Study Schemes and Syllabus of Regular Courses of Post Graduation Degree

Vision and Mission of the Department

VISION

"Department of Chemical Engineering shall strive for the development and transfer of technical competence in academic through formal and non-formal education, entrepreneurship and quality research to meet the challenges faced by Chemical and allied industries in an ever expanding and globalized world."

MISSION

M1: Imparting quality technical education to the students in emerging areas of Chemical Engineering.
M2: Integrating industrial training with curricula.
M3: Enhancing research & development in the area of Chemical Engineering and allied fields.
M4: Non-formal education through community development programs.
M5: To increase interaction with Chemical Process Industry.
M6: To impact consultancy services to the chemical and allied industries around the region.

Program Educational Objectives (PEOs)

PEO 01: Prepare students who can take up professional assignments in basic and applied research in chemical engineering industry and academic area.

PEO 02: To equip the students with ability in advanced conceptual understanding in solving real time problems with special emphasis on process integration, energy efficiency and cleaner production.

PEO 03: To equip the students with technical knowhow for economic and social development of rural and urban India.

SLIET LONGOWAL

1.2.1 - CHEMICAL ENGINEERING (PG-CE)

Program Outcomes (POs)

PO 01: Use mathematics, science and engineering knowledge for solving complex problems in the field of Chemical Engineering.

PO 02: Identify and analyze engineering problems to formulate appropriate solutions proficiently.

PO 03: Design and develop real-time system to meet desired needs in the field of Chemical Engineering.

PO 04: Compile, interpret and present research data in an appropriate format, taking into consideration scientific principles and methodology.

PO 05: Use effectively modern tools and techniques for modelling complex problems to provide alternative solutions.

PO 06: Design engineering systems to address societal, legal, cultural, security, health and safety issues.

PO 07: Use techniques, skills, and modern engineering tools required for environmental and sustainable development.

PO 08: Adopt and exhibit professional knowledge with ethical responsibilities.

PO 09: Function effectively as an individual as well as team member for achieving desired goals.

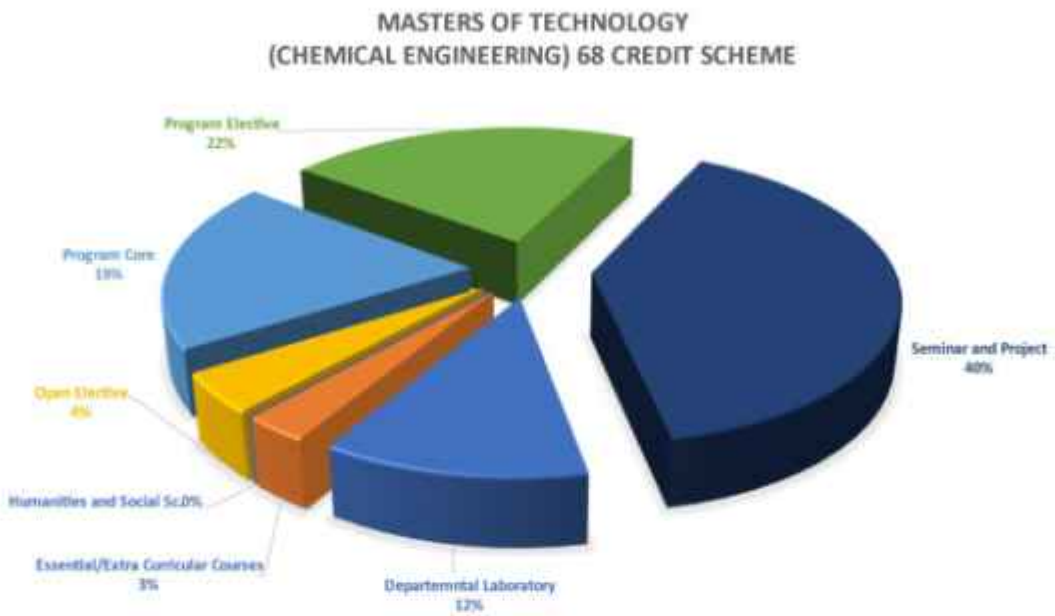
PO 10: Communicate in both verbal and written forms to compete globally.

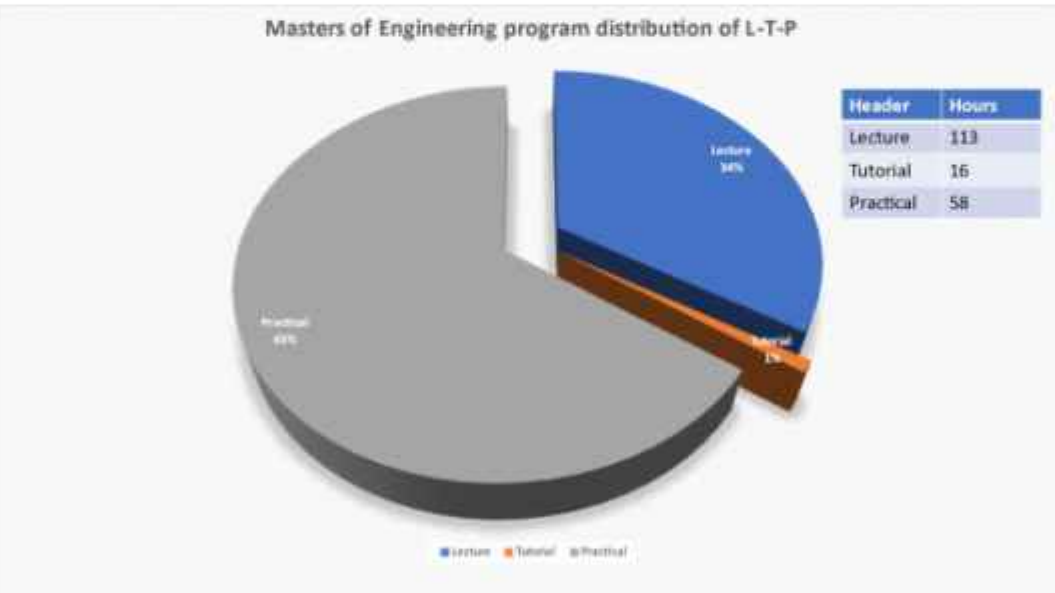
PO 11: Take up administrative responsibilities involving both project and financial management, confidently, exhibit confidence, leadership qualities and remain engaged in life-long learning.

Program Specific Outcome (PSO)

PSO 01: Ability to apply advanced chemical engineering knowhow for inception and development of process for the future utilization of renewable resources.

Study Scheme for Master of Technology, Chemical Engineering





Header	Hours
Lecture	113
Tutorial	16
Practical	58

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1.2.1 - CHEMICAL ENGINEERING (PG-CE)

M.Tech. (Chemical Engineering)							
Semester -I							
S No	**Sub Code**	**Subject Name**	**L**	**T**	**P**	**Hrs.**	**Credits**
1	PCCH-811	Advanced Fluid Mechanics	3	0	0	3	3
2	PCCH-812	Advanced Heat and Mass Transfer	3	0	0	3	3
3	PECH-811	Core Elective-1	3	0	0	3	3
4	PECH-812	Core Elective-2	3	0	0	3	3
5	RMAL-811	Research Methodology & IPR	2	0	0	2	2
6	ACMH-811	English Research Paper Writing & Professional Communication	2	0	0	2	0
7	PCCH-813	Advanced Heat and Mass Transfer lab	0	0	4	4	2
8	PECH-813	Core Elective lab	0	0	4	4	2
		Total	**16**	**0**	**8**	**24**	**18**
Semester -II (A)							
S No	**Sub Code**	**Subject Name**	**L**	**T**	**P**	**Hrs.**	**Credits**
1	PCCH-821	Advanced Chemical Engineering Thermodynamics	3	0	0	3	3
2	PCCH-822	Catalytic Reaction Engineering	3	1	0	4	4
3	PECH-821	Core Elective-3	3	0	0	3	3
4	PECH-822	Core Elective-4	3	0	0	3	3
5	ACMH-821	Constitution of India	2	0	0	2	0
6	PCCH-823	Reaction Engineering and Thermodynamics Lab	0	0	4	4	2
7	PECH-824	Core Elective lab	0	0	4	4	2
8	PCCH-824	Seminar	0	0	2	2	1
		Total	**14**	**1**	**10**	**25**	**18**
Semester -II (B)							
Student should be encouraged for four weeks training in reputed industry/laboratory in Institutions of repute such as IITs, IISc, NITs, CSIR, NCL, IICT, CIPET etc.							
Semester III							
S No	**Sub Code**	**Subject Name**	**L**	**T**	**P**	**Hrs.**	**Credits**
1	PECH-911	Core Elective-5	3	0	0	3	3
2	OEXX-911	Open Elective	3	0	0	3	3
3	PCCH-911	Dissertation (Part-1)	0	0	20	20	10
		Total	**6**	**0**	**20**	**26**	**16**
Semester IV							
S No	**Sub Code**	**Subject Name**	**L**	**T**	**P**	**Hrs.**	**Credits**
1	PCCH-921	Dissertation (Part-2)	0	0	32	32	16
		Total	**0**	**0**	**32**	**32**	**16**

SLIET LONGOWAL

1.2.1 - CHEMICAL ENGINEERING (PG-CE)

List of Core Elective Courses

Core Elective -1 (Semester -I). M.Tech. (Chemical Engineering)							
S. No.	Sub Code	Subject Name	L	T	P	Hrs.	Credits
1.	PECH-811A	Paper Technology	3	0	0	3	3
2.	PECH-811B	Biochemical Engineering	3	0	0	3	3
3.	PECH-811C	Polymer Technology	3	0	0	3	3
Core Elective -2 (Semester -I). M.Tech. (Chemical Engineering)							
S. No.	Sub Code	Subject Name	L	T	P	Hrs.	Credits
1.	PECH-812A	Energy Technology	3	0	0	3	3
2.	PECH-812B	Advanced Transport Phenomena	3	0	0	3	3
3.	PECH-812C	Analytical Instrumentation Methods and Characterization Techniques	3	0	0	3	3
Core Elective Lab (Semester -I). M.Tech. (Chemical Engineering)							
S. No.	Sub Code	Subject Name	L	T	P	Hrs.	Credits
1.	PECH-813A	Paper Technology Lab	0	0	4	4	2
2.	PECH-813B	Biochemical Engineering Lab	0	0	4	4	2
3.	PECH-813C	Polymer Technology Lab	0	0	4	4	2
Core Elective -3 (Semester -II). M.Tech. (Chemical Engineering)							
S. No.	Sub Code	Subject Name	L	T	P	Hrs.	Credits
1.	PECH-821A	Nanoscience and Nanotechnology	3	0	0	3	3
2.	PECH-821B	Bio-resource Technology	3	0	0	3	3
3.	PECH-821C	Environmental Engineering	3	0	0	3	3
Core Elective -4 (Semester -II). M.Tech. (Chemical Engineering)							
S. No.	Sub Code	Subject Name	L	T	P	Hrs.	Credits
1.	PECH-822A	Advanced Process Dynamics and Control	3	0	0	3	3
2.	PECH-822B	Process Modelling and Simulation	3	0	0	3	3
3.	PECH-822C	Advanced Separation Techniques	3	0	0	3	3
Core Elective Lab (Semester -II). M.Tech. (Chemical Engineering)							
S. No.	Sub Code	Subject Name	L	T	P	Hrs.	Credits
1.	PECH-824A	Advanced Process Dynamics and Control Lab	0	0	4	4	2
2.	PECH-824B	Process Modelling and Simulation Lab	0	0	4	4	2
3.	PECH-824C	Advanced Separation Processes Lab	0	0	4	4	2
Core Elective -5 (Semester -III). M.Tech. (Chemical Engineering)							
S. No.	Sub Code	Subject Name	L	T	P	Hrs.	Credits
1.	PECH-911A	Polymer Composites and Blends	3	0	0	3	3
2.	PECH-911B	Advanced Process Optimization	3	0	0	3	3
3.	PECH-911C	Energy Audit and Management	3	0	0	3	3
4.	PECH-911D	Paper Machine Operations	3	0	0	3	3

List of Open Elective Courses

Open Elective (Semester -III). M.Tech. (Chemical Engineering)							
S. No.	Sub Code	Subject Name	L	T	P	Hrs.	Credits
1.	OECH-911A	Environmental Engineering	3	0	0	3	3
2.	OECH-911B	Waste to Energy	3	0	0	3	3

SLIET LONGOWAL

1.2.1 - CHEMICAL ENGINEERING (PG-CE)

Title of the Course:	**Advanced Fluid Mechanics**	**L T P: 3 0 0**
Subject Code:	**PCCH-811**	**Weekly Load: 3 Hrs**
Course Category:	**Core Course**	**Credit: 3**

Course Outcomes: At the end of the course, the student will be able to:

CO1	Develop an intuitive understanding of fluid mechanics.
CO2	Analyze the fluid behavior and solve significant real-world problems.
CO3	Apply fluid mechanics principles for process design.

CO/PO Mapping: (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation):												
COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1
CO1	M		M					M	W	M	W	W
CO2	S	M	M		W	M		M	W	M	M	M
CO3	S	S	M		M	M	W	M	M	M	M	M

Unit	Main Topics	Course Outlines	Lectures
Unit-I	Introduction	Introduction to process fluid mechanics; Fluid statics; Macroscopic (integral) balances for mass, energy and momentum with applications; Engineering Bernoulli equation. Brief recapitulation of some preliminary concepts of Fluid Mechanics Fluid kinematics, Dynamics of inviscid flows and Reynold's transport theorem.	11
	Differential analysis	Conservation of mass, stream function, the differential linear momentum equation- Cauchy's equation, Differential analysis of fluid flow problems.	10
Unit-II	Navier-Stokes equation	Dynamics of viscous flows - Derivation of Navier-Stokes equation, Some exact solutions of Navier-Stokes Equation-Steady flows. Exact solutions of Navier-Stokes equation - Steady flows and practical applications.	08
	Compressible flows	One dimensional isentropic flow, isentropic flow through nozzles, shock waves and expansion waves, Duct flow with heat transfer, Adiabatic duct flow with friction.	09
	CFD	Introduction to computational fluid dynamics, laminar CFD calculations and turbulent CFD calculations.	04

Total = 4 2 hrs

Recommended Books:

1. Fluid Mechanics: by Pijush K. Kundu, Ira M. Cohen, David R Dowling, Academic Press
2. Fluid Mechanics Fundamentals and Applications: by Y.A. Cengel and J.M. Cimbala, McGraw-Hill Education
3. Fluid Mechanics: by F. M White, McGraw-Hill Education
4. Introduction to Fluid Mechanics by R. Fox and A. MacDonald, John Wiley and Sons

SLIET LONGOWAL

1.2.1 - CHEMICAL ENGINEERING (PG-CE)

Title of the Course:	**Advanced Heat and Mass Transfer**	**L T P: 3 0 0**
Subject Code:	**PCCH-812**	**Weekly Load: 3 Hrs**
Course Category:	**Core Course**	**Credit: 3**

Course Outcomes: At the end of the course, the student will be able to:

CO1	Understand the concepts of advanced convective heat transfer
CO2	Analyze the problems of Chemical Engineering pertaining to combined heat transfer.
CO3	compute the diffusion coefficients and mass transfer coefficient in multicomponent distillation.
CO4	Understand the design algorithm for multi component distillation

CO/PO Mapping: (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation):												
COs	**Programme Outcomes (POs)**											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1
CO1	**M**	**M**	**M**					**M**		**M**	**W**	
CO2	**S**	**S**	**S**	**W**	**W**	**S**	**M**	**M**		**M**	**W**	**M**
CO3	**S**	**S**	**S**	**W**	**W**	**S**	**M**	**M**		**M**	**M**	**M**
CO4	**S**	**S**	**S**	**W**	**M**	**M**		**M**		**M**	**M**	

Unit	**Main Topics**	**Course Outlines**	**Lectures**
Unit-I	Multi-dimensional steady state heat conductions	Multi-dimensional steady-state heat conduction, mathematical and graphical analysis of two-dimensional system, electrical analog of two-dimensional system, numerical relaxation method for two-dimensional system, three-dimensional system.	12
	Forced convection inside tubes and ducts	Analysis of laminar forced convection in long tube, correlations for laminar flow correction, analogy between heat and momentum transfer in turbulent flow, working correlation for turbulent forced convection, forced convection in non-circular sections.	
	Forced convection over Exterior surfaces	Flow over Bluff bodies, local heat transfer coefficient distribution around cylinders, effect of various parameters on local heat transfer coefficient, heat transfer from bundles in crossflow, heat transfer from non-circular sections.	
	Heat Transfer by combined conduction, convection, and radiation	Heat transfer in fixed bed, heat transfer in fluidized bed, heat transfer in cyclone heat exchanger, thermocouple lead error in surface temperature measurement, heat transferred from radiating fins, the flat plate solar collectors and the heat pipes.	09
Unit-II	Diffusion of multicomponent system	Fick's law approach to multicomponent diffusion and its limitation, Maxwell Stefan approach to multicomponent diffusion. Analysis of multicomponent diffusion from irreversible thermodynamics. Estimation of multicomponent diffusing coefficients.	12
	Multicomponent distillation and stage calculation for Multicomponent distillation	Key component; bubble point and due point calculations; stage calculation for different reflux ratio condition; Tray column; packed column; HTU and NTU for multicomponent distillation.	09

Total = 42 hrs

Recommended Books:

1. Convective heat and mass transfer; Kays W.M and Crawford M.E., McGraw hill International, 1993
2. Principles of heat transfer; Frank Kreith and Mark S., Asian Book Private limited, 2001
3. Multicomponent Mass transfer; Taylor R. and Krishna R.; Wiley Publication, 1993
4. Separation Process Principles; Seader J.D. and Henley E.J. ; Wiley Publicarion, 2016
5. Equilibrium stage separations: separation for chemical Engineers; Wankat P.C. Elsevier, 1988
6. Mass Transfer Operations; Treybal R.E., McGraw Hill Publication, 2017
7. Distillation Engineering; Billet R., Chemical Publishing, 1979

SLIET LONGOWAL

1.2.1 - CHEMICAL ENGINEERING (PG-CE)

Title of the Course: Paper Technology
Subject Code: PECH-811A
Course Category: Core Elective-1

L T P : 3 0 0
Weekly Load: 3 Hrs
Credit: 3

Course Outcomes : At the end of the course, the student will be able to:

CO1	Illustrate process flows in a pulp and paper mill
CO2	Analyze and solve technical problems related to Control parameters used in different process stages
CO3	Justify and develop solutions for environmental impact of different process stages
CO4	Devise latest advances in technology related to new products, process and raw materials of paper.

CO/PO Mapping: (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation):

COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1
CO1	M	M	W			W	M			M		S
CO2	S	S	S	S	S	M	M			M		S
CO3	M	M	M	M		M	S			M		S
CO4	M	S	M	M		M	M			M	M	S

Unit	Main Topics	Course outlines	Lectures
Unit-1	Introduction	Description of the process flows in a pulp and paper mill, Significance of different processes in paper industries, Raw material preparation, Storage and processing of non-conventional straws, grasses and bagasse, Pulping processes, Brown stock washing, Screening and centri- cleaning processes, Bleaching processes, Stock preparation and Paper machine operations. Specialized paper, their principal and operation, Modern concept of papermaking	11
	Control parameters & Methods of control of different processes	Control parameters used in different process stages, methods of control of different process stages, use simulations model for the pulp and paper processes, Energy consumption in the different process stages, Different measures to affect the energy consumption for the pulp and paper manufacturing.	10
Unit-II	Environmental impact of different paper mill processes	Environmental impact of different process stages, possibilities to minimize the environmental impact of a pulp and paper mill, changes in process flows affecting the process and the pulp and paper properties, Material and energy balance related to pulp and paper making.	10
	Latest advances in technology related to new products, process and raw materials of paper.	Interpretation and analysis of conclusions in scientific journals within the area of pulping and paper making processes, Latest advances in technology related to new products, process and raw materials of paper.	11 (10)

Total = 42 hrs

Recommended Books:

1. Robert C. Brown. 2003. Bio-renewable Resources: Engineering New Products from Agriculture. Iowa state Press, Blackwell Publishing.
2. Smook, Handbook for Pulp and Paper Technology, TAPPI Publication. 1992
3. M. J. Kocurek, Pulp and Paper manufacture, Vol. 2; TAPPI Publication. 1982
4. M. J. Kocurek, Pulp and Paper manufacture, Vol. 3; TAPPI Publication. 1985
5. M. J. Kocurek, Pulp and Paper manufacture, Vol. 4,5,6; TAPPI Publication.1992

SLIET LONGOWAL

1.2.1 - CHEMICAL ENGINEERING (PG-CE)

Title of the Course:	**Biochemical Engineering**	**L T P: 3 0 0**
Subject Code:	**PECH - 811B**	**Weekly Load: 3 Hrs**
Course Category:	**Core Elective-1**	**Credit: 3**

Course Outcomes: At the end of the course, the student will be able to:

CO1	Identify the main groups of microorganisms & their different structures and growth modes.
CO2	Illustrate key biochemical and cellular components and biochemical pathways and apply cell and enzyme kinetics.
CO3	Illustrate Heat & mass transfer considerations and downstream process to separate the products
CO4	Review bioprocess monitoring/control

CO/PO Mapping: (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation):

COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1
CO1	M			M		M		S		M	M	S
CO2	S	M	S	M		M	M	S	M	S		S
CO3	S	S	M	S		M	S	M	S	M	M	S
CO4	S					M	--	M	M	M	M	

Unit	Main Topics	Course outlines	Lectures
Unit-1	Introduction	Principles of microbiology, structure of cells, microbes, bacteria, fungi, algae, chemicals of life – lipids, sugars and polysaccharides, amino acids, proteins, nucleotides, RNA and DNA, hierarchy of cellular organization, Principles of genetic engineering, Recombinant DNA technology, mutation.	05
	Microbial Growth	Typical growth characteristics of microbial cells, Factors affecting growth, Batch and continuous cell growth, nutrient media, enrichment culture, culture production and preservation	04
	Metabolic pathways and energetics of the cell	Introduction, concept of energy coupling, ATP and NAD, Photosynthesis, Carbon metabolism, EMP pathway, Tricarboxylic cycle and electron transport chain, aerobic and anaerobic metabolic pathways, transport across cell membranes, Synthesis and regulation of biomolecules.	05
	Enzyme Kinetics	The enzyme substrate complex and enzyme action, simple enzyme kinetics with one and two substrates, determination of elementary step rate constants.	03
	Isolation and utilization of Enzymes	Production of crude enzyme extracts, enzyme purification, applications of hydrolytic enzymes, other enzyme applications, enzyme production - intercellular and extra cellular enzymes.	04
	Immobilization technology	Techniques of immobilization, Characterization and applications, Reactors for immobilized enzyme systems.	05

Unit-II	Bioreactor	Introduction to bioreactors, continuously stirred aerated tank bioreactors, mixing power correlation, Determination of volumetric mass transfer rate of oxygen from air bubbles and effect of mechanical mixing and aeration on oxygen transfer rate, heat transfer and power consumption, multiphase bioreactors and their applications.	06
	Downstream Processing	Downstream processing and product recovery in bio processes.	05
	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 tank fermenter	05

Total= 42 hrs

Recommended Books:

1. Lee J.M., Biochemical Engineering, Ebook, version 2.32, 2009.
2. James E. Bailey & David F. Ollis, Biochemical Engineering Fundamentals, 2nd edition, McGraw Hill International, 1986.
3. Michael L. Shuler & Fikret Kargi, Bioprocess Engineering – Basic Concepts, 2nd edition, Prentice Hall of India, New Delhi, 2002.
5. M.L. Shuler and F. Kargi, "Bio-process Engineering", 2nd Edition, Prentice Hall of India, New Delhi. 2002.
6. Blanch H.W and Clark D.S, Biochemical Engineering, Marcel Dekker, 1997.

SLIET LONGOWAL

1.2.1 - CHEMICAL ENGINEERING (PG-CE)

Title of the Course: Polymer Technology
Subject Code: PECH-811C
Course Category: Core Elective-1

L T P: 3 0 0
Weekly Load: 3 Hrs
Credit: 3

Course Outcomes: At the end of the course, the student will be able to:

CO1	Analyze the techniques and their characteristics/limitations of synthesis of polymers.
CO2	Assess the structure-processing-property relationship of polymers.
CO3	Apply the various processing and manufacturing techniques.
CO4	Devise polymer blends, composites and nanocomposites.

CO/PO Mapping: (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation):

COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1
CO1	S	M	M	W	S	M	M	M		M		M
CO2	S	S	M		M	M	M	W		M		M
CO3	S	S				M		M		M		M
CO4	S				S			M		M		S

Unit	Main Topics	Course Outlines	Lectures
Unit-I	Polymer chemistry	Concept of functionality and poly dispersity, classification of polymers, molecular weight averages and their measurement by membrane osmometry, vapor pressure osmometry, light scattering method, intrinsic viscosity method, ultracentrifugation , methods of polymerization such as bulk, solution, suspension and emulsion, kinetics and mechanism of chain growth (free radical, anionic, coordination), step growth and copolymerization reactions, Polymer degradation, glass transition and crystalline melting temperatures.	10
	Polymer Rheology and Testing	Basic concept of viscosity and its measurement, Introduction to viscoelasticity, Mechanical models of visco elastic behavior, Rheometers, Study of mechanical properties such as tensile, flexural, compressive, fatigue, shear, impact, hardness, creep and stress relaxation, Thermal properties such as heat deflection temperature, Vicat softening temperature, coefficient of thermal expansion, brittleness temperature, Underwriter Laboratories (UL) temperature index Important research techniques such as Fourier transform infrared spectroscopy (FTIR), scanning electron microscopy (SEM), transmission electron microscopy (TEM), thermal analysis such as thermo gravimetric analysis (TGA), differential scanning calorimetry (DSC) and thermo mechanical analysis (TMA)	11
Unit-II	Polymer Processing	Common additives used in polymers and mixing equipments, Processing techniques for polymers such as extrusion, Injection moulding, blow moulding, rotational moulding, compression moulding and calendaring, spinning techniques for fibres, common defects and their remedies.	11
	Polymer Applications	Applications of polymers in packaging, automobile, electrical, agricultural, building, sport, optical, marine, aerospace and medical fields. Study of inorganic, conductive, heat resistance polymers, Liquid crystalline polymers, thermoplastic elastomers (TPE)	10

Total = 42 hrs

Recommended Books:

1. Fred W. Billmeyer, Jr, Textbook of Polymer Science, John Wiley & Sons, New York, 1994.
2. Sinha S., Kumar V., Polymeric Systems and Applications, Studium Press, New Delhi, 2010
3. Shah, V., Handbook of Plastics Testing Technology, John Wiley and Sons, 1998.
4. Morton - Jones, D.H. Polymer Processing, Chapman and Hall, 1889.
5. Chanda M., Roy, S.K., Plastics Technology Handbook, Marcel Dekker, 1997.

SLIET LONGOWAL

1.2.1 - CHEMICAL ENGINEERING (PG-CE)

Title of the Course:	**Energy Technology**	**L T P: 3 0 0**
Subject Code:	**PECH-812A**	**Weekly Load: 3 Hrs**
Course Category:	**Core Elective -2**	**Credit: 3**

Course Outcomes: At the end of the course, the student will be able to:

CO1	Assess the importance, requirement and conservation of energy and fuels for sustainability
CO2	Develop insight of conventional and non-conventional sources of energy
CO3	Analyze the working of energy technology devices (conventional and alternative)

CO/PO Mapping: (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation):												
COs	**Programme Outcomes (POs)**											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1
CO1	**M**	**M**		**W**	**M**	**S**	**M**			**M**		**S**
CO2				**W**	**M**	**S**	**S**	**M**		**M**		**S**
CO3	**S**	**M**	**S**	**W**	**M**	**M**	**M**		**M**	**M**		**S**

Unit	Main Topics	Course outlines	Lectures
Unit-1	Energy scenario	Concept of Energy, units of energy, conversion factors, general classifications of Energy, world energy resources and energy consumption, Indian energy resources and energy consumption, energy crisis, energy alternatives.	06
	Conventional Fuels	Solid fuels: principal solid fuel, coal preparation, storage of coal, introduction of coal to liquid technology (CTL). Liquid fuels: gasoline, Naphtha, Kerosene, diesel. Gaseous fuel: Natural Gas, Producer Gas, Water Gas, LPG, LNG.	15
Unit-II	Alternate sources of Energy	Solar energy, solar thermal systems, flat plate collectors, focusing collectors, solar water heating. Solar cooling, solar distillation, solar refrigeration, solar dryers, solar pond, solar thermal power generation, solar energy application in India, energy plantations. Wind energy, types of windmills, types of wind rotors, wind electric power generation. Introduction to conversion of biomass technology, manufacturing and biodiesel and their application in chemical industries	11
	Energy conservation	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, cogeneration, pinch analysis.	10

Total = 42 hrs

Recommended Books:

1. Rai. G. D. Non conventional Energy Sources, Khanna Publishers
2. Sarkar Sameer, Fuel and Combustion, Orient Longman
3. Gupta. O.P, Fuel Furnaces and Refractories, Khanna Publishers
4. Haslam and Russel, Fuels and their combustion, McGraw Hill
5. Sukhatme S.P., Thermal Collection and Storage, Tata McGraw Hill
6. Reference booklets from Bureau of energy efficiency

SLIET LONGOWAL

1.2.1 - CHEMICAL ENGINEERING (PG-CE)

Title of the Course:	**Advanced Transport Phenomena**	**L T P: 3 0 0**
Subject Code:	**PECH -812B**	**Weekly Load: 3 Hrs**
Course Category:	**Core Elective -2**	**Credit: 3**

Course Outcomes: At the end of the course, the student will be able to

CO1	Assess mechanisms of molecular transport of momentum, heat and mass transfer
CO2	Analyze and solve technical problems related to temperature and concentration distributions
CO3	Deduce equations of change for isothermal and non-isothermal system for specific problems
CO4	Analyze, solve and justify unsteady state problems in momentum, energy and Mass Transfer operations

CO/PO Mapping: (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation):

COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1
CO1	S	S	S				M			M		M
CO2	S	S	S	M	M		M			M		
CO3	S	M	S	M	M		M			M		
CO4	S	S	S	M	M		M			M		

Unit	Main Topics	Course outlines	Lectures
Unit-1	Introduction	Mechanism of molecular transport of momentum, heat and mass transfer. Flux equations- Newton's, Fourier's and Fick's laws. Similarities and differences, non-Newtonian fluids, transport properties- estimation, temperature and pressure dependence, estimation of transport properties of binary gaseous mixtures. Velocity distributions in laminar flow – shell momentum balances- Flow of falling film flow of fluids through circular tubes, annulus and between parallel plates. Creeping flow around sphere- Drag calculations.	10
	Temperature and Concentration distributions	Temperature distributions in solids and in laminar flow- shell balances- Heat conduction with electrical, Nuclear, viscous and chemical heat source, Heat conduction through composite walls, and cooling fin. forced convection and free convection. Concentration distributions in solids and in laminar flow- shell mass balances, diffusion through a stagnant gas film, Diffusion with homogeneous chemical reaction and heterogeneous chemical reaction. Diffusion into a falling liquid film chemical reaction inside a porous catalyst.	11
Unit-II	Equations of change for isothermal and non-isothermal system	Equations of change for isothermal system- Equation of continuity, Equation of Motion, Equations of change in curvilinear coordinate, use of equations of change to setup steady flow problems. Equations of change for non-isothermal systems- Equation of energy- use of equations of change to setup steady state flow problems. Equation of change for a binary mixture- Equation of continuity of a component in curvilinear coordinates.	11

	Unsteady state problems in momentum, energy and mass Transfer operations	Unsteady state problems in momentum, energy and Mass Transfer operations. Turbulence- Time smoothing of equations of change of momentum, energy and mass transfer. Eddy properties- Intensity of turbulence Reynolds stresses, Semi empirical expressions for turbulent- momentum- energy and mass fluxes.	10

Total = 4 2 hrs

Recommended Books:

1. Bird, R.B. Wtewart, W.E. and Lightfoot, E.N., Transport Phenomena, John Wiley & Sons, 2002
2. Brodkey, R.S. and Hershey, H.C., Transport Phenomena: A Unified Approach, McGraw Hill Publications, 1988.
3. Beek, W.J. and Muttzal, K.M.K., Transport Phenomena, 2nd Edition John Wiley & Sons. and Van Heuven, J.W., 1999 Academic Press, 2006
4. Faghra, A. and Zhang, Y., Transport Phenomena in Multiphase Systems, Academic Press, 2006
5. Slattery, J. C., Advanced Transport Phenomena, Cambridge University Press. 1999

SLIET LONGOWAL

1.2.1 - CHEMICAL ENGINEERING (PG-CE)

Title of the Course:	**Analytical Instrumentation Methods and Characterization Techniques**	**L T P: 3 0 0**
Subject Code:	**PECH -812C**	**Weekly Load: 3 Hrs**
Course Category:	**Core Elective -2**	**Credit: 3**

Course Outcomes: At the end of the course, the student will be able to:

CO1	Categorize the analytical techniques and instrumental methods.
CO2	Adapt instrument for a particular analysis and predict its merits, demerits, and limitations.
CO3	Integrate the scientific method of planning, developing, conducting, reviewing, and reporting.

CO/PO Mapping: (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation):												
COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1
CO1	S	M	W	S	M	W	S	M	M	M	W	S
CO2	W	S	S	M	S	W	M	M	S	M	W	W
CO3	M	M	S	S	S	W	S	S	M	S	W	M

Unit	Main Topics	Course Outlines	Lectures
Unit I	Introduction to spectrometry	Properties of electromagnetic radiation: wave properties, components of optical instruments, sources of radiation: wavelength selectors, sample containers, radiation transducers, signal process and read outs: signal to noise ratio, sources of noise, enhancement of signal to noise: types of optical instruments, principle of Fourier Transform, optical measurements.	08
	Molecular spectroscopy	Molecular absorption spectrometry: Measurement of transmittance and absorbance, Beer's law, instrumentation, applications, theory of fluorescence and phosphorescence, theory of infrared absorption spectrometry IR instrumentation and applications, theory of Raman spectroscopy, instrumentation, and applications.	09
	Magnetic resonance spectroscopy	Theory of NMR, environmental effects on NMR spectra, chemical shift, NMR spectrometers, applications of 1H and 13C NMR	04
Unit II	Mass spectrometry	Molecular mass spectra, ion sources, mass spectrometer. Applications of molecular mass, electron paramagnetic resonance, g values, instrumentation.	03
	Separation methods	General description of chromatography, band broadening and optimization of column performance, liquid chromatography, Partition chromatography, adsorption chromatography, ion exchange chromatography, size exclusion chromatography, affinity chromatography, principles of GC and applications, HPLC, capillary electrophoresis, applications.	09

	Electro analysis and surface microscopy	Electrochemical cells, electrode potential cell potentials, potentiometry, reference electrode, ion selective and molecular selective electrodes, instrument for potentiometric studies, voltammetry, cyclic and pulse voltammetry, applications of voltammetry. study of surfaces, Scanning probe microscopes, AFM and STM.	09

Total = 42 hrs

Recommended Books:

1. Douglas Skoog, F. Holler, Stanley Crouch, "Principles of Instrumental Analysis". 7th Edition, CENGAGE Learning, 2020.
2. Hobart H. Willard, Lynne L. Merritt, John A. Dean, Frank A. Settle, "Instrumental Methods of Analysis". 7th Edition, CBS Publishers and Distributors Pvt. Ltd., 2004.
3. Robert D. Braun, "Introduction to Instrumental Analysis". PharmaMed Press/BSP Books, 2012.
4. Galen W. Ewing. "Instrumental Methods of Chemical Analysis", 5th Edition, McGraw-Hill College, 1985.

SLIET LONGOWAL

1.2.1 - CHEMICAL ENGINEERING (PG-CE)

Title of the Course:	**Advanced Heat and Mass Transfer Lab**	**L T P: 0 0 4**
Subject Code:	**PCCH-813**	**Weekly Load: 4 Hrs**
Course Category:	**Core Lab**	**Credit: 2**

Course Outcomes: At the end of the course, the student will be able to:

CO1	Experimentally predict the heat transfer coefficient in natural and forced convection heat transfer.
CO2	Evaluate the overall heat transfer coefficient in fluidized/packed bed heat transfer.
CO3	Experimentally analyze and compute rate of mass transfer in multicomponent systems.
CO4	Analyze diffusional problems in multicomponent and multiphase systems

CO/PO Mapping: (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation):												
COs	**Programme Outcomes (POs)**											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1
CO1	M	M	W	W	W	W	M	M	S	M	W	M
CO2	M	S	W	M	W	W	S	W	S	M	M	S
CO3	M	M	W	M	W	M	M	W	M	M	W	M
CO4	M	S	W	W	W	W	M	M	M	M	M	M

List of experiments:

1. To find out thermal conductivity of a composite wall for 2D heat flow.
2. To find out heat transfer coefficient h for natural heat transfer through a cylindrical surface and verify the correlation obtained with the empirical correlation available in the literature.
3. To find out heat transfer coefficient h for forced convection heat transfer through a cylindrical surface and verify the correlation obtained with the empirical correlation available in the literature.
4. To find out local heat transfer coefficient around a cylindrical surface and predict the parameters effecting the local heat transfer coefficient.
5. Study of overall heat transfer coefficient in a fluidized bed/packed bed.
6. Diffusional study of NaCl, HNO3, and water system.
7. Diffusional study of black liquor in pulp matrix.

8.Diffusional study of oxygen in pulp bleaching.

Separation of methanol, propanol, and water by distillation.

Separation of formic acid, acetic acid, water, and furfural by distillation.

Title of the Course:	**Paper Technology Lab**	**L T P: 0 0 4**
Subject Code:	**PECH-813 A**	**Weekly Load: 4 Hrs**
Course Category:	**Core Elective Lab**	**Credit: 2**

Course Outcomes: At the end of the course, the student will be able to:

CO1	Analyze experimentally the different agro based cellulosic materials for paper making.
CO2	Analyze Experimentally the effects of different additives on paper properties
CO3	Study of paper drying rates and affecting parameters
CO4	Study of use of nano fibers in paper making and affecting parameters

CO/PO Mapping: (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation):												
COs	**Programme Outcomes (POs)**											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1
CO1	S	M		M			S				M	S
CO2	S	M		M			S				M	S
CO3	S	M		M			S				M	M
CO4	S			M			S				M	M

List of Experiments:

1. Study of alpha, beta and gamma cellulose content in different ligno-cellulosic raw materials.
2. Study of Klason lignin in different ligno-cellulosic raw materials.
3. Study of effect of different filler percentages on mechanical, optical and surface properties of paper.
4. Study of effect of different internal sizing chemicals percentages on water absorption property of paper.
5. Analysis of fiber characteristics of different agro and wood based raw materials.
6. Study of paper drying rates and affecting parameters.
7. Study of effects of different parameters of paper manufacturing on lab sheet former
8. Study of manufacturing of nano fibers on electro spinning machine and effect in paper making
9. Analysis study of pulp refining for obtaining desired strength and surface properties in paper
10. Comparative Study of woody and non-woody raw materials for different strength and optical properties of paper
11. Study of rate of drainage of pulp stock at different degree SR and furnish percentages

SLIET LONGOWAL

1.2.1 - CHEMICAL ENGINEERING (PG-CE)

Title of the Course:	**Biochemical Engineering Lab**	**L T P: 0 0 4**
Subject Code:	**PECH-813B**	**Weekly Load: 4 Hrs**
Course Category:	**Core Elective Lab**	**Credit: 2**

Course Outcomes: At the end of the course, the student will be able to:

CO1	Evaluate microbial system based on its metabolic pathways and kinetics study in batch and continuous cultures
CO2	Develop enzyme reactions based on its kinetics study and applied catalysis
CO3	Predict bioconversion technologies of microbial, plant and animal cell culture for the production of value-added product.

CO/PO Mapping: (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation):												
COs	**Programme Outcomes (POs)**											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1
CO1	S	W		S		S	M	S	M	M		S
CO2	S	W		S		S	M	S	M	M		S
CO3	M	W	W	S		S	M	S	M	M		S

List of Experiments :

1. Glucose assay by dinitro salicylic colorimetric method
2. Measurements of Cell biomass concentration
3. To study the techniques of Biomass removal and disruption
4. To study the effect of environmental conditions on growth kinetics of saccharomyces cerevisiae/lactobacillus case in batch process
5. To determine the specific thermal death rate of microbes at different temperature in a batch cultivation.
6. To study the microbial growth and product formation kinetics of in fed-batch cultivation using different nutrient feeding strategies
7. To compare the effectiveness of three methods of enzyme immobilization by gel entrapment.
8. To investigate the conversion of glucose to ethanol by entrapped yeast cells in a continuous reactor.
9. To measure the kinetic parameters of invertase.
10. To study the effect of substrate concentration on enzyme kinetics
11. To analyse the mass transfer in Immobilized Cell Biocatalysts
12. To study the microbial growth and product formation kinetics of under continuous cultivation (steady state) conditions.
13. Open-ended experiment on bioconversion technology

SLIET LONGOWAL

1.2.1 - CHEMICAL ENGINEERING (PG-CE)

Title of the Course:	**Polymer Technology Lab**	**L T P: 0 0 4**
Subject Code:	**PECH-813C**	**Weekly Load: 4 Hrs**
Course Category:	**Core Elective Lab**	**Credit: 2**

Course Outcomes: At the end of the course, the student will be able to:

CO1	Understand the different polymerization techniques and synthesize a polymer material.
CO2	Characterize the synthesized polymeric material.
CO3	Analyze a synthesized polymeric material and find its application in various fields.

CO/PO Mapping: (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation):												
COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1
CO1	S		M	M	M	S	M	M	M	M	W	W
CO2	S	S	S	S	S	M	M	M	M	S	W	W
CO3	W	S	S	S	M	S	M	M	M	S	W	W

List of Experiments:

1. Synthesis of Polystyrene by Bulk/Solution polymerization.
2. Preparation of Phenol formaldehyde resin.
3. Determination of mechanical properties such as tensile, flexural, impact strength of phenol formaldehyde.
4. Determination of moisture content of resin or polymer solution.
5. Determination of Molecular Weight of a polymer by viscometer.
6. Determination of melt flow index (MFI) of a polymer.
7. Determination of properties of hydrogels i. e. swelling, tensile and solute transport properties.
8. Preparation of a moulded article by using processing (rotational moulding/ hydraulics pressing) technique and study it's defects and remedies.
9. Characterization of a given polymer sample using any technique like TEM, FTIR, SEM, TMA etc.
10. To study heat resistance polymers, thermoplastic elastomers, and their applications indifferent fields.

SLIET LONGOWAL

1.2.1 - CHEMICAL ENGINEERING (PG-CE)

Title of the Course:	**Advanced Chemical Engineering Thermodynamics**	**L T P: 3 0 0**
Subject Code:	**PCCH-821**	**Weekly Load: 3 Hrs**
Course Category:	**Core Course**	**Credit: 3**

Course Outcomes: At the end of the course, the student will be able to:

CO1	Integrate molecular and classical thermodynamics and their applications towards stability and equilibrium of the systems.
CO2	Establish Thermodynamic analysis of solutions and the chemical reaction equilibria
CO3	Analyze the thermodynamics of multicomponent multiphase systems
CO4	Apply the principles of chemical engineering thermodynamics and thermodynamic design the processes like power cycles, refrigeration, separation systems.

CO/PO Mapping: (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation):

COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1
CO1	S	S								M		
CO2	S	S		S						M		
CO3	S	S	S	S	S					M		
CO4	S	S	S		S	M				M	M	W

Unit	Main Topics	Course outlines	Lectures
Unit-1	Introduction to Laws of thermodynamics	Applications of first, second, and third laws of thermodynamics to open and closed systems	10
	Molecular & classical thermodynamics	Molecular concepts in relation to engineering thermodynamics Basic postulates of classical thermodynamics; Application to transient open and closed systems. Criteria of stability and equilibrium.	04
	Solution thermodynamics and reaction equilibria	Properties of mixtures, chemical potential, fugacity, and colligative properties, chemical reaction equilibrium and phase equilibrium.	07
Unit-II	Multicomponent & Multiphase chemical and biological systems	Thermodynamics of multi-component, Phase and chemical equilibrium of multicomponent systems. Multiphase chemical and biological systems; non-ideal solutions; Constitutive property models of pure materials and mixtures emphasizing molecular-level effects.	09
	Applications of Thermodynamics	Power cycles; refrigeration; separation systems. Applications emphasized through extensive problem work relating to practical cases.	12

Total = 42 hrs

Recommended Books:

1. Smith J. M., Van N. H. C. and Abbott, M. M., Chemical Engineering Thermodynamics, 6th edition, McGraw-Hill publication, 2001
2. Modell, Michael, Tester, Jefferson W., Thermodynamics and Its Applications, Prentice Hall PTR publication, 1996
3. Kyle, Chemical & Engineering Process Thermodynamics, Prentice Hall Ltd. 2000
4. Narayanan, K.V. Chemical Engg. Thermodynamics Prentice Hall Ltd. 2004
5. Rao, Y.V.C., Chemical Engineering Thermodynamics, University Press. 2003

SLIET LONGOWAL

1.2.1 - CHEMICAL ENGINEERING (PG-CE)

Title of the Course:	**Catalytic Reaction Engineering**	**L T P: 3 1 0**
Subject Code:	**PCCH-822**	**Weekly Load: 4 Hrs**
Course Category:	**Core Course**	**Credit: 4**

Course Outcomes: At the end of the course, the student will be able to:

CO1	Understand and investigate solid catalyzed reaction kinetics
CO2	Formulate solid catalysts for industrial applications
CO3	Understand the flow dynamics of solid catalyzed reactors
CO4	Apply kinetic and flow dynamics information for the design and performance evaluation of solid catalyzed reactors.

CO/PO Mapping: (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation):

COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1
CO1	S	S	S	S	M				W		S	S
CO2	M	M	S						W		M	
CO3	S	S	M	M	W							M
CO4	S	S	S		S						S	M

Unit	Main Topics	Course Outlines	Lectures
Unit-I	Catalyst preparation and characterization	Monolith and supported solid catalysts. General preparation methods for supported catalysts. Morphological characteristics of solid catalysts; specific surface area; pore size and pore size distribution; active elements on catalyst surface.	10
	Kinetics of heterogeneous catalytic reactions	Steps in heterogeneous catalytic reactions; external mass transfer effects; mass transfer within porous catalyst particles; effectiveness factor; concept of global rate of reaction. Non isothermal effects. Mechanism and kinetics of catalyst deactivation.	11
Unit-II	Fixed bed solid catalyzed reactors	Flow dynamics of fixed bed reactors. Plug flow fixed bed reactor model. Non isothermal operations in fixed bed reactors; temperature profiles in the bed.	10
	Fluidized bed solid catalyzed reactors	Fluidization phenomenon; flow dynamics of fluidized beds; different regimes. Fluidized bed reactor models for bubbling fluidized beds and circulating fluidized beds.	11

Total = 42 hrs

Recommended Books:

1. Ghatak, H.R., Reaction Engineering Principles, CRC Press, Taylor and Francis Group, 2016.
2. Davis, M.E.; and Davis, R. J., Fundamentals of Chemical Reaction Engineering, McGraw Hill, 2003.
3. Schimdt, L.D., The Engineering of Chemical Reactions, Oxford University Press, 2004.
4. Kunii, D.; and Levenspiel, O. Fluidization Engineering, Butterworth-Heinemann, 2013,
5. Fogler, H.S., Elements of Chemical Reaction Engineering, Prentice Hall, 1986.
6. Levenspiel, O., Chemical Reaction Engineering, Wiley, 3rd Edition, 2006.
7. Smith, J.M., Chemical Engineering Kinetics, McGraw Hill, 1981.

SLIET LONGOWAL

1.2.1 - CHEMICAL ENGINEERING (PG-CE)

Title of the Course:	**Nanoscience and Nanotechnology**	**L T P: 3 0 0**
Subject Code:	**PECH-821A**	**Weekly Load: 3 Hrs**
Course Category:	**Core Elective-3**	**Credit: 3**

Course Outcomes: At the end of the course, the student will be able to:

CO1	Describe the essential concepts of nanoscience and nanotechnology
CO2	Appraise different nanomaterials alongside their fabrication techniques & characterization.
CO3	Summarize the applications of nanomaterials & nanocomposites in Chemical Engineering.

CO/PO Mapping: (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation):

COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1
CO1	M	W	M	S	S	S	S	M	M	W	W	M
CO2	S	S	S	M	S	M	S	M	M	W	M	M
CO3	S	M	W	S	S	W	W	M	M	W	S	M

Unit	Main Topics	Course Outlines	Lectures
Unit-I	Introduction	Background and Definition of Nanotechnology. Applications in Different Fields, Bonding in atoms and giant molecular solids, Chemical Approaches to Nanostructured Materials, Solid State Devices.	05
	Carbon Nanotubes	Carbon Nanotubes - Structure of Carbon Nanotubes, Synthesis of Carbon Nanotubes, Growth Mechanisms of Carbon Nanotubes, Properties of Carbon Nanotubes, Carbon Nanotube-Based Nano-Objects, Applications of Carbon Nanotubes, Nano wires – Synthesis, Characterization and Physical Properties of Nanowires, Applications.	10
	Fabrication Techniques	Basic Microfabrication Techniques, MEMS Fabrication Techniques, Nanofabrication Techniques, Stamping techniques - High Resolution Stamps, Microcontact Printing, Nano transfer Printing, Applications.	06
Unit-II	Applications	Material aspects of NEMS and MEMS–Silicon, Germanium-Based Materials, Metals, GaAs, InP, and Related III-V Materials, MEMS Devices and Applications - Pressure Sensor, Inertial Sensor, Optical MEMS, RF MEMS, NEMS Devices and Applications, Current Challenges and Future Trends.	09
	Nano Composites	Introduction, Polymer as Matrix, Nylons, Polyolefins, Polystyrene, Epoxy resins, Nano Materials as a Filler, Nano fibre, Nano clay, Fabrication and Processing of Composites, Benefits to Ultimate Physical, Mechanical and Thermal Properties, Nano structured Materials,	09
	Microscopy	Microscopy - Scanning Tunneling Microscope, Atomic Force Microscope, Scanning Electron Microscopy, Principles of Noncontact Atomic Force Microscope (NCAFM).	03

Total = 42 Hrs

Recommended Books:

1. Bharat Bhushan (Ed.), "Springer Handbook of Nanotechnology", Springer-Verlag Berlin Heidelberg, 2017.
2. Charles P. Poole; Frank J. Owens," Introduction to Nanotechnology", John Wiley & Sons, Inc., 2003.
3. Narendra Kumar; Sunita Kumbhat, "Essentials in Nanoscience and Nanotechnology", John Wiley & Sons, Inc., 2016.
4. Kulkarni, Sulabha K., "Nanotechnology: principles and practices" 3rd Edition, Springer, 2014.

SLIET LONGOWAL

1.2.1 - CHEMICAL ENGINEERING (PG-CE)

Title of the Course:	**Bio-resource Technology**	**L T P: 3 0 0**
Subject Code:	**PECH-821B**	**Weekly Load: 3 Hrs**
Course Category:	**Core Elective-3**	**Credit: 3**

Course Outcomes: At the end of the course, the student will be able to:

CO1	Predict the utility of biomass for sustainable development
CO2	Devise processes for conversion of bioresource to energy products
CO3	Formulate and design processes for biomass conversion

CO/PO Mapping: (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation):												
COs	**Programme Outcomes (POs)**											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1
CO1	**M**	**M**	**M**	**W**	**W**	**M**	**S**	**M**	**S**	**S**	**W**	**S**
CO2	**M**	**S**	**S**	**W**	**M**	**M**	**S**	**M**	**S**	**S**	**M**	**S**
CO3	**M**	**M**	**S**	**W**	**S**	**S**	**S**	**S**	**S**	**S**	**M**	**S**

Unit	Main Topics	Course Outlines	Lectures
Unit-I	Types of bioresources	Agro-industrial, forest, aquatic, animal origin bioresource, Municipal Waste, Biomass waste, Paper Wastes etc. and their Characterization. Waste Management Planning, Monitoring and Control	09
	Thermo chemical processes	Thermo chemical Processes- Gasification Technology, Liquefaction Technology, Combustion Technology, Pyrolysis Technology, Biodiesel. Process design of gasifier, pyrolizer, combustor and biodiesel plant.	12
Unit-II	Briquetting Technology	Piston Press Technology, Screw Press Technology, Various Parameters Controlling Briquetting, Economic Evaluation. Case study of Saw Dust based Briquetting Technology	11
	Biochemical processes	Anerobic digestion, fermentation, Case study: Vegetable Waste- A Potential Source for Biogas, Energy from Biomass.	10

Total = 42 hrs

Recommended Books:

1. Upendra Pandel, Poonia, J.Mathur and S.Mathur; Waste to Energy by Prime Publishers.,2006
2. B.B.Hosetti; Prospects and perspectives of Solid; New Age International Publications., 2002
3. A.Nag, K. Vizayakumar, Environment Education and Solid; New Age International Publications., 2005

SLIET LONGOWAL

1.2.1 - CHEMICAL ENGINEERING (PG-CE)

Title of the Course:	**Environmental Engineering**	**L T P: 3 0 0**
Subject Code:	**PECH-821C**	**Weekly Load: 3 Hrs**
Course Category:	**Core Elective-3**	**Credit: 3**

Course Outcomes: At the end of the course, the student will be able to:

CO1	Assess environmental concerns and pollutants.
CO2	Design air and water pollution control equipment
CO3	Deduce solid waste management practices.

CO/PO Mapping: (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation):												
COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1
CO1	**M**	**S**	**S**	**W**	**M**	**S**	**S**	**M**	**M**	**W**	**W**	**S**
CO2	**M**	**S**	**S**	**M**	**M**	**S**	**S**	**M**	**M**	**W**	**W**	**S**
CO3	**M**	**S**	**S**	**M**	**M**	**S**	**S**	**M**	**M**	**W**	**W**	**S**

Unit	Main Topics	Course Outlines	Lectures
Unit-1	Introduction	Environmental Pollution: Monitoring & Control, Effects of Pollutants on Living systems and Structures, Effluent Guidelines & Standards for Air, Water & Land disposals; Conservation of Material resources & Energy through Recycling	08
	Water Pollution	Waste-Water characterization & its Treatment. Treatment, Utilization and Disposal of sewage, Industrial Wastewater Treatment & Disposal. Design of aerated lagoons, activated sludge process and trickling bed filters.	13
Unit-II	Air Pollution	Types of Air Pollutants and their effects on Living beings. Air sampling techniques. Plume Characteristics and Design of Chimney. Design of air pollution control equipment like, gravity settling chamber, scrubbers, cyclone separators, ESP, bag filter.	13
	Solid waste pollution	Characterization of Solid waste, Disposal of Solid waste, Solid waste management, Reuse of Solid waste materials, Recovery of materials & materials & metals, conversion into useful products.	08

Total = 42 hrs

Recommended Books:

1. Manual on emergency Preparedness for Chemical Hazards Ministry of environment & Forests, Govt. of India., 1989
2. Environmental Engineering - G.N.Panday, G.C..Carney, Tata McGraw , 1989
3. Environmental pollution control by C.S.Rao, new age International Publishers, 2006
4. Air Pollution Control Theory, Martin Craw ford, Tata Mcgraw Hill Publishing Company, 1980
5. Environmental Engineering, H.S. Peavy, D.R. Rowe, G. Tchobanoglous, Mcgraw- Hill International editions, 2017

SLIET LONGOWAL

1.2.1 - CHEMICAL ENGINEERING (PG-CE)

Title of the Course:	**Advanced Process Dynamics and Control**	**L T P: 3 0 0**
Subject Code:	**PECH-822A**	**Weekly Load: 3 Hrs**
Course Category:	**Core Elective -4**	**Credit: 3**

Course outcome: At the end of the course, the student will be able to

CO1	Develop fundamental and empirical models for dynamic processes.
CO2	Analyze the dynamical systems using matrix algebra, Laplace transforms, and Fourier transforms
CO3	Analyze properties of dynamic models & processes and controller setting of MIMO systems
CO4	Able to calculate the response of a sampled data system

CO/PO Mapping: (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation):

COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1
CO1	S	S	S	S					S	M		M
CO2	M	M	M	M	M				M			
CO3	M	M	S	M	M	M	M		S		S	M
CO4	S	S	S	S			M		S	M	S	M

Unit	Main Topics	Course outlines	Lectures
Unit-1	Feed Back Control systems	Concept of feedback control, block diagram development, closed loop transfer functions, closed loop transient response, closed loop stability, root locus diagram.	05
	Conventional Feed Back Controller design	Preliminary consideration, Controller design principles, controller tuning with fundamental process models, Controller tuning using approximate process models, control valve and its characteristics, controller tuning using frequency response models, Nyquist stability criterion, Bode stability criterion, controller tuning without a model.	04
	Laplace domain analysis of advanced control systems	Feed forward control and their Fundamentals, Open Loop unstable processes, Process with inverse response, Model based control. Process Identification, Step testing, ATV identification, least square method, State Estimators, Relationships among time, laplaces and frequency domain.	05
Unit-II	Introduction to multivariable systems	Matrix properties - State variables, Nature of multivariable systems, multivariable process model, multivariable transfer functions and Open loop & close loop dynamics systems	05
	Interaction analysis and multiple single loop design	Stability, Resiliency, Interaction: Preliminary considerations of interaction analysis and loop pairing, relative gain array, loop pairing using RGA, loop paring for nonlinear systems, loop pairing for nonsquare systems, Decoupling, feasibility of steady state decoupler design, steady state decoupling by singular value decomposition.	06
	Design of multivariable controllers	Problem definition, Selection of controlled variables, Selection of manipulated variables, Elimination of poor pairings, BLT tuning, Local rejection performance and Multivariable controllers.	04
	Z Transformations	Introduction, Impulse sampler, Basic sampling theorem, Z Transformation.	03
	Dynamic analysis of discrete time systems	Open loop responses, characteristics of open loop pulse transfer functions, block diagram analysis of sampled data systems, stability analysis of sampled data system: Stability in Z plane, Root Locus design methods, Bilinear transformation and Frequency domain design techniques	05

	Design of Digital Compensator	Physical realizability, Frequency domain effects, Minimal prototype design, Sampled data control of processes with dead time and Sample data control of open loop unstable processes.	05

Total = 42 hrs

Recommended Books:

1. Luyben W. L., "Process Modeling Simulation and Control for Chemical Engineers", McGraw Hill, 1988.
1. Chemical Process Control, George Stephanopoulos, PHI publication, 2015
2. Process System Analysis & Control, Donald R. Coughanour, Mc Graw Hill, 1991
3. Process Control – Modelling, Design & Control, B. Wayne Bequette, PHI Publication,2001
4. Process Dynamics, Modeling & Control – Babatunde A. Ogunnaike, W. Harmon Ray, Oxford University Press Inc. 1995
5. Instrument Engineers Handbook (Process Control) –Bella G. Liptak, Elsevier, 1990

SLIET LONGOWAL

1.2.1 - CHEMICAL ENGINEERING (PG-CE)

Title of the Course:	**Process Modelling and Simulation**	**L T P: 3 0 0**
Subject Code:	**PECH-822B**	**Weekly Load: 3 Hrs**
Course Category:	**Core Elective-4**	**Credit: 3**

Course Outcomes: At the end of the course, the student will be able to:

CO1	Analyze various modeling principles.
CO2	Develop mathematical models for chemical systems.
CO3	Perform error analysis of experimental data.
CO4	Articulate the application of optimization techniques and acquire skills of simulation.

CO/PO Mapping: (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation):

COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1
CO1	S		M			S	W		M	W	M	S
CO2	S	M	S		S		W		M	W		M
CO3				S	M		W			M		M
CO4	S	S			S		M		S	W		M

Unit	Main Topics	Course Outlines	Lectures
Unit-I	Deterministic Versus Stochastic Process	Deterministic vs. Stochastic Process, Physical Modelling, Mathematical Modelling, Chemical Systems Modelling, Principles of Similarity, Independent & dependent Variables and Parameters, Classification of Mathematical Modelling, Boundary Conditions, Artificial Neural Networks.	10
	Models	Models in Mass- Transfer Operations, Models in Heat Transfer Operations, Models in Fluid Flow Operations, Models in Reaction Engineering.	10
Unit-II	Treatment of Experimental Data & Optimization Techniques	Error Propagation and Data Regression, Traditional Optimization Techniques: Analytical Methods of Optimization, Optimization with Constraints (Lagrangian Multipliers), Gradient Method of Optimization, Other Methods. Non-Traditional Techniques: Simulated Annealing, Genetic Algorithms, Differential Evolution, Other Evolutionary Computational Techniques.	10
	Simulation	Modular Approaches and Equation solving Approach, Decomposition of Networks, Convergence Promotion and Physical and Thermodynamic Properties, Specific purpose simulation and dynamic Simulation: Auto-thermal Ammonia Synthesis Reactor, Thermal Cracking Operation, Design of Shell and Tube Heat-Exchanger.	12

Total = 4 2 hrs

Recommended Books:

1.B.V.Babu, Process Plant Simulation, Oxford University Press, 2004
2.Bequette, Analysis and Simulation, PHI publisher., 2003
3. Chawla, Process Modelling & Simulation, McGraw Hill, 1998
4. Leubegr, System Modelling & Simulations Control for Chemical Engineers., 2017

SLIET LONGOWAL

1.2.1 - CHEMICAL ENGINEERING (PG-CE)

Title of the Course: Advanced Separation Techniques
Subject Code: PECH-822C
Course Category: Core Elective -4

L T P: 3 0 0
Weekly Load: 3 Hrs
Credit: 3

Course Outcomes: At the end of the course, the students will be able to:

CO1	Appraise about modern separation techniques in chemical & biochemical industry.
CO2	Analyze and perform process and design calculations for advanced separation processes
CO3	Assess the governing mechanisms and driving forces of various advanced separation processes

CO/PO Mapping: (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation):

COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1
CO1	S	S			M	S	S			W		M
CO2	S	S	S	S	S					W		M
CO3	S	S	S	S	S	W	W		W	W		M

Unit	Main Topics	Course Outlines	Lectures
Unit-1	Super Critical Extraction	Working Principal, Advantage & Disadvantages of supercritical solvents over conventional liquid solvents, Advantage & Disadvantages of supercritical extraction over liquid- liquid extraction, Decaffeination, ROSE process, Commercial applications of supercritical extraction	05
	Short path Distillation	Concept & working of short path Distillation Unit (SPDU), Difference between short path Distillation & molecular distillation, applications of SPDU	04
	Reactive & Catalytic Distillation	Concept, Advantage & Disadvantages, BALE & KATMAX packing Manufacturing of MTBE and ETBE and its comparison with conventional techniques	04
	Pressure Swing Distillation	Concept & Working, Advantage & Disadvantages of PSD over azeotropic and Extractive Distillation, Applications	04
	Membrane separation technique	Principles, mechanisms, cross flow, membrane materials and various membrane modules used in membrane separation processes, Classification, application & advantages of membrane separation processes	04
Unit-II	Pressure Swing Adsorption	Concept & Working, Advantages & Disadvantages of PSA over cryogenic distillation, four step PSA, six step PSA, Purification of hydrogen, oxygen, Nitrogen & other commercial applications of PSA	05
	Pervaporization	Working principal, Advantages, Production of absolute alcohol and other commercial applications	04
	Liquid membranes	Types of liquid membranes, Transport mechanism, Factors affecting mass transfer and stability, Applications	04
	Ionic Separations	Controlling factors, Applications, Types of equipment employed for electrophoresis, Di-electrophoresis, Ion exchange chromatography and electro dialysis, Commercial Processes	04
	Membrane or Osmotic Distillation	Working Principal, Various applications, etc.	04

Total = 42 Hrs.

Recommended Books:

1. Seader J.D., Ernet J. Henlay, and Keith, D., Separation Process Principles, Wiley (2010).
2. Sourirajan, S. and Matsura, T., "Reverse Osmosis and Ultrafiltration Process Principles," NRC Publications, Ottawa,1985.
3. Porter, M. C., "Handbook of Industrial Membrane Technology," Noyes Publication, New Jersey, 1990.
4. Hatton, T. A., Scamehorn, J. F. and Harvell, J. H., "Surfactant Based Separation Processes", Vol. 23, Surfactant Science Series, Marcel Dekker Inc., New York 1989.
5. McHugh, M. A. and Krukonis, V. J., „Supercritical Fluid Extraction", Buterworths, Boston, 1985.

SLIET LONGOWAL

1.2.1 - CHEMICAL ENGINEERING (PG-CE)

Title of the Course:	**Reaction Engineering and Thermodynamics Lab**	**L T P: 0 0 4**
Subject Code:	**PCCH-823**	**Weekly Load: 4 Hrs**
Course Category:	**Core Course Lab**	**Credit: 2**

Course Outcomes: At the end of the course, the student will be able to:

CO1	Analyze experimentally the progress of reactions.
CO2	Experiment with process parameters effecting the rate of reactions.
CO3	Measure activation energy (E) and enthalpy (H) of reactions.

CO/PO Mapping: (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation):												
COs	**Programme Outcomes (POs)**											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1
CO1	**M**	**M**		**M**	**W**			**M**	**S**	**M**	**M**	**W**
CO2	**M**	**M**		**M**	**W**			**M**	**S**	**M**	**M**	**W**
CO3	**M**	**M**		**M**	**W**			**M**	**S**	**M**	**M**	**W**

List of Experiments:

1. To find the activation energy E and frequency factor k0 of saponification reaction in a batch reactor for a defined temperature range.
2. To find the activation energy E and frequency factor k0 of saponification reaction in CSTR reactor for a defined temperature range.
3. To find the activation energy E and frequency factor k0 of saponification reaction in PFR reactor for a defined temperature range.
4. Study of homogeneous catalytic reaction in a batch reactor under adiabatic condition.
5. To study the kinetics of liquid catalysed transesterification reaction for biodiesel formation.
6. To study the kinetics of solid catalysed transesterification reaction for biodiesel formation.
7. To determine the solubility of benzoic acid at various temperatures and to determine ΔH of the dissolution process.
8. To determine the enthalpy of neutralisation of HCL (Strong acid) by NaOH (Strong base).
9. To determine the critical temperature of the phenol-water system.
10. To determine various thermodynamic parameters of moist air at constant pressure using a psychometric chart.

SLIET LONGOWAL

1.2.1 - CHEMICAL ENGINEERING (PG-CE)

Title of the Course:	**Advance d Process Dynamics and Control Lab**	**L T P : 0 0 4**
Subject Code:	**PECH-824A**	**Weekly Load: 4 Hrs**
Course Category:	**Core Elective lab**	**Credit: 2**

Course Outcomes: At the end of the course, the students will be able to:

CO1	Manage the modern hardware and instrumentation needed to implement process control.
CO2	Corelate the theoretical concepts of open and closed loop runs with experiment.
CO3	Assess dynamic behavior of different processes and its relation to controller design and implementation.

CO/PO Mapping: (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation):												
COs	**Programme Outcomes (POs)**											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1
CO1	**S**	**M**	**M**	**S**	**M**	**S**			**W**	**W**	**M**	**W**
CO2	**S**	**M**	**M**	**M**	**M**	**S**			**W**	**W**	**M**	**M**
CO3	**S**	**M**	**M**	**S**	**M**	**S**			**W**	**W**	**M**	**M**

List of experiments

1. To design a Proportional controller for first order system with dead time using process reaction curve
2. To obtain the characteristics of ON-OFF controller for a thermal Process for the given set point.
3. To study the action of controllers for a flow process.
4. To study the action of controllers for a level process
5. To study the pressure control loop and pressure transmitter and to determine the effect of P, PI and PID controller on pressure control
6. To design a controller using Ziegler Nicholas method for the liquid level tank
7. Stability analysis of a close loop system
8. To study the cascade control process
9. To study the control of multivariable systems

SLIET LONGOWAL

1.2.1 - CHEMICAL ENGINEERING (PG-CE)

Title of the Course:	**Process Modeling and Simulation Lab**	**L T P: 0 0 4**
Subject Code:	**PECH-824B**	**Weekly Load: 4 Hrs**
Course Category:	**Core Elective Lab**	**Credit: 2**

Course Outcomes: At the end of the course, the students will be able to:

CO1	Simulate physical phenomena from the problem statement
CO2	Manage advanced computational techniques to model Chemical Engineering systems
CO3	Validate formal problem-solving methodologies
CO4	Demonstrate the ability to use a process simulation

CO/PO Mapping: (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation):												
COs	**Programme Outcomes (POs)**											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1
CO1	**S**	**S**	**S**	**M**		**M**				**W**		**M**
CO2	**S**		**S**		**S**	**S**			**S**	**W**		**M**
CO3	**S**	**S**	**S**			**S**	**M**		**M**	**W**		**M**
CO4	**S**	**M**		**S**	**M**				**S**	**W**		**M**

List of experiments :

Using MATLAB/ASPEN PLUS/HYSIS/Other Simulation Software

1. Steady state simulation of Heat Exchanger.
2. Steady state simulation of a CSTR
3. Steady state simulation of Flash vessel
4. Steady state simulation of Distillation Column
5. Steady state simulation of an Absorption column
6. Dynamic simulation of Heat Exchanger
7. Dynamic simulation of a CSTR
8. Dynamic simulation of Flash vessel
9. Dynamic simulation of Distillation Column
10. Dynamic simulation of an Absorption column
11. Simulation of a flowsheet.

SLIET LONGOWAL

1.2.1 - CHEMICAL ENGINEERING (PG-CE)

Title of the Course:	**Advanced Separation Processes**	**Lab**	**L T P: 0 0 4**
Subject Code:	**PECH-824C**		**Weekly Load: 4 Hrs**
Course Category:	**Core Elective lab**		**Credit: 2**

Course Outcomes: At the end of the course, the students will be able to:

CO1	Illustrate the modern separation techniques in various applications
CO2	Analyze and design novel membranes for intended application
CO3	Analyze and design pervaporation, chromatography, liquid membranes-based separation processes

CO/PO Mapping: (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation):

COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1
CO1	S	W	S			S	W		W	W	W	M
CO2	S		M	S		S	W		W	W	W	M
CO3	S		M	S		S	W		W	W	W	M

List of experiments

1. To study the separations of contaminants from the waste water streams by ion exchange resins.
2. To study the formulation of hydrophilic and hydrophobic polymeric membranes.
3. To study the separation of mixtures using hydrophilic and hydrophobic membranes.
4. To study the separation of carboxylic acids by liquid high-pressure chromatography.
5. To study the pervaporative separation of ethanol water system.
6. To study the effect of different parameters on the emulsion liquid membrane stability.
7. To study the extraction of carboxylic acid by emulsion liquid membrane.

SLIET LONGOWAL

1.2.1 - CHEMICAL ENGINEERING (PG-CE)

Title of the Course:	**Seminar**	**L T P: 0 0 2**
Subject Code:	**PCCH-824**	**Weekly Load: 2 Hrs**
Course Category:	**Core Course Lab**	**Credit: 1**

Course Outcomes: At the end of the course, the student will be able to:

CO1	Identify topic of interest beyond the syllabus.
CO2	Reflect on existing literature on selected topics
CO3	Exhibit Professional outcome of technical assignments
CO4	Argue in healthy technical and scientific debate

CO/PO Mapping: (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation):												
COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1
CO1	**W**	**M**		**M**	**S**		**W**		**S**	**S**	**M**	**W**
CO2	**W**	**M**		**M**	**S**		**W**		**S**	**S**	**M**	**W**
CO3	**W**	**M**		**M**	**S**		**W**	**S**	**S**	**S**	**M**	**W**
CO4	**W**	**W**		**M**	**S**	**M**	**W**	**S**	**S**	**S**	**M**	**W**

Students are supposed to give Seminar presentation of 30 Minutes on current topics of Chemical & Allied fields after thorough literature survey. They will be required to submit a hard copy of the same.

SLIET LONGOWAL

1.2.1 - CHEMICAL ENGINEERING (PG-CE)

Title of the Course:	**Polymer Composites and Blends**	**L T P: 3 0 0**
Subject Code:	**PECH-911A**	**Weekly Load: 3 Hrs**
Course Category:	**Core Elective-5**	**Credit: 3**

Course Outcomes: At the end of the course, the student will be able to:

CO1	Distinguish polymer composite materials with regard to constitutive materials, design and processing
CO2	Critically appraise the typical reinforcement fibers for modern polymer composites and to understand micromechanics in polymer composites
CO3	Manage knowledge of polymer engineering including forming technology and structure-processing-property relationship

CO/PO Mapping: (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation):

COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1
CO1	S	M	M	S	S	S	M	M		W		M
CO2	S	M	M	S	S	S	M	M		W		M
CO3	S	S	M	M	M	S	S	M		W		M

Unit	Main Topics	Course Outlines	Lectures
Unit-I	Thermoplastic Composite	Need for additive; Fiber reinforcement; long fiber reinforcement; natural fiber reinforcement; Mineral powder filler; Polymers; surface treatment; Study of thermoplastic composite; Application of thermoplastic structural composite; glass filled thermoplastics.	06
	Thermoset composites	Introduction; Resins (Polyester, epoxy, vinyl ester, PF, bismaleimide, polyamide etc); fibre (glass, carbon, aramid, ceramic, metallic fibre formals; BMC/ SMC; prepag; Applications	05
	Mechanical properties	Modulus; Strength; Influences of resin characteristics and resin reinforcement interaction on composite strength; Interfacial adhesion & coupling agent; Strength of fiber composites; creep behavior; fatigue behavior; Impact behavior; Dynamic Mechanical properties.	10
Unit-II	Fabrication Methods	Manual (Hand-lay- up, Spray-up. Auto clove molding); Semi auto (cold press molding. Hot press molding, resin injection, vacuum injection), automatic (filament winding, centrifugal casting, pultrusion, injection molding, compression molding). sandwich constructions.	11
	Polymer Alloys/ Blends	Introduction; nature of polymer blends; factors affecting nature of polymer blends; melt flow & Morphology of blends; polymer / Polymer miscibility; compatibility; Rubber toughening of plastics; blends of stiff compounds; preparation; processing; development of thermoplastic alloys	10

Total = 42 hrs

Recommended Books:

1. Themoplastic Aromatic Polymer Composites, F.N.Cogswell, Butterworth-Heinemann, Oxford 1992.
2. Polymer Alloys & Blends, L.A. Ultracki, Hanser Gardener, 1990
3. Handbook of computers, S.T. Peters, Springers, 1997
4. Engineering Polymers, Edited by R. W. Daysons, Blackies and Sons.

SLIET LONGOWAL

1.2.1 - CHEMICAL ENGINEERING (PG-CE)

Title of the Course:	**Advanced Process Optimization**	**L T P: 3 0 0**
Subject Code:	**PECH-911B**	**Weekly Load: 3 Hrs**
Course Category:	**Core Elective - 5**	**Credit: 3**

Course Outcomes: At the end of the course, the student will be able to:

CO1	Distinguish various optimization techniques with their advantages and disadvantages
CO2	Develop the ability for selecting the suitable techniques for optimization of selected process parameters.
CO3	Apply the optimization techniques in chemical process optimization.

CO/PO Mapping: (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation):

COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1
CO1	S	S		M	M		M				W	S
CO2	S	S		M	M		M				W	S
CO3	S	S	W	M	M		M	W	W		M	S

Unit	Main Topics	Course Outlines	Lectures
Unit-I	Introduction	Optimization and calculus based classical optimization techniques.	05
	One Dimensional Optimization Methods	Elimination methods- equally spaced points method, Fibonacci method and golden section method; Interpolation methods- quadratic interpolation and cubic interpolation, Newton and quasi-Newton methods.	07
	Multivariable Non-Linear Programming	Unconstrained- univariate method, Powell's method, simplex method, rotating coordinate method, steepest descent method, Fletcher Reeves method, Newton's method, Marquardt's method and variable metric (DFP and BFGS) methods; Constrained- complex method, feasible directions method, GRG method, penalty function methods and augmented Lagrange multiplier method.	10
Unit-II	Advance optimization methods	Genetic algorithms in process engineering, Differential evolution, Ant Colony optimization, particle swarm optimization	10
	Engineering case studies	Optimal Location of Coal-Blending Plant Optimization of Ethylene Glycol-Ethylene oxide process Optimal design of a compress air energy storage	10

Total = 42 Hrs.

Recommended Books:

1. Edgar T.F., Himmelblau D.M. and Lasdon L.S., Optimization of Chemical Processes, 2nd edition (2001), McGraw Hill

2. Beveridge G.S.G. and Schechter R.S., Optimization: Theory and Practice, (1970), McGraw Hill.

3. Rao S. S., Engineering Optimization Theory and Practice, 4th Ed. (2009), Wiley

SLIET LONGOWAL

1.2.1 - CHEMICAL ENGINEERING (PG-CE)

Title of the Course:	**Energy Audit and Management**	**L T P: 3 0 0**
Subject Code:	**PECH-911C**	**Weekly Load: 3 Hrs**
Course Category:	**Core Elective-5**	**Credit: 3**

Course Outcomes: At the end of the course, the student will be able to:

CO1	Comprehend general energy scenario in India and world
CO2	Articulate various provisions of the energy conservation act
CO3	Perform basic energy audit and prepare energy audit report
CO4	Identify energy conservation options in different important unit operations and processes

CO/PO Mapping: (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation):

COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1
CO1	W	W	M			M	M	M		W		W
CO2	W					S	S	M		W		
CO3	M	S	S	M	W	M	S	S		W		M
CO4	S	S	S	M	W			S		W		S

Unit	Main Topics	Course outlines	Lectures
Unit-1	Energy scenario and basics of Energy Audit	Energy Security, Energy Conservation and its importance, Energy conservation Act., Thermal Energy basics, Energy Audit its definition & methodology, Energy Audit Instruments, Benchmarking for energy performance, Energy Action Planning, Duties and responsibilities of Energy Manager; Energy financial management, Energy monitoring and targeting ,ESCO, Project management	07
	Fuels and Combustion	Types of fuels, Important properties of fuels, calorific values, storage, handling & preparation of coal properties of gaseous fuels, combustion and combustion calculations, 3T's of combustion, Burners, Turndown ratio, draft.	07
	Energy Conservation in Boilers	Introduction, different types and their classification, performance evaluation of boilers, Thermal efficiency and its determination by direct and indirect method, Blow-down, boiler water treatment, external water treatment, feed water preheating, combustion air preheating, excess air control, energy saving opportunities in boilers. Fluidized bed boilers: principles of fluidization, circulating fluidized bed, bubbling bed boilers, pressurized fluid bed combustion, advantages of fluidized bed combustion boilers.	07
Unit-II	Industrial furnaces	Types & classifications of furnaces, shanky diagram, Performance and its evaluation of a typical furnace, Heat losses in a furnace, furnace efficiency, Determination using direct and indirect methods, fuel economy measures in furnaces, Heat distribution in a reheating furnace, furnace draught, optimum capacity utilization, waste heat recovery from flue gases	07

	Energy Conservation in Fans, Blowers and Pumps	Difference between fans, blowers and compressors, Fan types, centrifugal fans arial flow fans, fan laws, fan design and selection criteria's, flow control strategies, fan performance, assessment, energy saving opportunities in fans. Pumps & Pumping System: Types of pumps, pump curves, factors affecting pump performance, flow control strategies, Energy conservation opportunities in pumping system.	07
	Energy Conservation in Utilities	Cooling Towers, flow control strategies. Energy saving options in cooling towers. Refrigeration System: Introduction, types of refrigeration system, Performance assessment of a refrigeration system, COP, factor affecting performance, energy savings opportunities in refrigeration systems. Compressed Air System: Compressor Type, free air delivery, efficiency of compression, leak test, energy efficiency opportunities in compressed air systems., Energy conservation in lighting system	07

Total = 42 hrs

Recommended Books :

1. Beggs. Clive, Energy Management supply and Conservation, Budseworth Heinemann Press
2. Albert Treemann & Paul Mehta, Handbook of Energy Engineering , Fiarmout Press
3. Books on energy conservation and Audit by Bureau of Energy efficiency (BEE)

SLIET LONGOWAL

1.2.1 - CHEMICAL ENGINEERING (PG-CE)

Title of the Course:	**Paper Machine Operations**	**L T P: 3 0 0**
Subject Code:	**PECH-911D**	**Weekly Load: 3 Hrs**
Course Category:	**Core Elective-5**	**Credit: 3**

Course Outcomes: At the end of the course, the student will be able to:

CO1	Design calculations for paper machines
CO2	Troubleshoot technical problems related to paper machines
CO3	Formulate surface sizing processes & analyze recent advances
CO4	Analyze, solve and justify latest advances in technology related to paper finishing plant.

CO/PO Mapping: (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation):

COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1
CO1	S		S		M	M	M			M	M	S
CO2	S	M			M	M	M		M	M	W	S
CO3	S		S				M		M	M		S
CO4	S	M	M	M	M	M	M	W	M	M		S

Unit	Main Topics	Course outlines	Lectures
Unit-1	Types of paper machines & machine components	Different types of paper machines (twin wire, top former etc.), suitability of different machines for different grades of paper, important parts and significance, effect on sheet formation. Stock distribution and drainage, Approach flow system, consistency regulation, constant level box, stock distribution, head box types & role in paper making, Theory and measurement of sheet formation, Principle, working & calculation of different drainage elements on fourdrinier wire like breast roll, forming board, couch roll table rolls, foils, and vacuum boxes.	10
	Pressing and drying	Forming fabrics and presses, Wire design & its type, Types & theory of pressing, types of press felts & their structure, functions of press felts, basic calculation on press section. Paper Drying and types of dryers Theory of paper drying on multi-cylinder and Yankee dryer, rate of drying and affecting parameters, Hoods, their types, purpose and effect on drying, dryer felts, special dryer systems like flakt, radiation etc. condensate removal system, pocket ventilation.	11
Unit-II	Surface sizing processes & recent advances	Paper Sizing and properties, Surface sizing processes, requirements and chemicals used with paper properties developed. Paper m/c drive and methods of speed control, safety parameters on paper m/c. Review of paper testing and process properties relationships, different paper defects and their remedies. Recent advances in this area.	11
	Paper Finishing	Paper Finishing Working of re-winders, cutters, coating, machine calendaring & super calendaring, and finishing plant defects of paper. Case studies of some specialty paper machines, and recent research topics related to paper machine operation.	10 (10)

Total = 42 hrs

Recommended Books:

1. M. J. Kocurek, Pulp and Paper manufacture, Vol. 7, 8 & 10; TAPPI Publication,1985
2. Smook, Handbook for Pulp and Paper Technology, TAPPI Publication., 2001
3. Macdonald, Pulp & paper manufacture Vol. 1 & 3, TAPPI Publication,1989
4. Casey, Pulp & Paper Chemistry & Chemical Tech. Vol. 2, 3; Wiley., 2000

SLIET LONGOWAL

1.2.1 - CHEMICAL ENGINEERING (PG-CE)

Title of the Course: Environmental Engineering
Subject Code: OECH-911A
Course Category: Open Elective

L T P: 3 0 0
Weekly Load: 3 Hrs
Credit: 3

CO1	Assess environmental concerns and pollutants.
CO2	Design air and water pollution control equipment
CO3	Deduce solid waste management practices.

Course Outcomes: At the end of the course, the student will be able to:

CO/PO Mapping: (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation):												
COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1
CO1												
CO2												
CO3												

Unit	Main Topics	Course Outlines	Lectures
Unit-1	Introduction	Environmental Pollution: Monitoring & Control, Effects of Pollutants on Living systems and Structures, Effluent Guidelines & Standards for Air, Water & Land disposals; Conservation of Material resources & Energy through Recycling.	08
	Water Pollution	Waste-Water characterization & its Treatment. Treatment, Utilization and Disposal of sewage, Industrial Wastewater Treatment & Disposal. Design of aerated lagoons, activated sludge process and trickling bed filters.	13
Unit-II	Air Pollution	Types of Air Pollutants and their effects on Living beings. Air sampling techniques. Plume Characteristics and Design of Chimney. Design of air pollution control equipment like, gravity settling chamber, scrubbers, cyclone separators, ESP, bag filter.	13
	Solid waste pollution	Characterization of Solid waste, Disposal of Solid waste, Solid waste management, Reuse of Solid waste materials, Recovery of materials & materials & metals, conversion into useful products.	08

Total = 42 hrs

Recommended Books:

1. Manual on emergency Preparedness for Chemical Hazards Ministry of environment & Forests, Govt. of India., 1989
2. Environmental Engineering - G.N.Panday, G.C..Carney, Tata McGraw , 1989
3. Environmental pollution control by C.S.Rao, new age International Publishers, 2006
4. Air Pollution Control Theory, Martin Craw ford, Tata Mcgraw Hill Publishing Company, 1980
5. Environmental Engineering, H.S. Peavy, D.R. Rowe, G. Tchobanoglous, Mcgraw- Hill International editions, 2017

SLIET LONGOWAL

1.2.1 - CHEMICAL ENGINEERING (PG-CE)

Title of the Course:	**Waste to Energy**	**L T P: 3 0 0**
Subject Code:	**OECH-911B**	**Weekly Load: 3 Hrs**
Course Category:	**Open Elective**	**Credit: 3**

Course Outcomes: At the end of the course, the student will be able to:

CO1	Comprehend the relevance of waste to energy generation in the context of sustainable development.
CO2	Characterize wastes from the point of view of their energy generation potential.
CO3	Understand the process engineering of different energy generation technologies from wastes.
CO4	Perform basic equipment design for generating energy from wastes.

CO/PO Mapping: (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation):

COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1
CO1												
CO2												
CO3												
CO4												

Unit	Main Topics	Course outlines	Lectures
Unit-1	Introduction	A brief overview of global energy scenario. Relevance of energy generated from wastes in the context of sustainable development.	04
	Classification and characterization of wastes	Liquid and solid wastes from different sources; industrial wastes, municipal wastes, agro residues, forest residues. Generation, collection, and transportation. Physical characterization; chemical characterization; thermal characterization; biological characterization. Morphology and physical structure of solid wastes.	09
	Biochemical processes for waste to energy	Overview of polysaccharide chemistry. Overview of lignin chemistry. Overview of protein and lipids chemistry. Production of first- and second-generation bioethanol. Production of biodiesel. Bio gasification and utilization of biogas.	08
Unit-II	Thermochemical processes for waste to energy	Thermochemical conversion processes; incineration; torrefaction; pyrolysis; gasification; hydrothermal treatment. Process chemistry; engineering aspects; equipments. Fischer Tropsch synthesis of liquid fuels.	09
	Equipment and process engineering	Biochemical reactors; design and operation. Incinerators and waste heat boilers. Gasifier design and operation. Combined cycle concepts.	08
	Environmental aspects	Gaseous emissions from thermochemical processes and their remediation.	04

Total = 42 hrs

Recommended Books:

1. Biorefinery: From biomass to chemicals and fuels. Michele Aresta, Angela Dibenedetto, Franck Dumeignil (Eds.). DeGruyter, 2012.
2. Waste to Energy Conversion Technology. N. Klinghoffer, M. Castaldi (Eds.). Elsevier, 2013.
3. Incineration Technologies. A. Buekens. Springer, 2013.
4. Biomass Gasification and Pyrolysis. P. Basu. Elsevier, 2010.
5. Biochemical Engineering Fundamentals. J.E. Bailey, D.F. Ollis. McGraw Hill, 2017.

SLIET LONGOWAL

1.2.1 - CHEMICAL ENGINEERING (PG-CE)

Title of the Course:	**Dissertation (part1, part2)**	**L T P: 0 0 2 0, 0 0 32**
Subject Code:	**PCCH-911, 921**	**Weekly Load: 20, 32 Hrs**
Course Category:	**Core Course**	**Credit: 10, 16**

Course Outcomes: At the end of the course, the student will be able to:

CO1	Reflect on scientifically and socially relevant issues.
CO2	Review existing literature on selected topics and understanding work done by different people.
CO3	Compose and professionally present outcome of technical assignments
CO4	Defend acquired technical knowhow in healthy technical and scientific debate

CO/PO Mapping: (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation):												
COs	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1
CO1	S	S	S	S	S	M	W	M	M	M	W	M
CO2	S	S	S	S	S	S	M	M	S	S	M	M
CO3	S	S	S	S	S	S	M	S	S	S	S	M
CO4	S	S	S	S	S	M	W	S	S	S	S	M

Students will work on specific problems of Industrial and /or academic importance. They will review the existing technical knowhow and prepare a work plan to accomplish the research goal. It will include experimental planning, generation of experimental data, its interpretation and analysis so as to propose a solution to the problem. In the process they will be required to apply chemical engineering concepts, mathematical and computational tools and economic analysis as required. The student will present the progress of their dissertation in the form of seminars and will submit a final thesis for evaluation.