Shree Warana Vibhag Shikshan Mandal's

Tatyasaheb Kore Institute of Engineering And Technology, Warananagar

Department of Chemical Engineering

First Year M. Tech. Chemical Engineering

Syllabus Structure under Autonomous Status of TKIET, Warananagar

2021-22

Tatyasaheb Kore Institute of Engineering and Technology, Warananagar

First Year M. Tech. Chemical Engineering (Semester-I)

(To be implemented from 2021-22)

Credit Scheme

Course Code	Category	Course Title	Teaching Scheme				Credit Scheme			
			TH	Tut	P	Total Contact Hours	TH	Tut	P	Total Credit Assigned
Ch - PCC- 1011	PCC	Advanced Momentum & Heat Transfer	3	--	--	3	3		--	3
Ch - PCC-1011T	PCC	Advanced Momentum & Heat Transfer		1		1		1		1
Ch - PCC- 1021	PCC	Advanced Chemical Engineering Thermodynamic	3	--	--	3	3	--	--	3
Ch - PCC-1021T	PCC	Advanced Chemical Engineering Thermodynamic		1		1	--	1	--	1
Ch – PE - 1031	PE	Program Elective – I (Process Modeling in Chemical Engineering)	3	--	--	3	3	--	--	3
Ch - PE- 1041	PE	Program Elective-II (Nano Technology)	3	--	--	3	3	--	--	3
Ch - PE- 1051	PE	Program Elective-III (Process Equipment Design)	3	--	--	3	3	--	--	3
Ch - LC- 1061	LC	Advanced Separation Laboratory	--	--	4	4	--	--	2	2
Ch - SW - 1071	SW	Seminar-I	--	--	2	2	--	--	1	1
			15	02	06	23	15	2	3	20

Evaluation Scheme

Course Code	Category	Course Title	Examination Scheme							
			ISE			ESE	TW	O	P	Total
			ISE -I	ISE -II	Avg.					
Ch - PCC- 1011	PCC	Advanced Momentum & Heat Transfer	40	40	40	60	--	--	--	100
Ch - PCC- 1011T	PCC	Advanced Momentum & Heat Transfer					25			25
Ch - PCC- 1021	PCC	Advanced Chemical Engineering Thermodynamic	40	40	40	60	--	--	--	100
Ch - PCC- 1021T	PCC	Advanced Chemical Engineering Thermodynamic					25			25
Ch - PE- 1031	PE	Program Elective – I (Process Modeling in Chemical Engineering)	40	40	40	60	--	--	--	100
Ch - PE-1041	PE	Program Elective-II (Nano Technology)	40	40	40	60	--	--	--	100
Ch - PE-1051	PE	Program Elective-III (Process Equipment Design)	40	40	40	60	--	--	--	100
Ch - LC-1061	LC	Advanced Separation Laboratory	--	--	--	--	25	25	--	50
Ch - SW 1071	SW	Seminar-I	--	--	--	--	50	--	--	50
			--	--	200	300	125	25	--	650

Tatyasaheb Kore Institute of Engineering and Technology, Warananagar

First Year M. Tech. Chemical Engineering (Semester-II)
(To be implemented from 2021-22)

Credit Scheme

Course Code	Category	Course Title	Teaching Scheme				Credit Scheme			
			TH	Tut	P	Total Contact Hours	TH	Tut	P	Total Credit Assigned
Ch - PCC- 2011	PCC	Advanced Mass Transfer	3		--	3	3		--	3
Ch – PCC 2011T	PCC	Advanced Mass Transfer		1				1		1
Ch - PCC- 2021	PCC	Chemical Process Control	3		--	3	3		--	3
Ch – PCC 2021T	PCC	Chemical Process Control		1				1		1
Ch - PE- 2031	PE	Program Elective-IV (Modern Reaction Engg.)	3	--	--	3	3	--	--	3
Ch - PE- 2041	PE	Program Elective-V (Advance Separation Techniques)	3	--	--	3	3	--	--	3
Ch - OEC- 2051	OEC	Open Elective Course (Project Management)	3	--	--	3	3	--	--	3
Ch - LC- 2061	LC	Analytical Laboratory	--	--	4	4	--	--	2	2
Ch - SW - 2071	SW	Seminar-II	--	--	2	2	--	--	1	1
Ch - 2081		Comprehensive Viva	--	--			--	--		
			15	02	06	23	15	2	3	20

Evaluation Scheme

Course Code	Category	Course Title	Examination Scheme							
			ISE			ESE	TW	O	P	Total
			ISE -I	ISE -II	Avg.					
Ch - PCC- 2011	PCC	Advanced Mass Transfer	40	40	40	60		--	--	100
Ch - PCC- 2011T	PCC	Advanced Mass Transfer					25	--	--	25
Ch - PCC- 2021	PCC	Chemical Process Control	40	40	40	60		--	--	100
Ch - PCC- 2021T	PCC	Chemical Process Control					25	--	--	25
Ch - PE- 2031	PCC	Program Elective-IV (Modern ReactionEngg.)	40	40	40	60	--	--	--	100
Ch - PE- 2041	PE	Program ElectiveV (Advance Separation Techniques)	40	40	40	60	--	--	--	100
Ch - OEC 2051	OEC	Open Elective Course (Project Management)	40	40	40	60	--	--	--	100
Ch - LC- 2061	LC	Analytical Laboratory	--	--	--		25	--	--	25
Ch - SW - 2071	SW	Seminar-II	--	--	--	--	50	--	--	50
Ch - 2081		Comprehensive Viva	--	--	--	--	--	25	--	25
			--	--	200	300	125	25	--	650

First Year M. Tech. ChemicalEngineering (Semester-I)					
Course Code	**Program Elective-I**	**Course Code**	**Program Elective-II**	**Course Code**	**Program Elective-III**
Ch - PE-10311	Process Modeling in Chem.Engg.	Ch - PE-10411	Nano Technology	Ch - PE-10511	Bio Process Engineering
Ch - PE-10312	Corrosion Engg.	Ch - PE-10412	Green Technology	Ch - PE-10512	Materials Engineering
Ch - PE-10313	Polymer & Rubber Technology	Ch - PE-10413	Pharmaceutical Biotechnology	Ch - PE-10513	Process Equipment Design

First Year M. Tech. Chemical Engineering(Semester-II)					
Course Code	**Program Elective-IV**	**Course Code**	**Program Elective-V**	**Course Code**	**Open Elective Course**
Ch - PE-20311	Modern Reaction Engg.	Ch - PE-20411	Computational Fluid Dynamics	Ch - OEC 20511	Cryogenics
Ch - PE-20312	Catalysis & Surface Phenome na	Ch - PE-20412	Energy Engineering	Ch - OEC 20512	Design for Manufacture andAssembly
Ch - PE-20313	Down Stream Processing	Ch - PE-20413	Advance Separation Techniques	Ch - OEC 20513	Waste To Energy.
				Ch - OEC 20514	Water Power Engineering.
				Ch - OEC 20515	Advanced Operating Systems
				Ch - OEC 20516	Artificial Intelligence
				Ch - OEC 20517	Project Management
				Ch - OEC 20518	Operational Research

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Tatyasaheb Kore Institute of Engineering And Technology, Warananagar

Department of Chemical Engineering

Second Year M. Tech. Chemical Engineering

Syllabus Structure under Autonomous Status of TKIET, Warananagar2021-2022

Tatyasaheb Kore Institute of Engineering and Technology, Warananagar

Second Year M. Tech. Chemical Engineering (Semester-III)

(To be implemented from 2021- 2022) Credit Scheme

Course Code	Category	Course Title	Teaching Scheme				Credit Scheme			
			TH	Tut	P	Total Contact Hours	TH	Tut	P	Total Credit Assigned
Ch - MC - 3011	MC	ResearchMethodology &Intellectual Property Rights	2			2	2			2
Ch - II - 3021	II	Industrial Training	--	--	4	4	--	--	2	2
Ch - SLC/AC-3031	SLC/AC	One Course from MOOC/SWAYAM	--	--			--	--	--	--
Ch - PC- 3041	PC	Dissertation Phase-I	--	--	16	16	--	--	8	8
			2	--	20	22	02	--	10	12

Evaluation Scheme

Course Code	Category	Course Title	Examination Scheme							
			ISE			ESE	TW	O	P	Total
			ISE -I	ISE -II	Avg.					
Ch - MC - 3011	MC	ResearchMethodology&Intellectual Property Rights	40	40	40	60				100
Ch - II - 3021	II	Industrial Training	--	--	--	--	50	--	--	50
Ch - SLC/AC -3031	SLC/AC	One Course from MOOC/SWAYAM	--	--	--	--	50	--	--	50
Ch - PC- 3041	PC	Dissertation Phase-I	--	--	--	--	50	50	--	100
			--	--	40	60	150	50	--	300

** Candidate who has unable to get passing marks in certification course has to reappear for improvement at institute level test/ **MOOC/SWAYAM**

Tatyasaheb Kore Institute of Engineering and Technology, Warananagar

Second Year M. Tech. Chemical Engineering (Semester-IV)

(To be implemented from 2021-22)

Credit Scheme

Course Code	Cate gory	Course Title	Teaching Scheme				Credit Scheme			
			TH	Tut	P	Total Contact Hours	TH	Tut	P	Total Credit Assigned
Ch - PC-4011	PC	Dissertation Phase-II	--	--	32	32	--	--	16	16
			--	--	32	32	--	--	16	16

Evaluation Scheme

Course Code	Cate gory	Course Title	Examination Scheme							
			ISE			ESE	TW	O	P	Total
			ISE -I	ISE -II	Avg.					
Ch - PC-4011	PC	Dissertation Phase-II	--	--	--	--	100	100	--	200
			--	--	--	--	100	100	--	200

List of Abbreviations

Abbreviations	Title
PCC	Professional Core Course
PE	Program Elective
OEC	Open Elective Course
LC	Laboratory Course
MC	Mandatory Course
SW	Seminar work
II	Industrial Internship
PC	Dissertation
SLC/AC	Self-Learning Course/Audit course

Tatyasaheb Kore Institute of Engineering & Technology, Warananagar				
First Year M.Tech.Chemical Engineering Semester- I				
(PCC) CH1011: Advanced Momentum and Heat Transfer				
Teaching Scheme			**Examination Scheme**	
Lectures	03Hrs/Week		ISE	40 Marks
Tutorials	01		ESE	60 Marks
Total Credits	04		TW	25 Marks
			Duration of ESE	.

Course Objectives (CO):

1: Introduce analogy between momentum and heat transfer

2: Explain general conservation equations for transport phenomena

3: Develop momentum balance for a given system at macroscopic and microscopic scale.

4: Analysis of governing equations to obtain velocity profiles

5 :Assist students in developing ability to make engineering judgments ,including judgements regarding process safety.

6. Discuss applications in various heat transfer equipment in process industries ,Heat Transfer Augmentation & Pinch Technology

	Course Contents	Hours
Unit 1	. **Boundary Layer Flow:** Boundary layer equations, separation of BL, Blasius solution for flat state, properties of BL equation, Momentum integral equations.	(04)
Unit 2	**Turbulent Flow:** Reynolds equation for turbulent flow, velocity distribution for flow in pipe. Statistical theory of turbulence. Drag reduction etc. **Non-Newtonian Fluids:** Rheological behavior of non-Newtonian fluids, laminar flow in cylindrical tubes, laminar flow between parallel plates, laminar flow in annuli. Generalized relationship for power law model	(04)
Unit 3	**Agitation And Mixing:** Velocities in stirred tanks. Flow patterns in stirred tanks, Power consumptions in stirred vessels, mixing equipments. **Multiphase Flow:** Two phase gas vapor liquid flow, horizontal and vertical flow of gas-liquids, liquids, gas-solid mixtures, slip and hold up effect, phase separation and settling behavior, analysis of stratified and bubble flow, formation of bubbles and drops and their size distribution and hold up in different flow system, momentum and energyrelations. **Motion In The Fluidized Bed:** Bubbling fluidization, semi-fluidization, mixing and segregation in fluidized bed, Numerical and application of fluidization.	(06) (05)

Unit 4	**Introduction: Review of heat Transfer, t**ransient heat conduction; Lumped system analysis, heat transfer analogies. **Turbulent Forced Convective Heat Transfer:** Momentum and energy equations - turbulent boundary layer heat transfer – mixing length concept - turbulence model, Heat pipe.	(04)
Unit 5	**Heat Transfer In Two Phase Systems:** Heat transfer regimes and flow maps. Condensation: Basic process, on planner surface, inside and over pipe of pure and multicomponent vapors. Heat transfer in paced bed and fluidized beds. Overall pressure drop and void calculation methods. Flow regimes in two phase flow. Drift flux model, annular flow, critical flow, flow instabilities, homogeneous flow, and separated flow. **Non-Newtonian Flow Heat Transfer:** Comparative study of Newtonian and non-Newtonian fluid in context with heat transfer, Newtonian and non-Newtonian heat transfer in circular tube, coils and other configuration, Non-Newtonian heat transfer in PFR, CSTR. Generalized relationship of power law fluid, forced convection heat transfer to Bingham plastic and power law fluid in circular conduits.	(05) (04)
Unit 6	**Heat Transfer Augmentation:** Active and passive techniques, rough surface, swirl flow generation and compound augmentation. Compact heat exchangers. Introduction of Pinch Analysis and Process integration.	(05)

Assignments: Each student will submit minimum 6 assignments based on the different topics in consultation with faculty, in the area of advanced momentum and heat transfer ; keeping track of the recent technological trends and developments.

Course Outcomes (CO): At the end of course students will

1: Able to understand the chemical and physical transport processes and their mechanism

2: Able to do heat, mass and momentum transfer analysis

3: Able to analyze industrial problems along with appropriate approximations and boundary conditions

4: Able to develop steady and time dependent solutions along with their limitations

5: Understand the concepts of boundary layer and its estimation in different flows

6: Understanding of various types of heat transfer process and devices

Text Books

1	R.B. Bird, W.E. Stewart and E.N. Lightfoot, ―Transport Phenomena , John ‖ Wiley & Sons, Inc, New York
2	Ranjeet Basugade ,- Advance Heat Transfer Augmentation Technique: Heat Transfer Augmentation in Triangular Fin Heat Exchanger Using Rectangular Wings Kindle
3	Pinch Analysis and Process Integration A User Guide on Process Integration for the Efficient Use of Energy Second edition by Ian C Kemp
2	The Flow of Complex Mixture in Pipes" by Govier and Aziz
3	ChemicalEngineering" by Coulson and Richardson, Volume I
4	D.G. Knudsan and D. L. Katz. Fluid Dynamics and Heat transfer. Mc-Graw Hill,
5	C.J. Geankoplis" Transport Processes Momentum And Mass" Bacon Inc.
6	HArison & Davidson, Fluidization Engg, Mc-Graw Hill, 1968

Useful Websites	
1	http://nptel.ac.in/
2	http://swayam.gov.in/
3	http://www.youtube.com/user/nptelhrd

Tatyasaheb Kore Institute of Engineering & Technology, Warananagar

First Year M. Tech Chemical Engineering Semester- I

PCC 1021: Advanced Chemical Engineering Thermodynamics

Teaching Scheme			**Examination Scheme**	
Lectures	03 Hrs/Week		ISE	40 Marks
Tutorials	01 Hr/Week		ESE	60 Marks
Total Credits	04		TW	25 Marks
			Duration of ESE	.

Course Objectives (CO):

1. Define & describe the basic laws of thermodynamic
2. Explain the criteria for equilibrium with stability of thermodynamic system.
3. Develop skills to make appropriate assumptions and ability to predict intermolecular potential and excess property behavior of multi- component systems.
4. Analysis & estimation of the Gibbs free energy and fugacity of a component in mixture
5. Judge the Chemical equilibrium and evaluate the degrees of freedom for chemically reacting systems
6. Discuss statistical thermodynamic terms.

	Course Contents	**Hours**
Unit 1	**Detailed review of thermodynamics laws and basic concepts:** Laws of thermodynamics, Concepts of entropy, Intensive and extensive variables, Enthalpy, Gibbs free energy, Equations of state, other important thermodynamic properties.	(08)
Unit 2	**Equilibrium and Stability in one component systems:** The criteria for equilibrium, Stability of thermodynamic system, The molar Gibbs free energy and fugacity of a pure component. The Gibbs phase rule for one component system. Thermodynamic properties of phase transitions Problems.	(08)

Unit 3	**The Thermodynamic of Multi Component Mixtures:** The thermodynamic description of mixtures. The partial molar gibbs free energy and the generalized Gibbs – Duhem equation. A notation for chemical reactions. The equations on change for a multicomponent system. Thermodynamic state for a multicomponent multi phase system. The Gibbs phase rule Problems (Non Reactive).	(08)
Unit 4	**The estimation of the Gibbs free energy and fugacity of a component in mixture:** The ideal gas mixture, The partial molar mixture properties. The fugacity of a species in gaseous, liquid and solid mixtures. Several correlative liquid mixtures (activity coefficient) models Problems. UNIFAC method, UNIQUAC equation, Vapor liquid equilibrium using activity coefficient models, problems.	(08)
Unit 5	**Chemical Reaction equilibrium:** Chemical equilibrium in a single phase system, Heterogeneous chemical reactions, Chemical equilibrium when several reactions occur in single phase, Phase rule and Duhem's theorem for reacting systems, Degree of freedom analysis for non reacting and reacting systems	(08)
Unit 6	**Introduction to Statistical thermodynamics :** Quantum considerations, Microstates, Macrostates and thermodynamic probability , Physical models, Boltzmann statistics, Fermi–Dirac statistics and Bose – Einstein statistics, Partition function, Phase space,	(08)

Assignments: Each student will submit minimum 6 assignments based on the different topics in consultation with faculty, in the area of thermodynamics of phase equilibria & chemical equilibria keeping track of the recent technological trends and developments.

Course Outcomes (CO): At the end of course students should be able to

1.Formulate and manipulate the thermodynamic treatment of arbitrary processes.

2.Formulate and analyze specific Chemical Engineering problems using fundamental concepts.

3.Select appropriate approximations for practical problem solving.

4.Understand the implications of approximations on the efficiency and accuracy of the solution

Text Books

1	Chemical Engineering Thermodynamics – Stanlay Sandler IInd edition Wiley graham in chemical engineering.

Reference Books	
1	Introduction to Chemical Engineering Thermodynamics: J.M. Smith, H.C.Vanness McGraw Hill International book company.
2	Thermodynamics – by J.P.Holman IVth edition McGraw Hill Inter
3	Statistical thermodynamics- M.C.Gupta Wiley Eastern Ltd.
4	” Chemical Engineering Thermodynamics” K.V.Narayanan
5	“Principles of Chemical Equilibrium”, Kenneth Denbigh
6	“Chemical Engineering thermodynamics”, Y. V. C. Rao,
7	” Chemical Engineering Thermodynamics“, T. E. Daubert
8	“Chemical and Process Thermodynamics”, B. G. Kyle
Useful Websites	
1	http://nptel.ac.in/
2	http://swayam.gov.in/
3	http://www.youtube.com/user/nptelhrd

Tatyasaheb Kore Institute of Engineering & Technology, Warananagar				
First Year M.Tech. Chemical Engineering Semester- I				
Elective-I : Ch-PE-1031 : Process Modeling in Chemical Engineering				
Teaching Scheme			**Examination Scheme**	
Lectures	03 Hrs/Week		ISE	40 Marks
Tutorials	--		ESE	60 Marks
Total Credits	03		TW	--
			Duration of ESE	.

Course Objectives (CO):

1. Introduce fundamentals of creating mathematical models of chemical process systems.
2. Generate steady and dynamic model for different processes.
3. Solve process design problems, based on fundamental analysis and using mathematical models of chemical processes.
4. Implementation on mathematical tools to analyze the system both to gain insight and make predictions.
5. Explain verification/ validation of simulation model through the simulators.

	Course Contents	Hours

Unit 1	**Introduction to dynamic models:** Mass balance equation - Balancing procedure, Case studies: CSTR, Tubular reactor, Coffee percolator, Total mass balance – Case Studies: Tank drainage, Component balances - Case Studies: Waste holding tank, Energy balance- Parallel reaction in a semi continuous reactor with large temperature difference, Momentum balances – CSTR, Gas liquid mass transfer in a continuous reactor**.** **Modeling of stage wise processes:** Reactor Configurations, Generalized model description, Heat transfer to and from reactors, Steam heating in jacket, Dynamics of the metal jacket walls.	(06)
Unit 2	**Mass transfer models:** liquid-liquid extraction, distillation, Multicomponent separation, multi component steam distillation, absorber- stage wise absorption, steady state gas absorption with heat effects, evaporator**.** **Model Discrimination And Parameter Estimation:** Rate equations, Batch reactor – Constant volume, Semi - batch reactor, CSTR - Constant volume CSTR, CSTR cascade.	(06)
Unit 3	**Lumped and distributed system:** Distributed system- Counter current heat exchanger, Flasher design, Condensation, Definition of lumped parameter model**.** Mathematical models of heat- transfer equipments: Shell & tube heat exchangers, Evaporators, Fired heaters, Partial condensers. Plug flow reactor, Plug flow reactor contactors, Liquid –liquid extraction column dynamics.	(06)
Unit 4	**Flow sheet simulation :** Process flow sheet simulation, Process and information matrix, Materials and Energy balance computation using modular approach, Process analysis, Process variables, selection, Equipment selection.	(06)
Unit 5	**Dynamic simulation:** Dynamic simulation of Reactors, distillation column, Absorbers, evaporators and crystallizes, introduction to simulation packages like GPSS, CSMP.	(06)
Unit 6	**Process Simulators:** Introduction to professional simulator like UNISIM, Aspen. Mathematical tools like SciLab, Introduction to Solver and Poly Math etc.	(06)

Course Outcomes (CO): At the end of course students will

1. define physical problems in terms of mathematical modeling and how it is related.
2. apply the need for modeling, estimate necessary model complexity through modeling process.
3. recognize how models are developing from rate laws, balances and constitutive equations.
4. solve the basis of chemical engineering process and adjustable parameters in them.
5. analyze the mathematical tool to predict the chemical engineering process
6. create the small modeling with simulation for any physical chemical engineering problem

Text Books	
1	John Ingham, Irving, J. Dunn, Elmar, Heinzle Jiri, E. Prenosil, "Chemical Engineering Dynamics", VCH Publishers Inc., New York, 1974.
2	Lubeyn W.L. "Process Modeling, Simulation and Control Engineering ", McGraw Hill Book
3	Edgar, T.F. and D.M. Himmelblau - "Optimization of Chemical Processes ", McGraw Hill BookCo., New York, 1989.
4	R. W. Gaikwad, Dr. Dhirendra, "Process Modeling and Simulation", Central Techno Publications, Nagpur, 2003.
Reference Books	
1	C. L. Smith, R. L. Pike and P. W. Murill, "Formulation Optimization of Mathematical models", International Text, Pennsylvania, 1970.
2	Roger G. E. Franks, "Modeling and Simulation in Chemical Engineer", Wiley Inter Science, New York, 1972.
Useful Websites	
1	Moocs/ Swayam Courses on Process Modeling & Simulation in Chemical Engineering, OpenModelica

Tatyasaheb Kore Institute of Engineering & Technology, Warananagar

First Year M.Tech. Chemical Engineering Semester- I

Elective-I : Ch-PE-1031 *: CORROSION ENGINEERING*

Teaching Scheme			**Examination Scheme**	
Lectures	03 Hrs/Week		ISE	40 Marks
Tutorials	--		ESE	60 Marks
Total Credits	03		TW	--
			Duration of ESE	.

Course Objectives (CO):

1. Introduce fundamentals of Corrosions.
2. Corrosion measurement techniques.
3. Mechanisms of corrosion.
4. Environmental aspects of corrosion.
5. Explain prevention and control of corrosion.

	Course Contents	**Hours**
Unit 1	**Basic concepts**: Definition and importance, Electrochemical nature and forms of corrosion, Corrosion rate and its determination.	(06)
Unit 2	**Electrochemical thermodynamics and kinetics**: Electrode potentials, Potential-pH (Pourbiax) diagrams, Reference electrodes and experimental measurements, Faraday's laws, Instrumentation and experimental procedure.	(06)
Unit 3	**Corrosion measurement through polarization techniques**: Tafel extrapolation plots, Polarization resistance method, Commercial corrosion probes, Other methods of determining polarization curves.	(06)

Unit 4	**Pitting and crevice corrosion**: Mechanisms of pitting and crevice corrosion, Secondary forms of crevice corrosion, Localized pitting, Metallurgical features and corrosion: Intergranular corrosion, Weldment corrosion, De-alloying and dezincification. .	(06)
Unit 5	**Environmental induced cracking**: Stress corrosion cracking, Corrosion fatigue cracking, Hydrogen induced cracking, Methods of prevention and testing, Erosion, Fretting and Wear.	(06)
Unit 6	**Environmental factors and corrosion**: Corrosion in water and aqueous solutions, Corrosion in sulphur bearing solutions, Microbiologically induced corrosion, Corrosion in acidic and alkaline process streams. **Prevention and control of corrosion**: Cathodic protection, Coatings and inhibitors, Material selection and design.	(06)

Course Outcomes (CO): At the end of course students will

1. define fundamentals of Corrosions.
2. apply the Corrosion measurement techniques..
3. recognize Mechanisms of corrosion.
4. solve the problems related to the environmental impact of corrosion.
5. analyze the problem and its preventive actions.

Text Books

1	*Fontana, M.G., Corrosion Engineering, Tata McGraw-Hill (2008). 3rd ed. (seventh reprint)*
2	*Jones, D.A., Principles and Prevention of Corrosion, Prentice-Hall (1996).*

Reference Books

1	*Pierre R. Roberge, Corrosion engineering: principles and practice, McGraw-Hill (2008).*
2	*Sastri, V.S., Ghali, E. and Elboujdaini, M., Corrosion prevention and protection: Practical solutions, John Wiley and Sons (2007)..*

Tatyasaheb Kore Institute of Engineering & Technology, Warananagar				
First Year M. Tech Chemical Engineering Semester- I				
Elective-I : Ch-PE-1031: Polymer and Rubber Technology				
Teaching Scheme			**Examination Scheme**	
Lectures	03 Hrs/Week		ISE	40 Marks
Tutorials	--		ESE	60 Marks
Total Credits	03		TW	--
			Duration of ESE	.

Course Objectives (CO):

1 Define & describe the basics of polymer and rubber.

2 Explain the criteria for the polymerization process.

3 Develop skills to understand and study various processes of polymer and rubber production.

4 To understand the advances in polymer and rubber technologies.

5 To prepare the students to take challenges of polymer field in his profession.

	Course Contents	Hours
Unit 1	**Polymerization Fundamentals** – Introduction and importance of polymers, Development of polymers, Classification of polymers based on physiochemical structure, Types of polymerization, Mechanism of polymerization, Physical properties and technical application, Polymer structure and stereo-regular polymers Molding of plastics into articles, Homogeneous, Bulk, Solution, Emulsion and suspension polymerization and their comparison	(06)
Unit 2	**Manufacture of industrially important polymers for Plastics** – Raw materials, polyolefines- polythene, Poly propylene, Vinyl polymers-polyvinyl chloride, polyvinyl acetate, polyvinyl alcohol, polyvinylidiene chloride, Formaldehyde and Epoxy resins and their types, alkyd resins, polyacrylonitrile, polystyrene and copolymers of styrene, polysters and polyamides,	(06)

Unit 3	**Manufacture of industrially important polymers for Synthetic fibers** –Introduction , Classification , properties and preparation , Nylon -6 , Nylon – 66, Rayon, Sillicones, Poly silicones, Orlan, Saron, Teflon, Cellulose, and its derivatives.	(06)

Unit 4	**Manufacture of rubber and elastomers** – Introduction and importance of rubber, physical and chemical properties of rubber, Classification, Natural Rubber- Structure and properties, Rubber latex production and processing, synthetic rubber- Polymerization methods and unit operations involved, Styrene – Butadiene copolymers, Nitrile rubber, Neoprene, Butyl Rubber, Polyisoprene, Polybutadiene, Thiokol, Hypalon, Sillicone Rubber, Polyurethane rubber, Spandex, Sponge rubber, Foam rubber, Laminates, Rubber cement.	(06)
Unit 5	**Processing and manufacture of rubber products –** Vulcanizing, Compounding, Rubber chemicals, Processing equipment and method, Tyres and tubes manufacture, Reclamation of rubber, Applications of rubber.	(06)
Unit 6	**Polymer and rubber industries in India** – Development and scope of plastics, Synthetic Fibre, and elastomer industry in India.	(06)

Course Outcomes (CO): At the end of course students should be able to	
1 Understand polymer and rubber processing	
2 Formulate and analyze specific polymer & rubber Engineering problems using fundamental concepts.	
3 Select appropriate approximations for practical problem solving.	
4 Understand the future of polymer & rubber industry in Indian context.	
5 Understand advanced processes	
Text Books	
1	. G.S. Misra, ―Introductory Polymer Chemistry ‖ , Wiley Eastern Ltd.,New Delhi,1993.
2	D.C. Miles, ―Polymer Technology ‖ , Chemical Publishing New York, 1979.
3	Fred Billmeyer, ―A Text Book of Polymer Science ‖ , 3rd Edition, John Wiley and Sons, New York, 1984.
4	b.k.Sharma ,"Industrial Chemistry," 10th edition, Krishna Prakashan,India Pvt. Ltd. Meerut, 1999
Reference Books	
1	Anil Kumar, S.K. Gupta, ―Fundamentals of Polymer Science and Engineering ‖ , Wiley, 1978.
2	D.J. Williams, ―Polymer Science and Engg ‖ . Prentice Hall, New York 1971.
3	F. Rodrigues, ―Principles of Polymers systems ‖ , McGraw Hill, New York 1970
4	George Odian, ―Principles of Polymerization ‖ , 2nd Edition John Wiley and Sons, New York 1981.
Useful Websites	
1	http://nptel.ac.in/
2	http://swayam.gov.in/
3	http://www.youtube.com/user/nptelhrd

Tatyasaheb Kore Institute of Engineering & Technology, Warananagar

First Year M.Tech. Chemical Engineering Semester- I

Elective-II : Ch-PE-1041 : Nanotechnology

Teaching Scheme			**Examination Scheme**	
Lectures	03 Hrs/Week		ISE	40 Marks
Tutorials	--		ESE	60 Marks
Total Credits	03		TW	---
			Duration of ESE	.

Course Objectives (CO):		
1. Introduce fundamentals of Nanoscience and Nanotechnology.		
2. Study the concept of nanomaterials.		
3. Explain the synthesis, purification and application of nanomaterials.		
4. Study the advances in nanotechnology		
5. Intellectual property rights of nanotechnology		
	Course Contents	**Hours**
Unit 1	**Introduction to Nanotechnology:** History, Importance of Nanoscales, Fundamental concepts (Bottom-up and Top-down processes).	(07)
Unit 2	Application of Nanotechnology	(07)
Unit 3	**Nanomaterials:** Fundamental concept of nanomaterial, Materials used in nanotechnology, carbon nanotubes-properties	(07)
Unit 4	Synthesis, Purification, Application of Nanomaterials.	(06)
Unit 5	Recent Advances in Nanotechnology	(07)
Unit 6	**Intellectual property rights on Nanotechnology:** Importance of IP Protection, copy rights and trade secrets	(06)
Course Outcomes (CO): At the end of course students will		
1. To understand the application of Nanoscience in catalysis and green chemistry.		
2. Demonstrate the understanding of length scale concepts, nanostructures and nanotechnology.		
3. Characterization of nanomaterials.		
4. Physico chemical aspects of different types of nanostructures.		
5. Systematically solve scientific problems related specifically to nano-technological materials using conventional scientific and mathematical notation		
6. Identify the principles of processing, and synthesis of nonmaterial's and nanostructures		
Text Books / Reference Books		
1	Principles of Nanotechnology" , Phani umar	
2	"Nanomaterials",Vishwanathan	
3	"The Nanoscope" Encyclopedia of Nanoscience and Nanotechnology Vol I to Vol 6, Edited by Dr.Parag Diwan and Ashish Bharadwaj	

TatyasahebKore Institute of Engineering & Technology, Warananagar				
First Year M.Tech Chemical Semester- I				
Elective-II : Ch-PE-1041: Green Technology				
Teaching Scheme			**Examination Scheme**	
Lectures	03 Hrs/Week		ISE	40 Marks
Tutorials	---		ESE	60 Marks
Total Credits	03		TW	-----
			Duration of ESE	.

Course Objectives (CO):		
	1.To present different concepts of green technologies.	
	2. To acquire principles of Energy efficient technologies	
	3. To gain knowledge of the importance of life cycle assessment	
	4. To learn the importance of green fuels and its impact on environment.	
	5 To learn zero pollution control aspect	
	Course Contents	**Hours**
Unit 1	Introduction to Organic Chemistry /Analytical Chemistry /Basic Chemical Engineering	(04)
Unit 2	**Introduction to Green Chemistry:** Principles of Green Chemistry, Reasons for Green Chemistry (resource minimisation, waste minimisation, concepts), Green reactions solvent free reactions, Catalyzed (heterogeneous/homogeneous) reactions, MW/ Ultrasound mediated reactions, Bio catalysts etc	(08)
Unit 3	Introduction to Pharmaceutical Process Chemistry: Introduction to process chemistry, the difference between synthesis and process,	(07)
Unit 4	Rote design, Route optimization, DOE	(05)
Unit 5	Role of Analytical Chemistry in Process Chemistry Role of Process Safety in Process Chemistry: TH classification, MSDS, Thermal Hazards, Waste segregation and disposal.	(07)
Unit 6	Scale-up aspects including PE in Process Chemistry: Case Studies; New Initiatives : Micro reactors.	(06)

Course Outcomes (CO): At the end of course students will
1. Understand the principles of green chemistry and engineering
2. Design processes those are benign and environmentally viable
3. Design processes and products those are safe and hazard free
4. Learn to modify processes and products to make them green safe and economically acceptable.
5. Apply the principles of green technology to specific industrial processes

Reference Books	
1	James H.Clarke & Duncan Maacquarrie, Handbook of Green Chemistry and Technology, Wiley-Blackwell; 1 edition (2002)
2	Paul T.Anastas and John C. Warner, Green Chemistry: Theory and Practice, Oxford University Press, USA (2000)
3	M.Lancaster, Green Chemistry (Paperback), Royal Society of Chemistry; 1 edition (2002)
4	Stanley E.Manahan, Green Chemistry and the Ten Commandments of Sustainability, 2nd ed (Paperback), ChemChar Research Inc (2005)
5	Albert Matlack, Introduction to Green Chemistry (Hardcover), CRC Press; 1 edition (2001)
6	Green Chemistry in the Pharmaceutical Industry, Peter Dunn (Editor), Andrew Wells (Editor), Michael T. Williams (Editor), Wiley-VCH (2010)
7	Kenneth M.Doxsee and James Hutchison Green Organic Chemistry: Strategies, Tools, and Laboratory Experiments (Paperback), Brooks Cole; 1 edition (May 7, 2003)

TatyasahebKore Institute of Engineering & Technology, Warananagar

First Year M.Tech Chemical Semester- I

Elective-II : Ch-PE-1041: Pharmaceutical Biotechnology

Teaching Scheme			**Examination Scheme**	
Lectures	03 Hrs/Week		ISE	40 Marks
Tutorials	---		ESE	60 Marks
Total Credits	03		TW	-----
			Duration of ESE	.

Course Objectives (CO):

1. To understand and evaluate the different pharmaceutical parameters of the current and future biotechnology related products on the market

2. Biotechnology products and their use in therapeutics and diagnostics will be discussed. Theadvantages of these products over conventional drugs will also be discussed

3. To Develop skills in biotechnological techniques for obtaining and improving thequality of natural products.

4. Imparts knowledge of enzymes , biosensors , Diagnostic kit .

5 .Imparts knowledge of Bioprocess engineering and technology

	Course Contents	**Hours**
Unit 1	Drug Development in Pharmaceutical Process- Production of pharmaceuticals by genetically engineered cells (hormones, interferrons) - Microbial transformation for production of important pharmaceuticals (steroids and semi-synthetic antibiotics)	(07)
Unit 2	Techniques for development of new generation antibioticsl,Protein engineering, drug design, drug targeting.	(06)
Unit 3	Disease Diagnosis and Therapy,ELISA and hybridoma technology,DNA vaccine,Gene Therapy, Toxicogenomics.	(06)
Unit 4	Proteomics in Drug Development,Role of Proteomics in Drug Developmen.	(05)
Unit 5	Diagnosis of disease by Proteomics,Separation and identification techniques for protein analysis,Development of antibody based protein assay for diagnosis.	(06)
Unit 6	Diagnosis and Kit Development,Use of enzymes in clinical diagnosis, Use of biosensors for rapid clinical analysis,Diagnostic kit development for microanalysis.	(06)

Course Outcomes (CO): At the end of course students will

1. Understand the various techniques used in modern biotechnology.

2. Design research strategy with step by step instructions to address a research problem

3. Provide examples of current applications of biotechnology and advances in the different areas like medical, microbial, environmental, bioremediation, agricultural,
plant, animal, and forensic

4. Demonstrate and Provide examples on how to use microbes and mammalian cells for
the production of pharmaceutical products.

5. Explain the general principles of generating transgenic plants, animals and microbes

Reference Books	
1	Balasubramanian, Bryce, Dharmalingam, Green and Jayaraman (ed), Concepts in Biotechnology, University Press, 1996
2	Epenetos A.A.(ed), Monoclonal antibodies: applications in clinical oncology, Chapman and Hall Medical, London

Tatyasaheb Kore Institute of Engineering & Technology, Warananagar				
First Year M.Tech Chemical Engineering Semester- I				
Elective-III :PE- 1051: Bio Process Engineering				
Teaching Scheme			**Examination Scheme**	
Lectures	03 Hrs/Week		ISE	40 Marks
Tutorials			ESE	60 Marks
Total Credits	03		TW	
			Duration of ESE	.

Course Objectives (CO):

1. Apply engineering principles to address issues in bioprocesses
2. Analyze and identify limiting factors in a bioprocess and Propose solutions to address biological and engineering problems
3. Explain the aerobic and anaerobic fermentation processes
4. Describe applications and solve problems relating to the use of enzymes for industrial bioprocessing
5. Determine and analyze Mass transfer in heterogeneous biochemical reaction systems with process parameter
6. Improve chemical parameters in bioreactors

	Course Contents	Hours
Unit 1	Review of fundamentals of microbiology and biochemistry. Bioprocess principles: Kinetics of biomass production. Substrate utilization and product formation.	(06)
Unit 2	Batch and continuous cultures. Fed batch culture introduction. Fermentation processes. General requirements of fermentation processes.	(06)

Unit 3	An overview of aerobic and anaerobic fermentation processes. Examples of simple and complex media. Design and usage of commercial media for industrial fermentation. Thermal death kinetics of microorganisms. Heat sterilizations of liquid media. Filter stabilizations of liquid mediaand air.	(06)
Unit 4	Enzyme technology- Microbial metabolism enzymes classification and properties. Applied enzyme catalysis-kinetics of enzyme catalytic reaction. Metabolic pathways. Protein synthesis in cells. Bioreactor design and operations. Selection scale up operations of bioreactors.	(06)
Unit 5	Mass transfer in heterogeneous biochemical reaction systems. Oxygen transfer rates and coefficients. Role of aeration and agitation in oxygen transfer. Heat transfer processes in biological systems. Recovery and purification of products.	(06)
Unit 6	Introduction to instrumentation and process control in bioprocesses. Measurement of physical and chemical parameters in bioreactors. Monitoring and control of dissolved oxygen, pH, Impeller speed and temperature in a stirred fermenter	(06)

Course Outcomes (CO): At the end of course students should be able to

1. Understanding of biological basics and bioprocessing
2. Understanding the difference between bioprocesses and chemical processes
3. Bioprocess design and operation
4. Choice of bioreactor
5. Heat & mass transfer considerations and scale up of bioprocesses
6. Introduction to bioprocess monitoring/control

Text Books

1	M. L. Shuler, F. Kargi. Bioprocess engineering. 2nd edition. PHI. New Delhi. 2002.
1	J. E. Bailey, D. F. Ollis. Biochemical engineering. 2nd edition. Mc Graw Hill Publication co.NY.1985..
2	Pauline M. Doran, Bioprocess Engineering Principles, Academic Press, 2001

Tatyasaheb Kore Institute of Engineering & Technology, Warananagar

First Year M. Tech Chemical Engineering Semester- I

Elective-III: PE- 1051: Material Engineering

Teaching Scheme			**Examination Scheme**	
Lectures	03 Hrs/Week		ISE	40 Marks
Tutorials			ESE	60 Marks
Total Credits	03		TW	
			Duration of ESE	.

Course Objectives (CO):

1. Explain the engineering materials characterization
2. Explain Metallic phases and their properties
3. To understand the principles of optical and electron microscopy for study of macro and micro-structure of materials.
4. Inspect properties through change in various parameters over composite materials
5. To gain knowledge in understanding the tools and techniques for studying the substructure and atomic structure of materials
6. To build an expertise in characterization of engineering materials.

	Course Contents	**Hours**
Unit 1	Engineering requirement of materials, atomic bonding, atomic arrangements, structural imperfections and atom movements, electronic structures & process binary alloys and equilibrium diagrams.	(06)
Unit 2	Metallic phases and their properties, phase transformations in iron carbon system.	(06)
Unit 3	Heat treatment, surface hardening, case hardening metals and their alloys, organic materials & their properties, ceramic phases and their properties, multiphase materials, reactions within solid materials.	(06)
Unit 4	Modification of properties through change in microstructure, corrosion, oxidation, thermal stability, radiation damage, composite materials	(08)
Unit 5	Crystallography, X-Ray Diffraction Methods, Reitveld Refinement, Neutron Diffraction, X-ray absorption, XRay Fluorescence spectroscopy, Electron Diffraction- diffraction pattern in specific modes.	(06)

Unit 6	LEED and RHEED, Electron Optics, Electron Microscopy-Transmission and Scanning Electron Microscopy, STM and AFM, Compositional analysis employing AES, ESCA and Electron Probe Microanalysis.	(06)

Course Outcomes (CO): At the end of course students should be able to

1. To review physics and chemistry in the context of materials science & engineering
2. To describe the different types of bonding in solids, and the physical ramifications of these differences
3. To describe and demonstrate diffraction, including interpretation of basic x-ray data.
4. To promote an understanding of the relationship between material structure, processing and properties
5. Gain important conceptual and operational understanding of a wide range of methods for characterizing Materials
6. Gained a broad perspective on materials chemistry and physics

Reference Books

1	James F. Shackelford, Introduction to Materials Science for Engineers, 7th Edition, Pearson Prentice Hall(2009)
2	W. D. Callister, Fundamentls of Materials Science and Engineering, Wiley (2007)
3	C. Kittle, Introductin to Solid State Physics, Wiley (2007)
4	R. W. Cahn and P. Haasen, Physical Metallurgy, North Holland (1996)
5	Bradley D. Fahlman Materials Chemistry, Kindle Edition 2008).
6	B.D.CullityElementS of X-ray Diffraction AddisionWesely Reading Mass 1978.
7	David D. Brandon and Wayne D. Kaplan Microstructural Characterization of Materials wiley
8	Dawn Bonnel Scanning Probe Microscopy and Spectroscopy: Theory, Techniques, and Applications 2000.
9	C. Julian Chen Introduction to Scanning Tunneling Microscopy Monographs on the Physics and Chemistry of Materials

Tatyasaheb Kore Institute of Engineering & Technology, Warananagar

First Year M. Tech Chemical Engineering Semester- I

<u>Elective-III</u> :Ch – PE – 1051 : Process and Equipment Design

Teaching Scheme			Examination Scheme	
Lectures	03 Hrs/Week		ISE	40 Marks
Tutorials	--		ESE	60 Marks
Total Credits	03		TW	--
			Duration of ESE	.

Course Objectives (CO):

1 Define and describe the basic design procedure for an equipment.

2 Explain the use of formula and correlations used for designing of equipment.

3 Develop skills to make appropriate assumptions and ability to predict the data required for designing.

4 Analysis and estimation of predicted data with calculated values.

5 Judge the design parameters along with the permissible design guidelines.

6 Discuss about trial and error estimations.

	Course Contents	Hours
Unit 1	**Shell and Tube Heat exchanger**: Classification, Shell and Tube side Heat Transfer Coefficients, Pressure drop, Fouling, Baffles, Passes Tubes Tube Sheet, Effectiveness, of Heat exchanger, Heat Exchangers sizing For Heating or Cooling in agitated vessel.	(06)
Unit 2	**Heat Exchange equipment**: Plate Heat Exchanger, Bayonet Heat Exchanger, Heat Regenerator, Thermic Fluid Heating System Design Consideration.	(06)
Unit 3	**Heat Exchange equipment**: Cooling Tower Design Consideration, Cooling Water Blow Down, Cooling Water Corrosion, Crossed flow induced Draft Cooling Tower , Evaporation, Single and Multiple Effect forward and Backward Feed Evaporators.	(06)
Unit 4	**Reactor**: Reactor Classification, Design Equation for Batch PFR and CSTR, Fluidized Bed Reactor, Scale Up.	(06)
Unit 5	**Separation Equipment**: Classifications of Separator, Design Procedure For Gas Liquid Separator Oil Water Separator, Decanter, Gravity Separators, Centrifugal Separators **Gas Cleaning Equipment**: Cyclone Separator, Electrostatic Precipitator, Granular Bed Filter, Hydro-cyclone.	(06)
Unit 6	**Pipe lines**: Pipe Thickness, Pipe diameter, Condensate Piping, Pipe Support, Design of Pipeline for Natural Gas, Transportation of Crude oil, Pipe Line in Sea Water, Pipeline Design on Fluid Dynamics Parameters.	(06)

Course Outcomes (CO): At the end of course students should be able to	
1 Recall their concepts in designing the chemical equipments	
2 Interpret causes of failure of chemical equipment	
3 Have awareness on advances in process engineering design of many process equipments	
4.Take part in remedial or preventive measurements to avoid failure of vessel with safe design Guide lines	
5 Evaluate and apply their ideas on dimensional analysis to explore the optimum design variables	
6 Test the process equipment with prior safety.	
Text Books	
1	Process Design Of Equipments Vol.-1, 4th Edition by Dr. S .D. Dawande, Denett & Company Publication 2011
2	Process Design Of Equipments Vol.-2, 4th Edition by Dr. S. D. Dawande, Denett & Company Publication 2012
Reference Book	
1	Introduction to Process Engineering and Design 4th Reprint 2011, S. B. Thakore, B. I. Bhatt, Tata Mc-. Graw Hill, Education Pvt. Ltd, Delhi
Useful Websites	
1	http://nptel.ac.in/
2	http://swayam.gov.in/
3	http://www.youtube.com/user/nptelhrd

Tatyasaheb Kore Institute of Engineering & Technology, Warananagar				
First Year M.Tech Chemical Engineering Semester- I				
CH-LC-1061: ADVANCED SEPARATION LABORATORY				
Teaching Scheme			**Examination Scheme**	
Lectures	----		ISE	
Tutorials	---		ESE (Oral)	25
Practical	02Hrs/Week		TW	25
Total Credits	02		Duration of ESE	------.
Course Objectives (CO):				
1.Learn new techniques of separation				
2.Learn possible cases of industrial application.				
3. Learn estimation of separation coefficient.				

	Course Contents	Hours
1	**Ultrafilteration a) Pilot scale**	(04)
2	**Ultrafilteration a) Small scale**	(04)
2	**Supported liquid membranes.**	(04)
3	**Microfiltration of raw material**	(04)
4	**Ion Exchange a) Resin**	(04)
5	**Ion Exchange b) Equillibria**	(04)
6	**Ion Exchange c) Column**	(04)
7	***Electro coagulation***	(04)
8	***Pressure swing Adsorption***	(04)
9	**Electrostatic precipitator**	(04)

Course Outcomes (CO): At the end of course students will get

1.Knowledgeof recent advances in separation techniques..

2. Ability to separate different chemical compounds.

3. Ability to handle different advance equipments.

4.Considerably more in-depth knowledge of the major subject.

5.Deeper knowledge of Experimental methods

6. Knowledge of industrial methods used for the separation processes.

Reference Books

1	C.J.King "Separation Processes" 2nd Ed., Tata McGraw Hill Publishing Co. Ltd., New Delhi, 1986.
2	Sirkar K. & Winston H.O. "Membrane Hand Book" Van Nostrand Reinhold, New York, 1992.
3	McCabe & Smith "Unit Operations of Chemical Engineering" 5th Ed.,McGraw Hill International .
4	Richardson and Coulson,"Chemical Engineering Volume –II",Pergamon Press,1970.
5	Schweitzer P.A , "Handbook of Separation Techniques for Chemical Engineering" 2nd edn.,McGraw Hill Book Co.,1986.
6	Souri Rajan S. "Reverse Osmosis" Logos Press Ltd.

Tatyasaheb Kore Institute of Engineering & Technology, Warananagar

First Year M.Tech. Chemical Engineering Semester- I

Ch - SW - 1071: Seminar – I

Teaching Scheme			**Examination Scheme**	
Lectures	-----		ISE	---
Tutorials	---		ESE (Oral)	---
Practical	02Hrs/Week		TW	50
Total Credits	01		Duration of ESE	------.

Course Objectives (CO):

1.To Identify, understand and discuss current, real-world issues.

2.To Distinguish and integrate differing forms of knowledge and academic disciplinaryapproaches (e.g., humanities and sciences) with that of the student's own academic discipline (e.g., in agriculture, architecture, art, business, economics, education,
engineering, natural resources, etc.). And apply a multidisciplinary strategy to addresscurrent, real-world issues.

3. To Improve oral and written communication skills.

4. To Improve presentation skills

	Course Contents	Hours
1	Seminar-I should be based on the literature survey on any topic relevant to Design Engineering (should be helpful for selecting a probable title of the dissertation). Each student has to prepare a write up of about 25-30 pages of "A4" size sheets and submit it in IEEE format in duplicate as the term work. The student has to deliver a seminar talk in front of the faculty of the department and his classmates. The concerned faculty should assess the students based on the quality of work carried out, preparation and understanding of the candidates. Some marks should be reserved for the attendance of a student in the seminars of other students.	(--)

Course Outcomes (CO): At the end of course students will

1. Apply principles of ethical leadership, collaborative engagement, socially responsiblebehavior, respect for diversity in an interdependent world, and a service-oriented commitment to advance and sustain local and global communities.

2. Learn and integrate. Through independent learning and collaborative study, attain, use, and develop knowledge in the arts, humanities, sciences, and social sciences, withdisciplinary specialization and the ability to integrate information across disciplines.

3. Think and create. Use multiple thinking strategies to examine real-world issues, explore creative avenues of expression, solve problems, and make consequentialdecisions

4.Communicate. Acquire,articulate,create and convey intended meaning using erbal and non-verbal method of communication that demonstrates respect andunderstanding in a complex society.

SEMESTER-II

Tatyasaheb Kore Institute of Engineering & Technology, Warananagar				
First Year M.Tech. Chemical Engineering Semester- II				
PCC-CH2011: Advanced Mass Transfer				
Teaching Scheme			**Examination Scheme**	
Lectures	03 Hrs/Week		ISE	40 Marks
Tutorials	01 hr/Week		ESE	60 Marks
Total Credits	04		TW	25 Marks
			Duration of ESE	.

Course Objectives (CO):	
1	Introduce fundamentals of macroscopic and microscopic models of chemical process systems.
2	Compare and classify various mass transfer operations with or without chemical reaction.
3	Solve process design problems, based on fundamental analysis and using mathematical models of chemical processes.
4	Implementation on mathematical predictions for multi-component system.
5	Explain Extraction, ion-exchange, adsorption processes.

	Course Contents	**Hours**
Unit 1	**Physical-Chemical Phenomena:** Diffusivity and mechanism, Diffusion dispersion, Diffusivity measurements and prediction in non- electrolytes and electrolytes, solubility of gases in liquids, Inter-phase mass transfer in two phase and multi component system.	(06)
Unit 2	**Mass transfer with Chemical reaction:** Fluid-fluid reactions involving diffusion transfer, application of mass transfer to reacting systems Residence time distribution analysis, mass transfer coefficients, determination and prediction in dispersed multiphase contractors under the conditions of free forced convection, prediction of mean drop or bubble size of dispersion.	(06)
Unit 3	**Contacting devices**: Capacity and efficiency, energy requirements of separation process. Extractive distillation, Reactive distillation, cryogenic distillation and molecular distillation.	(06)
Unit 4	**Multicomponent distillation:** Mass transfer models, Binary distillation in tray columns, Multicomponent distillation tray column, Distillation in packed column – Non-equilibrium models, solving the model equations, Design studies of De-propanizer.	(06)

Unit 5	**Adsorption, Ion exchange and chromatography:** Adsorption, equilibrium considerations, pure gas adsorption, liquid adsorption, Ion exchange equilibrium, equilibrium in chromatography, Kinetic and transport considerations, external and internal transport, mass transfer in ion exchange and chromatography.	(06)
Unit 6	**Extraction:** Supercritical fluid extraction, Supercritical fluid, phase Equilibria, industrial applications, residuum oil Supercritical process – decaffeination of coffee, extraction of oil from seeds, residual oil Supercritical application (ROSE), Supercritical fluid chromatography.	(06)

Course Outcomes (CO): At the end of course students will

1. Define various operations like distillation, extraction, leaching, Compare and classify various mass transfer operations with or without chemical reaction
2. Design calculation of distillation column for the multi-component system
3. Analyze the problem of Separation by adsorption and design of absorber, chromatographic separation
4. Evaluate the separation by liquid extraction, leaching used and justify the extract operation to choose for specific problem
5. Estimate final data for designing number of stages, Height of column in the operations
6. Define various operations like distillation, extraction, leaching

Text Books

1	"Separation process" by J. Sieder and Henley, Wileypublishers,1998
2	"Principles of Mass Transfer and Separation Process" Binay K Datta, EEE, PHI Pvt Ltd.
3	"Unit operation in Chemical Engineering" 6^{TH} edition, McCabe Smith, Mc Graw Hill
4	"Mass Transfer Operations" by Trebyal, McGraw Hill
5	"Mass Transfer Fundamentals and Applications", Anthony L. Hines & Maddox.

Reference Books

1	"Transport Separations and Unit Operations" 3^{rd} edition, G.J.Geankoplis, Prentice Hall.
2	"Seperationprocess" by C. Judson King, McGrawHill,1982
3	"Distillation" , Matther Van Winkle, Mc Graw Hill, Book Company

Useful Websites

1	Moocs/ Swayam/NPTEL Courses on Mass Transfer Operations I

Tatyasaheb Kore Institute of Engineering & Technology, Warananagar

First Year M.Tech. Chemical Engineering Semester- II

M.Tech . (Chemical Engineering), Sem.-II

Ch-PCC-2021 Chemical Process Control

Teaching Scheme			**Examination Scheme**	
Lectures	03 Hrs/Week		CIE	40 Marks
Tutorials	01 hr/Week		ESE	60 Marks
Total Credits	04		TW Duration of ESE	25 Marks 02 Hrs. 30 Min.

Course Objectives (CO):

1. CO1: Develop structured, logical control schemes for complex processes.
2. CO2: Study dynamics of process and control behaviour.
3. CO3: Choose control configurations for standard operations.
4. CO4: Estimate controller parameter setting.
5. CO5: Understand type of controller that can be used for specific problem in chemical industry.
6. CO6: Design digital control systems.

	Course Contents	**Hours**
Unit 1	**Introduction To Feed Back Control:** Concept of feedback Control, Types offeedback Controllers, Measuring Devises, Transmission Lines, Final ControlElements. **Dynamic Behavior Of Feedback Control System:** Block Diagram and closed looped response, effect of P Control, I Control, D Control, and Composite Control Action on response of a controlled process.	(06)
Unit 2	**Mass transfer with Chemical reaction:** Fluid-fluid reactions involving diffusion **Stability Analysis Of Feedback System:** Notion of Stability, the characteristics equation, Routh–Hurwitz Criterion for stability, Root locus analysis. **Design Of Feedback Controller:** Outline of Design Problem, Simple Performance Criteria, Time integral performance criteria, Select the type of feedback Controller, Controller tuning	(06)
Unit 3	**Frequency Response Analysis Of Linear Process:** Response of First Order System to Sinusoidal input, frequency response characteristics of a general linear system, Bode Diagram, Nyquist Plots. **Design Of Feedback Control System Using Frequency Response Technique** Bode Stability Criteria, Gain and Phase Margin, Ziegler- Nicholas Tuning Techniques, Nyquist Stability Criteria.	(06)

Unit 4	**Feed Back Control Of System With Large Dead Time Or Inverse Response :** Processes with Large dead time, Dead Time compensation, Control of System with Inverse response. **Control System With Multiple Loop:** Cascade Control, Selective Control System, Split Range Control.	(06)
Unit 5	**Feed Forward And Ratio Control:** Logic of Feed Forward Control, Problem of Designing feed forward controllers, Prctical Aspect on Design of Feed forward controllers, Feed forward- Feed Back Control, Ratio Control. **Adaptive and Inferential control system:** Adaptive Control, Inferential Control **Introduction To Plant Wide Control:**Plant Wide Control issues, Hypothetical plant for Plant wide control Studies, Internal Feedback of Material and Energy, Interaction of Plant Design and control system design.	(06)
Unit 6	**Plant Wide Control System Design:** Procedures for Designs of Plant wide control systems, A Systematic procedure for plant wide control system design, Case studies: The Reactor Flash Unit Plant, Effect of Control Structure on Closed looped performance. **Digital Process Control System:** Hard ware and Software, Distributed Digital Control System, Analog and Digital Signals and Data transfer, Microprocessors and Digital Hardware in Process Control, Software Organization.	(06)

Reference Books

1	Chemical Process Control An Introduction To Theory And Practice- George Stephanopolous, Prentice Hall Of India , New Delhi2003
2	Process Dynamics And Control, Dale E Seborg, Yhomas F Edgar, Duncan A,Mellichamp- Wiley India2006
3	Process Control Modeling, Design And Simulation, B.Wayne Beqnette, Prentice Hall Of India, New Delhi2004

Tatyasaheb Kore Institute of Engineering & Technology, Warananagar

First Year M.Tech. Chemical Engineering Semester- II

Elective - IV

Ch-PE-2031 Modern Reaction Engineering

Teaching Scheme			**Examination Scheme**	
Lectures	03 Hrs/Week		CIE	40 Marks
Tutorials	--		ESE	60 Marks
Total Credits	03		TW	--
			Duration of ESE	.

Course Outcome:

CO1: To understand the principles of designing reactors

CO2: To evaluate reaction rates in different types of reactors

CO3: To understand the design and operation of catalytic reactors

CO4: To design and modify rectors to make processes safe and efficient

CO5: Analyze multiple reactions carried out both isothermally and non-isothermally in flow, batch and semi batch reactors to determine selectivity and yield.

CO6: Describe the steps in a catalytic mechanism and how one goes about deriving a rate law, mechanism, and rate-limiting step that are consistent with experimental data.

	Course Contents	**Hours**
Unit 1	A brief review of Chemical kinetics and Ideal reactor.	(06)
Unit 2	**Non Ideal flow and mixing:** Mixing concept, RTD, Response measurement, segregated flow model, Dispersion model, Tank in Series model, recycle rector model, analysis non ideal reactor.	(06)
Unit 3	**Heterogeneous reaction:** Classification, Rate Controlling step, globale rate of reaction.	(06)
Unit 4	**Fluid-solid Non Catalytic reaction:** Sinking core model, untreated core model, kinetics of non catalytic reaction for spherical and cylindrical solid particles, Contacting patterns, Reactor design.	(06)
Unit 5	**Fluid-Fluid Reaction:** Gas-liquid reaction, practical ability of film theory, kinetic regime identification, kinetics of fluid-fluid reaction, Contacting patterns, Reactor design.	(06)

Unit 6	**Catalysis and Catalytic reaction:** Classification of catalysis, surface area measurement, BET theory, pore size distribution, adsorption, adsorption isotherm, Internal and External transport in pore catalyst, effectiveness factor and their modules, Effect of internal transport on selectivity, Catalyst deactivation, poison,Sintering of catalyst, and uniform posing model, Mechanism and kinetics of deactivation, catalyst regeneration. **Design of heterogeneous catalyst:** Isothermal and adiabatic fixed bed reactors, non-isothermal, non-adiabatic fixed bed reactor, Introduction to multiphase reactor design, two phase fluidized bed model, slurry reactor model, trickle bed reactor model.	(06)

Reference Books

1	Octave Levanspeil, Chemicaal Reaction Engineering,Jhon Wiley,London
2	S.M.Walas,ReactionKineticsforChemicalEngineers,McGrawHill,NewYark
3	J.M.Smith, Chemical Reaction Kinetics, Mc GrawHill,1981
4	Bischott and Fromment, Chemical Reactor Designandanalysis,Wesley-1982
5	Fogler H.S, Ellement of Chemical Reactionengineering,prantice-hall19863

Tatyasaheb Kore Institute of Engineering & Technology, Warananagar

First Year M.Tech. Chemical Engineering Semester- II

Elective – IV

Ch-PE – 2031 Catalysis and Surface Phenomena

Teaching Scheme			**Examination Scheme**	
Lectures	03 Hrs/Week		CIE	40 Marks
Tutorials	--		ESE	60 Marks
Total Credits	03		TW	--
			Duration of ESE	.

Course Outcome:-

CO1: To understand the concepts of homogenous and heterogeneous catalysis, catalytic activity and selectivity and the relevance to green chemistry and technology

CO2: To understand the kinetics of homogenous and heterogeneous catalytic reactions and catalytic cycles

CO3: To familiarize with the synthesis and characterization of catalysts

CO4: To understand the application and mechanisms of several types of catalysts

CO5: Knowledge of heat and mass transfer effects on catalytic reactions.

CO6: Ability to design different types of reactors for conducting catalytic reactions.

	Course Contents	**Hours**
Unit 1	**Introduction of Catalysis :** Classification of Catalysis - Homogeneous, Heterogeneous, Biocatalysts, Preparation of catalysis - Laboratory Techniques, Industrial methods, Transition models, Dual functional catalysts, Zeolites, Enzymes, Solid Catalysts, Powder Catalysts, Pellets, Composition, Active ingredients, Supportive materials, Catalysts activation.	(06)

Unit 2	**Catalysts Characterization:** Surface area measurements, BET Theory, Pore size distribution, Porosimetry Chemisorption techniques, Static and dynamic methods, Crystallography and surface analysis techniques, XRD, XPS, ESCA, ESR, NMR, Raman and Masbauar spectroscopies, Surfaceacidityandtoxicity,Activity,Lifetime, Bulkdensity,Thermalstabilityetc.	(06)
Unit 3	**Theories of Catalysts:** Crystal structure and its defects, Geometric and electronic factors, Analysis of transition model catalysis, Chemistry and thermodynamics of adsorption, Adsorption isotherms - Langmuir model, Tempkin model, Freundich model, Elovich equation, Langmiur Hinshel - wood model, Rideal - Eely mechanism, Reversible - irreversible mono and bimolecular reactions with and without inerts, Determination of rate controlling steps, Inhibition, parameter estimation.	(06)
Unit 4	**Mass and Heat Transport in Porous Catalysts :**Internal and external transport, fixed bed, Fluidized bed reactors, Effect of internal transport on selectivity. Effectiveness factor and Thiele modulus.	(06)
Unit 5	**Catalyst Deactivation :** Poisons, sintering of catalysts, Pore mouth plugging and uniform poisoning models, Kinetics of deactivation, Catalyst regeneration.	(06)
Unit 6	**Industrial Catalysis :**Industrial catalysts preparation methods, Typical industrial catalytic processes, Case studies, Catalytic deactivation prevention methods, New techniques for catalyst characterization, Overall study.	(06)

Reference Books

1	Emmett, P.H. - "Catalysis Vol. I and II, Reinhold Corp.", New York,1954.
2	"Smith, J.M. - "Chemical Engineering Kinetics ", McGraw Hill,1971.
3	Thomas and Thomas - "Introduction to Heterogeneous Catalysts ", Academic Press, London 1967

Tatyasaheb Kore Institute of Engineering & Technology, Warananagar

First Year M.Tech. Chemical Engineering Semester- II

Elective – IV

Ch-PE-2031 Down Stream Processing

Teaching Scheme			**Examination Scheme**	
Lectures	03 Hrs/Week		CIE	40 Marks
Tutorials	--		ESE	60 Marks
Total Credits	03		TW	--
			Duration of ESE	.

Course Outcome:-

CO1: Understanding the fundamentals of downstream processing for biochemical product recovery.

CO2: Assessing the impact of change on overall process performance

CO3: Examining traditional unit operations, as well as new concepts and emerging technologies that are likely to benefit biochemical product recovery in the future.

CO4: Understanding analytical and process validation issues that are critical to successful manufacturing

CO5: Strategies for biochemical process analysis and synthesis.

CO6: Design and operation of unit processes with centrifugation, chromatography, filtration, and membrane processes

	Course Contents	**Hours**
Unit 1	**Requirement of Downstream Processing :**Basic concepts of separation Technology, Overview of a bioprocess including upstream and downstream processing, Importance of downstream processing in biotechnology, characteristics of biological molecules, New Separation process in modern biotechnology; Separation characteristics of proteins and enzymes – size, stability & other biological properties; Selection of purification methodologies, Characteristics of fermentation broth & its pretreatment.	(06)
Unit 2	**Biomass Removal and Disruption:** Biomass removal and disruption: Cell disruption by Mechanical and non mechanical methods, Chemical lysis, Enzymatic lysis, physical methods, Sonication, Types of Homogenizers, Centrifugation; Sedimentation; Flocculation.	(06)
Unit 3	**Biomass Removal and Disruption:** Biomass removal and disruption: Cell disruption by Mechanical and non mechanical methods, Chemical lysis, Enzymatic lysis, physical methods, Sonication, Types of Homogenizers, Centrifugation; Sedimentation; Flocculation.	(06)
Unit 4	**Membrane Based Separation:** Membrane based purification: icrofiltration, Ultrafiltration, Reverse osmosis (UF and RO); Dialysis; Electrodialysis; Diafiltration; Pervaporation; Perstraction, Biotechnological application, Structure and characteristics of membranes; Liquid membranes; Supported liquid membrane; Membranereactors. RO); Dialysis; Electrodialysis; Diafiltration; Pervaporation; Perstraction, Biotechnological application, Structure and characteristics of membranes; Liquid membranes; Supported liquid membrane; Membranereactors..	(06)

Unit 5	**Separation by Adsorption and Chromatography:** Types of adsorption; adsorbents types, their preparation and properties, Types of adsorption isotherms and their importance; Chromatography: general theory, partition coefficients, zone spreading, resolution and plate height concept and other chromatographic terms and parameters; chromatographic method selection; selection of matrix; separation based on size, charge, hydrophobicity and affinity: Gel filtration, Ion exchange chromatography, Affinity chromatography, IMAC chromatography; Covalent chromatography; Reverse phase chromatography (RPC) and hydrophobic interaction chromatography (HIC), HPLC, role of HPLC in protein characterization; Chromatofocussing; Polishing of Bioproducts by Crystallization of small and large molecules, drying andFormulations.	(06)
Unit 6	**Case Studies :**Baker's yeast, Ethanol, Power alcohol, Citric acid, Intracellular proteins, Penicillin, Streptomycin, Insulin, Casein, interferon, Large scale separation and purification of *E.coli*, yeast, Recombinant products.	(06)

Reference Books

1	E L V Harris and S. Angal, Protein Purification Methods, Ed. IRL Press at Oxford University Press,1989
2	P.A. Belter, E.L. Cussler and Wei-Shou Hu., Bioseparations-Downstream Processing for Biotechnology, Wiley-Interscience Publication,1988.
3	J.E.Baileyand D.F.Ollis,BiochemicalEngineeringFundamentals,2ndEdition,Mc-Graw Hill, Inc.,1986
4	ComprehensiveBiotechnology"Vol.2Ed.:M.Moo-Young(1985)
5	Seperation, Recoveryand Purificationin Biotechnology, Aenjo J.A.and J.Hong
6	Priniciples of fermentation technology" by P F Stanbury and A Whitaker, Pergamonpress (1984)
7	"Biotreatment, Downstream Processing and Modeling" (Advances in Biochemical Engineering/Biotechnology, Vol 56) by T. Schepleretal,Springer Verlag
8	Downstream Processing" by J.P. Hamel, J.B. Hunter and S.K. Sikdar, American Chemical Society
9	Protein Purification" by M.R. Ladisch, R.C. Wilson, C.C. Painton and S.E. Builder, American Chemical society,Verlag
10	Chromatographic and Membrane Processes in Biotechnology" by C.A. Costa andJ.S. Cabral, Kluwer, AcademicPublisher
11	Protein purification: Principle and practice, third edition, Robert k. Scopes, Springer,editor: Charles R.Cantor

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First Year M.Tech. Chemical Engineering Semester- II

Elective – IV

Ch-PE-2041 COMPUTATIONAL FLUID DYNAMICS

Teaching Scheme			**Examination Scheme**	
Lectures	03 Hrs/Week		CIE	40 Marks
Tutorials	--		ESE	60 Marks
Total Credits	03		TW	--
			Duration of ESE	.

Course Outcome:-

CO1: Provide the student with a significant level of experience in the use of modern CFD software for the analysis of complex fluid-flow systems.

CO2: Understand solution of aerodynamic flows. Appraise & compare current CFD software. Simplify flow problems and solve them exactly

CO3: Define and setup flow problem properly within CFD context, performing solid modelling and producing grids via meshing tool

CO4: Understand both flow physics and mathematical properties of governing Navier-Stokes equations and define proper boundary conditions for solution

CO5: Develop an awareness of the power and limitations of CFD.

CO6: Place CFD in the context of a useful design tool for industry and a vital research tool for thermos-fluid research across many disciplines.

	Course Contents	**Hours**
Unit 1	**Governing Differential Equation And Finite Difference Method :** Classification, Initial and Boundary conditions – Initial and Boundary Value problems – Finite difference method, Central, Forward, Backward difference.	(06)
Unit 2	Uniform and non uniform Grids, Numerical Errors, Grid Independence Test.	(06)
Unit 3	**Conduction Heat Transfer** Steady one-dimensional conduction, two and three dimensional steady state problems, Transient one-dimensional problem, Two-dimensional Transient Problems	(06)
Unit 4	**Incompressible Fluid Flow** Governing Equations, Stream Function – Verticity method, Determination of pressure for viscous flow, SIMPLE Procedure of Patankar and Spalding, Computation of Boundary layer flow, finite difference approach.	(06)
Unit 5	**Convection Heat Transfer And Fem** Steady One-Dimensional and Two-Dimensional Convection – diffusion, Unsteady one- dimensional convection – diffusion, Unsteady two-dimensional convection –Diffusion – Introduction to finite element method – solution of steady heat conduction by FEM – Incompressible flow – simulation byFEM.	(06)
Unit 6	Algebraic Models – One equation model, K – ϵ Models, Standard and High and Low Reynolds number models, Prediction of fluid flow and heat transfer using standard codes.	(06)

Reference Books	
1	Muralidhar, K., and Sundararajan, T., "Computational Fluid Flow and Heat Transfer", Narosa Publishing House, New Delhi,1995.
2	Ghoshdasdidar, P.S., "Computer Simulation of flow and heat transfer" Tata McGraw-Hill Publishing Company Ltd.,1998.
3.	Subas, V.Patankar "Numerical heat transfer fluid flow", Hemisphere PublishingCorporation, 1980.
4	Taylor, C and Hughes, J.B. "Finite Element Programming of the Navier-Stokes Equation", Pineridge Press Limited, U.K.,1981.
5	Anderson, D.A.,Tannehill, J.I., and Pletcher, R.H., "Computational fluid USA,1984
6	Fletcher, C.A.J. "ComputationalTechniquesfor Fluid Dynamics 1" Fundamental and General Techniques, Springer – Verlag,1987.
7	Fletcher, C.A.J. "ComputationalTechniques for fluid Dynamics 2"Specific Techniques for Different Flow Categories, Springer – Verlag,1987.
8	Bose,T.X.,"NumericalFluidDynamics"NarosaPublishingHouse,1997

Tatyasaheb Kore Institute of Engineering & Technology, Warananagar

First Year M.Tech. Chemical Engineering Semester- II

Elective – IV

Ch-PE-2041 Energy Engineering

Teaching Scheme			**Examination Scheme**	
Lectures	03 Hrs/Week		CIE	40 Marks
Tutorials	--		ESE	60 Marks
Total Credits	03		TW	--
			Duration of ESE	.

Course Outcome:-

CO1: Discuss and compare various types of energy resources and the principles for converting from one form to another.

CO2: Analyse and evaluate energy use over the lifecycle of a product or project.

CO3: Collect data from thermodynamic systems and evaluate the performance of the system.

CO4: Evaluate the global considerations of energy production, management and conservation including the environmental and economic impact of common fuels.

CO5: Understanding Energy management methods. Rational energy consumption. Energy conservation. Waste heat recovery.

CO6: Understanding Energy conservation in industry.

	Course Contents	**Hours**
Unit 1	Energy, units of energy, conversion factors, general classification of energy, Historical Events, Energy requirement of Society in Past and Present situation, World energy resources and energy consumption, Indian energy resources and energy consumption, energy crisis, energy alternatives, future possibilities of energy need and availability, electrical energy from conventional energy resources, internal combustion engines, steam turbines, gas turbines, hydroturbines (thermodynamic cycles not included).	(06)

Unit 2	Nuclear reactors, thermal, hydel and nuclear power plants (process outlines only), efficiency, merits and demerits of the above power plants, combined cycle power plants, fluidized bed combustion, small hydropower.	(06)
Unit 3	Solar energy, solar thermal systems, flat plate collectors, focusing collectors, solar water heating, solar cooing, solar distillation, solar refrigeration, solar dryers, solar pond, solar thermal power generation, solar photovoltaic systems, solar cells, solar photovoltaic power generation, solar energy application in India, energy plantations, wind energy, types of windmills, types of wind rotors,	(06)
Unit 4	Darrieus rotor and Gravian rotar, wind electric power generation, wind power in India, economics of wind farm, ocean wave energy conversion, ocean thermal energy conversion, tidal energy conversion, geothermal energy.	(06)
Unit 5	Biomass energy resources, thermochemical and biochemical methods of biomass conversion, combustion, gasification, pyrolysis, biogas production, ethanol, fuel cells, alkaline fuel cell, phosphoric acid fuel cell, molten carbonate fuel cell, solid oxide fuel cell, solid polymer electrolyte fuel cell, magneto hydro dynamics, open cycle and closed cycle systems, magneto hydro dynamic power generation, energy storage routes like thermal energy storage, chemical, mechanical storage, electrical storage.	(06)
Unit 6	Energy conservation in chemical process plants, energy audit energy saving in heat exchangers, distillation columns, dryers, ovens and furnaces and boilers, steam economy in chemical plants, energy conservation in petroleum, fertilizer and steel industry, cogeneration, pinch technology, recycling for energy saving, electrical energy conservation in chemical process plants, environmental aspects of energy use.	(06)

Reference Books

1	Goldmberg J., Johansson, Reddy A.K.N. & Williams R.H., Energy fora Sustainable World, JohnWiley
2	Bansal N.K., Kleeman M. & Meliss M., Renewable Energy Sources &Conversion Tech., Tata McGrawHill
3.	Sukhatme S.P., Solar Energy, Tata McGrawHill
4	Mittal K.M., Non-Conventional EnergySystems, WheelerPub
5	Venkataswarlu D., Chemical Technology, I, S.Chand
6	PandeyG.N.,ATextBookonEnergySystemand Engineering,VikasPub.
7	Rao S. & Parulekar B.B., EnergyTechnology, KhannaPub.
8	RaiG.D.,Non-ConventionalEnergySources,KhannaPub.
9	Nagpal G.R., Power Plant Engineering, KhannaPub.

Text Books

1	Power Plant Engineering, P. K. Nag Tata McGraw Hill 2nd edn2001.
2	Power Plant Engineering, Domakundawar, Dhanpath Rai sons.2003

Tatyasaheb Kore Institute of Engineering & Technology, Warananagar

M.Tech. (Chemical Engineering), Sem.-II

Ch-PE-2041 (Elective IV) Advanced Separation Techniques

Teaching Scheme			**Examination Scheme**	
Lectures	03 Hrs/Week		CIE	40 Marks
Tutorials	--		ESE	60 Marks
Total Credits	03		TW	--
			Duration of ESE	.

Course Outcome:-

CO1: Apply modern separation techniques in various applications.

CO2: To design a process based on separation principles.

CO3: Appropriate application of separation steps in industrial processes.

CO4: To compute the kinetics of various types of separation processes.

CO5: Analyze and design pervaporation, chromatography and dialysis based separation processes.

CO6: Analyze and design novel membranes for intended application.

	Course Contents	**Hours**
Unit 1	**General** Review of Conventional process, recent advances in separation technique based on size, surface properties ionic properties and other special characteristics of substance.	(04)
Unit 2	**Filtration** Process Concept, Theory and Equipment used in Cross flow filtration , Cross flow electro filtration, duel functional filtration surface based solid- liquid separation involving stead liquid , Siroflocfilter.	(04)
Unit 3	**Membrane filtration** Types and choice of membranes, Plates and frame, tubular, Spherial wounded and hollow fibre membrane, reactor and their relative merits , commercial, pilot plant, and labortary membranes, Permeates involving analysis, reverse osmosis, nano filtration, ultrafiltration, microfiltration and donan analysis, economics of membrane operation, cevanic membrane.	(05)
Unit 4	**Separation by Adsorption technique** Mechanism, Choice and type of adsorbent, normal adsorption technique, affinity chromatography, and immune chromatography, types of equipment and commercial processes, recent advance and processes, Economics.	(05)
Unit 5	**Ionic Separation:** Controlling factor, application, type of equipment used in electrophoresis, dielectrophoresis, ion exchange chromatography, and electro-dialysis, commercial processes.	(05)

Unit 6	**Other technique:** Separation Involving lyophilisation, pervaporation and permeation technique for solid, liquid, and gases, industrial variables and examples, zone melting, add crystallization, other separation processes, supercritical fluid extraction, oil spillage management.	(05)

Reference Books

1	LaceyR.E andS.loaeb,industrialprocessingwithmembrane,wiely,newyark-1972
2	KingC.J,Separationprocesses,TataMc-Graw–hillpublicationCo.ltd-1982
3	Schoew, HM, New Chemical Engineering Separation technique, future sciencepublisher 1972
4	Ronald W.Ronssel,HandbookofprocessTechnology,wilynewYork198

Tatyasaheb Kore Institute of Engineering & Technology, Warananagar

First Year M.Tech. Chemical Engineering Semester- II

OEC-CH2051: Project Management

Teaching Scheme			**Examination Scheme**	
Lectures	03 Hrs/Week		ISE	40 Marks
Tutorials	----------		ESE	60 Marks
Total Credits	03		TW	----------
			Duration of ESE	.

Course Objectives : -
1 To study concept of Project Management and skills
2 Ability to understand organization structure
3 To acquaint with staffing the project office and team
4 Ability to understand controlling parameters and human behaviour
5 To study and develop a project scope
6 Ability to use CPM and PERT methods

	Course Contents	**Hours**
Unit 1	**Project Management growth** Concept and Definition , General System Management, Project management, Resistance to Change, System programmed, Project product vs project management a definition focus of success,Face of failure,Project life cycle,Project management methodologies,Corporate culture	(05)

Unit 2	**Organizational structure** Introduction, organizational work flow, Traditional organization, Developing work , integration position, Project coordinator, Projected organization , Matrix structure, Strong weak balanced matrix, Project management Expertise, Studying tips for the PMF (Project Management CertificateExam)	(05)
Unit 3	**Organizing and staffing the project office and team** The staffing environment, Selecting the project manager,Skill requirement for project and programme manager, Organizational staffing progress,The project office, Project organizational chart.	(05)
Unit 4	**management function** Controlling, Directing ,Project Authority, Interpersonal life cycle, leadership in a project management environment, life cycle leadership, organizational impact ,employee manager problem, management pitfalls, Communication, Human behavior education, Management policies andprocedure.	(05)
Unit 5	**Special Topic** Performance measurement, Financial compensation and rewards, Critical Issues with rewarding project team, mega Project, Morality, Ethics and corporate culture, Professional Responsibility, Internal Prternership , External Prternership, Training and education, Integrated project team , Virtual project team,Break through	(05)

Course Outcomes (CO): At the end of course students will
1. Define various operations like distillation, extraction, leaching, Compare and classify various mass transfer operations with or without chemical reaction
2. Design calculation of distillation column for the multi-component system
3. Analyze the problem of Separation by adsorption and design of absorber, chromatographic separation
4. Evaluate the separation by liquid extraction, leaching used and justify the extract operation to choose for specific problem
5. Estimate final data for designing number of stages, Height of column in the operations
6. Define various operations like distillation, extraction, leaching

Text Books

1	"A system Approach to planning, Scheduling, Controlling, by Harolad Kerzner 10th Ed Willy

Reference Books

1	Project Management Theory and Practices Crary L Richardsion, CRC press, Taylor and Franas Group, boca ration London, Newyark
2	Project Management for Engineer business, technology 4th Ed, Jhon M Nicholas,Herman

Tatyasaheb Kore Institute of Engineering & Technology, Warananagar

First Year M.Tech. Chemical Engineering Semester- II

Ch-OEC-2051 Operation Research

Teaching Scheme			**Examination Scheme**	
Lectures	03 Hrs/Week		CIE	40 Marks
Tutorials	--		ESE	60 Marks
Total Credits	03		TW	--
			Duration of ESE	.

Course Outcome:-

CO1: Identify and develop operational research models from the verbal description of the real system.

CO2: Understand the mathematical tools that are needed to solve optimisation problems.

CO3: Use mathematical software to solve the proposed models

CO4: Develop a report that describes the model and the solving technique, analyse the results and propose recommendations in language understandable to the decision-making processes in Management Engineering.

CO5: Conduct and interpret post-optimal and sensitivity analysis and explain the primal-dual relationship.

CO6: Define and formulate linear programming problems and appreciate their limitations.

	Course Contents	**Hours**
Unit 1	Introduction to Operations Research: Basics definition, scope, objectives, phases, models and limitations of Operations Research. Linear Programming Problem – Formulation of LPP, Graphical solution of LPP. Simplex Method, Artificial variables, big-M method, two-phase method, degeneracy and unbound solutions	(06)
Unit 2	Transportation Problem. Formulation, solution, unbalanced Transportation problem. Finding basic feasible solutions – Northwest corner rule, least cost method and Vogel's approximation method. Optimality test: the stepping stone method andMODImethod.	(06)
Unit 3	Assignment model. Formulation. Hungarian method for optimal solution. Solving unbalanced problem. Traveling salesman problem and assignment problem.	(06)
Unit 4	Sequencing models. Solution of Sequencing Problem – Processing n Jobs through 2 Machines – Processing n Jobs through 3 Machines – Processing 2 Jobs through m machines – Processing n Jobs through m Machines.	(06)
Unit 5	Dynamic programming. Characteristics of dynamic programming. Dynamic programming approach for Priority Management employment smoothening, capital budgeting, Stage Coach/Shortest Path, cargo loading and Reliability problems.	(06)
Unit 6	Games Theory. Competitive games, rectangular game, saddle point, minimax (maximin) method of optimal strategies, value of the game. Solution of games with saddle points, dominance principle. Rectangular games without saddle point – mixed strategy for 2 X 2 games.	(06)

Text Books	
1	P. Sankara Iyer, "Operations Research", Tata McGraw-Hill,2008.
2	A.M. Natarajan, P. Balasubramani, A. Tamilarasi, "Operations Research",Pearson Education,2005.
Reference Books	
1	JKSharma.,"OperationsResearchTheory&Applications,3e",MacmillanIndiaLtd,2007.
2	P. K. Gupta and D. S. Hira, "Operations Research", S. Chand & co.,2007.
3	JKSharma.,"OperationsResearch,ProblemsandSolutions,3e",MacmillanIndiaLtd.
4	N.V.S. Raju, "Operations Research", HI-TECH,2002.

Tatyasaheb Kore Institute of Engineering & Technology, Warananagar

First Year M.Tech. Chemical Engineering Semester- II Practical

Ch-LC-2061 Analytical Laboratory

Teaching Scheme			**Examination Scheme**	
Practical's	04 hr/Week		ESE	--
Total Credits	02		TW	25 Marks
			Duration of ESE	

Course Outcome:-

CO1: Apply mathematical, physical and chemical concepts to routine tasks such as the analysis and synthesis of chemical compounds and samples.

CO2: Describe and understand the capabilities and limitations of instrumental methods

CO3: Demonstrate competence in collecting and interpreting data in the laboratory.

CO4: Apply principles of chemistry to the observations of substances experiencing physical or chemical changes.

CO5: Laboratory skills for the purpose of collecting, interpreting, analyzing, and reporting (in written form) chemical data.

CO6: Conduct basic manual quantitative and qualitative analyses accurately, using prescribed laboratory procedures.

	Course Contents 1. Analysis Of Given Sample by using Gas Chromatography 2. Detail study and Analysis of High Performance Liquid Chromatography(HPLC) 3. Instrument Exploration :Scanning Electron Microscopy(SEM) 4. Measurement , analyze, and discussion of three different types of Samplevia Thermogravimetric Analysis, orTGA 5. Determination of the amount of carbon monoxide in exhaust samples byFTIR spectroscopy 6. Spectrophotometry: Absorption spectra and the use of light absorption tomeasure concentration 7 Analysis by using GelElectrophoresis	

Tatyasaheb Kore Institute of Engineering & Technology, Warananagar				
First Year M.Tech Chemical Engineering) Semester- II				
Ch-SW-2071: Seminar – II				
Teaching Scheme			**Examination Scheme**	
Lectures	----		ISE	---
Tutorials	---		ESE (Oral)	---
Practical	02Hrs/Week		TW	50
Total Credits	01		Duration of ESE	------.
Course Objectives (CO):				
1.To Identify, understand and discuss current, real-world issues.				
2.To Distinguish and integrate differing forms of knowledge and academic disciplinaryapproaches (e.g., humanities and sciences) with that of the student's own academic discipline (e.g., in agriculture, architecture, art, business, economics, education,engineering, natural resources, etc.). and apply a multidisciplinary strategy to addresscurrent, real-world issues.				
3. To Improve oral and written communication skills.				
4. To Improve presentation skills				
	Course Contents			**Hours**

1	Seminar II shall be based on tentative topic of dissertation such as review paper on some specific well defined area/ specialized stream of Mechanical Engineering.Each student has to prepare a write up of about 25-30 pages of "A4" size sheets and submit it in IEEE format in duplicate as the term work. The student has to deliver a seminar talk in front of the faculty of the department and his classmates. The faculty, based on the quality of work, carried out, preparation and understanding of the candidates. Some marks should be reserved for the attendance of a student in the seminars of other students. .	(--)

Course Outcomes (CO): At the end of course students will

1. Apply principles of ethical leadership, collaborative engagement, socially responsiblebehavior, respect for diversity in an interdependent world, and a service-oriented commitment to advance and sustain local and global communities.

2. Learn and integrate. Through independent learning and collaborative study, attain, use, and develop knowledge in the arts, humanities, sciences, and social sciences, withdisciplinary specialization and the ability to integrate information across disciplines.

3. Think and create. Use multiple thinking strategies to examine real-world issues, explore creative avenues of expression, solve problems, and make consequentialdecisions

4.Communicate. Acquire,articulate,create and convey intended meaning using verbal and non-verbal method of communication that demonstrates respect and understanding in a complex society.

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First Year M.Tech Chemical Engineering Semester- II

Ch-2081: Comprehensive Viva

Teaching Scheme			**Examination Scheme**	
Lectures	------		ISE	---
Tutorials	---		ESE (Oral)	25
Total Credits	----		TW	----
			Duration of ESE	------.

Course Objectives (CO):

1.To verify the continuous assessment and performance of students by external examiner and internal examiner.

	Course Contents	**Hours**

1	The students have to prepare on all subjects which they have studied in I[st] and II[nd] semesters The viva will be conducted by the External/Internal Examiner jointly and their appointments will be made by institute. The in-depth knowledge, preparation and subjects understanding will be assessed by theExaminers.	(--)
Course Outcomes (CO): At the end of course students will		
	1. Verify their knowledge based on the subjects they have studied in Semester-I and Semester-II.	

SEMESTER-III

Tatyasaheb Kore Institute of Engineering & Technology, Warananagar				
First Year M. Tech Chemical Engineering Semester- II				
Ch-MC-3011 Research Methodology				
Teaching Scheme			**Examination Scheme**	
Lectures	02 Hrs/Week		ISE	40 Marks
Tutorials	--		ESE	60 Marks
Total Credits	02		TW	--
			Duration of ESE	.

Course Objectives (CO):	
	1 Understand some basic concepts of research and its methodologies
	2 Identify appropriate research topics
	3 Select and define appropriate research problem and parameters
	4 Prepare a project proposal (to undertakeproject)
	5 Organize and conduct research (advanced project) in a more appropriate manner
	6 Understanding how to write a research report and thesis

	Course Contents	**Hours**
Unit 1	**Objectives and types of research:** Motivation and objectives – Research methods *vs* Methodology. Types of research– Descriptive *vs.* Analytical, Applied *vs*. Fundamental, Quantitative *vs.* Qualitative, Conceptual *vs.* Empirical.	(04)

Unit 2	**Research Formulation** – Defining and formulating the research problem - Selecting the problem - Necessity of defining the problem - Importance of literature review in defining a problem – Literature review – Primary and secondary sources – reviews, treatise, monographs- patents – web as a source – searching the web - Critical literature review – Identifying gap areas from literature review - Development of working hypothesis.	(04)
Unit 3	**Research design and methods** – Research design – Basic Principles- Need of research design — Features of good design – Important concepts relating to research design – Observation and Facts, Laws and Theories, Prediction and explanation, Induction, Deduction, Development of Models. Developing a research plan - Exploration, Description, Diagnosis, and Experimentation. Determining experimental and sample designs.	(04)
Unit 4	**Data Collection and analysis:** Execution of the research - Observation and Collection of data - Methods of data collection – Sampling Methods- Data Processing and Analysis strategies Data Analysis with Statistical Packages - Hypothesis-testing - Generalization and Interpretation.	(04)
Unit 5	**Reporting and thesis writing** – Structure and components of scientific reports - Types of report – Technical reports and thesis – Significance – Different steps in the preparation – Layout, structure and Language of typical reports – Illustrations and tables - Bibliography, referencing and footnotes - Oral presentation – Planning – Preparation – Practice – Making presentation – Use of visual aids - Importance of effective communication.	(04)
Unit 6	**Application of results and ethics** - Environmental impacts - Ethical issues - ethical committees - Commercialization – Copy right – royalty - Intellectual property rights and patent law–Trade Related aspects of Intellectual Property Rights–Reproduction of published material Plagiarism - Citation and acknowledgement - Reproducibility and accountability	(04)
Assignments: Each student will submit minimum 4 assignments based on the different topics in consultation with faculty, in the area of research methodology keeping track of the recent trends in research and developments. At the end of the semester one seminar on relevant topic of research.		

Course Outcomes (CO): At the end of course students should be able to	
1 Identify comprehensive understanding of principal in **demonstrating** academic research	
2 Differentiate possible research resources and **transform** issue in broader perspective	
3 Communicating research in own words to **create** new meaning	
4 Choose and **propose** a good research proposal in systematic way.	
5 Apply appropiate research techniques and tools from different approached with profound intellectual **integrity and ethics**	
Text Books	
1	Kothari,C.R.,1990.Research Methodology :Methods and Techniques. New Age International.
Reference Books	
1	Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., 2002. An introduction to Research Methodology, RBSA Publishers.
2	Sinha,S.C.and Dhiman,A.K.,2002.Research Methodology, Ess Ess Publications.2 volumes
3	Trochim, W.M.K., 2005. Research Methods: the concise knowledge base, Atomic Dog Publishing.
4	Wadehra, B.L. 2000. Law relating to patents, trademarks, copyright designs and geographical indications. Universal Law Publishing.

Tatyasaheb Kore Institute of Engineering & Technology, Warananagar

First Year M.Tech. Chemical Engineering Semester- III

Ch-MC-3021 Industrial Training

Teaching Scheme			**Examination Scheme**	
Lectures	--=--		ISE	----
Tutorials	--		ESE	------
Practical	04 Hrs/Week		TW	50
Total Credits	02		Duration of ESE	-----.

Course Objectives (CO):

1. To expose the students to actual working environment and enhance their knowledge and skill from what they have learned in the college.

2.To instill the good qualities of integrity, responsibility and self confidence. All ethical values and good working practices must be followed by student.

3.To help the students about the safety practices and regulations inside the industry and to instill the spirit of teamwork and good relationship between students and employees.

	Course Contents	**Hours**
Unit 1	The student has to prepare the report of training undergone in the industry during vacation after semester II. It shall include the brief details of assignment completed by the candidate and general observation and analysis. The identified areas for undertaking the dissertation work shall form part of report. The term work marks should be based on report and departmental oral exams. The training should be of minimum two weeks from reputed industries and certificate of the same should be a part of the report.	---

Course Outcomes (CO): At the end of course students will

1.	Ability to demonstrate the use, interpretation and application of an appropriate international engineering standard in a specific situation.
2	Ability to analyze a given engineering problem, identify an appropriate problem solving methodology, implement the methodology and propose a meaningful solution.
3	Ability to apply prior acquired knowledge in problem solving
4	Ability to identify sources of hazards, and assess/identify appropriate health & safety measures
5	Ability to work in a team and take initiatives
6	Ability to effectively communicate solution to problems (oral, visual, written)
7	Ability to manage a project within a given time frame
8	Ability to adopt a factual approach to decision making andto take engineering decision

Tatyasaheb Kore Institute of Engineering & Technology, Warananagar

Second Year M.Tech Chemical Engineering, Semester-III

Ch - SLC/AC -3031: MOOC/Swayam

Teaching Scheme			**Examination Scheme**	
Lectures	----		ISE	----
Tutorials	--		ESE	------
Total Credits	--		TW	50
			Duration of ESE	----

Course Objectives (CO):

1. To teach use of Mooc/Swayam as a learning platform designed to provide educators,administrators and learners with a single robust, secure and integrated system to create personalized learning environment.

	Course Contents	**Hours**
Unit 1	Students will be able to choose course of their choice from Mooc/swayam and to be acquaintance with recent developments in Chemical Engineering beyond syllabus **The term work under this submitted by the student shallinclude.** 1) Work diary maintained by the student and countersigned by his guide. 2) The content of work diary shall reflect the efforts taken by candidates for (a) Searching the suitable project work. (b) Visits to different factories or organizations. **(c) The brief report of feasibility studies carried to come to final conclusion.** **(d) Rough sketches** **(e) Design calculations etc. carried by the student.** 3) The student has to make a presentation in front of panel of experts in addition to guide as decided by department head. .	--

Course Outcomes (CO): At the end of course students will

Students will be able to choose course of their choice from Mooc/swayam and to be acquaintance with recent developments in Chemical Engineering beyond syllabus.

Tatyasaheb Kore Institute of Engineering & Technology, Warananagar

Second Year M.Tech Chemical Engineering, Semester-III

Ch-PC-3041: Dissertation Phase-I

Teaching Scheme			**Examination Scheme**	
Lectures	-----		ISE	----
Tutorials	----		ESE (Oral)	50
Practical	16Hrs/Week		TW	50
Total Credits	08		Duration of ESE	-----.

Course Objectives (CO):

1. To grow deeper knowledge, understanding, capabilities and attitudes in the context of the programme of study.
2. To investigate more deeply into and synthesise knowledge acquired in previous studies.

	Course Contents	**Hours**
Unit 1	**The dissertation submitted by the student on topic already approved by academic council on basis of initial synopsis submitted by the candidate, shall be according to following guidelines.** **Format of dissertation report:** The dissertation work report shall be typed on A4 size bond paper. The total No. of minimum pages shall not less than 60. Figures, graphs, annexure etc be as per the requirement. **The report should be written in the standard format.** 1. Title sheet 2. Certificate 3. Acknowledgement 4. List of figures, Photographs/Graphs/Tables 5. Abbreviations. 6. Abstract 7. Contents. 8. Text with usual scheme of chapters. 9. Discussion of the results and conclusions Bibliography (the source of illustrative matter be acknowledged clearly at appropriate place IEEE/ASME/Elsevier Format)	---

Course Outcomes (CO): At the end of course students will
1. Design and engage in, an independent and sustained critical investigation and evaluation of a chosen research topic.
2. Systematically identify relevant theory and concepts, relate these to appropriate methodologies and evidence, apply correct techniques and draw suitable conclusions.
3. Involve in systematic finding and critical review of appropriate and relevant information sources
4.Understand and apply ethical standards of conduct in the collection and evaluation of data and other resources
5. Present research concepts and contexts clearly and effectively both in writing and orally

Tatyasaheb Kore Institute of Engineering & Technology, Warananagar				
Second Year M.Tech Chemical Engineering, Semester-III				
Ch-PC-4011: Dissertation Phase-II				
Teaching Scheme			**Examination Scheme**	
Lectures	-----		ISE	----
Tutorials	----		ESE (Oral)	100
Practical	32Hrs/Week		TW	100
Total Credits	16		Duration of ESE	-----.
Course Objectives (CO):				
1. To grow deeper knowledge, understanding, capabilities and attitudes in the context of the programme of study.				
2. To investigate more deeply into and synthesise knowledge acquired in previous studies.				

	Course Contents	Hours
Unit 1	**The dissertation submitted by the student on topic already approved by academic council on basis of initial synopsis submitted by the candidate, shall be according to following guidelines.** **Format of dissertation report:** The dissertation work report shall be typed on A4 size bond paper. The total No. of minimum pages shall not less than 60. Figures, graphs, annexure etc be as per the requirement. **The report should be written in the standard format.** 1. Title sheet 2. Certificate 3. Acknowledgement 4. List of figures, Photographs/Graphs/Tables 5. Abbreviations. 6. Abstract 7. Contents. 8. Text with usual scheme of chapters. 9. Discussion of the results and conclusions Bibliography (the source of illustrative matter be acknowledged clearly at appropriate place IEEE/ASME/Elsevier Format) The students should publish at least one paper in a reputed journal (UGC approved/ SCOPUS Indexed etc.) **The student has to make a presentation in front of panel of experts in addition to guide as decided by department head**	---

Course Outcomes (CO): At the end of course students will

1. Design and engage in, an independent and sustained critical investigation and evaluation of a chosen research topic.

2. Systematically identify relevant theory and concepts, relate these to appropriate methodologies and evidence, apply correct techniques and draw suitable conclusions.

APPROVED BY

Institute PG Co-ordinator
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