Solution of ODEs and PDEs- Case Studies from Units III, IV and V of CH251 - Isothermal PFR, Non-isothermal PFR, Chemical reactors with mole changes and variable density, Chemical Reactors with mass transfer limitations, Transient CSTRs, Diffusion and Reaction across a flat slab, Diffusion and Reaction across a spherical domain, Transient heat transfer, Linear adsorption - Chromatography, Pressure Swing Adsorption							CO3	
Process Simulation using DWSIM / ASPEN - Ammonia Process, Benzene Process, Integrated Gasification Combined Cycle							CO4	
Lecture Periods:-		Tutorial Periods:-		Practical Periods:60		Total Periods:60		
Reference Books								
1. Introduction to Chemical Engineering Computing, Bruce A Finlayson, John Wiley and Sons, 2012								
2. Numerical Methods with Chemical Engineering Applications, Kevin D Dorfman, Prodromos Daoutidis, Cambridge University Press, 2017								

Department: Chemical Engineering				Programme: M.Tech.(Chemical Engineering)				
Semester: I				Course Category Code: PCC			Semester Exam Type: TY	
CourseCode	CourseName	Periods/ Week			Credit	MaximumMarks		
		L	T	P		CA	SE	TM
CH355	Research Methodology and IPR	2	-	-	2	40	60	100
Prerequisite								
Course Outcome	On completion of the course, the student will be able to							
	CO1	Understand research problem formulation and methods						
	CO2	Analyze research related information and follow research ethics						
	CO3	Gain competency in writing a research paper and proposal						
	CO4	Comprehend the need for IPR for growth of individuals & nation.						
	CO5	Be aware that IPR protection provides an incentive to inventors for further research work and investment in R&D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.						
UNIT I	Research Problem Formulation					Periods:6		
Meaning of research problem, Sources of research problem, Criteria and 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 methods.								CO1
UNIT II	Research Procedure and Ethics					Periods:6		
Effective literature studies approaches, analysis, Plagiarism, Research ethics								CO2
UNIT III	Outcomes of Research					Periods:6		
Effective technical writing, how to write report/Paper. Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee.								CO3
UNIT IV	Intellectual Property					Periods:6		
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.								CO4
UNIT V	Patent Rights					Periods:6		
Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. New Developments in IPR: Administration of Patent System								CO5
Lecture Periods:30		Tutorial Periods:-		Practical Periods:-		Total Periods:30		
Reference Books								
1. Stuart Melville and Wayne Goddard, "Research methodology: An introduction, Second edition, Juta & Co, 2007								
2. Kothari, C.R., Research Methodology- Methods and Techniques, Wiley Eastern Limited, New Delhi, 2020.								
3. Ranjit Kumar, "Research Methodology: A Step by Step Guide for beginners", 2 nd Edition, Pearson Education, Singapore, 2005.								
4. D.J. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd, 2007.								
5. Robert P. Merges, Peter S. Menell, Mark A. Lemley, "Intellectual Property in New Technological Age", 2016.								
6. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008.								

Department: Chemical Engineering			Programme: M.Tech.(Chemical Engineering)					
Semester: II			Course Category Code: PCC			Semester Exam Type: TY		
Course Code	Course Name	Periods/ Week			Credit	Maximum Marks		
		L	T	P		CA	SE	TM
CH356	Advanced Transport Phenomena	3	-	-	3	40	60	100
Prerequisite								
		On completion of the course, the student will be able to						
Course Outcome	CO1	Relate all transport equations in vector and tensor notations						
	CO2	Write conservation equations						
	CO3	Solve conservation equations in limiting cases						
	CO4	Solve heat transfer problems						
	CO5	Solve mass transfer problems						
UNIT I	Basics of Transport Phenomena					Periods:9		
Continuum hypothesis, reference frames and coordinate systems, scalar, vector and tensor fields; Kinetics and dynamics, Eulerian and Lagrangian specifications, differentiation following the motion, decomposition of motion, irrotational and solenoidal flows; body and surface forces and Cauchy's fundamental theorem for stress								CO1
UNIT II	Conservation Equations and Constitutive Equations					Periods:9		
Conservation equations and control volumes, mass conservation, linear momentum conservation, angular momentum conservation, energy conservation; constitutive equations, pressure, heat flux and stress; initial and boundary conditions, rigid impermeable walls, fluid-fluid interface, boundaries at infinity, symmetry boundaries, flow equations, dimensional analysis approximates solutions								CO2
UNIT III	Applications					Periods:9		
Slow flow, inviscid flow, nearly non-accelerating flow, boundary layer flow								CO3
UNIT IV	Transport Approach for Heat Transfer					Periods:9		
Foundations for energy transfer: Energy, Entropy and behavior of materials; Differential balances in energy transfer; integral averaging in energy transfer and applications								CO4
UNIT V	Transport Approach for Mass Transfer					Periods:9		
Foundations for mass transfer; differential balances in mass transfer; integral averaging in mass transfer and applications.								CO5
Lecture Periods:45		Tutorial Periods:-		Practical Periods:-		Total Periods:45		
Reference Books								
1. Rutherford Aris, Vectors, Tensors and the Basic Equations of Fluid Mechanics, Dover Publications Inc.; New edition (17 September 1990)								
2. Stefan M Richardson, Fluid Mechanics, Hemisphere publishing corporation, Taylor and Francis, 1989								
3. John C. Slattery, Advanced Transport phenomena, Cambridge University Press, 1999.								
4. K.S. Gandhi, Heat and Mass Transfer A transport phenomena approach, New age international publishers, 2011.								
5. R. Byron Bird, Warren E. Stewart, et. al. Transport Phenomena, Revised 2ed (An Indian Adaptation), Wiley, 2021								
6. William M. Deen, Analysis of transport phenomena, Oxford University Press; Edition (18 October 2013)								
7. P.A. Ramachandra, Advanced transport phenomena analysis, modeling and computations, Cambridge University Press, 2014.								

Department: Chemical Engineering			Programme: M.Tech. (Chemical Engineering)					
Semester: II			Course Category Code: PCC			Semester Exam Type: TY		
Course Code	Course Name	Periods/ Week			Credit	Maximum Marks		
		L	T	P		CA	SE	TM
CH357	Advanced Separation Processes	3	-	-	3	40	60	100
Prerequisite								
Course Outcome	On completion of the course, the student will be able to							
	CO1	List and select various separation processes based on various properties						
	CO2	Understand various bubble fractionation and membrane separation processes						
	CO3	Classify organic and inorganic membranes and various industrial applications						
	CO4	Explain various special separation processes						
	CO5	Describe various chromatographic separation processes						
UNIT I	Conventional Separation processes					Periods: 9		
Introduction: Conventional separation processes - Absorption, Adsorption, Distillation, Drying, Extraction, Diffusion, Leaching, Crystallization, Advances in separation techniques based on size, Advances in separation techniques based on surface properties, Advances in separation techniques based on ionic properties, Cross flow filtration, Electro filtration, Dual functional filter, Surface based solid-liquid separations involving a second liquid, Sirofloc filter							CO1	
UNIT II	Bubble, Foam Fractionation and Membranes					Periods: 9		
Nature of bubbles and foams, stability of foams, foam fractionation techniques, batch, Continuous, single stage and multi-stage columns. Types and choice of membranes, Plate and frame, spiral wound membranes, Tubular and hollow fibre membrane reactors, Membrane Permeates: Dialysis, Reverse osmosis, Nano-filtration, ultra-filtration, microfiltration, Donnan dialysis, Ceramic membranes							CO2	
UNIT III	Membrane Separation					Periods: 9		
Characteristics of organic and inorganic membranes, basis of membrane selection, osmotic pressure, partition coefficient and permeability, concentration polarization, electrolyte diffusion and facilitated transport, macro-filtration, ultra-filtration, reverse osmosis, electro-dialysis. Industrial applications.							CO3	
UNIT IV	Special Processes					Periods: 9		
Liquid membrane separation, super-critical extraction, adsorptive separation-pressure, vacuum and thermal swing, pervaporation and permeation, nano-separation							CO4	
UNIT V	Chromatographic Methods of Separation					Periods: 9		
Gel, solvent, ion and high performance liquid chromatography, Gas Chromatography, Moving Bed Chromatography, Size based Exclusion chromatography and Bio-molecular Separation.							CO5	
Lecture Periods: 45		Tutorial Periods: -		Practical Periods: -		Total Periods: 45		
Reference Books								
1. King C.J., "Separation Processes", Tata McGraw Hill, 1982.								
2. Nakagawal, O.V., "Membrane Science and Technology", Marcel Dekker, 1992								
3. Humphrey, J. and G. Keller, Separation Process Technology, McGraw-Hill, 1997								
4. Wankat P.C., "Separation Process Engineering", 2nd Ed., Prentice Hall, 2006.								
5. Seader J.D. and Henley E.J., "Separation Process Principles", 2nd Ed., Wiley, 2006								
6. Phillip C. Wankat, Separation Process Engineering (2nd Edition), Prentice Hall, 2007								
7. Rousseau, R. W., "Handbook of Separation Process Technology", John Wiley, New York, 2009.								

Department: Chemical Engineering				Programme: M.Tech.(Chemical Engineering)				
Semester: II				Course Category Code: PCC			Semester Exam Type: TY	
CourseCode	CourseName	Periods/ Week			Credit	MaximumMarks		
		L	T	P		CA	SE	TM
CH358	Advanced ProcessControl	3	-	-	3	40	60	100
Prerequisite								
Course Outcome	On completion of the course, the student will be able to							
	CO1	List and select various separation processes based on various properties						
	CO2	Understandvariousbubblefractionationandmembraneseparationprocesses						
	CO3	Classifyorganicandinorganicmembranesandvariousindustrialapplications						
	CO4	Explain various special separation processes						
	CO5	Describe various chromatographic separation processes						
UNITI	Review of Stability Analysis and PID Controller Tuning					Periods:9		
Bode's and Nyquist Stability Criteria - Relative Stability Calculations, Gain Margin and Phase Margin, Nichols Chart and Peak Gain ;PID controller tuning - Zeigler -Nichols tuning formula, Direct Synthesis tuning, IMC tuning, Controller tuning using approximate process models -Cohen-Coon tuning rules, Time Integral tuning rules, Auto tuning with relay controller								CO1
UNITII	State Space Methods and Multivariable Control					Periods:9		
State variables and State Space description, Open loop dynamic analysis in state space, Multivariable Process Models, Multivariable Transfer Functions and open loop dynamic analysis, Closed loop dynamic analysis, Interaction analysis and loop pairing, Relative Gain Array (RGA), Design of Multivariable controllers,Decoupling,DecouplingbySingularValueDecomposition,ModelBasedControllersfor MultivariableProcesses,Stateobserversandstatefeedbackcontrollers								CO2
UNITIII	Sampled-Data Control Systems					Periods:9		
IntroductiontoSampled-Datasystems,Z-Transform,PulseTransferFunctions,Dynamicanalysisofdiscrete-timesystems,Designofdigitalcontrollers-DiscretePIDandothercontrollersbasedon continuousdomainstrategies								CO3
UNITIV	Theoretical Analysis of Distributed Parameter Systems					Periods:9		
Distributed Parameter Systems - Heat Conduction into a Solid, Transportation lag as a distributed parameter system,DoublePipeHeatExchanger-Approximatetransferfunctionmodels,TubularReactorwithAxial Dispersion-dynamic model for axial mixing and estimation of Peclet Number								CO4
UNITV	SpecialTopicsin Control					Periods:9		
ModelPredictiveControl-GeneralPrinciplesofMPC,DynamicMatrixControl(DMC),SISO unconstrainedproblem,ExtensiontoMultivariablesystems,ModelAlgorithmicControl(MAC), Commercial MPC schemes, Introduction to State Estimator and Kalman Filter.								CO5
LecturePeriods:45		TutorialPeriods:-		PracticalPeriods:-		TotalPeriods:45		
ReferenceBooks								
1. ProcessDynamics,Modeling,andControl,B.A.Ogunnaike,W.HarmonRay,OxfordUniversityPress, 1994								
2. ProcessSystemsAnalysisandControl,D.R.Coughanowr,McGraw-Hall,1991								
3. ChemicalProcessControl:AnIntroductiontoTheoryandPractice,GeorgeStephanopoulos,PrenticeHall,1984								
4. ProcessDynamicsandControl,D.E.Seborg,T.F.Edgar,D.A.Mellichamp,Wiley-India.2005								

Department: Chemical Engineering				Programme: M.Tech.(Chemical Engineering)				
Semester: II				Course Category Code: PCC			Semester Exam Type: LB	
CourseCode	CourseName	Periods/Week			Credit	MaximumMarks		
		L	T	P		CA	SE	TM
CH359	Advanced Chemical Engineering Laboratory	-	-	4	2	40	60	100
Prerequisite								
		On completion of the course, the student will be able to						
Course Outcome	CO1	Knowledge of mass transfer operations and mechanical operations						
	CO2	Students should be able to know the synthesis of materials and applications in separation processes.						
	CO3	Students will be able to provide applicable solutions to separation processes						
	CO4	Able to verify and calculate heat and mass transfer parameters						
		List of experiments: Advanced Separation Processes						
		1) Separation of phenolic compounds in a pilot plant RO membrane system 2) Study the effect of pressure on permeate flux and solution rejection in RO system 3) Determination of phenolic compounds in waste water using a HPLC system 4) Deducing the identity of an unknown hydrocarbon using gas chromatograph 5) Studies on flooding and weeping characteristics in tall columns 6) Studies on effect of filter aids on effectiveness of filtration 7) RDC studies on rotary dryer 8) Colour removal from synthetic effluent using Adsorption column and analysis using UV/Visible spectrophotometer 9) Studies on bare and finned tube vertical condenser 10) Non-Newtonian fluid characteristics :an experiment using capillary tube 11) Batch sedimentation-verification of Kynch theory 12) Extraction studies using RDC/Paced Columns 13) A study on absorption with chemical reaction 14) Studies on fluid flow/heat transfer in helical coils 15) Studies on draining a fluid from a tank 16) Supercritical extraction of the fragrance. 17) Study the reaction with mass transfer: e.g. Synthesis of calcium carbonate. 18) Study the reactive distillation system considering batch and continuous mode						
Lecture Periods:		Tutorial Periods:-		Practical Periods:-		Total Periods:60		
Reference Books								

1. Perry's Chemical Engineers Hand book, McGraw Hill, 2018
2. Handbook of separation process technology, Edited by Ronald W. Rousseau, Wiley India (1 January 2009)
3. Handbook of Analytical techniques, Editor(s): Prof. Dr. Helmut Günzler, Alex Williams, WILEY - VCH Verlag GmbH, 2001
4. Garlapati Chandrasekhar, Laboratory experiments in chemical and allied engineering: emphasis on low cost experiments, Penram international publishing (India) Pvt. Ltd, 2017.
5. Appropriate Journal papers

Department: Chemical Engineering		Programme: M.Tech.(Chemical Engineering)						
Semester: II		Course Category Code : PAC				Semester Exam Type: LB		
Course Code	Course Name	Periods/ Week			Credit	Maximum Marks		
		L	T	P		CA	SE	TM
CH360	Mini Project and Seminar	-	-	4	2	100	-	100
Prerequisite	-							
Course Outcome	On completion of the course, the student will be able to							
	CO1	Ability to carry out a portion of a research work						
	CO2	Ability to extend the project to find an application for society						
	CO3	Ability to work in a team and present the ideas and thoughts with a clarity						
In the course of the degree programme each group of not more than two students has to identify a mini project work in the area of their specialization and the mini project will be implemented under the supervision of a faculty. The progress of the work will be monitored and assessed internally. A project report has to be submitted at the end of the semester after completion of the project work.								CO1, CO2, CO3
Lecture Periods:-		Tutorial Periods:-		Practical Periods:60		Total Periods:60		

Department: Chemical Engineering				Programme: M.Tech.(Chemical Engineering)					
Semester: III				Course Category Code: PAC			Semester Exam Type: PR		
Course Code	Course Name		Periods/ Week			Credit	MaximumMarks		
			L	T	P			CA	SE
CH361	Dissertation–Phasel		-	-	20	10	250	250	500
Prerequisite	-								
Course Outcome	On completion of the course, the student will be able to								
	CO1	Ability to transform knowledge in to an experimental process							
	CO2	Ability to demonstrate the motivation to extend the work to a research							
	CO3	Abilitytoidentifyandapplyappropriatetoolstosolveaproblemandalsohas thecapability to examine hypotheses							
Each student will do an exhaustive literature survey and identify an experimental and / or a theoretical project to be carried out under a supervision of a guide. The phase I of the project work has to be completed by the end of third semester. The progress of the work will be monitored and assessed internally for 250 marks by a committee comprising departmental faculty members and project guide. A project report has to be submitted at the end of the semester after completion ofthe phase Iof the project work.Theexternalassessmentwillbecarriedoutfor250marksasperregulations.								CO1 , CO2 , CO3	
LecturePeriods:-		TutorialPeriods:-		PracticalPeriods:300			TotalPeriods:300		

Department: ChemicalEngineering			Programme: M.Tech.(ChemicalEngineering)					
Semester: IV			CourseCategoryCode: PAC			SemesterExamType: PR		
CourseCode	CourseName	Periods/ Week			Credit	MaximumMarks		
		L	T	P		CA	SE	TM
CH362	Dissertation–PhaseII	-	-	32	16	250	250	500
Prerequisite	-							
Course Outcome	On completion of the course, the student will be able to							
	CO1	Ability to transform knowledge in to an experimental process						
	CO2	Ability to demonstrate the motivation to extend the work to a research						
	CO3	Abilitytoidentifyandapplyappropriatetoolstosolveaproblemandalsohas the capability to examine hypotheses						
The phase II of the project work has to be completed by the end of the fourth semester. The progress of the work will be monitored and assessed internally for 250 marks by a committee comprising departmental faculty members and project guide. A project report summarizing the entire project work has to be submitted at the end of the semester after completion of the phase II of the project work. The externalevaluationwillbecarriedoutasperregulationsfor250marks.								CO1, CO2, CO3
Lecture Periods:-		Tutorial Periods:-		Practical Periods:480		TotalPeriods:480		

PROGRAMMESPECIFICELECTIVES

Department: Chemical Engineering			Programme: M.Tech.(Chemical Engineering)					
Semester: I			Course Category Code: PSE			Semester Exam Type: TY		
CourseCode	CourseName	Periods/ Week			Credit	MaximumMarks		
		L	T	P			CA	SE
CHE01	Advanced Downstream Processing	3	-	-	3	40	60	100
Prerequisite								
Course Outcome	On completion of the course, the student will be able to							
	CO1	To learn concepts of downstream processing in chemical industry.						
	CO2	Understand the role of downstream processing in petro chemical industry						
	CO3	Analyze reactors, upstream and downstream processes in production						
	CO4	Understand the concepts of advanced distillation process						
	CO5	Understand the separation methods for non-ideal mixtures						
UNIT I	Introduction				Periods:9			
Introduction to Downstream processes theory, applications in chemical separation for Gas-Liquid system, Gas-Solids system. Supercritical fluid extraction in food, pharmaceutical, environmental and petroleum applications, water treatment, desalination, Bioseparation, dialysis, industrial dialysis.							CO1	
UNIT II	Downstream Processes in Petrochemical Industry				Periods:9			
Cryogenic distillation for refinery, petrochemical off gases, natural gases, gas recovery-Olefin, Helium, Nitrogen, Desulfurization - coal, flue gases							CO2	
UNIT III	Advanced Distillation Processes				Periods:9			
Azeotropic & extractive distillation-residue curve maps, homogeneous azeotropic distillation, Pressure swing distillation, Column sequences, heterogeneous azeotropic distillation.							CO3	
UNIT IV	Energy Conservation in Separation Processes				Periods:9			
Energy balance, molecular sieves-zeolites, adsorption, catalytic properties, manufacturing processes, hydrogel process, application, New trends.							CO4	
UNIT V	Non-Ideal Mixtures and Ion Exchange				Periods:9			
Separation process synthesis for non azeotropic mixtures, non ideal liquid mixtures, separation synthesis algorithm, Ion exchange-manufacture of resins, physical & chemical properties, capacity, selectivity, application, regeneration, equipment, catalysis used							CO5	
Lecture Periods:45		Tutorial Periods:-		Practical Periods:-		Total Periods:45		
Reference Books								
1. Perry's "Chemical Engg. Handbook": McGraw Hill Pub. 2. Douglas J.M., "Conceptual Design of Chemical Processes", McGraw Hill 3. Liu Y.A., "Recent Developments in Chemical Process & Plant Design", John Wiley & Sons Inc. 4. Timmerhaus K.D., "Cryogenic Process Engg.", Plenum Press 5. Othmer Kirk "Encyclopaedia of Separation Technology, Vol. I & II", Wiley Inter-science								

Department: Chemical Engineering			Programme: M.Tech.(Chemical Engineering)					
Semester: I			Course Category Code: PSE			Semester Exam Type: TY		
CourseCode	CourseName	Periods/ Week			Credit	MaximumMarks		
		L	T	P			CA	SE
CHE02	Transport Process in Porous Media	3	-	-	3	40	60	100
Prerequisite								
Course Outcome	On completion of the course, the student will be able to							
	CO1	Quantify fundamentals						
	CO2	Calculate Effective properties						
	CO3	Solve exact solutions						
	CO4	Do modeling						
	CO5	Give real-time engineering solutions						
UNITI	Fundamentals				Periods:9			
Mass,momentumandenergytransport,DarcyandNon-Darcy equations,equilibriumandnon-Equilibrium conditions, species transport radioactive decay.								CO1
UNITII	Effective Medium Approximation				Periods:9			
Equivalentthermalconductivity,viscosity,dispersion.								CO2
UNITIII	ExactSolutions				Periods:9			
Flow over a flat plate, flow past a cylinder, boundary-layers, reservoir problems.								CO3
UNITIV	Special Topics				Periods:9			
Field scale and stochastic modeling, Turbulent flow, compressible flow, multiphase flow, numerical techniques, hierarchical porousmedia ,nano-scale porous media, multi scale modeling.								CO4
UNITV	Engineering Applications				Periods:9			
Groundwater, waste disposal,oilandgasrecovery,regenerators,energystoragesystems.Experimental techniques: Flow visualization, quantitative methods, inverse parameter estimation.								CO5
LecturePeriods:45		TutorialPeriods:-		PracticalPeriods:-		TotalPeriods:45		
ReferenceBooks								
1. Principles of Heat Transfer in Porous Media, by M.Kaviany, SpringerNewYork (1995).								
2. TransportPhenomenainPorousMedia, VolumesI-III,editedbyD.R.InghamandI.Pop, Elsevier, New York (1998-2005).								
3. Dynamics of Fluids in Porous Media, J.Bear,Dover (1988).								
4. IntroductioentoModelingofTransportPhenomenainPorousMedia,J.BearandY.Bachmat,Kluwer Academic Publishers, London (1990).								
5. TheMathematicsofReservoirSimulation,R.E.Ewing,SIAMPhiladelphia(1983).								
6. StochasticMethodsforFlowinPorousMedia:CopingwithUncertainties,Zhang,D., Academic Press,California(2002).								
7. The Method of Volume Averaging, S.Whitaker, Springer,NewYork(1999).								

Department: Chemical Engineering			Programme: M.Tech.(Chemical Engineering)					
Semester: I			Course Category Code: PSE			Semester Exam Type: TY		
Course Code	Course Name	Periods/ Week			Credit	Maximum Marks		
		L	T	P			CA	SE
CHE03	Modern Concepts in Catalysis and Surface Engineering	3	-	-	3	40	60	100
Prerequisite								
Course Outcome	On completion of the course, the student will be able to							
	CO1	To understand the concepts of homogenous and heterogeneous catalysis, with specific examples						
	CO2	To study reaction mechanisms and kinetics of homogenous and heterogeneous catalytic reactions.						
	CO3	To familiarize with the characterization of catalysts						
	CO4	To estimate characteristics of catalysts used in chemical industry.						
	CO5	To understand the application and mechanisms of several types of catalysts in chemical industry.						
UNIT I	Introduction toCatalysis					Periods:9		
Definition of Catalytic activity, Magnitude of Turnover Frequencies and Active Site Concentrations, EvolutionofImportantConceptsandTechniquesinHeterogeneousCatalysis,ClassificationofCatalysts-Homogenous,Heterogeneous,Biocatalysts,DualFunctionalCatalysts,Enzymes,Solid Catalysts,PowderCatalysts,Pellets,Composition,ActiveIngredients,Supportivematerials, Catalysts Activation, Catalyst Deactivation.							CO1	
UNIT II	Adsorption in Catalysis					Periods:9		
Adsorption and its importance in Catalysis, Adsorption and potential energy curves, Surface Reconstruction, Adsorption Isotherms and Isobars, Dynamical Considerations, Types of Adsorption IsothermsandtheirDerivationfromKineticPrinciples,MobilityatSurfaces,Kineticsofsurface Reactions,Photochemistryonoxideandmetallicsurfaces,Characterizationoftheadsorbed molecules							CO2	
UNIT III	Catalyst Characterization					Periods:9		
Catalyst Characterization Methods - Their Working Principle and Applications - XRF, XRD, IR Spectroscopy, XPS, UPS, ESR, NMR; Infrared, Raman, NMR, Mossbauer and X-Ray Absorption spectroscopy,SurfaceAcidityandToxicity,Activity,Lifetime,Bulkdensity,ThermalstabilityCrystal Defects, Peroviskites, Spinels, Clays, Pillared Clays, Zeolites							CO3	
UNIT IV	Significance of Pore Structure and Surface Area					Periods:9		
Importance of Surface Area and Pore Structure, Experimental Methods for Estimating Surface Area- Volumetric, Gravimetric, Dynamic Methods, Experimental Methods for Estimating Pore Volume and Diameter - Gas Adsorption and Mercury Porosimeter Method, Models of the Pore Structure -Hysteresis Loops,GeometricModels,Wheeler’sModel,DustyGasModel,RandomPoreModel,Diffusionin Porous Catalysts - Effective Diffusivity, Knudsen Diffusion, Effect of Intra particle Diffusion, Non-isothermal Reactions in Pores, Diffusion Control.							CO4	
UNIT V	Industrial Applications-Case Studies					Periods:9		
Industrial processes involving heterogeneous solid catalyst: Synthesis of Methanol, Fischer-Tropsch Catalysis, Synthesis of Ammonia, Automobile Exhaust Catalysts and Catalyst Monolith, Photo catalytic Breakdown of Water and the Harnessing of Solar Energy. Contribution of homogeneous catalytic processinchemicalindustry:OxidationsofAlkenessuchasproductionofacetaldehyde,propylene oxideetc,Polymerization such as production of polyethylene, polypropylene or polyester production							CO5	
LecturePeriods:45		TutorialPeriods:-		PracticalPeriods:-		TotalPeriods:45		

Reference Books

- Emmett, P.H. - "Catalysis Vol. I and II, Reinhold Corp.", New York, 1954
- Smith, J.M. - "Chemical Engineering Kinetics ", McGraw Hill, 1971
- Thomas and Thomas - "Introduction to Heterogeneous Catalysts", Academic Press, London 1967
- Piet W.N.M. van Leeuwen, Homogeneous catalysis: Understanding the Art, Springer, 2004
- Piet W.N.M. van Leeuwen, and John C. Chadwick, Homogeneous catalysis: Activity-Stability deactivation, Wiley, VCH, 2011.

Department: Chemical Engineering				Programme: M.Tech.(Chemical Engineering)				
Semester: I				Course Category Code: PSE		Semester Exam Type: TY		
Course Code	Course Name	Periods/ Week			Credit	Maximum Marks		
		L	T	P		CA	SE	TM
CHE04	Membrane Technology and its Applications	3	-	-	3	40	60	100
Prerequisite								
Course Outcome	On completion of the course, the student will be able to							
	CO1	Understand the principle behind membrane separation						
	CO2	Design various membrane separation processes						
	CO3	Describe the key aspects of membrane bioreactors						
	CO4	Discussion various pretreatment techniques to prevent membrane fouling						
	CO5	Know various case studies on membrane based water and wastewater treatment systems						
UNIT I	Introduction					Periods: 9		
Solid Liquid separation systems-Filtration systems- Theory of Membrane separation – mass Transport Characteristics Cross Flow filtration-Membrane Filtration- Types and choice of membranes, porous, non porous, symmetric and asymmetric–Plate and Frame, spiral wound and hollow fibre membranes–Liquid Membranes								CO1
UNIT II	Membrane Processes and Systems					Periods: 9		
Microfiltration – Ultrafiltration- Nano Filtration – Reverse Osmosis – Electro dialysis- Pervaporation - Membrane manufactures – Membrane Module/Element designs – Membrane System components – Design of Membrane systems-pump types and Pump selection–Plant operations–Economics of Membrane systems								CO2
UNIT III	Membrane Bioreactors					Periods: 9		
Introduction and Historical Perspective of MBRs, Bio-treatment Fundamentals, Biomass Separation MBR Principles, Fouling and Fouling Control, MBR Design Principles, Design Assignment, Alternative MBR Configurations, Commercial Technologies, Case Studies								CO3
UNIT IV	Pretreatment Systems					Periods: 9		
Membrane Fouling – Pretreatment methods and strategies– monitoring of Pretreatment – Langlier Index, Silt Density Index, Chemical cleaning, Bio foulant control								CO4
UNIT V	Case Studies					Periods: 9		
Case studies on the design of membrane-based water and wastewater treatment systems–zero Liquid effluent discharge Plants								CO5
Lecture Periods: 45		Tutorial Periods:-		Practical Periods:-		Total Periods: 45		
Reference Books								
1. Jorgen Wagner, Membrane Filtration handbook, Practical Tips and Hints, Second Edition, Revision Osmonics Inc., 2001								
2. K. Yamamoto and Urase T, Membrane Technology in Environmental management, special issue, Water Science and technology, Vol.41, IWA Publishing, 2000								
3. Mulder, M., Basic Principle of Membrane Technology, Kluwer Academic Publishers, 1996								
4. Noble, R.D. and Stern, S.A., Membrane Separations Technology: Principles and Applications, Elsevier, 1995.								
5. Symon Jud, MBR Book – Principles and application of MBR in water and wastewater treatment, Elsevier, 2006								
6. Water Environment Federation (WEF), Membrane Systems for Wastewater Treatment, McGraw-Hill, USA, 2005								

Department: Chemical Engineering				Programme: M.Tech.(Chemical Engineering)				
Semester: I				Course Category Code: PSE		Semester Exam Type: TY		
CourseCode	CourseName	Periods/ Week			Credit	MaximumMarks		
		L	T	P		CA	SE	TM
CHE05	Process Design and Synthesis	3	-	-	3	40	60	100
Prerequisite								
Course Outcome	On completion of the course, the student will be able to							
	CO1	Understandtheusageofcommercialflowsheetingsoftwaretoprocessdesign applications						
	CO2	Apply life cycle assessment techniques in process industries						
	CO3	Design processes involving reactor networks						
	CO4	Integrateandapplytechniquesandknowledgetodesignseparationbasedequipment						
	CO5	Designandsynthesisprocessesforheatexchangernetworkingapplications						
UNIT I	Introduction					Periods:9		
Introductiontofundamentalconceptsandprinciplesofprocesssynthesisanddesignanduseofflowsheet Simulators to assist process design. Process Flow sheet Models: An Introduction to Design, Chemical process synthesis, analysis and optimization.								CO1
UNIT II	Product Design and Developments					Periods:9		
ProcessengineeringeconomicsandprojectevaluationLifeCycleAssessments of process: From design to product development, Engineering Economic Analysis of Chemical Processes, Project costing and performance analysis, Environmental concerns, Green engineering, Engineering ethics, Health and safety								CO2
UNIT III	Reactor Networks					Periods:9		
Geometry of mixing and basic reactor types, The Attainable Region (AR) approach, AR in higher Dimensions & for other processes, Reactive Separation processes, Fundamental behavior and problems, Separation through reactions. Reactive Residue Curve Maps								CO3
UNIT IV	Synthesis of Separation Trains					Periods:9		
Criteria for selection of separation methods, selection of equipment: Absorption, Liquid-liquid extraction Membrane separation, adsorption, leaching, drying, crystallization, Ideal distillation - Column and sequence fundamentals, Sharp splits & sequencing Phased diagrams for 2, 3 and 4 components, Feasibility and vapor flow rates for single columns, Residue curve basics.								CO4
UNIT V	Heat Exchanger Network Synthesis					Periods:9		
Minimum heating and cooling requirements, Minimum Energy Heat Exchanger Network, Loops and Paths, Reducing Number of Exchangers, HENS basics & graphics, The pinch point approach, Stream Splitting, Performance targets.								CO5
Lecture Periods:45		Tutorial Periods:-		Practical Periods:-		Total Periods:45		
Reference Books								
1. Douglas, J. "Conceptual Design of Chemical Processes", New York, : McGraw-Hill, 1988. ISBN: 0070177627.								
2. Seider, W.D., J.D. Seader, and D.R. Lewin. "Product and Process Design Principles: Synthesis, Analysis and Evaluation", 2nd ed. New York, NY: Wiley, 2004. ISBN: 0471216631.								
3. Richard Turton, Richard C. Bailie, Wallace B. Whiting, Joseph A. Shaeiwitz., "Analysis, Synthesis, and Design of Chemical Processes", 2nd Edition, 2002, Prentice Hall ISBN-10: 0-13-064792-6								
4. Biegler L. T., Grossmann I. E. and Westerberg A. W., "Systematic Methods of Chemical Process Design", Prentice Hall, 1997.								

Department: Chemical Engineering				Programme: M.Tech.(Chemical Engineering)				
Semester: I				Course Category Code: PSE			Semester Exam Type: TY	
Course Code:	Course Name:	Periods/ Week			Credit	Maximum Marks		
		L	T	P		CA	SE	TM
CHE06	Food Processing Technology	3	-	-	3	40	60	100
Prerequisite								
Course Outcome	On completion of the course, the student will be able to							
	CO1	Understand the working and principles of various food handling equipments.						
	CO2	Understand the working and principles of various food processing equipments.						
	CO3	Understand various food preservation techniques.						
	CO4	Understand various methods of food processing.						
	CO5	Understand and demonstrate the production of various types of value added and innovative food products of commercial importance.						
UNIT I	Food Handling Equipments					Periods: 9		
Principle consideration of food handling equipments; belt conveyor, screw conveyor, bucket elevator and pneumatic conveyors; equipments for size reduction, Size classification, Mixing, Kneading, Blending, Extrusion and emulsification.								CO1
UNIT II	Food Processing Equipments					Periods: 9		
Principle considerations of food processing equipments; Types and Principle of dryers, heat exchangers, Evaporators, pasteurizer, Blancher, Retorts and distillation units; mechanical separation: filtration, sieving, centrifugation, sedimentation.								CO2
UNIT III	Food Preservation					Periods: 9		
Introduction; principles and methods of food preservation; High Temperature Preservation; Low temperature preservation; Drying, dehydration and concentration; Food irradiation; Preservation using sugar, salt and acids; Preservation by use of chemicals.								CO3
UNIT IV	Recent Methods in Food Processing					Periods: 9		
Introduction; PEF, HPP, ultrasound, dielectric heating; microwave heating, ohmic heating; infrared heating; UV light, X-rays, membrane processing, ozonisation; high intensity electric field in pulses; new Hybrid drying technologies; monitoring by NMR and MRI Technology								CO4
UNIT V	Innovative and Value Added Food Products					Periods: 9		
Processing & Utilization of Soya bean for value added products; Innovative products from cereals, pulses and oilseeds; Extrusion technology for cereals; Oil seeds Processing; Prepared meat products; Manufacturing of fruit juice concentrates, Preparation of jam, jellies and marmalades; Preparation of Preserved and can dried fruits; Pickling of fruits and vegetables.								CO5
Lecture Periods: 45		Tutorial Periods:-		Practical Periods:-		Total Periods: 45		
Reference Books								
1. Fundamental of Food Process Engineering; Toledo RT; 2nd ed, 2000, CBS Publishers.								
2. Carl. W. Hall. (1988). Processing Equipments for Agri. Products. McGraw Hill Pub. Co.								
3. Subbulakshmi. G., and Shobha A. Udipi, Food Processing and Preservation, New Age International Publications, New Delhi, 2007.								
4. Toledo, R. T., "Fundamental of Food Process Engineering", CBS Publishers and Distribution, New Delhi, 1997.								

Department: Chemical Engineering			Programme: M.Tech.(Chemical Engineering)					
Semester: I			Course Category Code: PSE			Semester Exam Type: TY		
Course Code	Course Name	Periods/ Week			Credit	Maximum Marks		
		L	T	P		CA	SE	TM
CHE07	Fluidization Engineering	3	-	-	3	40	60	100
Prerequisite								
		On completion of the course, the student will be able to						
Course Outcome	CO1	Know industrial applications						
	CO2	Map the various regimes						
	CO3	Write various fluidization models						
	CO4	Write dispersion models						
	CO5	Design fluidization systems						
UNIT I	Introduction to Fluidization and Applications					Periods:9		
Phenomenon of fluidization, behavior of fluidized bed, contacting modes, advantages and disadvantages of fluidization, fluidization quality, selection of contacting mode, Beds for Industrial applications, coal gasification, synthesis reactions, physical operations, cracking of hydrocarbons							CO1	
UNIT II	Mapping of Fluidization Regimes					Periods:9		
characterization of particles, mechanics of flow around single particles, minimum fluidization velocity, pressure drop versus velocity diagram, The Geldart classification of solids, fluidization with carryover of particles, terminal velocity of particles, distributor types, gas entry region of bed, pressure drop requirements, design of gas distributor, power consumption							CO2	
UNIT III	Bubbling Fluidized Beds					Periods:9		
Davidson model for bubble in a fluidized bed, and its implications, the wake region and movement of solids at bubbles, coalescence and splitting of bubbles, bubble formation above a distributor, slug flow, Turbulent and fast fluidization - mechanics, flow regimes and design equations, Emulsion movement, estimation of bed properties, bubbler rise velocity, scale up aspects, flow models, two phase model, K-L model							CO3	
UNIT IV	Solids Movement and Gas Dispersion					Periods:9		
Vertical and horizontal movement of solids, Dispersion model, large solids in beds of smaller particles, staging of fluidized beds, gas dispersion in beds, gas interchange between bubble and emulsion, estimation of gas interchange coefficient, Heat and mass transfer in fluidized systems, Mixing in fluidized systems-measurements and models.							CO4	
UNIT V	Fluidized Bed Reactors and Applications					Periods:9		
Entrainment and elutriation, Freeboard behavior, gas outlet, entrainment from tall vessel, freeboard entrainment model, high velocity fluidization, pressure drop in turbulent and fast fluidization, Slugging, Spouted beds, Circulating Fluidized Beds, fluidized bed driers. Mathematical model of a homogeneous fluidized bed, Design of catalytic reactors, pilot plant reactors, information for design, bench scale reactors, design decisions, deactivating catalysts, Design of non catalytic reactors, kinetic models for conversion of solids, models for shrinking particles, conversion of solids of unchanging size							CO5	
Lecture Periods:45		Tutorial Periods:-		Practical Periods:-		Total Periods:45		
Reference Books								
1. Levenspiel O. and Kunii D., "Fluidization Engineering", John Wiley, 1972								
2. Liang-Shih Fan, "Gas-Liquid-Solid Fluidization Engineering", Butterworths, 1989								
3. Fluidization edited by J.F. Davidson and D. Harrison, Academic Press, 1971.								
4. Gas fluidization technology edited by D. Geldart, Wiley-Blackwell (3 December 1986)								
5. J.R. Howard, Fluidized bed Technology principles and applications, Adam Hilger, 1989.								
6. Max Leva, Fluidization, McGraw Hill, 1980								

Department: Chemical Engineering			Programme: M.Tech.(Chemical Engineering)					
Semester: I			CourseCategoryCode: PSE			SemesterExamType: TY		
CourseCode	CourseName	Periods/ Week			Credit	MaximumMarks		
		L	T	P		CA	SE	TM
CHE08	Design of Experiments and Parameter Estimation	3	-	-	3	40	60	100
Prerequisite								
Course Outcome	On completion of the course, the student will be able to							
	CO1	Understand the basic concepts involved in design of experiments						
	CO2	Use statistics in experimentation						
	CO3	Include statistical approach to propose hypothesis from experimental data						
	CO4	Estimate parameters by multi-dimensional optimization						
	CO5	Apply Response surface methodology in practical cases						
UNIT I	Introduction, Data Analysis and Distributions					Periods:9		
Design of experiments. Basic concepts, Bias and confounding, controlling bias, causation, Random Variables- Exploratory Data Analysis- Variable types, Displaying the distribution, mean variance and typical spread, quartiles and unusual spread, multivariate data: finding relations- Probability								CO1
UNIT II	Estimation Techniques and Linear Regression Analysis					Periods:9		
Point Estimation -Interval Estimation -Hypothesis Testing – Linear Regression Model –Parameter Estimation-Matrix approach to linear regression-ANOVA-quantifying regression fit of experimental data, Extra sum of squares approach, confidence intervals on regression coefficients, lack of fit analysis.								CO2
UNIT III	Single Factor Experiments					Periods:9		
Completely randomized design–Randomized block design–Effects of coding the observations, Latin square design-orthogonal contrasts-comparison of treatment means–Duncan’s Multiple range test, Newman –Keul’s test, Tukey’s test.								CO3
UNIT IV	Factorial Experiments					Periods:9		
Main and interaction effects–Rules for sum of squares and expected mean square, two and three factor full factorial design, 2k designs with two and three factors. Yate’s algorithm, practical applications								CO4
UNIT V	Taguchi Techniques & Response Surface Methodology					Periods:9		
Orthogonal designs–data analysis–parameter design-noise factors, objective functions (S/N ratios)– applications Response Surface Methodology: Method of steepest ascent, first and second order models, identification of optimal process conditions Introduction to Design of Experiments using R								CO5
Lecture Periods:45		Tutorial Periods:-		Practical Periods:-		Total Periods:45		
Reference Books								
1. Douglas C. Montgomery, Design of Experiments. John Wiley & Sons, 2005 2. Hanneman, Robert A., Kposowa, Augustine J., Riddle, Mark D. Research Methods for the Social Sciences: Basic Statistics for Social Research. John Wiley & Sons, 2012. 3. Saunders, Mark, Brown, Reva Berman, Dealing with Statistics: What You Need to Know. McGraw-Hill Education, 2007. 4. Philip J. Ross (1989). Taguchi Techniques for Quality Engineering, Prentice Hall.								

Department: Chemical Engineering			Programme: M.Tech.(Chemical Engineering)					
Semester: II			Course Category Code: PSE			Semester Exam Type: TY		
Course Code	CourseName	Periods/ Week			Credit	MaximumMarks		
		L	T	P		CA	SE	TM
CHE09	Process Intensification	3	-	-	3	40	60	100
Prerequisite								
Course Outcome	On completion of the course, the student will be able to							
	CO1	Understand the basic techniques involved in Process Intensification						
	CO2	Apply the process intensification techniques to a range of chemical processes						
	CO3	Develop various equipment to intensify the mixing processes						
	CO4	Develop various strategies to intensify the heat exchange processes						
	CO5	Understand the intensification processes applied in various fields						
UNIT I	Introduction				Periods:9			
Introduction: Techniques of Process Intensification (PI) Applications, The philosophy and opportunities of Process Intensification, Main benefits from process intensification, Process Intensifying Equipment, Process intensification toolbox, Techniques for PI application.								CO1
UNIT II	Process Intensification in various processes				Periods:9			
Process intensification through micro reaction technology: Effect of miniaturization on unit operations and reactions, Implementation of Micro-reaction Technology, From basic Properties To Technical Design Rules, Inherent Process Restrictions in Miniaturized Devices and their Potential Solutions, Micro-fabrication of Reaction and unit operation Devices- Wet and Dry Etching Processes.								CO2
UNIT III	Mixing				Periods:9			
Scales of mixing Flow patterns in reactors, Mixing in stirred tanks: Scale up of mixing, Heat transfer. Mixing in intensified equipment, Chemical Processing in High-Gravity Fields Atomizer Ultrasound Atomization, Nebulizers, High intensity inline MIXERS reactors Static mixers, Ejectors, Tee mixers, Impinging jets, Rotor stator mixers, Design Principles of static Mixers Applications of static mixers, High speed reactors.								CO3
UNIT IV	Intensification in Heat Exchangers				Periods:9			
Combined chemical reactor heat exchangers and reactor separators: Principles of operation; Applications, Reactive Absorption, Reactive distillation, Applications of RD Processes, Fundamentals of Process Modelling, Reactive Extraction Case Studies: Absorption of NO _x Coke Gas Purification. Compact heat exchangers: Classification of compact heat exchangers, Plate heat exchangers, Spiral heat exchangers, Flow pattern, Heat transfer and pressure drop, Flat tube and fin heat exchangers, Micro channel heat exchangers, Phase change heat transfer, Selection of heat exchanger technology, Feed/effluent heat exchangers, Integrated heat exchangers in separation processes, Design of compact heat exchanger - example.								CO4
UNIT V	Intensification in Enhanced fields				Periods:9			
Enhanced fields: Energy based intensifications, Sono-chemistry, Basics of cavitation, Cavitation Reactors, Flow over a rotating surface, Hydrodynamic cavitation applications, Cavitation reactor design, Nusselt-flow model and mass transfer, The Rotating Electrolytic Cell, Microwaves, Electrostatic fields, Sonocrystallization, Reactive separations, Supercritical fluids								CO5
Lecture Periods:45		Tutorial Periods:-		Practical Periods:-		Total Periods:45		
Reference Books								
1. Stankiewicz, A. and Moulijn, (Eds.), Reengineering the Chemical Process Plants, Process Intensification, Marcel Dekker, 2003.								
2. Reay D., Ramshaw C., Harvey A., Process Intensification, Butterworth-Heinemann, 2008.								
3. Kamelia Boodhoo (Editor), Adam Harvey (Editor), Process Intensification Technologies for								

Green Chemistry: Engineering Solutions for Sustainable Chemical Processing, Wiley, 2013.

- Segovia-Hernández, Juan Gabriel, Bonilla-Petriciolet, Adrián (Eds.) Process Intensification in Chemical Engineering Design Optimization and Control, Springer, 2016.

Reay, Ramshaw, Harvey, Process Intensification, Engineering for Efficiency, Sustainability and Flexibility, Butterworth-Heinemann, 2013.

Department: Chemical Engineering				Programme: M.Tech.(Chemical Engineering)				
Semester: II				Course Category Code: PSE		Semester Exam Type: TY		
Course Code	Course Name	Periods/ Week			Credit	MaximumMarks		
		L	T	P		CA	SE	TM
CHE10	Process Integration	3	-	-	3	40	60	100
Prerequisite								
CourseOutcome	On completion of the course, the student will be able to							
	CO1	Understandthevariousopportunitiesintheprocessintegrationinchemical industries.						
	CO2	Understand the key elements involved in pinch technology						
	CO3	Identify maximum heat recovery techniques for a given processes						
	CO4	Integrate various energy intensive thermal separation operations						
	CO5	Evaluate the process integration measures with waste treatment systems						
UNITI	Introduction				Periods:9			
Introduction to process Intensification and Process Integration (PI).Areas of application and techniques available for PI, onion diagram.								CO1
UNITII	Pinch Technology				Periods:9			
PinchTechnology-anoverview:Introduction,Basicconcepts,Howitisdifferentfromenergyauditing, Rolesofthermodynamiclaws,problemsaddressedbyPinchTechnology,KeystepsofPinchTechnology: Concept ofT _{min} , Data Extraction, Targeting, Designing, Optimization Super targeting, Basic Elements of Pinch Technology: Grid Diagram, Composite curve, Problem Table Algorithm, Grand Composite Curve.								CO2
UNITIII	Network Analysis				Periods:9			
Heatexchangernetworksanalysis,MaximumEnergyRecovery(MER)networksformultipleutilities andmultiple,ChemicalEngineeringPre-requisites:Knowledgeofbasicprocessdesignofprocess equipment. Pinches, design of heat exchanger network.								CO3
UNITIV	Heat Integrated Units				Periods:9			
Heatintegrateddistillationcolumns,evaporators,dryers,andreactors								CO4
UNITV	Integration of Waste Treatment Systems				Periods:9			
Waste and wastewater minimization, flue gas emission targeting, and heat and power integration. Case studies.								CO5
LecturePeriods:45		Tutorial Periods:-		Practical Periods:-		TotalPeriods:45		
ReferenceBooks								
1. ShenoyU.V.;"HeatExchangerNetworkSynthesis",Gulf Publishingcompany,1995								
2. SmithR.;"Chemical Process Design",McGraw-Hill,2006								
3. Linnhoff B., Townsend D. W.,Boland D, Hewitt G. F., Thomas B.E.A., Guy A. R., and MarslandR.H.;"A User Guide on Process Integration for the Efficient Use of Energy",Inst. of Chemical Engineers.1994								

Department: Chemical Engineering				Programme: M.Tech.(Chemical Engineering)				
Semester: II				Course Category Code: PSE		Semester Exam Type: TY		
Course Code	Course Name	Periods/ Week			Credit	Maximum Marks		
		L	T	P		CA	SE	TM
CHE11	Process Plant Design and Flow Sheeting	3	-	-	3	40	60	100
Prerequisite								
Course Outcome	On completion of the course, the student will be able to							
	CO1	Understand the basic principles involved in Process Design Development						
	CO2	Synthesize flowsheet for various systems and develop strategies for heat integration						
	CO3	Learn various flow sheet optimization techniques						
	CO4	Estimate fixed and working capital and operating costs for process plants						
CO5	Apply optimization techniques for various plant operations							
UNIT I	Introduction					Periods:9		
Basic concepts: General design considerations, Process design development, Layout of plant items, Flow sheets and PI diagrams, Economic aspects and Optimum design, Practical considerations in design and engineering ethics, Degrees of freedom analysis in interconnected systems, Network analysis, PERT/CPM, Direct and Indirect costs, Optimum scheduling and crashing of activities.							CO1	
UNIT II	Flow Sheet Synthesis and Heat Integration					Periods:9		
Hierarchy of chemical process design; Nature of process synthesis and analysis; Developing a conceptual design and flow sheet synthesis. Synthesis of reaction-separation systems; Distillation sequencing; Energy targets. Heat integration of reactors, distillation columns, evaporators and driers; Process change for improved heat integration. Heat and mass exchange networks and network design.							CO2	
UNIT III	Flow Sheet Generation and Optimization					Periods:9		
Synthesis of flow sheet: Propositional logic and semantic equations, Deduction theorem, Algorithmic flowsheet generation using P-graph theory, Sequencing of operating units, Feasibility and optimization of flowsheet using various algorithms viz, Solution Structure Generation (SSG), Maximal Structure Generation (MSG), Simplex, Branch-and-bound etc.							CO3	
UNIT IV	Cost Estimation					Periods:9		
Analysis of Cost estimation: Factors affecting Investment and production costs, Estimation of capital investment and total product costs, Interest, Time value of money, Taxes and fixed charges, Salvage value, Methods of calculating depreciation, Profitability, Alternative investments and replacements.							CO4	
UNIT V	Optimum Design					Periods:9		
Optimum Design and Design Strategy: Break-even analysis, Optimum production rates in plant operation, Optimum batch cycle time applied to evaporator and filter press, Economic pipe diameter, Optimum insulation thickness, Optimum cooling water flow rate and optimum distillation reflux ratio.							CO5	
Lecture Periods:45		Tutorial Periods:-		Practical Periods:-		Total Periods:45		
Reference Books								
1. Peters, M.A. and Timmerhaus, K.D., Plant Design and Economics for Chemical Engineers, McGraw Hill (2003).								
2. Anil Kumar, Chemical Process Synthesis and Engineering Design, Tata McGraw Hill (1982).								
3. Ulrich, G.D., A Guide to Chemical Engineering Process Design and Economics, John Wiley & Sons (1984).								
4. Perry, R.H. and Green, D., Chemical Engineer's Handbook, McGraw-Hill (1997).								

Department: Chemical Engineering				Programme: M.Tech.(Chemical Engineering)				
Semester: II				Course Category Code: PSE			Semester Exam Type: TY	
CourseCode	CourseName	Periods/ Week			Credit	Maximum Marks		
		L	T	P		CA	SE	TM
CHE12	Bio process Engineering	3	-	-	3	40	60	100
Prerequisite								
Course Outcome	On completion of the course, the student will be able to							
	CO1	Understand the different types of living cells and their use in biochemical processes.						
	CO2	Understand enzymes and cell immobilization process.						
	CO3	Understand and Analyzed different bioreactors and upstream process used in production of bio-products.						
	CO4	Analyze and understand various downstream processes used in production of bio-products.						
	CO5	Understand the principles and applications of plant, animal and mixed microbial culture techniques.						
UNIT I	Introduction and Microbial Stoichiometry					Periods:9		
Introduction to Bioprocess engineering, overview of basics of microbial and enzyme kinetics, Stoichiometry Of microbial growth and product formation: basic definitions, stoichiometric calculations, elemental balances, degree of reduction, theoretical predictions of yield coefficients, design of media.								CO1
UNIT II	Enzyme and Cell Immobilization					Periods:9		
Free and enzyme immobilized enzyme kinetics, external mass transfer limitations, Damkohler number, internal mass transfer limitations, Thiele modulus, immobilization efficiency, effectiveness factor, active immobilization of cells, passive immobilization and diffusional limitations in immobilized cell systems.								CO2
UNIT III	Bioreactors					Periods:9		
Batch growth kinetics, continuous culture (chemostat/turbidostat), Chemostat with recycle, multistage chemostat, fed batch and perfusions reactors, bioreactors considerations in immobilized cell and enzyme systems, Selection, scale-up, scale down of bioreactors, bioreactor instrumentation and control, sterilization of processes fluids.								CO3
UNIT IV	Recovery and Purification of Products					Periods:9		
Strategies to recover and purify products, separation of insoluble products, cell disruption: mechanical, chemical and enzymatic methods; separation of soluble products: extraction, ATPS, precipitation, adsorption, filtration, Chromatography.								CO4
UNIT V	Bio process Considerations in Using Animal, Plant Cell and Mixed Cultures					Periods:9		
Methods used for cultivation of animal and plant cells; Bioreactor considerations for animal and plant cell culture; products of animal cell culture. Mixed cultures - introduction; models for interaction in mixed cultures; mixed cultures in nature; industrial utilization of mixed cultures; biological waste treatment using mixed cultures.								CO5
Lecture Periods:45		Tutorial Periods:-		Practical Periods:-		Total Periods:45		
Reference Books								
1. Shuler M.L., Kargi F., "Bioprocess Engineering", Prentice-Hall								
2. Bailey J.E. and Ollis D.F., "Biochemical Engineering Fundamentals", McGraw-Hill								
3. Doran P.M., "Bioprocess Engineering Principles", Academic Press								
4. Mukesh Doble, Sathyanarayana N. Gummadi., "Biochemical Engineering", PHI learning Pvt Ltd.								

Department: Chemical Engineering				Programme: M.Tech.(Chemical Engineering)				
Semester: II				Course Category Code: PSE			Semester Exam Type: TY	
Course Code	Course Name	Periods/ Week			Credit	Maximum Marks		
		L	T	P		CA	SE	TM
CHE13	Application of Nanotechnology in Chemical Engineering	3	-	-	3	40	60	100
Prerequisite								
Course Outcome	On completion of the course, the student will be able to							
	CO1	Conceptualize the fundamentals of nanotechnology						
	CO2	Understand the various synthesis and characterization techniques of nanomaterials						
	CO3	Gain knowledge on semiconductors and quantum dots						
	CO4	Describe polymer nanoparticles and nano composites						
CO5	List down the applications of nanotechnology in safety and environment							
UNIT I	Introduction to Nanotechnology					Periods: 9		
Introduction nanotechnology, Feynman's Vision- There's Plenty of Room at the Bottom, Classification of nanostructures, Nanoscale architecture, Chemical interactions at nanoscale, Types of carbon based nanomaterials, Synthesis of fullerenes, Graphene, Carbon nanotubes, Functionalization of carbon nanotubes, One, two and multidimensional structures, Crystallography.						to	CO1	
UNIT II	Approaches to Synthesis of Nanoscale Materials and Characterisation					Periods: 9		
Top-down approach, Bottom-up approach, Bottom-up vs. top-down fabrication; Top-down: Atomization, Sol-gel technique, Arc discharge, Laser ablation, RF sputtering; Bottom-up: Chemical Vapor Deposition (CVD), Metal Oxide Chemical Vapor Deposition (MOCVD), Atomic layer deposition (ALD), Molecular beam Molecular self-assembly; Ultrasound assisted, microwave assisted, Mini, micro and nano emulsion. Wet grinding method, Spray pyrolysis, Ultrasound assisted pyrolysis, atomization techniques. Surfactant based synthesis procedures, Types of molecular modeling methods. Size, shape, crystallinity, topology, chemistry analysis using X-ray imaging, Transmission Electron Microscopy, HRTEM, Scanning Electron Microscopy, SPM, AFM, STM, PSD, Zeta potential, DSC and TGA						CO2		
UNIT III	Semiconductors and Quantum Dots					Periods: 9		
Intrinsic semiconductors, Extrinsic semiconductors, Review of classical mechanics, de Broglie's hypothesis, Heisenberg uncertainty principle Pauli exclusion principle Schrödinger's equation Properties of the wave function, Applications: quantum well, wire, dot, Quantum cryptography						CO3		
UNIT IV	Polymer based and polymer filled Nano composites					Periods: 9		
Nanoscale Fillers, Nanofiber or Nanotube Fillers, Plate-like Nanofillers, Equi-axed Nanoparticle Fillers, Inorganic Filler Polymer Interfaces, Processing of Polymer Nanocomposites, Nanotube/Polymer Composites, Layered Filler Polymer Composite Processing, Nanoparticle/Polymer Composite Processing: Direct Mixing, Solution Mixing, In-Situ Polymerization, In-Situ Particle Processing, In-Situ Particle Processing Metal/Polymer Nanocomposites, Properties of nanocomposites.						CO4		
UNIT V	Applications to Safety, Environment and Others					Periods: 9		
Chemical and Biosensors- Classification and Main Parameters of Chemical and Biosensors, Nanostructured Materials for Sensing, Waste Water Treatment, Nanobiotechnology, Drug Delivery, Nanocoatings, Self-cleaning Materials, Hydrophobic Nanoparticles, Photocatalysts, Biological nanomaterials, Nanoelectronics, Nanomachines & nanodevices, Societal, Health and Environmental Impacts.						CO5		
Lecture Periods: 45		Tutorial Periods:-		Practical Periods:-		Total Periods: 45		
Reference Books								

1. Louis Hornyak G., Dutta Joydeep, Tibbals Harry F. and Rao Anil K., "Introduction to Nanoscience", (CRC Press of Taylor and Francis Group LLC), May 2008, 856pp, ISBN-13: 978142004805

2. Ajayan P.M., Schadler L.S., Braun P.V., "Nanocomposite Science and Technology", Edited by WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim ISBN: 3-527-30359-6, 2003.
- 3 Kelsall Robert W., Hamley Ian W., Geoghegan Mark, "Nanoscale Science and Technology", John Wiley & Sons, Ltd, 2006.
- Kal Ranganathan Sharma, "Nanostructuring Operations in Nanoscale Science and Engineering", McGraw-Hill Companies, Inc. ISBN: 978-0-07-162609-5, 2010.
- "Organic and inorganic nanostructures".-(Artech House MEMS series), Nabok, Alexei, ISBN 1-58053-818-5, 2005.

Department: Chemical Engineering			Programme: M.Tech.(Chemical Engineering)					
Semester: II			Course Category Code: PSE			Semester Exam Type: TY		
CourseCode	CourseName	Periods/ Week			Credit	Maximum Marks		
		L	T	P		CA	SE	TM
CHE14	Process Modeling and Simulation	3	-	-	3	40	60	100
Prerequisite								
Course Outcome	On completion of the course, the student will be able to							
	CO1	Understand various classes of mathematical models and formulate a mathematical model for any particular chemical engineering system and classify it appropriately						
	CO2	Formulate a mathematical model for any chemical engineering system represented by ODE with constant coefficients and obtain appropriate analytical solution for it.						
	CO3	Formulate a mathematical model for any chemical engineering system represented by ODE with variable coefficients and obtain appropriate analytical solution for it.						
	CO4	Formulate a mathematical model for any chemical engineering system represented by PDE and obtain appropriate analytical solution for it						
	CO5	Formulate mathematical models for chemical engineering systems represented by PDEs and solve it using similarity solution method or using Green's function						
UNIT I	Formulation and Classification of Mathematical Models				Periods:9			
Lumped parameter Steady State Models - Equations of State, Stage wise separation process, Reactors in series ; Lumped parameter unsteady state models - models resulting in ODEs IVP - dynamics of a CSTR, Two-pool Urea kinetic model for haemo dialysis, Bio-artificial membrane device for controlled insulin release; Distributed parameter steady state models - models resulting in ODEs BVP -Heat diffusion with generation in composite cylinders, modelling of a bio-filtration, modelling of a differential contactor for extractive fermentation ; Models resulting in partial differential equations - unsteady state heat transfer through a rectangular fin, unsteady state heat conduction in a rectangular solid, oxygen transport in tissues, absorption of a drug through the skin, slow release of fertilizer through polymer coating, controlled release of drug through a Drug-Eluting Stent (DES); Model equations in non-dimensional form								CO1
UNIT II	Solution of ODEs and Applications				Periods:9			
Solution of First order ODEs - cooling of a ball by natural convection, modelling of cancer stem cell hypothesis, drug administration at regular intervals ; Solution of Second and Higher order linear ODEs with constant coefficients and Cauchy - Euler equation - Heat flow in a rod connecting two walls, microwave heating of a slab, solute transport in a haemodialyser, two - pool urea kinetic model for haemodialysis, oxygen limited growth of follicles, oxygen transport in tissues, axial dispersion in a tubular reactor, diffusion with reaction in membrane, diffusion and metabolic consumption of oxygen in small organism, gas absorption with chemical reaction in a slurry of catalyst particles, Facilitated transport through a membrane, diffusion controlled sensitivity of a semiconductor gas sensor, Slow release of a fertilizer, Mathematical modelling of a wound healing, diffusion controlled growth of a solid tumor, Laplace transform technique, system of linear ODEs								CO2
UNIT III	Special Functions and Solution of ODEs With Variable Coefficients				Periods:9			
Gamma function, Beta function, Error function, Gamma distribution, Series solution of second order ODEs with variable coefficients, Series solution of second order ODEs leading to special functions - Bessel functions, Legendre function, Hyper geometric functions, Case studies - Heat transfer from a radial fin, Micro wave heating of a slab, Bio heat transfer antitumor, Modelling of diffusion-reaction in a hollow fibre bioreactor, Oxygen transport in a plant root								CO3
UNIT IV	Partial Differential Equations-I				Periods:9			
Common second order PDEs in Science and Engineering, Boundary Value Problems, Types of boundary conditions, Techniques of analytical solutions of a second order PDE - Separation of variable - Thermal transient in a large plane wall, Solution of non-homogeneous PDEs - method of partial solution - unsteady state heat conduction in a large wall with different surface temperatures, method of Eigen function								CO4

expansion - Dynamics of an enzyme electrode, Steady state temperature distribution in a rectangular block, Unsteady state heat conduction in a long cylinder, Unsteady state heat conduction in a sphere, Steady state reaction-diffusion in a short cylinder catalyst pellet, Steady state concentration profile in a laminar flow tubular reactor for a first order reaction, Drug release from a cylindrical DES			
UNIT V	Partial Differential Equations-II	Periods:9	
Similarity solution - Unsteady heat conduction in a semi-infinite solid, Higbie's Penetration theory, Cooling of a stretching sheet in viscous flow, Moving Boundary Problems - Freezing of a large pool of water, Gas absorption with an instantaneous chemical reaction, Dissolution of a sphere in a large volume of stagnant liquid, Evaporation of a droplet, Principle of superposition - Unsteady state heating of a sphere with linearly time - varying surface temperature, Diffusion accompanied by a first order chemical reaction in a stagnant liquid, Unsteady state gas absorption with an accompanying first order reaction in a liquid pool of finite depth, Green Function - Solution of an ODE using Green's function, Solution of Diffusion equation and construction of the Green's function			CO5
Lecture Periods:45	Tutorial Periods:-	Practical Periods:-	Total Periods:45
Reference Books 1. Mathematical methods in chemical and biological engineering, Binay K Dutta, CRC Press, 2020 2. Applied mathematics and modeling for chemical engineers, R. G. Rice, D. D. Do, John Wiley and Sons, 1995 3. Mathematical methods in chemical engineering, Arvind Varma, Massimo Morbidelli, Oxford University Press, 2008 4. Mathematical methods in chemical engineering, S. Pushpavanam, Prentice Hall of India, 1998			

Department:Chemical Engineering				Programme:M.Tech.(Chemical Engineering)					
Semester:II				Course Category Code:PSE			Semester Exam Type:TY		
CourseCode	CourseName	Periods/ Week			Credit	Maximum Marks			
		L	T	P			CA	SE	TM
CHE15	Micro and NanoFluidics	3	-	-	3	40	60	100	
Prerequisite									
Course Outcome	On completion of the course, the student will be able to								
	CO1	Understand the basic principles involved in Microflows							
	CO2	Applyvariousconceptsinvolvedinmicrofluidstodevicemicrofluiddevices							
	CO3	Analyse fluid flow in nanosized devices							
	CO4	Understand the fabrication of micro fluidic devices							
	CO5	Describe the fundamentals of Bio MEM Sand medical micro devices							
UNITI	Introduction					Periods:9			
Fundamentals of kinetic heory-molecular models,micro and macroscopic properties, binary collisions, distribution functions, Boltzmann equation and Maxwellian distribution functions-Wallslipeffectsandaccommodationcoefficients,flowandheattransferanalysisofmicroscale Couette flows, Pressure driven gas micro-flows with wall slip effects, heat transfer in micro-Poiseuilleflows,effectsofcompressibility.PressureDrivenLiquidMicroflow:apparentslipeffects, physics of near-wall micro scale liquid flows, capillary flows, electro-kinetically driven liquid micro - flows and electric double layer (EDL) effects, concepts of electroosmosis, electrophoresisand dielectro-phoresis.								CO1	
UNITII	Micro fluids					Periods:9			
Laminarflow:Hagen-Poiseullieeqn,basicfluidideas,Specialconsiderationsofflowinsmall channels, mixing, microvalvesµpumps, Approaches toward combining living cells,microfluidicsand‘thefody’onachip,Chemotaxis,cellmotility.CaseStudiesinMicrofluidic Devices.Ionictransport:Polymertransport-microtubuletransportinnanotubulechannelsdrivenby Electric Fields and by KinesinBiomolecular Motors - Electrophoresis of individual nanotubulesinmicrofluidic channels.								CO2	
UNITIII	Nan fluids					Periods:9			
Fabrication techniques for Nanofluidic channels - Biomolecules separation using Nanochannels - Biomolecules Concentration using Nanochannels - Confinement of Biomolecules using Nanochannels. Hydrodynamics:Particlemovinginflowfields-PotentialFunctionsinLowRenoyldsNumberFlow-ArraysofObstacles andhowparticlesMovein them:PuzzlesandParadoxesinLowReFlow.								CO3	
UNITIV	Fabricate of Micro fluidic Devices					Periods:9			
Microfluidics and Lab-on-a-chip: Microfluidic Devices - Microchannels, Microfilters, Microvalves, Micropumps, Microneedles, Microreserviors, Micro-reaction chambers. Concepts and Advantages of Microfluidic Devices - Fluidic Transport - Stacking and Scaling - Materials for The Manufacture(Silicon,Glass,Polymers)-FluidicStructures-FabricationMethods-Surface Modifications - Spotting - Detection Mechanisms. Microcontact printing of ProteinsStrategies- printing types-methodsandcharacterization-Cellnanostructureinteractions-networksforneuronalcells. ApplicationsinAutomaticDNAsequencing,DNAandProteinmicroarrays								CO4	
UNITV	MicroElectroMechanicalSystem					Periods:9			

BioMEMS (Micro-Electro-Mechanical Systems): Introduction and Overview, Biosignal Transduction Mechanisms: Electromagnetic Transducers Mechanical Transducers, Chemical Transducers, Optical Transducers - Sensing and Actuating mechanisms (for all types). Case Studies in Biomagnetic Sensors, Applicationsof optical and chemical transducers. Ultimate Limitsof Fabrication and Measurement, Recent Developments in BioMEMS and BioNEMS- An alternative approach to traditional surgery, Specific targeting of tumors and other organs for drug delivery, Micro-visualization and manipulation, Implantation of microsensors, microactuators and other components of a larger implanted device or external system (synthetic organs).	CO5
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Lecture Periods: 45	Tutorial Periods:-	Practical Periods:-	Total Periods: 45
<u>Reference Books</u>			
1. Joshua Edel "Nanofluidics" RSC Publishing, 2009. 2. Patric Tabeling "Introduction to Microfluids" Oxford U. Press, New York 2005. 3. K. Sarit "Nano Fluids; Science and Technology", RSC Publishing, 2007. 4. M. Madou, Fundamentals of Microfabrication, CRC Press, 1997 5. G. Kovacs, Micromachined Transducers, McGraw-Hill, 1998 6. Steven S Saliterman, Fundamentals of BioMEMS and Medical Microdevices, 2006			

Department: Chemical Engineering			Programme: M.Tech.(Chemical Engineering)					
Semester: II			Course Category Code: PSE			Semester Exam Type: TY		
CourseCode	CourseName	Periods/ Week			Credit	Maximum Marks		
		L	T	P			CA	SE
CHE16	Industrial PollutionControl	3	-	-	3	40	60	100
Prerequisite								
		On completion of the course, the student will be able to						
Course Outcome	CO1	Understand different types of wastes generated in an industry, their environmental regulatory legislations and standards.						
	CO2	Analyze the mechanism of proliferation of pollution						
	CO3	Develop methods for pollution abatement and waste minimization						
	CO4	Design treatment methods for gas, liquid and solid wastes						
	CO5	Understandaboutanalysisandquantificationofhazardoussolidwaste, treatmentand disposal.						
UNITI	Industries & Environment				Periods:9			
IndustrialscenarioinIndia-IndustrialactivityandEnvironment-Industrialwastes &their sources: various industrial processes, sources and types of wastes-solid, liquid, gaseous, noise & radiation emissions. Characterizationofemissionandeffluents,-Industrialwastesurvey-Industrialwastewatergeneration rates, - Population equivalent - Toxicity of industrial effluents and Bioassay tests. Environmental Laws and rules, standards for ambient air, noise emission and effluents.							CO1	
UNITII	Industrial Noise pollution				Periods:9			
Sourcesofnoisepollution,characterizationofnoisepollutionprevention&controlofnoisepollution, Factories Act 1948 for regulatory aspects of noise pollution, Pollution Control acts.							CO2	
UNITIII	Air Pollutant Abatement				Periods:9			
Airpollutantsscalesofconcentration, lapserateandstability, plumebehaviour, dispersionofair pollutants, atmospheric dispersion equation and its solutions, Gaussian plume models. Air pollution control methods,Sourcecorrectionmethods,Designconceptsforpollutionabatementsystemsforparticulatesand gases.Such as gravity chambers, cyclone separators, filters, electrostatic precipitators, condensation, adsorption and absorption, thermal oxidation and biological processes.							CO3	
UNITIV	Waste Water Treatment Processes				Periods:9			
Design concepts for primary treatment, secondary - Bacterial population dynamics, kinetics of biological growth and its applications to biological treatment, determination of kinetic coefficients, activated sludge process.Design,tricklingfilterdesignconsiderations,advancedtreatmentprocesses,Studyof environmentpollutionfromprocessindustriesandtheirabatement:Fertilizer,paperandpulp,inorganic acids,petroleumandpetrochemicals,recoveryofmaterialsfromprocesseffluents.							CO4	
UNITV	Solid Waste and Hazardous Waste Management				Periods:9			
Sources and classification, properties, public health aspects, Sanitary land fill design, Hazardous waste classification and rules, management strategies, Nuclear waste disposal Treatment methods -component separation,chemicalandbiologicaltreatment,incineration,solidificationandstabilization,and disposal methods, LatestTrendsinsolidwastemanagement, SoilManagement.							CO5	
LecturePeriods:45		Tutorial Periods:-		Practical Periods:-		TotalPeriods:45		
Reference Books								

- Rao C.S., "Environmental Pollution Control Engineering", 2nd edition
- Mahajan S.P., "Pollution Control in Process Industries".
- Stern A.C., "Air pollution", Volumes I to VI, Academic Press, New York, 1968
- Peterson and Gross E.Jr., "Hand Book of Noise Measurement", 7th Edn., 2003.
- Pollution Control Acts, Rules, Notifications issued there under" CPCB, Ministry of Env. and Forest, G.O.I., 3rd Ed. (2006).
- Industrial Water Pollution Control, 3rd edition Eckenfelder W.W.,
- Handbook of Solid Waste Management, 2nd edition Kreith F. and Tchobanoglous G.

Department: Chemical Engineering			Programme: M.Tech.(Chemical Engineering)					
Semester: III			Course Category Code: PSE			Semester Exam Type: TY		
CourseCode	Course Name	Periods/ Week			Credit	Maximum Marks		
		L	T	P			CA	SE
CHE17	Optimization of ChemicalProcesses	3	-	-	3	40	60	100
Prerequisite								
Course Outcome	On completion of the course, the student will be able to							
	CO1	Formulate an Optimization Problems in chemical engineering domain						
	CO2	Formulateandsolvesingleandmultivariableunconstrainedoptimizationproblem						
	CO3	Analyzeequalityandinequalityconstrainedoptimizationproblemsbyapplying Lagrangian multiplier technique and KKT optimality criterion						
	CO4	Formulate and solve LP, QP and IP problems						
	CO5	Solveproblemsinoptimizationofstagedanddiscreteprocessesusingdynamic programming and Generalized Bender Decomposition methods						
UNITI	Formulation of Optimization Problem and Concepts of Unconstrained Optimization				Periods:9			
Formulation of Optimization Problems in Chemical Engineering – Case Studies – Optimization of liquid storage tank, Optimization of Pump Configuration, Optimization of systems with chemical reactions, Calculation of optimum insulation thickness, optimization of simple heat exchanger network, optimum cost of an alloy using LP problem, Least square method								CO1
Basic concepts of unconstrained optimization -vectors and matrices, eigenvectors and Eigen values, vector andmatrixnorms,quadraticform,classificationoffunctions,optimalityconditions–necessaryand sufficientconditionsforlocaloptimality								
UNITII	Single and Multi-Variable Unconstrained Optimization				Periods:9			
Single variable unconstrained optimization methods – Direct Search Methods – Region elimination method, Dichotomous search, Interval halving method, Fibonacci method, Golden section method, Derivative based method – Newton’s method, Quasi Newton method, Secant method, Polynomial approximation method – quadratic interpolation and cubic interpolation methods, Trust Region method								CO2
Multivariable unconstrained optimization – Direct Search Methods – Grid search method, Univariate method, Pattern search methods – Powell’s method, Hooke – Jeeves method, Gradient Search method – Steepest descent method, Conjugate gradient method, Newton’s method, Marquardt method, Levenberg – Marquardtalgorithm,Quasi–Newtonmethod,TrustRegionmethods–Convexmodelproblems,Non-Convex model problems								
UNITIII	Concepts of Constrained Optimization				Periods:9			
Problemstwithequalityconstraints–Lagrangemultipliermethod,Problemstwithinequalityconstraints– Necessaryandsufficientconditions(KKTconditions)foroptimality,AnalysisofKKTconditions–Linearly constrainedproblems,Nonlinearlyconstrainedproblems,Secondorderconditions								CO3
UNITIV	Linear, Quadratic and Integer Programming				Periods:9			
Linear Programming – Basic concepts, Simplex method for solving LP problems, Duality in Linear Programming, Karmarkar’s Interior Point method ;Integer Linear Programming – Warehouse location and BlendingProblem,BranchandBoundmethod;QuadraticProgramming–GeneralizedReducedGradient Method								CO4
UNITV	Optimization of Staged and Discrete Processes				Periods:9			
DynamicProgramming–Descriptionofamultistageddecisionprocess,Applicationofdynamicprogrammingtowater distributionsystemandoptimalreplacementofequipment;IntegerandMixedInteger Programming–Formulation of MINLP, Generalized Bender Decomposition								CO5
Lecture Periods:45		Tutorial Periods:-		Practical Periods:-		TotalPeriods:45		

Reference Books
• Optimization of Chemical Processes, T.F. Edgar, D.M. Himmelblau, McGraw Hill, 1989 • Nonlinear Programming-Concepts, Algorithms, and Applications to Chemical Processes, L.T. Biegler, SIAM, 2010 • Optimization in Chemical Engineering, Suman Dutta, Cambridge University Press, 2016

Department: Chemical Engineering				Programme: M.Tech.(Chemical Engineering)				
Semester: III				Course Category Code: PSE			Semester Exam Type: TY	
Course Code	Course Name	Periods/ Week			Credit	Maximum Marks		
		L	T	P		CA	SE	TM
CHE18	Chemical Reactor Analysis	3	-	-	3	40	60	100
Prerequisite								
		On completion of the course, the student will be able to						
Course Outcome	CO1	Quantify factors affecting the choice of the reactor						
	CO2	Write models for catalytic reactors and reactions						
	CO3	Perform the energy balance and obtain concentration profiles in multiphase reactors						
	CO4	Estimate the performance of multiphase reactors under non-isothermal conditions						
	CO5	Calculate stability of reactor						
UNIT I	Factors Affecting Reactor Analysis				Periods: 9			
Chemical factor affecting the choice of the reactor, fundamental mass, energy and momentum balance, Model for a semi-batch reactor, optimum operation policies and control strategies, optimal batch operation time, optimal temperature policies, stability of operation and transient behavior for mixed flow reactor. Transient CSTR analysis, Hot spot equation; Optimization using Lagrange multiplier, Poynting's maximum principle.							CO1	
UNIT II	Catalytic Reactor and Reactions				Periods: 9			
Fixed bed catalytic reactor: The importance and scale of fixed bed catalytic processes, factors in preliminary design, modeling of fixed bed reactor. Pseudo-homogeneous model, the multi-bed adiabatic reactor, auto-thermal operation, non-steady-state model with axial mixing, two dimensional pseudo-homogeneous models, heterogeneous models, global and intrinsic rates, Mechanism of catalytic reactions, Engineering properties of catalysts-BET surface area, pore volume, pore size, pore size distribution, one dimensional and two dimensional model equation							CO2	
UNIT III	Multiphase Flow Reactors				Periods: 9			
Multiphase flow reactor: Types of multiphase flow reactors, packed columns, plate columns, empty columns, stirred vessel reactors. Development of rate equations for solid catalyzed fluid phase reactions; Estimation of kinetic parameters. External mass and heat transfer in catalyst particles. Stability and selectivity Packed bed reactor, slurry reactor; Trickle bed reactor and fluidized bed reactor. Intra-particle heat and mass transfer-Wheelers parallel pore model, random pore model of Wakao and Smith. Deactivation of catalyst, Ideal and non-ideal flow in reactors.							CO3	
UNIT IV	Multiphase Flow Reactors Design				Periods: 9			
Design model for multiphase flow reactors, gas and liquid phase in completely mixed and plug flow, gas phase in plug flow and liquid phase in completely mixed flow, effective diffusion model, two zone model, specific design aspects, packed absorber, two-phase fixed bed reactor, plate column, spray tower, bubble reactor, stirred vessel reactor. Computer-aided reactor design.							CO4	
UNIT V	Temperature Effects In Reactor				Periods: 9			
Introduction, well mixed system with steady feed, the stability and start-up of CSTR, limit cycles and oscillatory reactions, the plug flow reactors, tubular reactor, diffusion control, propagation of reaction zone.							CO5	
Lecture Periods: 45		Tutorial Periods:-		Practical Periods:-		Total Periods: 45		
Reference Books								

- Froment G. F. and K. B. Bischoff, "Chemical Reactor Analysis and Design", John Wiley & Sons
- Denbigh K. G. and J. C. Turner, "Chemical Reactor and Theory - an Introduction", 3rd edition Cambridge University Press.
- Bruce Nauman, "Chemical Reactor Design", John Wiley & Sons
- H. Scott Fogler, Elements of Chemical Reaction Engineering by, Pearson education
- R. E. Hayes and J. P. Mombage, Introduction to chemical reactor Analysis, CRC Press, 2015.
- Charles G. Hill & Thatcher W. Root, Introduction to chemical Engineering Kinetics & Reactor Design, Wiley, 2014.
- John B. Butt, reactor kinetics and reactor design second edition revised and expanded, Marcel Dekker Inc, 2000

Department: Chemical Engineering				Programme: M.Tech.(Chemical Engineering)				
Semester: III				Course Category Code: PSE			Semester Exam Type: TY	
Course Code	Course Name	Periods/ Week			Credit	Maximum Marks		
		L	T	P		CA	SE	TM
CHE19	Chemo Informatics	3	-	-	3	40	60	100
Prerequisite								
		On completion of the course, the student will be able to						
Course Outcome	CO1	Understand the concept of Chemo-informatics related to chemical structure databases and database search methods						
	CO2	Understand the application of chemical libraries and various pharmacological properties						
	CO3	Understand the quantum methods and models involved in drug discovery and targeted drug delivery						
	CO4	Describe the various modeling and structure elucidation techniques						
	CO5	Understand the models involved in drug delivery systems						
UNIT I	Introduction					Periods: 9		
Introduction, scope and application, Basics of Chemo-informatics, Current Chemo-informatics resources for synthetic polymers, pigments. Primary, secondary and tertiary sources of chemical information, Databases: Chemical Structure Databases (PubChem, Binding database, Drugbank), Database search methods: chemical indexing, proximity searching, 2D and 3D structure and sub structure searching. Drawing the Chemical Structure: 2D & 3D drawing tools (ACD/Chemsketch) Structure optimization.								CO1
UNIT II	Product Design and Developments					Periods: 9		
Combinatorial chemistry (library design, synthesis and deconvolution), spectroscopic methods and analytical techniques, Representation of Molecules and Chemical Reactions: Different types of Notations, SMILES Coding, Structure of Molfiles and Sdfiles (Molecular converter, SMILES Translator).								CO2
UNIT III	Introduction to Quantum Methods					Periods: 9		
Geometry of mixing and basic reactor types, The Attainable Region (AR) approach, AR in higher dimensions & for other processes, Reactive Separation processes, Fundamental behavior and problems, Separation through reactions. Reactive Residue Curve Maps								CO3
UNIT IV	Target Identification					Periods: 9		
Molecular Modeling and Structure Elucidation: Homology Modelling (Modeller 9v7, PROCHECK), Visualization and validation of the Molecule (Rasmol, Pymol Discovery studio), Applications of Chemoinformatics in Drug Research- Chemical Libraries, Virtual Screening, Prediction of Pharmacological Properties.								CO4
UNIT V	Drug Discovery					Periods: 9		
Structure based drug designing, Docking Studies (Target Selection, Active site analysis, Ligand preparation and conformational analysis, Rigid and flexible docking, Structure based design of lead compounds, Library docking), Pharmacophore - Based Drug Design, Pharmacophore Modeling (Identification of pharmacophore features, Building 2D/3D pharmacophore hypothesis), Toxicity Analysis- Pharmacological Properties (Absorption, Distribution and Toxicity), Global Properties (Oral Bioavailability and Drug-Likeness) (ADME, OSIRIS, and MOLINSPIRATION)								CO5
Lecture Periods: 45		Tutorial Periods: -		Practical Periods: -		Total Periods: 45		
Reference Books								
1. Bajorath J (2004), "Chemoinformatics: Concepts, Methods and Tools for Drug Discovery" Humana Press 2. Leach A, Gillet V, "An Introduction to Chemoinformatics" Revised edition, Springer 3. Gasteiger J, Engel T. "A text book of Chemoinformatics" Wiley-VCH GmbH & Co. KGaA 4. Bunin B, Siesel B, Guillermo M. "Chemoinformatics: Theory, Practice & Products", Springer								

- Bunin Barry A. Siesel Brian, Morales Guillermo, Bajorath Jürgen.
Chemoinformatics: Theory, Practice, & Products Publisher: New
York, Springer. 2006.
- Leach Andrew R., Valerie J. Gillet, "An introduction to Chemoinformatics", Publisher: K
luwer Academic, 2003. ISBN: 1402013477
- Gasteiger Johann, Handbook of Chemoinformatics: From Data to Knowledge (4 Volumes),
2003. Publisher: Wiley-VCH.

Department: Chemical Engineering			Programme: M.Tech.(Chemical Engineering)					
Semester: III			Course Category Code: PSE			Semester Exam Type: TY		
Course Code	Course Name	Periods/ Week			Credit	Maximum Marks		
		L	T	P		CA	SE	TM
CHE20	Cleaner Production	3	-	-	3	40	60	100
Prerequisite								
Course Outcome	On completion of the course, the student will be able to							
	CO1	Explain the concepts and principles of cleaner production						
	CO2	Describe various cleaner production methodologies						
	CO3	Evaluate basic methods and techniques of pollution prevention during production						
	CO4	Understand the financial evaluation of cleaner production methods						
	CO5	Get knowledge on the practical application of cleaner production technology						
UNIT I	Introduction					Periods: 9		
Cleaner production definition: Evaluation of cleaner production, Cleaner production network, Area covered by cleaner production (what is not cleaner production). Difference between cleaner production and other methods, End of the pipe treatment to curb pollution, Prerequisites of cleaner production.								CO1
UNIT II	Cleaner Production Methodology					Periods: 9		
Waste reduction at source, (a) Good housekeeping, (b) Process changes: change in raw material, batter process, control, and equipment modification and technology changes, Recycling: on site recovery and reuse creation of useful byproducts, Product modification. Methods of environmental protection -- preventive strategy, Methods of environmental protection -- preventive strategy, making team for cleaner production, Analyzing process steps, Generating Cleaner Production opportunities, Selection of cleaner production solution, Implementing Cleaner production solution								CO2
UNIT III	Cleaner Production Assessment Techniques					Periods: 9		
Overview of CP Assessment Steps and skills, Preparing for the site visit, Information Gathering, and process flow diagram, material balance, CP Option Generation Technical and Environmental feasibility analysis-Economic valuation of alternatives fuels, Total cost analysis-CP, Financing, Establishing a program, Organizing a program preparing a program plan-Measuring progress- pollution prevention and cleaner production Awareness plan-Waste audit-Environmental Statement. Energy audit related to cleaner production, Energy audit's need and scope, Types of energy audit. Preliminary or walk through energy audit. Detailed energy audit, Methodology of energy audit, Energy balance and identifying the energy conservation opportunities.								CO3
UNIT IV	Financial Evaluation of cleaner production					Periods: 9		
Gathering baseline information, Determining the capital or investment cost, Establishing lifetime of equipment and annual depreciation, Determine revenue implication of the project. Estimating change in operating cost, Calculating incremental cash flow, Assessing project's viability.								CO4
UNIT V	Case studies and Cleaner Production Applications					Periods: 9		
Application (Industrial application of CP, LCA, EMS and Environmental Audits. C.P in chemical process industry, Practical ways & means to save material loss in loading/unloading and unit operation equipment like distillation column, drying and other equipments like heat exchanger, vacuum unit, conveying, etc. Practical ways & means for energy saving in industries. Case Studies of cleaner production.								CO5
Lecture Periods: 45		Tutorial Periods: -		Practical Periods: -		Total Periods: 45		
Reference Books								

1. "Cleaner Production Worldwide", 1993, United Nations Environment Programme, Industry and Environment, Paris, France, 1993
2. "Cleaner Production: Training Resource Package", UNEP, Paris, 1996
3. "Clean Technology for manufacture of Specialty Chemicals", Editor - W. Hoyle and M. Lancaster, Royal Society of Chemistry, U.K., 2001.

- Randall Paul M., "Engineers Guide to Cleaner Production Technologies". Technomic Publishing in 1997
- Ahluwalia V.K., "Green Chemistry: Environmentally Benign Reactions" Springer Nature, 2021
- Sanders R.E., "Chemical Process Safety: Learning from Case Histories", Oxford Butterworth Publication, 2005
- "Training Manual Package" by NCPC

**OPEN ELECTIVES
AND
MANDATORY AUDIT COURSES FOR
M.TECH. PROGRAMMES**

(Approved in Sixth Academic Council Meeting held on 20th March 2021)

O P E N E L E C T I V E S

Department:IT			Programme:M.Tech.						
Semester:III			Course Category Code:OEC				Semester Exam Type:TY		
CourseCode	CourseName		Periods/ Week			Credit	Maximum Marks		
			L	T	P			CA	SE
OE301	Business Analytics		3	-	-	3	40	60	100
Prerequisite									
Course Outcome	On completion of the course, the student will be able to								
	CO1	Students will demonstrate knowledge of data analytics.							
	CO2	Studentswilldemonstratetheabilityofthinkcriticallyinmakingdecisionsbasedon data and deep analytics.							
	CO3	Studentswilldemonstratetheabilitytouse technicalskillsinpredicativeand Prescriptive modeling to support business decision-making.							
	CO4	Studentswilldemonstratetheabilitytotranslatedataintoclear, actionableinsights.							
UNITI							Periods:9		
Business analytics: Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organization, competitive advantages of Business Analytics. Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling, sampling and estimation methods overview.								CO1	
UNITII							Periods:8		
TrendinessandRegressionAnalysis:ModellingRelationshipsandTrendsinData,simpleLinear Regression.ImportantResources,BusinessAnalyticsPersonnel,DataandmodelsforBusinessanalytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology.								CO2	
UNITIII							Periods:9		
Organization Structures of Business analytics, Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes. Descriptive Analytics, predictive analytics, predicative Modelling, Predictive analytics analysis, Data Mining,Data Mining Methodologies,Prescriptive analytics and its Step in the businessanalyticsProcess, PrescriptiveModelling,nonlinearOptimization.								CO3	
UNITIV							Periods:10		
Forecasting Techniques: Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models. Monte Carlo Simulation and Risk Analysis: Monte Carle SimulationUsingAnalyticSolverPlatform,New-ProductDevelopmentModel,NewsvendorModel, Overbooking Model,Cash Budget Model.								CO3	
UNITV							Periods:8		
DecisionAnalysis: FormulatingDecisionProblems, DecisionStrategieswiththewithoutOutcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making.								CO4	
UNITVI							Periods:4		
RecentTrendsin: Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism.								CO4	
LecturePeriods:48		Tutorial Periods:-		Practical Periods:-			Total Periods:48		
Reference Books									

1. BusinessanalyticsPrinciples, Concepts,andApplicationsbyMarcJ.Schniederjans,DaraG.Schniederjans, Christopher M. Starkey, Pearson FT Press.2014
2. Business Analytics by James Evans, Persons Education.2019.

Department: ME			Programme: M.Tech.					
Semester: III			Course Category Code: OEC			Semester Exam Type: TY		
Course Code	Course Name	Hours/ Week			Credit	Maximum Marks		
		L	T	P	C	CA	SE	TM
OE302	Industrial Safety and Maintenance	3	0	0	3	40	60	100
Prerequisite								
Course Outcomes	On completion of the course, the student will be able to							
	CO1	Can appreciate the need of industrial safety requirements and can implement general guidelines of safety.						
	CO2	Can understand fundamental sand principles of maintenance engineering.						
	CO3	Canacquiretheknowledgeaboutconventionalmaintenancetechniquesadopted to reduce/prevent wear and corrosion.						
	CO4	CanabletoadoptFaulttracingtechniquesforgeneralmachinesand equipmentsusedinindustries.						
	CO5	Can apply periodic and preventive maintenance techniques used for general electrical and mechanical machines and equipments used in industries.						
UNIT-I	IndustrialSafety				Periods: 9			
Accident, causes, types, results and control,mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, washrooms,drinkingwaterlayouts,light,cleanliness,fire,guarding,pressurevessels,etc, Safetycolorcodes.Firepreventionandfirefighting,equipmentandmethods.								CO1
UNIT-II	Fundamentals of Maintenance Engineering				Periods: 9			
Definitionandaimofmaintenanceengineering,Primaryandsecondaryfunctionsand responsibilityofmaintenancedepartment,Typesofmaintenance,Typesandapplicationsof tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.								CO2
UNIT-III	WearandCorrosionandtheir Prevention				Periods: 9			
Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Sidefeedlubrication,vii.Ringlubrication,Definition,principleandfactorsaffectingthe corrosion.Typesofcorrosion,corrosionpreventionmethods.								CO3
UNIT-IV	Fault Tracing				Periods: 9			
Fault tracing-concept and importance, decision tree concept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic,pneumatic,automotive,thermalandelectrical equipment'slike,I.Anyonemachine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electricalmotors, Types of faults in machine tools and their general causes.								CO4

UNIT-V	Periodic and Preventive Maintenance	Periods: 9	
Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: i. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of Preventive maintenance. Repair cycle concept and importance.			CO5
Lecture Periods: 45	Tutorial Periods: 0	Practical Periods: 0	Total Periods: 45
Reference Books			
1. LMDeshmukh, "Industrial Safety Management", TATA McGraw Hill, 2010 2. Lindley R. Higgins, R. Keith Mobley and Darrin Wikoff, "Maintenance Engineering Handbook", 7th edition, McGraw Hill publication, 2008. 3. Garg H.P, "Maintenance Engineering", S. Chand and Company, 2010. 4. Audels, "Pump-hydraulic Compressors", McGraw Hill Publication, 1978. 5. Hans F. Winterkorn, "Foundation Engineering Handbook", Chapman & Hall London, 2013.			

Department:ME			Programme:M.Tech.							
Semester:III			CourseCategoryCode:OEC				SemesterExamType:TY			
CourseCode	CourseName		Hours/ Week			Credit	MaximumMarks			
			L	T	P	C	CA	SE	TM	
OE303	Operations Research		3	0	0	3	40	60	100	
Prerequisite										
Course Outcomes			On completion of the course, the student will be able to							
			CO1	Students should able to apply the linear programming to solve problems of discrete and continuous variables.						
			CO2	Students should able to apply the concept of non-linear programming.						
			CO3	Students should able to carry out sensitivity analysis.						
			CO4	Students should able to model the real world problem and simulate it.						
UNIT-I							Periods: 9			
Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models.							CO1			
UNIT-II							Periods: 9			
Formulation of a LPP - Graphical solution, revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming.							CO1			
UNIT-III							Periods: 9			
Nonlinear programming problem - Kuhn-Tucker conditions - min cost flow problem - max flow problem - CPM/PERT.							CO2			
UNIT-IV							Periods: 9			
Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models - Geometric Programming.							CO3			
UNIT-V							Periods: 9			
Competitive Models, Single and Multi-channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation.							CO4			
Lecture Periods:45			Tutorial Periods:0		Practical Periods:0			Total Periods:45		
Reference Books										
1. H.A.Taha, Operations Research, An Introduction, PHI, 2008 2. H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982. 3. J.C.Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008 4. Hitler Libermann Operations Research: McGraw Hill Pub. 2009 5. Pannerselvam, Operations Research: Prentice Hall of India 2010 6. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010										

Department:CE		Programme:M.Tech.						
Semester:III		CourseCategoryCode:OEC				SemesterExamType:TY		
CourseCode	CourseName	Periods/ Week			Credit	MaximumMarks		
		L	T	P		CA	SE	TM
OE304	Cost Management of Engineering Projects	3	-	-	3	40	60	100
Prerequisite								
CourseOutcome	On completion of the course, the student will be able to							
	CO1	Understanding the cost controls, data inventory and decision making						
	CO2	Understandingtheprojectdocumentationfromconceptiontocommissioning						
	CO3	Understandingtheprojectcostandprofitanalysisduringthecommissioning						
	CO4	Understanding the project resource planning and activity based cost management						
	CO5	Understandingtheprojectbudgetingandquantitativetechniquesfor cost management						
UNITI	Project Cost Management					Periods:9		
Introduction and Overview of the Strategic Cost Management Process. Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a CostingSystem;Inventoryvaluation;CreationofaDatabaseforoperationalcontrol;Provisionof dataforDecision-Making.								CO1
UNITII	Project Execution					Periods:9		
Project: meaning, Different types, why to manage, cost overruns centre, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and nontechnical activities. Detailed Engineering activities. Pre project execution main clearances and documentsProjectteam:Roleofeachmember.ImportanceProjectsite:Datarequiredwith significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram.								CO2
UNITIII	Project Commissioning					Periods:9		
Projectcommissioning:mechanicalandprocessCostBehaviorandProfitPlanningMarginalCosting; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems. Standard Costing and Variance Analysis.								CO3
UNITIV	Pricing Strategies					Periods:9		
Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector.Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality ManagementandTheoryofconstraints.Activity-BasedCostManagement,BenchMarking; BalancedScoreCardandValue-Chain Analysis.								CO4
UNITV	Project Budgets					Periods:9		
BudgetaryControl;FlexibleBudgets;Performancebudgets;Zero-basedbudgets.Measurementof Divisionalprofitabilitypricingdecisionsincludingtransferpricing.Quantitativetechniquesfor cost management,LinearProgramming,PERT/CPM,Transportationproblems,Assignmentproblems, Simulation, Learning Curve Theory.								CO5
LecturePeriods:45		Tutorial Periods:-		Practical Periods:-		TotalPeriods:45		
Reference Books								
1. CostAccountingAManagerialEmphasis,PrenticeHallofIndia,NewDelhi								
2. CharlesT.HorngrenandGeorgeFoster,AdvancedManagementAccounting								
3. RobertSKaplanAnthonyA.Alkinson,Management&Cost Accounting								
4. AshishK.Bhattacharya,Principles&PracticesofCostAccountingA.H.Wheelerpublisher								
5. N.D.Vohra,QuantitativeTechniquesinManagement,TataMcGrawHillBookCo.Ltd.								

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1		2	1	3	3	3
CO2		2	1	3	3	3
CO3		2	1	3	3	3
CO4		2	1	3	3	3
CO5		2	1	3	3	3

Score:3–High;2–Medium;1–Low

Department: Physics			Programme: M.Tech.					
Semester: III			Course Category Code: OEC			Semester Exam Type: TY		
Course Code	Course Name	Periods/ Week			Credit	Maximum Marks		
		L	T	P		CA	SE	TM
OE305	Composite Materials	3	-	-	3	40	60	100
Prerequisite								
Course Outcome	On completion of the course, the student will be able to							
	CO1	Able to understand and describe the basic concept and classification of composite.						
	CO2	To Learn the concepts of reinforcements and its mechanical behaviour.						
	CO3	To acquire the knowledge in metal matrix, ceramic matrix and carbon composites and its applications.						
	CO4	To acquire the knowledge in polymer matrix composites and its processing methods.						
	CO5	To understand the behavior of strength of Laminates						
UNIT I	Introduction to Composite Materials						Periods: 9	
Definition–Classification and characteristics of Composite materials. Advantages and application of composites. Functional requirements of reinforcement and matrix. Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.								CO1
UNIT II	Reinforcements						Periods: 9	
Preparation–layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle reinforcements. Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures. Isostrain and Iso stress conditions.								CO2
UNIT III	Manufacture of Composites						Periods: 9	
Manufacturing of Metal Matrix Composites: Casting – Solid State diffusion technique, Cladding – Hot isostatic pressing, Properties and applications. Manufacturing of Ceramic Matrix. Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving. Properties and applications.								CO3
UNIT IV	Fabrication of Polymer Matrix Composites						Periods: 9	
Preparation of Moulding compounds and prepress–hand layup method–Autoclave method– Filament winding method – Compression moulding – Reaction injection moulding. Properties and applications.								CO4
UNIT V	Laminar Strength Analysis						Periods: 9	
Strength: Laminar Failure Criteria–strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hydrothermal failure. Laminate first ply failure–insight strength; Laminate strength–ply discount truncated maximum strain criterion; strength design Using caplet plots; stress concentrations.								CO5
Lecture Periods: 45		Tutorial Periods:-		Practical Periods:-		Total Periods: 45		
Reference Books								
1. Material Science and Technology–Vol 13–Composites by R.W.Cahn–VCH, West Germany.								
2. Materials Science and Engineering, An introduction. W.D Callister, Jr., Adapted by R. Balasubramaniam, John Wiley & Sons, NY, Indian edition, 2007.								
3. Handbook of Composite Materials–ed-Lubin.								
4. Composite Materials–K.K.Chawla.								
5. Composite Materials Science and Applications–Deborah D.L.Chung.								
6. Composite Materials Design and Applications–Danial Gay, Suong V.Hoa, and Stephen W. Tasi.								

Department:CE		Programme:M.Tech.						
Semester:III		Course Category Code:OEC				Semester ExamType:TY		
Course Code	Course Name	Periods/ Week			Credit	Maximum Marks		
		L	T	P		CA	SE	TM
OE306	Waste to Energy	3	-	-	3	40	60	100
Prerequisite								
Course Outcome	On completion of the course, the student will be able to							
	CO1	Knowingaboutthetypesofsourcesofwastesandaboutitsconversiontechniques						
	CO2	Understanding about the concepts of Pyrolysis and its application						
	CO3	Understanding about the processes involved in gasification of biomass and its operation process						
	CO4	Understandingtheprocessofbiomasscombustiontechniquesanditsdesign concepts in operation						
	CO5	Knowing about the Bio gas production techniques and about the status of production in India.						
UNITI	Waste &Conversion Techniques					Periods:9		
Introduction to Energy fromWaste: Classification of waste as fuel– Agro based, Forestresidue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digesters						CO1		
UNITII	Biomass Pyrolysis					Periods:9		
Biomass Pyrolysis: Pyrolysis–Types, slow fast– Manufacture of charcoal– Methods- Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.						CO2		
UNITIII	Biomass Gasification					Periods:9		
Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement forthermalheating–Gasifierenginearrangementandelectricalpower–Equilibriumand Kinetic consideration in gasifier operation.						CO3		
UNITIV	Biomass Combustion					Periods:9		
Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.						CO4		
UNITV	Biogas					Periods:9		
Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion -biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion -Types of biogas Plants – Applications - Alcohol productionfrombiomass-Biodieselproduction-Urbanwastetoenergyconversion-Biomass energy programme in India.						CO5		
LecturePeriods:45		TutorialPeriods:-			PracticalPeriods:-		TotalPeriods:45	
Reference Books								
1. Non-ConventionalEnergy,Desai,AshokV.,WileyEasternLtd.,1990.								
2. Biogas Technology - APractical Hand Book - Khandelwal, K. C. and Mahdi,S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.								
3. Food,Feed and FuelfromBiomass,Challal,D.S.,IBHPublishingCo.Pvt.Ltd., 1991.								
4. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.								

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1		2	1	3	3	3
CO2		2	1	3	3	3
CO3		2	1	3	3	3
CO4		2	1	3	3	3
CO5		2	1	3	3	3

Score:3–High;2–Medium;1–Low

MANDATORY AUDIT COURSES

Department:HS		Programme:M.Tech.						
Semester:I/II		Course Category Code:MAC				Semester Exam Type:TY		
Course Code	CourseName	Periods/ Week			Credit	Maximum Marks		
		L	T	P		CA	SE	TM
AD301	English for Academic Writing	2	-	-	-	-	-	-
Prerequisite								
Course Outcome	On completion of the course, the student will be able to							
	CO1	Understand principles of academic writing						
	CO2	Understand the importance of proper literature review						
	CO3	Develop critical perspective and analytical skills						
	CO4	Overcome challenges faced in the process of academic writing						
	CO5	Present research in the most effective way						
UNITI	Academic Writing					Periods:6		
What, why,how,Word Order – organizing and structuring sentences and paragraphs –grammar and punctuation – accuracy, brevity and clarity. Planning and Preparation,								CO1
UNITII	Literature Review					Periods:6		
Methods	-readingtechniques–Notetaking,HedgingandCriticizing,Paraphrasingand annotation							CO2
UNITIII	Critical Analysis and Evaluation					Periods:6		
Academic tone and language-presenting results and discussion -preparation of outline–drafting - editing								CO3
UNITIV	Sections of a Paper					Periods:6		
Title – abstract – Introduction – conclusion – thesis statement – research proposals – articles –theses								CO4
UNITV	Acknowledgements					Periods:6		
Referencing-bibliography-researchethics-academicintegrity-plagiarism								CO5
LecturePeriods:30		Tutorial Periods:-		Practical Periods:-		Total Periods:30		
Reference Books								
1. GoldbortR, WritingforScience, YaleUniversityPress(availableonGoogleBooks),2006								
2. DayR,HowtoWriteandPublishaScientificPaper,CambridgeUniversityPress,2006								
3. HighmanN,HandbookofWritingfortheMathematicalSciences,SIAM.Highman’sbook.,1998								
4. AdrianWallwork,EnglishforWritingResearchPapers,SpringerNewYorkDordrechtHeidelberg London, 2011								

Department:CE		Programme:M.Tech.						
Semester:I/II		Course Category Code:MAC				Semester Exam Type:TY		
Course Code	CourseName	Periods/ Week			Credit	Maximum Marks		
		L	T	P			CA	SE
AD302	Disaster Management	2	-	-	-	-	-	-
Prerequisite								
Course Outcome	On completion of the course, the student will be able to							
	CO1	Knowing about the Types of Disasters						
	CO2	Knowing about the economics and life after the different disasters						
	CO3	Knowing the disaster zones in India and its epidemics						
	CO4	Understanding the disaster preparations and disaster managing procedures						
	CO5	Knowing the risk assessment procedure and mitigation techniques						
UNITI	Types of Disasters					Periods:6		
Introduction: Disaster: Definition, Factors and Significance; Difference Between Hazard and Disaster; Natural and Manmade Disasters: Difference, Nature, Types and Magnitude.								CO1
UNITII	Repercussions of Disasters And Hazards					Periods:6		
Economic Damage, Loss of Human and Animal Life, Destruction of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts and Famines, LandslidesandAvalanches,Manmadedisaster:NuclearReactorMeltdown,Industrial Accidents, Oil Slicks and Spills, Outbreaks of Disease and Epidemics, Warand Conflicts.								CO2
UNITIII	Disaster Prone Areas in India					Periods:6		
StudyofSeismicZones;AreasPronetoFloodsandDroughts,LandslidesandAvalanches; AreasPronetoCyclonicandCoastalHazardswithSpecialReferencetoTsunami;Post-DisasterDiseases and Epidemics.								CO3
UNITIV	Disaster Preparedness and Management Preparedness					Periods:6		
Monitoring of Phenomena Triggering A Disaster Or Hazard; Evaluation of Risk: ApplicationofRemoteSensing,DataFromMeteorologicalandOtherAgencies,MediaReports: Governmental and Community Preparedness.								CO4
UNITV	Disaster Risk Assessment &Mitigation					Periods:6		
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.								CO5
Meaning, Concept and Strategies of Disaster Mitigation, Emerging Trends in Mitigation. Structural Mitigation and Non-Structural Mitigation, Programs of Disaster Mitigation in India.								
LecturePeriods:30		Tutorial Periods:		Practical Periods:		TotalPeriods:30		
Reference Books								
1. R.Nishith,SinghAK,“DisasterManagementinIndia:Perspectives,issuesandstrategies“New Royal book Company,2012.								
2. Sahni,Pardeepet.al.(Eds.),”DisasterMitigationExperiencesAndReflections”,PrenticeHall of India, New Delhi,2001.								
3. Goel S.L.,Disaster Administration And Management Text And Case Studies”, Deep & Deep Publication Pvt. Ltd., New Delhi,2007.								

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1		2	1	3	3	3
CO2		2	1	3	3	3
CO3		2	1	3	3	3
CO4		2	1	3	3	3
CO5		2	1	3	3	3

Score:3–High;2–Medium;1–Low

Department: HS		Programme: M.Tech.						
Semester: I/II		Course Category Code: MAC				Semester Exam Type: TY		
Course Code	CourseName	Periods/ Week			Credit	Maximum Marks		
		L	T	P		CA	SE	TM
AD303	Value Education	2	-	-	-	-	-	-
Prerequisite								
Course Outcome		On completion of the course, the student will be able to						
		CO1	Understand the importance and need for value education					
		CO2	Appreciate and develop desirable values					
		CO3	Understand core values of one's personality through self-analysis					
		CO4	To be sensitized towards challenging social issues					
		CO5	To inculcate an essential value system towards building a healthy society					
UNITI	Purpose of Value Education					Periods:6		
Selfexploration-valuesandselfdevelopment-understandingneeds-holisticliving- ethics- duties and responsibilities - standards and rulesof behavior- value judgments.								CO1
UNITII	Stages of Moral Development					Periods:6		
Developingobjectivity-dedication,self-reliance,confidence,truthfulness,cleanliness, sincerity,honesty,humaneness,tolerance,internationalunderstanding-loveornature, discipline , self control – ethical public behaviour								CO2
UNITIII	Personality and BehaviorDevelopment					Periods:6		
SWOTanalysisandintrospection-scientifictemper-positivethinking-integrityanddiscipline - punctuality, love and kindness - dignity of labour.								CO3
UNITIV	Human Rights					Periods:6		
Socialinclusion-social evilsandproblems-impactofmedia,consumerismand globalizationontheindividual andhis/herexistence-valueeducationforational andglobal development								CO4
UNITV	Personal Values					Periods:6		
Family values- social values and individual attitudes-cultural values- national values- professional values – aesthetic values – social and professional behaviour								CO5
LecturePeriods:30		Tutorial Periods:-		Practical Periods:-		TotalPeriods:30		
Reference Books								
1. Chakroborty,S.K: Values and Ethics for organizations Theory and practice, Oxford University Press, New Delhi,1999. 2. Das,M.S.&Gupta,V.K.:SocialValuesamongYoungadults:AchangingScenario,M.D. Publications, New Delhi, 1995 3. Bandiste, D.D.: Humanist Values: A Source Book, B.R. Publishing Corporation, Delhi, 1999 4. ValuesandEthicsforthe21 st Century:BBVA,2011 5. Srivastava,Smriti.HumanValuesandProfessionalEthics,S.K.Kataria&Sons,NewDelhi,2011 6. Ruhela,SatyaPal. Dimensions of Value Education. New Delhi: Motilal Banaridass Publishing House.2002.								

Department: HS		Programme: M.Tech.						
Semester: I/II		CourseCategoryCode: MAC				SemesterExamType: TY		
CourseCode	CourseName	Periods/ Week			Credit	MaximumMarks		
		L	T	P		CA	SE	TM
AD304	ConstitutionofIndia	2	-	-	-	-	-	-
Prerequisite								
Course Outcome	On completion of the course, the student will be able to							
	CO1	UnderstandandDiscusstheemergence,evolutionandmeaningofIndian Constitution						
	CO2	Comprehendthesignificanceofconstitutionalrightsandduties						
	CO3	Understandandanalysethethreeorgansofgovernmentandthesystemof governance						
	CO4	Understandanddescribedecentralization,powerandrole						
	CO5	Understandtheroleofconstitutionalandnon-constitutionalbodies						
UNITI	MakingoftheIndianConstitution:Evolutionand Development					Periods:6		
HistoricalbackgroundoftheconstituentAssembly–variouscommittees(Composition&Working). Philosophy of the Indian Constitution: Preamble Salient Features -amendments							CO1	
UNITII	ContoursofConstitutionalRights&Duties					Periods:6		
FundamentalRights-RighttoEquality-RighttoFreedom-RightagainstExploitation-Right to Freedom of Religion - Cultural and Educational Rights - Right to Constitutional Remedies -Directive Principles of State Policy - Fundamental Duties.							CO2	
UNITIII	OrgansofGovernance					Periods:6		
Parliament – Composition - Qualifications and Disqualifications - Powers and Functions – Executive – President – Governor - Council of Ministers - Judiciary, Appointment and Transfer ofJudges,Qualifications-PowersandFunctions.–systemofgovernment-theunionandits territories–emergencyprovisions							CO3	
UNITIV	Local Administration					Periods:6		
District Administration: Role and Importance - Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation - Panchayat raj: Introduction, PRI: Zilla Panchayat - Elected officials and their roles, CEO Zilla Panchayat: Position and role - Block level:OrganizationalHierarchy(Differentdepartments)-Villagelevel:RoleofElectedand Appointedofficials-Importanceofgrassrootdemocracy.							CO4	
UNITV	ConstitutionalandNon-ConstitutionalBodies					Periods:6		
Election Commission: Role and Functioning - Chief Election Commissioner and Election Commissioners- State Election Commission: Role and Functioning - Institute and Bodies for the welfare of SC/ST/OBC and women – Equality and social justice							CO5	
LecturePeriods:30		TutorialPeriods:-			PracticalPeriods:-		TotalPeriods:30	
ReferenceBooks								
1. TheConstitutionofIndia,1950(BareAct),GovernmentPublication. 2. Dr.S.N.Busi,Dr.B.R.AmbedkarframingofIndianConstitution,1stEdition,2015. 3. M.P.Jain,IndianConstitutionLaw,7thEdn.,LexisNexis,2014. 4. D.D.Basu.IntroductiontotheConstitutionofIndia,LexisNexis,2015.								

Department: HS		Programme: M.Tech.						
Semester: I/II		CourseCategoryCode: MAC				SemesterExamType: TY		
Course Code	Course Name	Periods/ Week			Credit	MaximumMarks		
		L	T	P		CA	SE	TM
AD305	Pedagogy Studies	2	-	-	-	-	-	-
Prerequisite								
Course Outcome	On completion of the course, the student will be able to							
	CO1	Understand the pedagogical practicesbeing used by teachers in formal and informal classrooms						
	CO2	Reflectonthedifferenttheoriesof learning						
	CO3	Applyappropriateinstructionalmethods						
	CO4	Explorepedagogicalinnovation						
	CO5	Identifygapsinresearchandeffectivelyapplyconceptsofcommunication theory						
UNIT I	Introduction and Methodology					Periods:6		
Aimsandrationalae,,Conceptualframeworkandterminology-Theoriesofmotivationand learning, Curriculum, Teacher education : policies and programmes								CO1
UNIT II	Pedagogical Theory and Approaches					Periods:6		
Thematicoverview-historicalperspective-teachingpracticesinformalandinformal classrooms in developing countries – teacher education and training – attitudes and beliefs								CO2
UNIT III	PedagogicStrategies					Periods:6		
Effectiveness of pedagogical practices - - Theory of change – New learning – didactic, authentic, transformative perspectives – teacher competency and accountability – professional ethics								CO3
UNIT IV	Professional Development					Periods:6		
Alignment with classroom practices and follow-up – classroom management - Peer and community support -- Curriculum and assessment – inclusive teaching – evaluation concepts and approaches –digital initiatives - Barriers to learning								CO4
UNIT V	Research Gaps and Future Directions: Maintaining Standards					Periods:6		
Researchdesign–Contexts–communication-Disseminationandresearchimpact- innovation.								CO5
LecturePeriods:30		Tutorial Periods:-		Practical Periods:-		TotalPeriods:30		
Reference Books								
1. AckersJ,HardmanF, ClassroominteractioninKenyanprimaryschools,Compare,31 (2):245-261, 2001. 2. AgrawalM, Curricular reforming schools: The importance of evaluation, Journal of Curriculum Studies, 36 (3): 361-379, 2004, 3. Akyeamong K, Teacher training in Ghana –does it count? Multi-site teacher education research project (MUSTER) country report 1. London: DFID,2003 4. Akyeamong K, Lussier K, Pryor J, Westbrook J, Improving teaching and learning of basic math sand readingin Africa:Does teacher preparation count?International Journal Educational Development, 33 (3): 272–282, 2013. 5. AlexanderRJ, Culture and pedagogy: International comparisons in primary education. Oxford and Boston: Blackwell., 20021 6. ChavanM, Read India:Amassscale, rapid, ‘learning to read’ campaign.2003. 7. www.pratham.org/images/resource%20working%20paper%202.pdf.								

Department: HS			Programme: M.Tech.					
Semester: I/ II			Course Category Code: MAC			Semester Exam Type: TY		
Course Code	Course Name	Periods/ Week			Credit	Maximum Marks		
		L	T	P		CA	SE	TM
AD306	Stress Management by Yoga	2	-	-	-	-	-	-
Prerequisite								
Course Outcome	On completion of the course, the student will be able to							
	CO1	To know the role of Yoga						
	CO2	To understand the importance of mind and meditations						
	CO3	To know how-to overcome stress.						
UNIT I	Yoga					Periods:10		
Definition of yoga – Importance of yoga – Basic rules of yoga – Eight stages of yoga: Iyama – Niyama – Aasana – Pranayama – Prathyagara – Dhaarana – Dhyana – Samaadhi – Asanas- Kayakalpa yoga - Mudras.								CO1
UNIT II	Meditation					Periods:10		
Definition – Importance of meditation – Mental wave frequency – Benefits of Agna, Shanthi, Thuriyam and Thuriyaadheetham meditations.								CO2
UNIT III	Stress Management					Periods:10		
Definition of Pain, Pleasure, Peace and Ecstasy – Reasons for Stress – Knowing the relation among self, nature and society - Analysis of Thoughts - Moralisation of Desire - Neutralisation of Anger -Eradication of Worries-Realisation of Self-Harmony in Life -Greatness of Women –Benefit of Blessings.								CO3
Lecture Periods:30		Tutorial Periods:-		Practical Periods:-		Total Periods:30		
Reference Books								
1. G.V.Vethathiri, Yoga for Modern Age, The World Community Service Centre Publications, 2010.								
2. Yogapractices-2, The World Community Service Centre Publications, 2016.								
3. The Mother. Foundations of Education. Sri Aurobindo Ashram. Pondicherry. 2012.								