Board of Studies

(UG PROGRAMME in CHEMICAL ENGINEERING)

(160 Credit)

DATE

02.07.2021

रसायन अभियांत्रिकी विभाग
Department of Chemical Engineering
संत लौंगोवाल अभियांत्रिकी एवं प्रौद्योगिकी संस्थान
ANT LONGOWAL INSTITUTE OF ENGINEERING AND TECHNOLOG
(भारत शासन, शि. म. अधीन, सम विश्वविद्यालय)
(Deemed to be University under MoE, Government of India)
लौंगोवाल – १४८१०६. संगरूर (पंजाब) भारत
Longowal -148106. Sangrur (Punjab) India

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.

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Program Educational Objectives (PEOs)

PEO 01: To prepare students for successful professional career in Indian and multinational Chemical process and allied industries, design and consultancy organizations and relevant government agencies.

PEO 02: To build up capacity in students for problem analysis, interpretation and solution related to application of Chemical engineering for sustainable development.

PEO 03: To prepare students who can provide leadership and companionship in multidisciplinary teams.

PEO 04: To inculcate in students the qualities that enable them to apply their domain knowledge as enlightened citizens for the upliftment of society.

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Program Outcomes (POs)

PO 01: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO 02: Problem analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO 03: Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO 04: Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO 05: Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

PO 06: The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO 07: Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO 08: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO 09: Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO 10: Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO 11: Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and Leader in a team, to manage projects and in multidisciplinary environments.

PO 12: Life-long learning: Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

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Program Specific Outcomes (PSOs)

PSO 01: Natural Resource Utilization: The candidate should have sufficient technical knowledge to cater to the need of existing and upcoming chemical industry and efficient utilization of natural resources.

PSO 02: Cleaner production: Applying Chemical Engineering fundamentals for green and energy efficient processes.

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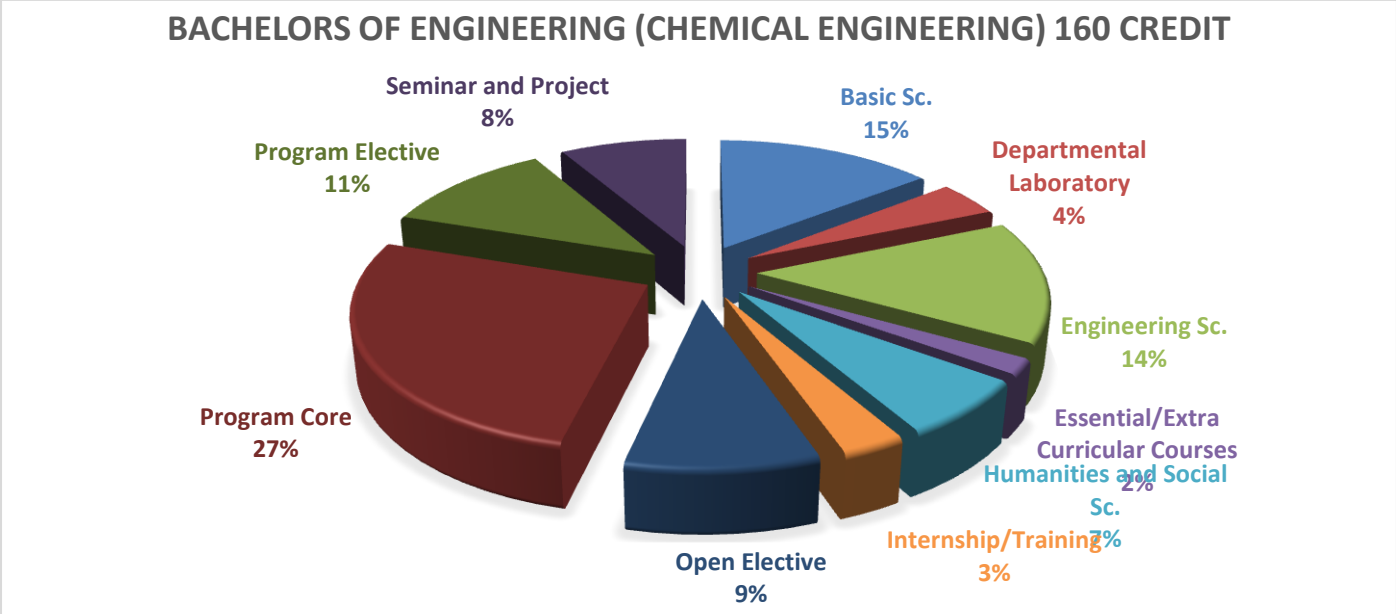
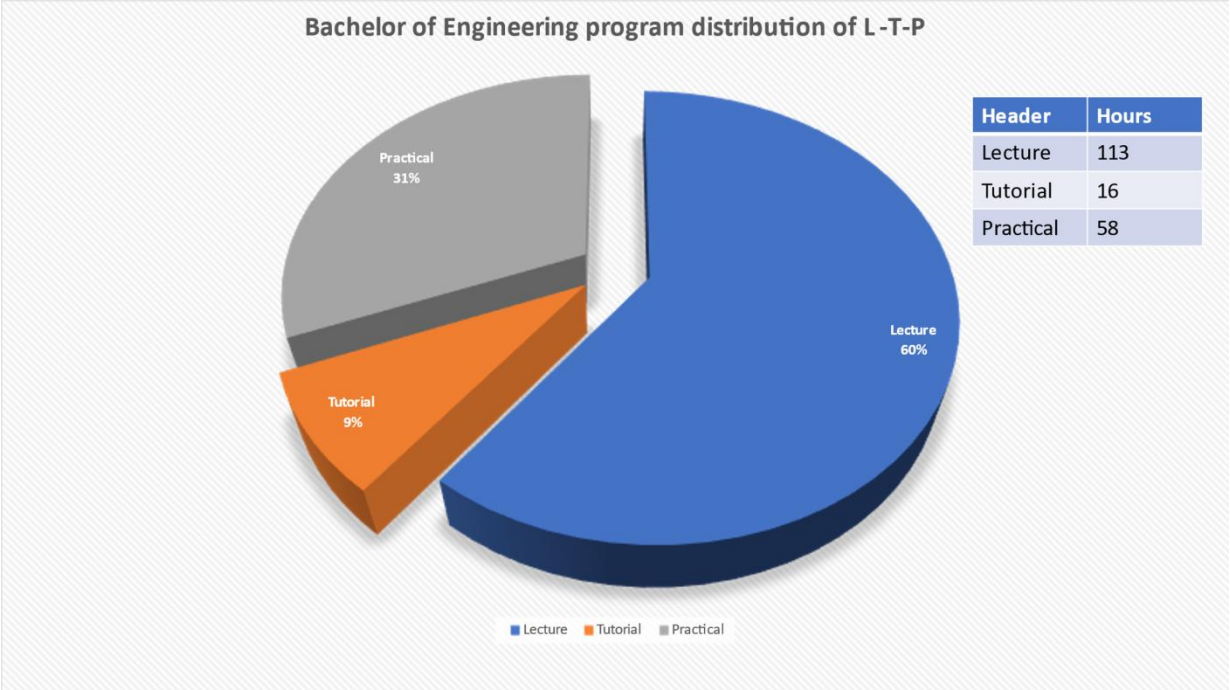
Bachelor of Engineering (Chemical Engineering) 160 Credit scheme





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Study Scheme and Syllabus for Bachelor of Engineering in Chemical Engineering

Semester-I

S No	Sub Code	Subject Name	L	T	P	Hrs.	Credits
1	BSMA-401	Engineering Mathematics I	3	1	0	4	4
2	BSCH-401	Applied Chemistry	3	1	0	4	4
3	ESME-401	Elements of Mechanical Engineering	2	1	0	3	3
4	ESME-402	Workshop Technology and Practice	1	0	0	1	1
5	HSMC-401	English Communication and Soft Skills	1	0	0	1	1
6	BSCH-402	Applied Chemistry Lab	0	0	2	2	1
7	ESME-403	Elements of Mechanical Engineering Lab	0	0	2	2	1
8	ESME-404	Engineering Drawing	0	0	4	4	2
9	ESME-405	Workshop Technology and Practice Lab	0	0	4	4	2
10	HSMC-402	English Communication and Soft Skills Lab	0	0	2	2	1
11	MCCH-401	Environmental Studies	3	0	0	3	0
		Total	**13**	**3**	**14**	**30**	**20**

Semester-II A

S No	Sub Code	Subject Name	L	T	P	Hrs.	Credits
1	BSMA-402	Engineering Mathematics II	3	1	0	4	4
2	BSPH-401	Applied Physics	3	1	0	4	4
3	ESEE-401	Elements of Electrical Engineering	2	1	0	3	3
4	ESCS-401	Elements of Computer Engineering	2	0	0	2	2
5	ESEC-401	Elements of Electronics Engineering	2	0	0	2	2
6	BSPH-402	Applied Physics Lab	0	0	2	2	1
7	ESEE-402	Elements of Electrical Engineering Lab	0	0	2	2	1
8	ESCS-402	Elements of Computer Engineering Lab	0	0	4	4	2

9	ESEC-402	Elements of Electronics Engineering Lab	0	0	2	2	1
		Total	**12**	**3**	**10**	**25**	**20**
Semester-IIB							
1	TPIN-421	Practical Training During Summer Vacations (In-house) 02 weeks				40	1 (S/US)
2	TPIN-422	Technical Competency				40	1 (S/US)
	Semester-III						
S No	**Sub Code**	**Subject Name**	**L**	**T**	**P**	**Hrs.**	**Credits**
1	ESME-501	Engineering Mechanics	3	1	0	4	4
2	PCCH-511	Material and Energy Balance	3	1	0	4	4
3	PCCH-512	Fluid Mechanics	3	0	0	3	3
4	PCCH-513	Chemical Engineering Thermodynamics	3	1	0	4	4
5	HSMC-501	Principles of management	3	0	0	3	3
6	PCCH-514	Fluid Mechanics lab	0	0	2	2	1
7	PCCH-515	Process Technology lab	0	0	2	2	1
8	MCMH-501	Indian Constitution	3	0	0	3	0
		Total	**18**	**3**	**4**	**25**	**20**
	Semester-IVA						
S No	**Sub Code**	**Subject Name**	**L**	**T**	**P**	**Hrs.**	**Credits**
1	BSMA-501	Numerical and Statistical Methods	3	0	0	3	3
2	BSMA-502	Numerical and Statistical Methods Lab	0	0	2	2	1
3	BSBL-501	Biology for Engineers	2	0	0	2	2
4	PCCH-521	Mass Transfer - I	3	1	0	4	4
5	PCCH-522	Heat Transfer	3	1	0	4	4
6	PCCH-523	Fluid and Particle Mechanics	3	1	0	4	4
7	PCCH-524	Heat & Mass Transfer Lab	0	0	2	2	1
8	PCCH-525	Fluid and Particle Mechanics Lab	0	0	2	2	1
		Total	**14**	**3**	**6**	**23**	**20**
Semester-IVB							
1	TPID-521	Industrial Training 02 weeks				80	1 (S/US)

2	EAA-521+	Fractional credit course/Extra Academic Activity +GROUP A/B/C					1 (S/US)
Semester-VA							
S No	**Sub Code**	**Subject Name**	**L**	**T**	**P**	**Hrs.**	**Credits**
1	HSMC-603	Engineering Economics and Entrepreneurship	3	0	0	3	3
2	PCCH-611	Chemical Reaction Engineering - I	3	1	0	4	4
3	PCCH-612	Mass Transfer - II	3	0	0	3	3
4	OEXX-611	Open Elective-1	3	0	0	3	3
5	OEXX-612	Open Elective-2	3	0	0	3	3
6	PECH-611	Professional Elective-1	3	0	0	3	3
7	PCCH-613	Reaction Engineering Lab	0	0	2	2	1
		Total	**18**	**1**	**2**	**21**	**20**
Semester-V B							
1	EAA-611+	Fractional credit course/Extra Academic Activity +GROUP A/B/C					1 (S/US)
	Semester-VI A						
S No	**Sub Code**	**Subject Name**	**L**	**T**	**P**	**Hrs.**	**Credits**
1	HSMC-601	Technical communication	2	0	0	2	2
2	PCCH-621	Transport Phenomena	3	1	0	4	4
3	PCCH-622	Chemical Reaction Engineering - II	3	0	0	3	3
4	OEXX--621	Open Elective-3	3	0	0	3	3
5	OEXX-622	Open Elective-4	3	0	0	3	3
6	PECH-621	Professional Elective-II	3	0	0	3	3
7	PCCH-623	Design and simulation lab	0	0	2	2	1
8	HSMC-602	Technical communication lab	0	0	2	2	1
		Total	**17**	**1**	**4**	**22**	**20**
Semester-VI B							
1	TPID-621	Industrial Training 04 weeks				160	2 (S/US)
2	EAA-621+	Fractional credit course/Extra Academic Activity +GROUP A/B/C					1 (S/US)

LIST OF OPEN ELECTIVES (Subjects offered by Department of Chemical Engineering for the students of other Department)

Semester-VII

S No	Sub Code	Subject Name	L	T	P	Hrs.	Credits
1	PCCH-711	Chemical Process Industries	3	0	0	3	3
2	PCCH-712	Process Instrumentation and Control	3	1	0	4	4
3	OEXX-711	Open Elective-5	3	0	0	3	3
4	PECH-711	Professional Elective-III	3	1	0	4	4
5	PECH-712	Professional Elective-IV	3	0	0	3	3
6	PCCH-713	Process Instrumentation and Control lab	0	0	2	2	1
7	PRCH-711	Project stage 1 and seminar	0	0	4	4	2
		Total	**15**	**2**	**6**	**23**	**20**

Semester-VIII

S No	Sub Code	Subject Name	L	T	P	Hrs.	Credits
1	PECH-721	Professional Elective	3	0	0	3	3
2	PECH-722	Professional Elective	3	0	0	3	3
3	PRCH-721	Project Stage II	0	0	12	12	6
		Total	**6**	**0**	**12**	**18**	**12**

OR

S No	Sub Code	Subject Name	L	T	P	Hrs.	Credits
1	INID-721	Internship in Industry					6
2	PRCH-721	Project Stage II	0	0	12	12	6
		Total					**12**

OEXX: To be opted from the list of open elective subjects offered by other Departments for the students of Department of Chemical Engineering

S. No	Sub. Code	Subject Name	L	T	P	Hrs.	Credits
1		**Open Elective-I**	3	0	0	3	3
	OECH-611A	Fuel Cells	3	0	0	3	3
	OECH-611B	Renewable Energy Sources	3	0	0	3	3
2		**Open Elective-II**	3	0	0	3	3
	OECH-612A	Electrochemical Engineering	3	0	0	3	3
	OECH-612B	Analytical Methods and Instrumentation	3	0	0	3	3
3		**Open Elective-III**	3	0	0	3	3
	OECH-621A	Agro Residue Utilization	3	0	0	3	3
	OECH-621B	Corrosion Engineering	3	0	0	3	3
4		**Open Elective-IV**	3	0	0	3	3
	OECH-622A	Industrial Pollution Control	3	0	0	3	3
	OECH-622B	Energy Audit and Management	3	0	0	3	3
5		**Open Elective-V**	3	0	0	3	3
	OECH-711A	Optimization Techniques for Engineers	3	0	0	3	3
	OECH-711B	Polymer Technology	3	0	0	3	3
	OECH-711C	Paper Technology	3	0	0	3	3

LIST OF PROFESSIONAL ELECTIVES

Sr.No	Sub. Code	Subject Name	L	T	P	Hrs.	Credits
1		**Professional Elective-I**					
	PECH-611A	Agro Residue Utilization	3	0	0	3	3
	PECH-611B	Paint Technology	3	0	0	3	3
	PECH-611C	Polymer Science and Engineering	3	0	0	3	3
	PECH-611D	Computational Fluid Dynamics	3	0	0	3	3
2		**Professional Elective-II**					
	PECH-621A	Pulping and Bleaching Technology	3	0	0	3	3
	PECH-621B	Biochemical Engineering	3	0	0	3	3
	PECH-621C	Polymer Technology	3	0	0	3	3
	PECH-621D	Modeling and Simulation	3	0	0	3	3
	PECH-621E	Fuel Cells	3	0	0	3	3
3		**Professional Elective-III**					
	PECH-711A	Novel Separation Technology	3	1	0	4	4
	PECH-711B	Electrochemical Engineering	3	1	0	4	4
	PECH-711C	Polymer Composites	3	1	0	4	4
	PECH-711D	Industrial Pollution Control	3	1	0	4	4
	PECH-711E	Biorefineries	3	1	0	4	4
	PECH-711F	Molecular Simulation	3	1	0	4	4
4		**Professional Elective-IV**					
	PECH-712A	Stock Preparation and Paper Making	3	0	0	3	3
	PECH-712B	Polymer Materials	3	0	0	3	3
	PECH-712C	Petroleum Refining and Petrochemicals	3	0	0	3	3
	PECH-712D	Fluidization Engineering	3	0	0	3	3
	PECH-712E	Renewable Energy Sources	3	0	0	3	3
5		**Professional Elective-V**					
	PECH-721A	Energy Audit and Management	3	0	0	3	3
	PECH-721B	Nanoscience and Nanotechnology	3	0	0	3	3
	PECH-721C	Chemical Plant Utilities and Safety	3	0	0	3	3
	PECH-721D	Pharmaceutical Formulation	3	0	0	3	3
	PECH-721E	Fertilizer Technology	3	0	0	3	3
	PECH-721F	Hazardous Waste Management	3	0	0	3	3
6		**Professional Elective-VI**					
	PECH-722A	Chemical Recovery Processes in Pulp and Paper Industry	3	0	0	3	3
	PECH-722B	Rubber Technology	3	0	0	3	3

	PECH-722C	Advance Process Control	3	0	0	3	3
	PECH-722D	Combustion Technology	3	0	0	3	3
	PECH-722E	Environmental Impact Assessment	3	0	0	3	3

Title of the Course : Environment Studies **L T P : 3 0 0**

Subject Code : **MCCH-401** **Weekly Load : 3 Hrs**
Course Category : **Mandatory Course-1** **Credit : 0**

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

CO1	Appreciate the need for Environmental integration for sustainable development
CO2	Understand the importance of Biodiversity and its conservation
CO3	Recognize reasons for Environmental pollution and remedial measures
CO4	Familiarize with national & international Environmental regulation

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	PO12	PSO1	PSO2
CO1		**M**	**M**		**M**	**S**	**S**	**S**	**W**			**M**	**S**	**S**
CO2			**M**			**S**	**S**	**S**	**W**			**M**	**S**	
CO3	**M**		**M**			**S**	**S**		**S**			**M**		**S**
CO4			**M**		**M**	**M**			**W**		**W**	**M**	**S**	**S**

Unit	**Main Topics**	**Course outlines**	**Lecture(s)**
Unit-1	Introduction to environmental studies	Multidisciplinary nature of environmental studies, Scope and importance; Concept of sustainability and sustainable development.	02
	Ecosystems	What is an ecosystem? Structure and function of ecosystem; Energy flow in an ecosystem: food chains, food webs and ecological succession. Case studies of the following ecosystems : a) Forest ecosystem b) Grassland ecosystem c) Desert ecosystem d) Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries)	06
	Natural Resources : Reneable and Non-renewable Resources	Land resources and landuse change; Land degradation, soil erosion and desertification. Deforestation: Causes and impacts due to mining, dam building on environment, forests, biodiversity and tribal populations. Water: Use and over-exploitation of surface and ground water, floods, droughts, conflicts over water (international & inter-state). Energy resources: Renewable and non-renewable energy sources, use of alternate energy sources, growing energy needs, case studies.	08
	Biodiversity and Conservation	Levels of biological diversity: genetic, species and ecosystem diversity; Biogeographic zones of India; Biodiversity patterns and global biodiversity hot spots India as a mega-biodiversity nation; Endangered and endemic species of India Threats to biodiversity: Habitat loss, poaching of wildlife, man-wildlife conflicts, biological invasions; Conservation of biodiversity : In-situ and Ex-situ conservation of biodiversity. Ecosystem and biodiversity services: Ecological, economic, social, ethical, aesthetic and Informational value.	08

Unit-II	Environmental Pollution	Environmental pollution : types, causes, effects and controls; Air, water, soil and noise pollution Nuclear hazards and human health risks Solid waste management : Control measures of urban and industrial waste. Pollution case studies.	08
	Environmental Policies & Practices	Climate change, global warming, ozone layer depletion, acid rain and impacts on human communities and agriculture Environment Laws: Environment Protection Act; Air (Prevention & Control of Pollution) Act; Water (Prevention and control of Pollution) Act; Wildlife Protection Act; Forest Conservation Act. International agreements: Montreal and Kyoto protocols and Convention on Biological Diversity (CBD). Nature reserves, tribal populations and rights, and human wildlife conflicts in Indian context.	07
	Human Communities and the Environment	Human population growth: Impacts on environment, human health and welfare. Resettlement and rehabilitation of project affected persons; case studies. Disaster management : floods, earthquake, cyclones and landslides. Environmental movements : Chipko, Silent valley, Bishnois of Rajasthan. Environmental ethics: Role of Indian and other religions and cultures in environmental conservation. Environmental communication and public awareness, case studies (e.g., CNG vehicles in Delhi).	06
	Field work	Visit to an area to document environmental assets: river/ forest/ flora/fauna, etc. Visit to a local polluted site-Urban/Rural/Industrial/Agricultural. Study of common plants, insects, birds and basic principles of identification. Study of simple ecosystems-pond, river, Delhi Ridge, etc.	05

Total= 50 Hrs

Recommended Books :

1. Carson, R. 2002. Silent Spring. Houghton Mifflin Harcourt.
2. Gadgil, M., & Guha, R. 1993. This Fissured Land: An Ecological History of India. Univ. of California Press.
3. Gleeson, B. and Low, N. (eds.) 1999. Global Ethics and Environment, London, Routledge.
4. Gleick, P. H. 1993. Water in Crisis. Pacific Institute for Studies in Dev., Environment & Security. Stockholm Env. Institute, Oxford Univ. Press.
5. Groom, Martha J., Gary K. Meffe, and Carl Ronald Carroll. Principles of Conservation Biology. Sunderland: Sinauer Associates, 2006.
6. Grumbine, R. Edward, and Pandit, M.K. 2013. Threats from India's Himalaya dams. Science, 339: 36-37.
7. McCully, P. 1996. Rivers no more: the environmental effects of dams (pp. 29-64). Zed Books.
8. McNeill, John R. 2000. Something New Under the Sun: An Environmental History of the Twentieth Century.
9. Odum, E.P., Odum, H.T. & Andrews, J. 1971. Fundamentals of Ecology. Philadelphia: Saunders.
10. Pepper, I.L., Gerba, C.P. & Brusseau, M.L. 2011. Environmental and Pollution Science. Academic Press.
11. Rao, M.N. & Datta, A.K. 1987. Waste Water Treatment. Oxford and IBH Publishing Co. Pvt. Ltd.
12. Raven, P.H., Hassenzahl, D.M. & Berg, L.R. 2012. Environment. 8th edition. John Wiley & Sons.
13. Rosencranz, A., Divan, S., & Noble, M. L. 2001. Environmental law and policy in India. Tripathi 1992.

14. Sengupta, R. 2003. Ecology and economics: An approach to sustainable development. OUP.
15. Singh, J.S., Singh, S.P. and Gupta, S.R. 2014. Ecology, Environmental Science and Conservation. S. Chand Publishing, New Delhi.
16. Sodhi, N.S., Gibson, L. & Raven, P.H. (eds). 2013. Conservation Biology: Voices from the Tropics. John Wiley & Sons.
17. Thapar, V. 1998. Land of the Tiger: A Natural History of the Indian Subcontinent.
18. Warren, C. E. 1971. Biology and Water Pollution Control. WB Saunders.
19. Wilson, E. O. 2006. The Creation: An appeal to save life on earth. New York: Norton.
20. World Commission on Environment and Development. 1987. Our Common Future. Oxford University Press.

Title of the Course : **Material and Energy Balance** **L T P : 3 1 0**
Subject Code : **PCCH-511** **Weekly Load : 4 Hrs**
Course Category : **Departmental Core** **Credit : 4**

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

CO1	Understand and develop general strategy for solving chemical engineering problems.
CO2	Understand and apply/ use the basic concepts & calculations including the units and their conversions and concentration calculations, ideal / non-ideal solutions, gases and gas mixtures.
CO3	Understand and apply the stoichiometric calculations to the industrial chemical reactions
CO4	Formulate and solve the material and energy balance problems applicable to chemical processes (under steady state and unsteady state)
CO5	Apply the modern tools (software/ simulator) to solve material and energy balance problems

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	PO12	PSO1	PSO2
CO1	**W**	**W**		**W**					**M**	**M**	**M**	**M**		
CO2	**M**	**M**							**W**	**W**		**W**		
CO3	**S**	**M**							**W**	**W**		**W**	**W**	**M**
CO4	**S**	**S**	**S**	**S**					**W**	**W**		**W**	**W**	**S**
CO5		**M**	**M**	**W**	**S**				**W**	**W**		**M**	**W**	**M**

Unit	**Main Topics**	**Course outlines**	**Lecture(s)**
Unit-1	1.Introduction and Basic Techniques of problem solving	Overview of Concept of unit operations and unit processes, Types of problems in chemical engineering, various steps of techniques of problem solving, barriers to problem solving, comparison between problem solving habits of novice and an expert, Process flow sheet.	03
	2.Basic Calculations	Units and conversions, Mole concept, Concentration calculations, stoichiometry and stoichiometric calculations, Limiting and excess reactants, Gas laws (for ideal and real gases) and equations of state, Concept of vapour pressure and partial pressure, Raoult's Law for ideal solutions, Henry's Law, Dalton's Law for gaseous mixtures	04
	3. Material Balance	Material balance without and with chemical reactions, Recycle, bypass and purge operations with and without chemical reactions. Application of material balance to combustion of fuels, estimating stack gases compositions (ORSAT analysis) (Steady State)	11
	4. Psychrometry	Humidification operations, psychrometric chart for air water system, psychrometric operations calculations for air – water and other systems, Humidity charts & their uses.	03
Unit-II	5.Energy Balance	Concept of Thermodynamic properties, Law of conservation of energy, heat capacities of solid, liquid, gases and solutions, latent heat, heat of formation, heat of combustion, heat of reaction, theoretical flame temperature, Use of steam tables, formulation and solution of energy balance problems to chemical processes, Application of energy balance to combustion of fuels (steady state)	08
	6. Material and Energy Balance to Unsteady state Operations	Concept of unsteady state operation, concept of material and energy balance to unsteady state operations	05

	7. Applications of material and energy balance	Degree of freedom analysis, Applications of material and energy balance to various chemical plant operations. Basic calculations using chemical flow sheet simulator.	08

Total=42 Hrs.

Recommended Books:

1. Himmelblau, Basic Principles and Calculations in Chemical Engineering, Prentice Hall (I)
2. Felder, R. M., Elementary Principles of Chemical Processes, Wiley (India) Pvt. Limited
3. Hougen & Watson, Chemical Process Principles, Wiley International Edition.
4. Bhat & Vora, Industrial Stoichiometry, Tata McGraw Hill
5. Lewis & Lewis, Industrial Stoichiometry, McGraw Hill

Title of the Course : **Fluid Mechanics** **L T P : 3 0 0**
Subject Code : **PCCH-512** **Weekly Load : 3 Hrs**
Course Category : **Professional Core** **Credit : 3**

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

CO1	Characterise different fluids
CO2	Select and characterize various flow measurement and fluid motive devices
CO3	Analyse the behaviour of fluids and their applications in chemical industries.
CO4	Apply fluid mechanics principles for process design.
CO5	Prepare basic Process data sheets for fluid motive devices.

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	PO12	PSO1	PSO2
CO1	**M**				**M**							**S**		
CO2	**S**	**W**				**W**		**W**			**W**		**W**	
CO3	**S**	**M**			**S**		**M**	**M**			**W**	**S**		**W**
CO4	**S**	**S**	**S**	**M**			**M**		**W**	**W**			**M**	
CO5	**S**	**W**	**M**	**M**	**M**	**M**	**S**		**M**	**M**	**M**	**M**		**M**

Unit	Main Topics	Course outlines	Lecture(s)
Unit-1	Concept, Definitions	Review of various types of flow and types of fluids, flow of incompressible fluids in pipes, Bernoulli's equation and applications, laminar flow in pipes. Valves and fitting, Effect of roughness, continuity equation, correction of Bernoulli's equation for fluid friction, Friction-factor chart, friction losses from sudden expansion, sudden contraction, p i p e joints, fittings and valves.	06
	Flow Measuring Devices	Principles, components, working and applications of orifice meter, venturi meter, rotameter, Weirs and Notches, pitot tube, numerical related to these topics.	05
	Newtonian and non-newtonian fluids	Reynolds experiment, boundary layer formation on a plate and enclosed conduits and boundary layer separation, mixing length. Flow past immersed bodies, Stoke's Law, terminal velocity & drag coefficient, Estimation of economic pipe diameter.	08
Unit-II	Pumps and their Characteristics	Pumps: Reciprocating: - single and double acting, single cylinder and multi cylinder. Rotary: Internal gear and external gear. Centrifugal, different types of impellers, NPSH, Cavitation, pump priming, specific speed. Pump selection, power requirements of pump, actual and ideal pump performance, pump performance curve, System resistance curve, basic process data sheet.	11
	Fans & Blowers	Principle, Construction & Working of Fans, Blowers, Compressors and Nozzles and their applications, basic process data sheet	04
	Flow of Compressible Fluids	Processes of compressible flow through variable area conduits, adiabatic frictional flow, and isothermal frictional flow. Friction losses from sudden expansion, sudden contraction, p i p e joints, fittings and valves.	08

Total = 42 Hrs.

Recommended Books:

1. McCabe & Smith, Unit Operation of Chemical Engineering, Tata McGraw Hill
2. Richardson & Coulson, Chemical Engg. Vol.-I & II, Pergamon Press.
3. Badger & Banchero, Introduction to Chemical technology, Tata McGraw Hill.
4. Foust, Principles of Unit Operation, John Wiley

Title of the Course : **Chemical Engineering Thermodynamics** **L T P : 3 1 0**
Subject Code : **PCCH-513** **Weekly Load : 4 Hrs**
Course Category : **Departmental Core** **Credit : 4**

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

CO1	Comprehend the basic thermodynamics terminology, scope and laws of Thermodynamics and their basic applications
CO2	Select and use an appropriate equation of state for representing the P-V-T behaviour of gases and liquids.
CO3	Compute the thermodynamic properties for ideal and non-ideal systems including the use of thermodynamic diagrams.
CO4	Compute VLE data and verify the consistency of experimental data.
CO5	Analyse the chemical reaction equilibrium for reacting systems.
CO6	Apply the principles of chemical engineering thermodynamics on the chemical 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	PO12	PSO1	PSO2
CO1	**S**	**M**		**W**					**W**	**W**		**W**	**M**	**S**
CO2	**S**	**M**		**W**					**W**	**W**		**W**	**M**	**S**
CO3	**S**	**S**		**M**					**W**	**W**		**W**	**M**	**S**
CO4	**S**	**S**	**M**	**S**	**W**				**W**	**W**		**W**	**M**	**S**
CO5	**S**	**S**	**M**	**S**					**W**	**W**		**W**	**M**	**S**
CO6	**S**	**S**	**S**	**S**	**M**				**W**	**W**		**W**	**M**	**S**

Unit	Main Topics	Course outlines	Lecture(s)
Unit-I	1. Introduction	Introduction and scope of chemical engg. thermodynamics, concept of system and surroundings, classification of thermodynamic processes, concept of temperature and Zeroth law of thermodynamics, thermodynamic properties	02
	2. Laws of Thermodynamics	First law of Thermodynamics for cyclic process, non-flow and flow process, concept of enthalpy and calculations. Second law of thermodynamics: statement, concept of entropy, Carnot's cycle and Carnot's engine, third law of thermodynamics	05
	3. Refrigeration and Liquefaction	Refrigeration & liquefaction cycles (single stage), refrigeration and liquefaction cycles (multiple stage).	04
	4.Volumetric Properties of Fluids & Heat Effects	P-V-T behaviour of pure fluids, ideal gas law, equations of state for real gases, compressibility charts, heat effects accompanying chemical reactions	04
	5.Thermodynamic properties of pure fluids	Classification, work function, free energy, relationships among thermodynamic properties: Maxwell's equations and their uses, Clapeyron equation, Method of Jacobian and thermodynamic properties, Fugacity, Activity, Departure functions, Thermodynamic diagrams.	06
Unit-II	6. Properties of solutions	Properties of homogeneous mixtures; partial molar properties, chemical potential & its applications, Fugacity in solutions, Henry's law, excess properties & their applications, activity and Activity coefficients in solutions, Gibb's Duhem equation, properties changes of mixing.	04
	7.Phase equilibria	Criteria for Phase equilibria, Phase equilibria in single and multi-component systems, Phase rule for non-reacting systems, Duhem's theorem, Vapour liquid equilibria in ideal and non-ideal solutions at low and moderate pressures, Azeotrope calculations, Consistency test for	08

		VLE data, VLE for high pressure systems, Flash vaporization, Calculation of activity coefficients for solutions. VLE for partially miscible and immiscible solutions.	
	8. Chemical Reaction Equilibria	Criteria for chemical reaction equilibria, calculation of equilibrium constant and Gibb's free energy change, effects of various parameters on equilibrium constant and equilibrium compositions, liquid phase and heterogeneous reaction equilibria, phase rule for reacting system.	05
	9. Applications of thermodynamics	Applications of thermodynamics to various operations, thermodynamic analysis of distillation, evaporation and condensation processes, minimum work of separation and thermodynamic efficiency of separation.	04

Total=42 HRS

Recommended Books :

1. Smith and Van Ness, Introduction to Chemical Engineering Thermodynamics, Tata McGraw Hill
2. Kyle , Chemical & Engineering Process Thermodynamics, Prentice Hall (I) Ltd.
3. Narayanan, KV, Chemical Engg. Thermodynamics, Prentice Hall (I) Ltd.
4. Rao, YVC, Chemical Engineering Thermodynamics, University Press.

Title of the Course : **Fluid Mechanics Lab** **L T P : 0 0 2**
Subject Code : **PCCH-514** **Weekly Load : 2 Hrs**
Course Category : **Professional Core** **Credit : 1**

Course Outcomes : At the end of the course, the students will

CO1	have the knowledge of basic principles of fluid flow and capability to analyse fluid flows as well as fluid machinery
CO2	be able to analyse fluid flow problems with the application of the momentum and energy equations
CO3	gain the practical knowledge on the measurement of Fluid Flow and their characteristics at different operating conditions

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	PO12	PSO1	PSO2
CO1	**S**	**M**	**M**	**S**		**M**	**M**	**M**	**M**			**S**	**W**	**M**
CO2	**M**	**S**	**M**	**M**		**M**	**M**	**M**	**M**	**M**		**S**	**W**	**S**
CO3	**S**	**S**	**S**	**S**		**S**	**M**		**M**	**W**		**S**	**W**	**M**

Lists of Experiments :

1. To find drag force for verifying Stoke's law & plot a graph between Reynolds's number of a ball & drag coefficient.
2. To calculate the settling time and effect of different concentration for hindered settling.
3. To verify Bernoulli's equation using hydraulic bench.
4. To calibrate the given rotameter & calculate rotameter coefficient & also plot the graph. between flow rate and rotameter reading.
5. Study of Friction losses due to different pipe fittings.
6. To Study the Friction losses in non-circular pipes.
7. To find losses due to sudden expansion and sudden contraction in pipes.
8. To calculate Reynold's number for laminar and turbulent flow.
9. To determine volumetric and mass flow rates through the Venturi meter.
10. To determine volumetric and mass flow rates using Orifice meter.
11. To find coefficient of friction in pipes of different materials
12. To determine the efficiency of a pump.

Note: Minimum 08 Experiments must be conducted.

Title of the Course: **Process Technology Lab** **L T P: 0 0 2**
Subject Code: **PCCH-515** **Weekly Load: 2 Hrs**
Course Category: **Departmental Core** **Credit: 1**

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

CO1	Apply engineering knowledge to manufacturing processes of various inorganic and organic chemical products like soap, sugar, oils etc
CO2	Appreciate the applications of various unit operations and processes to the chemical industries
CO3	Understand the engineering problems and their remedies associated with manufacturing processes in chemical industries
CO4	Acquire the knowledge to determine acid value, Saponification value, smoke, flash and fire point of given oil sample

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	PO12	PSO1	PSO2
CO1	**S**	**S**	**M**	**M**		**W**	**M**			**M**	**S**		**M**	
CO2	**S**	**S**	**M**	**M**	**M**		**M**				**S**	**M**	**M**	
CO3	**S**	**S**	**W**	**M**	**M**		**M**	**M**	**M**	**M**	**S**	**S**	**M**	**M**
CO4	**M**	**M**	**M**	**M**			**S**	**S**		**M**	**S**		**S**	

S.No. **Name of the Experiment**

1. To determine the acid value of a vegetable oil and lubricating oil.
2. To determine the saponification value of vegetable oil
3. To estimate the given reducing sugar.
4. To estimate the given non reducing sugar.
5. To study loss on heating of Tar and Bitumen.
6. To analyze the given cement sample.
7. To determine the viscosity of a given sample by Redwood Apparatus.
8. Preparation of Soap
9. Preparation of dye and pigments.
10. To determine the viscosity of a given sample by U-tube viscometer.

Note: Minimum 08 Experiments must be conducted.

Title of the Course : **Mass Transfer-I** **L T P : 3 1 0**
Subject Code : **PCCH-521** **Weekly Load : 4 Hrs**
Course Category : **Departmental Core** **Credit : 4**

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

CO1	Compute diffusivities and mass transfer coefficients and their applications
CO2	Appreciate the fundamentals of process design to various mass transfer operations
CO3	Carryout process design of distillation columns, humidifiers, absorbers
CO4	Apply the engineering fundamentals to the complexities of 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	PO12	PSO1	PSO2
CO1	**S**	**S**	**S**	**W**	**S**	**M**		**W**	**M**	**W**		**M**	**M**	**M**
CO2	**S**	**M**	**S**	**W**		**M**	**M**	**S**	**M**			**M**	**S**	**M**
CO3	**S**	**M**	**S**	**M**	**M**	**M**	**M**		**M**			**M**	**M**	**M**
CO4	**S**	**S**	**M**	**S**					**M**	**W**	**W**	**S**	**S**	**S**

Unit	**Main Topics**	Course outlines	**Lecture(s)**
Unit-1	1. Introduction	Classifications of mass transfer operations, choice of separation methods, design principles.	02
	2. Diffusion	Steady state molecular diffusion in fluids at rest and laminar flow, mass transfer coefficients in laminar and turbulent flow, mass, heat and momentum transfer analogies.	04
	3. Inter phase Mass Transfer	Equilibrium between phases, local and overall mass transfer coefficients, diffusion between phases with co-current and counter current arrangement material balance and stage calculations efficiencies.	06
	4.Gas-Liquid Contacting Equipment	Equipments for gas-liquid operations: general characteristics and operational features of tray towers and packed towers, types of trays , flow through a packed towers, tray towers, venturi-scrubbers	05
	5. Distillation	Vapour - Liquid equilibria (ideal and non-ideal solutions), Enthalpy concentration diagram, Single stage operation-Flash vaporization, Differential distillation, Continuous Rectification-Binary systems, Multistage Tray towers-Design of trays by McCabe-Thiele and Ponchon-Savarit methods, Tray efficiencies, Optimization of cost	07
Unit-II	6. Distillation Equipment	Condensers, Partial Condenses, Reflux, Rectification of Azeotropic Mixtures, Rectification of Extractive Distillation,	04
	7.Humidification Operations	VLE & enthalpy of pure substance, vapour-gas mixtures, Gas- liquid contact operations: Fundamental relationship for adiabatic and non-adiabatic operations for air-water system for humidification and dehumidification. Water cooling towers- construction, operation and process calculations.	04
	8.Gas Absorption	Equilibrium in gas-liquid systems: Two components and multi component systems, ideal and non-ideal solutions, Selection of suitable solvent, Counter-current multistage operations- one component transferred, Real trays and tray efficiencies.	05
	9.Gas Absorption Equipments	Continuous contact equipments: Packed towers, HETP & NTU, Overall transfer coefficients and transfer units	05
		Total	**42**

Recommended Books:

1. Treybal, Robert, Mass Transfer Operations, McGraw Hill
2. Sherwood, Thomas Mass transfer McGraw Hill
3. Badger & Banchero Introduction to Chemical Technology McGraw Hill
4. Dutta, B.K, Principles of Mass Transfer and Separation Processes, Prentice Hall of India
5. McCabe, Smith & Harriot, Unit Operations of Chemical Engineering, McGraw Hill

Title of the Course : **Heat Transfer** **L T P : 3 1 0**
Subject Code : **PCCH-522** **Weekly Load : 4 Hrs**
Course Category : **Professional Core** **Credit : 4**

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

CO1	Understand the fundamentals of modes of heat transfer i.e. conduction, convection and radiation
CO2	Design and analyze the performance of heat exchangers, evaporators, heating and cooling systems in process industries
CO3	Appreciate the applications of heat transfer principles and equipments to the process industries

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	PO12	PSO1	PSO2
CO1	**M**					**W**	**M**	**W**				**S**		
CO2	**S**	**M**	**S**	**W**					**M**		**S**		**W**	**M**
CO3	**M**	**M**	**S**	**S**	**M**	**M**			**M**	**W**	**S**	**M**		**S**

Unit	**Main Topics**	Course outlines	**Lecture(s)**
Unit-1	Steady State Heat Transfer	Conduction: Review of Fourier's Law, one-dimensional heat conduction through composites having plane wall, spherical & cylindrical geometry. Steady state heat flow with heat source through plane wall and cylindrical surface. Thermal conductivity of materials. Optimal thickness of insulation, Fins and their applications.	10
	Unsteady State Heat Transfer	Unsteady-state conduction; Lumped heat capacity system, semi-infinite solid and Heisler chart.	05
	Convection	Convection: free and forced convection, concept of thermal boundary layer, concept of overall heat transfer coefficient for laminar and turbulent flow, heat transfer inside & outside tubes with significance of Nusselt, Prandlt, Reynold, Biot, Fourier and Peclet number. modeling of convective heat transfer coefficient by using dimensional analysis.	07
Unit-II	Radiation	Radiation: Distribution of radiant energy, Definition of emissivity, absorpitivity, Reflectivity and Transmissivity, concept of Black and Grey bodies, Plank's Law of monochromatic radiation, Kirchhoff's Law, Wein's displacement law, Stefan-Boltzmann law, intensity of radiation. Radiation formula for radiation exchange between simple bodies, parallel surfaces and other source and receiver.	08
	Heat Transfer with Phase Change	Boiling, Condensation, Heat Exchangers and Evaporators: Drop wise and Film wise condensation of pure and mixed vapors, Nucleate & Film boiling, Review of correlations of heat transfer.	06
	Heat Transfer Equipments	Heat Exchangers: Theory & design of Double Pipe Heat Exchanger, Shell and Tube Exchangers, Selection of passes of 1-2, 2-4 Shell-and-Tube Heat Exchangers, Temp. Correction factor for shell & tube exchangers, Theory of plate type heat exchanger. Reboiler and Condensers, Counter Current dry contact condenser, parallel current-wet contact condensers. Theory and design of single effect evaporators, Various types of evaporators: Standard vertical tube evaporator, basket type vertical evaporator, forced circulation evaporator and horizontal tube evaporators. Various feed arrangements in multiple effect evaporators.	07

Total=42 hrs

Recommended Books:

1. Holman, J.P., Heat Transfer, McGraw Hill
2. Kreith, Principles of Heat Transfer, Harper & Row
3. McAdams, Heat Transmission, McGraw Hill
4. McCabe & Smith, Unit Operations of Chemical Engg, McGraw Hill
5. Kern, D.Q., Process Heat Transfer, Tata McGraw Hill

Title of the Course :	**Fluid and Particle Mechanics**	**L T P : 3 1 0**
Subject Code :	**PCCH-523**	**Weekly Load : 4 Hrs**
Course Category :	**Professional Core**	**Credit : 4**

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

CO1	Comprehend various mechanical operations and their applications.
CO2	Estimate the energy consumption in various Comminution operations
CO3	Analyse the hydrodynamics of fixed and fluidized beds

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	PO12	PSO1	PSO2
CO1	**S**	**S**				**W**	**W**	**W**		**W**			**W**	
CO2	**S**	**M**	**M**	**M**	**W**	**W**	**M**	**W**	**M**	**W**		**M**	**W**	**W**
CO3	**S**	**M**	**M**	**M**	**W**	**W**		**W**	**W**	**W**		**M**	**M**	**W**

Unit	**Main Topics**	**Course outlines**	**Lecture(s)**
Unit-1	Properties of Particulate Masses	Mixing of solids, kneaders, dispersers and masticators, Muller mixture and pug mill, mixing index for paste and granular solids. Mixer selection and scale up, power requirements	04
	Size Reduction	Working principles and applications of Gyratory crusher, smooth roll crushers, Toothed roll crusher, derivation of critical speed of tumbling mill, fluid energy mill, Knife Cutters. Crushing laws & work index	04
	Basics of particle technology	Bulk density, Particle density. Methods for their determination, funnel flow, mass flow, Arching and rathole formation in silos.	04
	Mechanical separation and filtration	Screening, Screen analysis, Screening equipment namely stationary Screens & Grizzles, Gyrating Screen, Vibrating Screens, material balance over screen, capacity & effectiveness of screen. Concept of filtration, Plate & Frame filter press, Shell & Leaf filters, continuous Rotary Vacuum Filter, Principle of filtration, Centrifugal filtration. Principle of cake filtration, pressure drop through filtration.	10
Unit-II	Sedimentation	Flocculation, theory of settling, continuous Thickener and their application in industry, determination of Thickener area, Gravity settling processes, Gravity classifier, differential settling methods, Clarifiers & Thickeners. Centrifugal sedimentation- principles and working	08
	Centrifugal separation	Air cyclone separator, Different types of Cyclone Separators, Wet scrubbers and their different types, Batch top & under driven centrifuge, vertical solid bowl centrifuge, disc type centrifuge, Centrifugal decanters, Centrifuge theory & calculations, rate of separations.	08
	Fixed and Fluidised beds	Concepts and functioning of packed bed, fluidization and their applications. Pressure drop calculations	04

Total = 42 Hrs.

Recommended Books:

1. McCabe, Smith, Unit Operations in Chemical Engineering, McGraw Hill
2. Coulson and Richardson, Chemical Engineering Vol. II, Pergamon press
3. Foust, Principle of Unit Operations, John Wiley
4. Badger and Banchero, Introduction to Chemical Engineering, Tata McGraw Hill

Title of the Course : Heat and Mass Transfer Lab **L T P : 0 0 2**
Subject Code : PCCH-524 **Weekly Load : 2 Hrs**
Course Category : Professional Core **Credit : 1**

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

CO1	Understand qualitatively conduction, convection, and radiation and have experience with one or more modes during experiments
CO2	Apply heat transfer to various unit operations and analyse theoretical aspects of experiments conducted in heat transfer laboratory.
CO3	Analyse liquid-solid operations and understand the principles which are having wide applications in various industries
CO4	Determine important data for the design and operation of the process equipments like, extraction, diffusion and crystallization.

	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	PO12	PSO1	PSO 2
CO1	**S**	**M**	**S**	**M**	**-**	**M**	**M**	**-**	**M**	**-**	**M**	**M**	**M**	**M**
CO2	**S**	**M**	**M**	**S**	**W**	**S**	**M**	**W**	**S**	**M**	**M**	**S**	**M**	**M**
CO3	**M**	-	-	-	**W**	-	-	-	**M**	-	-	-	**W**	**M**
CO4	**M**	-	-	-	-	-	-	**W**	**M**	-	-	-	**W**	**M**

List of experiments:

1. To find out heat transfer coefficient of vertical cylinder in natural convection.
2. To determine the total thermal resistance & thermal conductivity of composite wall and also plot temperature gradient along with composite wall structure.
3. To find out the thermal conductivity of metal rod apparatus.
4. To determine the emissivity of gray surface.
5. To determine the value of Stefan Boltzmann apparatus constant for radiation heat transfer.
6. To find out the thermal conductivity of liquids.
7. To study the mass transfer coefficient for sublimation of naphthalene balls in air using a packed bed of spherical particles of naphthalene.
8. Determination of the gas film coefficient in wetted wall column using air water system.
9. Determination of the diffusion coefficient of an organic vapour in air and study the effect of temperature on the diffusion coefficient.
10. To estimation of LMTD of heat exchangers.
11. To study the drying characteristics of the given wet material (forced convection).
12. To study the process of crystallization in an agitated batch crystallizer and to plot a graph between weight of crystals vs. temp.
13. To study liquid-solid equilibria.
14. Determination of the exchanger capacity of an anion and cation ion exchanger resin.

Note: Minimum 08 Experiments have to be conducted.

Title of the Course : Fluid and Particle Mechanics Lab **L T P : 0 0 2**
Subject Code : PCCH-525 **Weekly Load : 2 Hrs**
Course Category : Professional Core **Credit : 1**

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

CO1	handle devices of mechanical operations practically and properly
CO2	handle raw materials of chemical industries perfectly and importance of power consumption of various devices of mechanical operations both
CO3	gain the practical knowledge and hands on various separation techniques like filtration, sedimentation, screening cyclone separator etc.

CO/PO Mapping: (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation):														
COs	Programme Outcomes (POs)													
	PO1	PO2	PO3	PO4	PO 5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	**S**	**M**	**M**	**W**		**M**	**M**	**M**		**W**	**W**	**W**	**W**	**M**
CO2	**S**	**S**	**S**	**W**	**W**	**M**	**M**	**M**			**W**	**M**	**W**	**S**
CO3	**S**	**S**	**S**	**W**	**W**	**S**	**M**	**M**		**W**	**W**	**W**	**W**	**S**

List of Experiments:

1. To find the rate of filtration through Rotary Drum Vacuum filter.
2. To calculate the settling time and effect of different concentration for hindered settling.
3. To find out the moisture content of any sample.
4. To calculate cumulative fraction and differential analysis of given sample using sieve shaker.
5. To calculate the power required for jaw crusher for a given sample.
6. To calculate the power required for Ball mill for given sample.
7. Determination of cake resistance and filter medium resistance (Plate & frame filter press).
8. To find out the collection efficiency of a cyclone separator.
9. Determination of screening efficiency in a vibrating screen.
10. To study the settling characteristics in a batch settling experiment and use the data to design a thickener for the given flow rate.
11. Determination of power consumption and study of agitation and mixing characteristic of a fluid.

Note: Minimum 08 Experiments have to be conducted.

Title of the Course : **Chemical Reaction Engineering – I** **L T P : 3 1 0**
Subject Code : **PCCH-611** **Weekly Load : 4Hrs**
Course Category : **Professional Core** **Credit : 4**

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

CO1	Understand and apply homogeneous reaction kinetics for engineering applications
CO2	Design isothermal ideal reactors for single and multiple reactions
CO3	Design and evaluate the performance of combination of ideal reactors
CO4	Understand non-isothermal operation of ideal reactors for single and multiple 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	PO12	PSO1	PSO2
CO1	**M**	**M**					**W**						**S**	**S**
CO2	**S**	**M**	**S**	**W**	**M**		**W**		**W**			**W**	**S**	**M**
CO3	**M**	**M**	**S**	**S**	**M**				**M**		**W**	**W**	**S**	**S**
CO4	**W**	**S**	**W**			**W**		**W**	**W**	**M**	**W**	**M**	**S**	**M**

Unit	**Main Topics**	**Course Outlines**	**Lectures**
Unit-I	Kinetics of homogeneous reaction	Concept of reaction rate, rate equation, single and multiple reactions, elementary and non-elementary reactions, molecularity and order of reactions, concept of rate constant k, representation of reaction rate. Determination of reaction rate from given mechanism. Variable volume reacting systems.	08
	Single ideal reactors	Ideal batch reactors—design equation, application of batch reactors; reaction kinetics from batch reactor experiments. Ideal continuous reactors concept of space time, space velocity, performance equations of steady-state mixed flow reactors and plug flow reactors, concept of holding time.	08
	Design for single reactions	Size comparison of single reactors—batch reactors, mixed flow reactor, plugs flow reactors. Multiple reactor systems—plug flow reactors in series/or in parallel, equal size mixed reactors in series, mixed flow reactors of different sizes in series, reactors of different types in series, recycle reactors, autocatalytic reactions.	09
Unit-II	Design for multiple reactions	Reactions in parallel—qualitative discussion about distribution, quantitative treatment of product distribution and of reactor size. Reactions in series; quantitative analysis for 1^{st} order irreversible reactions in series. Series parallel reactions.	09
	Non-Isothermal Reactor Design	Concept of adiabatic and non-isothermal operation. Energy balance equation for batch CSTR and PFR and their applications for design of reactors, reactor stability and multiple steady states in CSTRs.	08

Total = 42 hrs

Recommended Books :

1. Ghatak, H.R., Reaction Engineering Principles, CRC Press, Taylor and Francis Group
2. Levenspiel, O., Chemical Reaction Engineering, Wiley
3. Fogler, H.S., Elements of Chemical Reaction Engineering, Prentice Hall
4. Hill, G.C.; and Root, T.W., Introduction to Chemical Engineering kinetics and Recator Design, Wiley
5. Schmal, M, Chemical Reaction Engineering: Essentials, Exercises and Examples, CRC Press, Taylor and Francis Group

Title of the Course : **Mass Transfer-II** **L T P : 3 0 0**
Subject Code : **PCCH-612** **Weekly Load : 3 Hrs**
Course Category : **Departmental Core** **Credit : 3**

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

CO1	Comprehend the principles and operations of various mass transfer operations and related equipments
CO2	Apprehend the design of mass transfer operations
CO3	Analyse and appreciate the applications of mass transfer equipments

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	PO12	PSO1	PSO2
CO1	**S**	**M**						**M**		**M**			**S**	**S**
CO2	**S**	**M**	**S**	**M**			**W**	**M**	**M**				**M**	**M**
CO3		**S**	**M**	**M**			**W**	**M**	**M**	**M**			**M**	**M**

Unit	**Main Topics**	Course outlines	**Lecture(s)**
Unit-I	1.Liquid-Liquid Extraction Operations	Liquid-Liquid Equilibria, Equilateral triangle coordinate systems, Suitable solvent selection, Design calculations for single stage and multiple extraction	07
	2.Liquid-Liquid Extraction Equipment	Liquid-Liquid Extraction Equipments- Spray Towers, Packed Towers, Mechanically Agitated Counter current Extractors, Rotating Disc Extractor.	04
	3.Leaching Operations	Liquid-Solid Equilibria, Design calculations for single stage and multiple stage leaching.	06
	4.Leaching Operations' Equipment	Unsteady State leaching systems: Percolation tank, batch settling, Steady state continuous operations- Agitated vessels, thickeners, continuous counter current decantation, classifiers, method of calculations related to single stage and multistage leaching	04
Unit-II	5.Adsorption & Ion-Exchange Operations	Adsorption and adsorbents-Type and nature, Adsorption equilibria and various popular mathematical models, Selection of suitable adsorbents, Adsorption hysteresis, Batch adsorption, Stage-wise adsorption-single stage and multiple stage, Ion-Exchange, Equilibrium distribution of ions.	07
	6. Adsorption & Ion-Exchange Operations' Equipment	Adsorption in a fixed bed. Adsorption equipments-agitated vessels for liquid-solid contact, fluidized and teeter beds, slurry adsorption of gases and vapours, steady-state-moving-bed adsorbers, Unsteady state-Fixed Bed Adsorbers, Concept of Chromatography, Elution, Percolation etc and equipment concerning these concepts.	04
	7.Drying Operation and Equipment	Drying equilibria, Physical mechanism of drying, batch drying rate of dying curve, time of drying rate data, Drying equipments-Batch and continuous dryers.	05
	8. Crystallization	Solid-liquid phase equilibria, nucleation and crystal growth, crystal size distribution, batch crystallization, crystallization equipments	05
		Total	**42**

Recommended Books:

1. Treybal, Robert; Mass Tansfer Operations, McGraw Hill
2. Sherwood, Thomas, Mass transfer, McGraw Hill Publications
3. Badger & Banchero, Introduction to Chemical Technology, McGraw Hill
4. Dutta, B.K , Principles of Mass Transfer and Separation Processes, Prentice Hall of India
5. McCabe, Smith & Harriot, Unit Operations of Chemical Engineering, McGraw Hill

Title of the Course : Fuel cells **L T P : 3 0 0**
Subject Code : OECH-611A **Weekly Load : 3 Hrs**
Course Category : Open Elective-1 **Credit : 3**

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

CO1	Understand the energy dynamics of fuel cell operation.
CO2	Comprehend the kinetics and current voltage relationship for fuel cell operation.
CO3	Understand the cell design for different types of fuel cells.
CO4	Select fuel cells for different applications.

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	PO12	PSO1	PSO2
CO1	**S**	**W**				**S**	**S**			**W**				
CO2	**S**	**M**			**M**		**W**			**W**				
CO3	**S**	**S**	**S**	**M**	**M**		**W**			**W**				
CO4	**S**	**S**		**M**	**S**	**M**	**M**	**W**		**W**	**W**	**W**		

Unit	**Main Topics**	**Course outlines**	**Lecture(s)**
Unit-1	Thermodynamics and electrochemistry of fuel cells	Electrochemical half cell reactions for different fuel cells. Free energy changes and enthalpy changes in fuel cell reactions; relationship with cell potential; Nernst equation for fuel cell. Effects of temperature and pressure. Overpotential; its different types and relationship with current density. Efficiency of fuel cell.	07
	Alkaline fuel cells	Reactions involved; and efficiency. The electrolyte; poisoning of electrolyte. Anion exchange membranes. Type of electrodes. Basis design and construction; static and flowing electrolyte types. Applications of alkaline fuel cells.	07
	PEM fuel cells	Reactions involved, and efficiency. Components of PEM fuel cell. Working of proton exchange membrane. Electrocatalysts for PEM fuel cells and the construction of electrodes. Gas diffusion. Applications of PEM fuel cells.	07
Unit-II	Solid oxide fuel cells	Reactions involved, and efficiency. Working of solid oxide or ceramic electrolyte; different materials used. Electrodes and the construction of cell; tubular and planar designs. Operating temperatures. Application of solid oxide fuel cells.	07
	Molten carbonate fuel cells	Reactions involved, and efficiency. Electrolyte and electrolyte support. Electrodes and the cell design. Internal reforming of fuel. Operating temperatures. Applications of molten carbonate fuel cells.	07
	Direct methanol fuel cells	Reactions involved, and efficiency. Electrolyte membrane and electrodes. Operating temperatures. Applications of direct methanol fuel cells.	07

Total = 42 Hrs.

Recommended Books :

1. Fuel Cell Systems Explained, J. Larminie and A. Dicks, 2nd Edition, John Wiley & Sons Inc., 2000.
2. PEM Fuel Cells Theory and Practice, Frano Barbir, Elsevier Academic Press, 2005.
3. Fuel Cell Technology Handbook, Gregor Hoogers, SAE International, 2003.
4. Fuel Cell Principles and Applications, B Viswanathan and M A. Scibioh, Universities Press, 2006.

Title of the Course : Analytical Methods and Instrumentation **L T P : 3 0 0**
Subject Code : OECH-611B **Weekly Load : 3 Hrs**
Course Category : Open Elective-1 **Credit : 3**

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

CO1	acquire knowledge about the widely used analytical Instruments and explain different types of Instrumental methods.
CO2	Select Instrument for a particular analysis with come idea of its merits, demerits and limitations.
CO3	To expand skills in 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	PO12	PSO1	PSO2
CO1	**M**	**W**		**S**	**S**									
CO2	**M**	**S**		**S**	**S**									
CO3	**M**	**M**		**S**	**S**				**M**	**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.	09
	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.	08
	Magnetic Resonance Spectroscopy	Theory of NMR, environmental effects on NMR spectra, chemical shift, NMR spectrometers, applications of 1H and 13C NMR	05
Unit,II	**Mass Spectrometry**	Molecular mass spectra, ion sources, Mass spectrometer. Applications of molecular mass, Electron paramagnetic resonance, g values, instrumentation.	04
	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.	08
	Electro analysis and Surface Microscopy	Electrochemical cells, Electrode potential cell potentials, potentiometry, reference electrode, ion selective and molecular selective electrodes, Instrument for potentiometric studies, Voltametry, Cyclic and pulse voltametry, Applications of voltametry. Study of surfaces, Scanning probe microscopes, AFM and STM.	08

Total = 42 Hrs

Recommended Books :

1. Skoog, D.A. F. James Holler, and Stanky, R.Crouch "Instrumental Methods of Analysis". Cengage Learning , 2007.
2. Willard, Hobart, etal., "Instrumental Methods of Analysis". 7th Edition, CBS, 1986.
3. Braun, Robert D. " Introduction to Instrumental Analysis". Pharma Book Syndicate, 1987.
4. Ewing,G.W. "Instrumental Methods of Chemical Analysis", 5th Edition, McGraw Hill, 1985.

Title of the Course : **Electrochemical Engineering** **L T P : 3 0 0**
Subject Code : **OECH-612A** **Weekly Load : 3 Hrs**
Course Category : **Open Elective-2** **Credit : 3**

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

CO1	Analyze the electrochemical processes to ascertain their kinetic and thermodynamic behavior
CO2	Comprehend electrode preparation and characterization and their industrial applications.
CO3	Select and utilize appropriate electrode materials under optimized process conditions for industrial applications.

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**	**PO12**	**PSO1**	**PSO2**
CO1	S	M					M		W	W				
CO2	S	M	W			M			W	W		W		
CO3	S	S	S	M			M		W	W	W	W		

Unit	**Main Topics**	**Course Outlines**	**Lectures**
Unit-1	Introduction	Electrochemistry basics; Thermodynamics of ideally polarizable and non-polarizable interfaces. Electrochemical cells; reversible and irreversible cells, EMF.	4
	Electrode kinetics	Equilibrium potential, Nernst equation, overpotential and its different types. Equilibrium exchange current density; Butler-Volmer equation; high field and low field approximations; charge transfer resistance and polarizability of the interface. Rate determining step, stoichiometric number, reaction order. Determination of kinetic parameters.	10
	Electro-analytical techniques	Potentiometry and amperometry. Linear sweep voltammetry and cyclic voltammetry. Analysis of cyclic voltammograms. Potential steps under mass transfer control; Cottrell equation for a planar and spherical electrode. Faradaic impedance	8
Unit-2	Electrodes and electrolytic membranes	Electrodes for the electrochemical reactors. Preparation, characteristics and applications of graphite, magnetite, lead dioxide coated anodes, noble metal coated anodes, noble metal oxide coated anodes, steel cathodes, coated cathodes, diaphragms and ion exchange membranes.	10
	Industrial applications	Chlor alkali industry. Manufacture of potassium and ammonium persulphates, hydrogen peroxide, potassium permanganate. Production of hydrogen by water electrolysis. Electrodialysis and electrochemical incineration. Batteries and fuel cells. Electrometallurgy.	10

Total = 42 Hrs.

Recommended Books :

1. Bockris, J.O.M.; and Reddy, A.K.N. Modern, Electrochemistry, Plenum Press
2. Bard, A.J., and Faulkner, L.R., Electrochemical Methods Fundamentals and Applications, Wiley
3. Scott, K., Electrochemical Reaction Engineering, Academic Press
4. Linden, D., and Reddy, T.B., Hand Book on Batteries and Fuel Cell, McGraw Hill
5. Pletcher, D., and Walsh, F.C., Industrial Electrochemistry, Chapman

Title of the Course : **Renewable Energy Sources** **L T P : 3 0 0**
Subject Code: **OECH-612B** **Weekly Load : 3 hrs**
Course Category: **Open Elective-2** **Credit : 3**

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

CO1	Compare between Renewable & non-renewable energy sources.
CO2	Appraise the fundamentals and applications of biomass, bio-diesel, ethanol, geothermal, solar, wind as sources of energies
CO3	Understand energy generation technologies from biomass, ethanol, geo-thermal, solar and wind.
CO4	Assess the environmental issues related with utilization of biomass, bio-diesel, ethanol, geothermal, solar and wind as sources of energies.

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	PO12	PSO1	PSO2
CO1	M	W				S	S	M				M		
CO2	S	S	S			S	M	M		M	W	S		
CO3	S	M	M	W		S	M	M	W	M	W	S		
CO4	S	S	M	W		S	S	M	W	M	M	S		

Unit	Main Topics	Course Outlines	Lectures
Unit-1	Introduction	Introduction to Energy Science & Technology, Law of conservation of energy, Energy calculations, energy demand, various resources of non-conventional energy.	05
	Biomass, bio-diesel and ethanol as sources of energy	Introduction to biomass energy; Thermo-chemical conversion of biomass; Anaerobic digestion to methane for bio-gas generation; Ethanol production. Environmental considerations.	10
	Geo-Thermal Energy	Introduction to geo-thermal energy; Vapour dominated (stream) geothermal electrical power plant; Liquid dominated (hot-water) geo-thermal electrical power plant; Energy generations processes through various types of geo-thermal energy plants; Environmental considerations.	07
Unit-II	Solar Energy	Introduction to fundamentals and applications of Solar thermal energy conversion systems: Solar Collectors, Solar thermal power plants, Solar photovoltaic systems-Prospects of solar PV systems, principles of a photo voltaic cell, V-I characteristics of a solar cell, efficiency of a solar cell; Environmental considerations.	10
	Wind Energy	Introduction to wind energy. Basic principles of Wind Energy Conservation: The nature of the wind, the power in the wind, forces on blades, wind energy conservation; Site selection considerations; Basic components of a WECS (Wind Energy Conservation System); Advantages and disadvantages of WECS; Types of Wind Machines-Horizontal-Axial machines, Vertical –Axis Machines.	10

Total = 42 hrs

Recommended Books:

1. Saha, S.N., Food Combustion Energy Technology; Dhanpat Rai Pub.
2. Rai, G.D., Non-conventional Energy Sources; Khanna Publishers.
3. Gupta, O.P., Elements of Fuels, Furnaces and Refractories, Khanna Publishers

Title of the Course : **Agro Residue Utilization** **L T P : 3 0 0**
Subject Code : **PECH-611A** **Weekly Load : 3 Hrs**
Course Category : **Professional Elective-1** **Credit : 3**

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

CO1	Classify and appraise about the use of agro-residues
CO2	Analyze the characteristics of agro-residues for utilization and sustainability
CO3	Appraise the technologies and processes for effective utilization of agro-residues

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	PO12	PSO1	PSO2
CO1		**M**				**S**	**S**	**M**					**S**	**M**
CO2	**S**	**M**	**M**	**M**		**M**	**S**	**M**		**M**	**M**		**S**	**M**
CO3	**S**	**M**				**M**	**M**	**M**		**M**	**M**		**S**	**S**

Unit	**Main Topics**	Course outlines	**Lecture(s)**
Unit-1	Production and utilization scenario of agro-residue	Availability of different agro residues in India and other countries; Agro-residues as bio-renewable materials; Current utilization scenario at national and international level; Introduction to Conversion technologies– biochemical, thermochemical, chemical and physical.	10
	Constituents of agro residue and production of combustible materials	Physical and chemical characteristics of various agro-residues available in India; Important constituents and their possible uses in industries; The similarity and difference among different agro-residues; Charcoal production, Briquetting; Bio-gas generation technologies for fuel.	11
Unit-II	Processing of biomass	Biochemical Conversion- Anaerobic digestion to methane, Ethanol fermentation; Thermo-chemical Conversion- Pyrolysis, Gasification, Liquefication, combustion.	10
	Utilisation of agro-residues for value-added products	Utilazation of agro-residues as adsorbents; Utilization of agro-residues for paper manufacture; Utilization of agro-residues for bio-diesel production; Utilization of agro-residues as building materials	11

Total = 42 Hrs.

Recommended Books:

1. Robert C. Brown. 2003. Bio-renewable Resources: Engineering New Products from Agriculture. Iowa state Press, Blackwell Publishing.
2. D. O. Hall, G. N. Barnard, and P. A. Moss, Biomass for energy in the developing countries, current roles, potential, problems, prospects, Pergamon Press Ltd.
3. L.P. White, L.G. Claskett, Biomass as Fuel, Academic Press
4. M. J. Kocurek, Pulp and Paper manufacture, Vol. 2, 3 & 4; TAPPI Publication.

Title of the Course : **Paint Technology** **L T P : 3 0 0**
Subject Code : **PECH-611B** **Weekly Load : 3 Hrs**
Course Category : **Professional Elective-1** **Credit : 3**

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

CO1	Classify paints for various applications
CO2	Discuss the properties of paints and the factors affecting them.
CO3	Appraise about applications of paints
CO4	Comprehend the safety and hazards aspects of paints

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	PO12	PSO1	PSO2
CO1	**M**					**M**	**M**			**W**	**M**		**M**	**S**
CO2	**S**	**M**				**M**	**M**						**M**	**M**
CO3	**S**	**M**	**M**	**W**				**W**		**M**	**S**	**W**	**S**	**W**
CO4	**M**	**M**		**M**		**S**	**M**	**W**		**W**	**S**	**W**	**W**	**M**

Unit	Main Topics	Course outlines	Lecture(s)
Unit-I	Introduction	Paints and their general ingredients, function of ingredients and classification of paints. Decorative and industrial coating, latest types of surface coating and their advantages.	04
	Raw Materials for Paints	Raw materials of Paints like drying oil boiled oils, natural and synthetic resins. Extends and prime pigments and additives.	04
	Varnishes and Lacquers	Classification of varnishes and lacquers. Formulation and manufacture of varnishes and lacquers.	06
	Paint Manufacturing	Formulation and manufacture of paints and machinery used in paint manufacture.	07
Unit-II	Paint Applications : Surface Preparation	Selection of industrial paints for different end uses. Practical aspects for use & application of paints. Type of surfaces and paint application techniques for large surfaces, Surface preparation and treatments, Surface Preparation (a) Mechanical - Hard cleaning, power tool cleaning, flame cleaning, Blast cleaning, cleaning & welds (b) Chemical - Solvent wiping & degreasing, alkali cleaning, emulsification.	07
	Application techniques	Paint application techniques. Paint defects: Classification, causes & remedies.	06
	Quality control of paints	Various tests of paints. Quality control and management of paints.	04
	Safety and Hazards	Safety practices and devices used in paint industries. Health hazards and prevention in paint industries. Case studies.	04

Total = 42 Hrs.

Recommended Books:

1. W.M.Morgan, Outlines of Paint Technology
2. Swaraj Paul, Surface Coating Technology
3. Malshe & Sikchi, Basics of Paint Technology (Part I & II)
4. OCCA, Australia, Surface Coatings Vol. I & II

Title of the Course : **Polymer Science and Engineering** **L T P : 3 0 0**
Subject Code : **PECH-611C** **Weekly Load : 3 Hrs**
Course Category : **Professional Elective-I** **Credit : 3**

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

CO1	Comprehend various techniques to develop polymers and their processing for applications
CO2	Distinguish different polymerization reactions and their mechanisms/kinetics
CO3	Describe the viscoelastic behaviour of polymers with respect to their chemical structures and molecular weights

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	PO12	PSO1	PSO2
CO1	**S**	**M**	**M**				**W**					**M**	**S**	**M**
CO2	**S**	**M**	**M**	**W**		**W**							**M**	**M**
CO3	**S**	**M**		**W**					**W**	**M**	**M**		**M**	**M**

Unit	**Main Topics**	Course outlines	**Lecture(s)**
Unit-1	Introduction	Concepts of polymers, Classification of polymers , Poly dispersity , Functionality, Solubility parameter, Glass transition temperature,	04
	Molecular Weight (MW) and its Determination	Average molecular weight and its distribution, Methods of MW measurement such as End group analysis, Colligative properties, Light scattering, Osmometry and Sedimentation	04
	Chain Growth polymerization	Chemistry of free radical, anionic, cationic , coordination polymerization, Co polymerization, Kinetics of free radical polymerization	05
	Step Growth Polymerization	Carother's equation, Chemistry and kinetics of step growth polymerization, Cross linking and Gelation	04
	Methods of Polymerization	Design criterion for a polymerization system, Bulk, Solution, Suspension, Emulsion polymerization	04
Unit-II	Basics About Polymer Processing	Selection of polymer process, Viscosity and polymer processing, Non Newtonian flow, K value, Melt Flow Index, Polymer compounding	04
	Molding Techniques For Thermoplastics	Extrusion, Injection Molding, Blow Molding, Rotational Molding, Thermoforming, Calendaring	04
	Molding Techniques for Thermo sets	Compression and Transfer molding	04
	Processing of Reinforced Plastics	Hand layup, Spray up, Filament winding, Pultrusion, Pressure/ Vacuum bag molding, Auto clave molding , Resin transfer molding	04
	Misc. Polymer Processing Techniques	Gas injection molding, Casting, Reaction injection molding, Spinning techniques of fiber, Finishing, Fastening and joining of plastics, Decorating & printing of plastic parts	05

Total=42 hrs

Recommended Books:

1. Premamoy Ghosh, Polymer Science and Technology, Tata McGraw Hill
2. Gowarikar, Polymer Science Wiley Eastern
3. DH Morton Jones Polymer Processing
4. Joel Frados Plastics Engineering Handbook VanNostrand Reinhold Company Publication
5. Shishir Sinha,Vinay Kumar Polymeric Systems and Applications

Computational Fluid Dynamics **L T P : 3 0 0**

Title of the Course :

Subject Code : PECH-611D **Weekly Load : 3 Hrs**

Course Category : Professional Elective-1 **Credit : 3**

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

CO1	Understand the basic concept of CFD.
CO2	Distinguish various discretization techniques with their advantages and disadvantages
CO3	Understand the use of conservation equation in the application of CFD.
CO4	Develop the ability for selecting the suitable techniques for CFD.
CO5	Understanding the application of CFD in chemical process industries.

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**	**PO12**	**PSO1**	**PSO2**
CO1	**S**		**M**		**M**				**M**	**W**	**S**	**M**	**W**	**M**
CO2	**S**	**S**	**M**	**W**		**W**					**S**	**W**	**S**	**W**
CO3		**S**	**M**		**M**					**W**	**M**		**M**	**M**
CO4	**M**		**S**	**M**			**W**	**W**		**S**	**M**	**M**	**S**	**S**
CO5	**S**	**S**	**S**	**M**	**S**		**M**	**W**	**M**	**S**	**S**		**M**	**W**

Unit	Main Topics	Course Outlines	Lectures
Unit-1	Introduction	Basic Concepts and Equations of Fluid Dynamics; Basic Concepts, Continuum model of a fluid, Kinematics, Steady and unsteady flow, Description of fluid motion by Lagrangian method, Eulerian method.	05
	Modelling Equation	Acceleration of a fluid particle, Forces acting on a fluid particle, Laws governing fluid motion, derivation of governing equation, continuity equation, Navier-Stokes equation and its derivation, Energy equation, Equations of motion in conservation and vector forms. Euler's equation. Reynold's equation for turbulent flow: Averaging procedure, Mass weighted averaging, Reynold's form of continuity, momentum and energy equation, Boundary layer equations, Mathematical behaviour of Governing equations in CFD	09
	Solution Techniques	Comparison of various numerical techniques for CFD, Review of finite difference and finite element methods; Solution to discretised algebraic equation. Finite-volume method for diffusion problems; Finite-volume method for convection and diffusion problems-pressure velocity coupling.	10
Unit-2	Simulation of Governing Equation	Construction of geometry and discretion using Fluent, annuals, Simulation of Incompressible Flow using Lattice-Boltzmann Method; CFD for Process Equipment Application; Modelling of some physical phenomena encountered in chemical process industries.	10
	Commercial CFD solvers	Turbulence modelling; Implementation of boundary conditions, Introduction to multiphase flow, Customizing commercial CFD solver, Unsteady state simulations.	08

Total = 42 Hrs.

Recommended Books :

1. Anderson, J.D., Computational Fluid Dynamics: The Basics with Application. McGraw-Hill Co. Inc.
2. Anderson, D.A., Tannehill, J.C. and Pletcher, R.H., Computational Fluid Mechanics and Heat Tranasfer, Hemisphere Publishing Corporation.
3. Versteeg, H.K. and Malalasekera, W., An Introduction to Computational Fluid Dynamics: The Finite Volume Method, Prentice-Hall Inc.

Title of the Course :	**Reaction Engineering Lab**	**L T P : 0 0 2**
Subject Code :	**PCCH-613**	**Weekly Load : 2 Hrs**
Course Category :	**Professional Core**	**Credit : 1**

Course outcomes: At the end of the course, the students will

CO1	Understand the basic concepts of chemical reaction engineering.
CO2	Attain a sound working knowledge on different types of reactors.
CO3	Analyze the performance of reactors and determine kinetics of chemical reactions progressed in 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	PO12	PSO1	PSO2
CO1	S	S					W	M	S	S	M	S	M	M
CO2	S	M	M	M			W	M	S	S	M	S	M	M
CO3	S	M	M	M			W	M	S	S	M	S	M	M

Lists of Experiments :

1. To determine the order of reaction (n) and the reaction rate constant (k) for the given saponification reaction in an isothermal batch reactor.
2. To perform kinetic studies to established rate constant (K) using a series of reactors i.e. PFR followed by a CSTR.
3. To determine the kinetic constants k, n for saponification of ethyl-acetate with NaOH in isothermal CSTR at room temperature.
4. Study of RTD (Residence time distribution) in packed bed reactor by experiment & also plot Exit Age Distribution E.
5. To determine the rate constants k, and order of reaction, n in plug flow reactor.
6. To determine the rate constant (k) for a 2nd order saponification reaction of ethyl acetate in aqueous NaOH solution in isothermal Semi-Batch Reactor.
7. To determine the space time τ_1, τ_2 and τ_3 of CSTR's in series (Cascade CSTR) & also evaluate kinetic constants (k, n) at ambient temperature.
8. Study of catalytic homogenous reaction in a batch reactor under adiabatic condition.
9. Study the effect of temperature on kinetic parameters k, n in isothermal batch reactor.
10. Study the effect of temperature on kinetic parameters k, n in isothermal CSTR.
11. Study the effect of temperature on kinetic parameters k, n in isothermal Plug flow reactor.
12. Study the effect of temperature on kinetic parameters k, n in isothermal Semi-batch reactor.

Note: Minimum 08 Experiments have to be conducted.

1.

Title of the Course : **Transport Phenomena** **L T P : 3 1 0**
Subject Code : **PCCH-621** **Weekly Load : 4 Hrs**
Course Category : **Professional Core** **Credit : 4**

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

CO1	Analyze the chemical and physical transport processes and their mechanism.
CO2	Solve industrial problems with appropriate approximations and boundary conditions.
CO3	Develop steady and time dependent solutions along with their limitations.

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	PO12	PSO1	PSO2
CO1	**S**	**M**	**M**	**M**			**W**			**M**	**S**		**M**	**M**
CO2	**S**	**S**	**S**	**M**	**M**			**M**	**M**	**M**	**M**	**W**	**M**	**M**
CO3	**M**	**M**	**M**	**M**	**M**		**W**			**M**	**W**		**M**	**M**

Theory:

Unit	Main Topics	Course Outlines	Lectures
Unit-I	Introduction to Transport Phenomena	Transport Phenomena and Unit Operation, Equilibrium and Rate Processes, Fundamental variables and units, The analogy between Heat, Mass & Momentum Transfer, Concept of Thermal Conductivity, and Diffusion Coefficient & Viscosity.	10
	Momentum Transport	Viscosity & Mechanism of Momentum Transport, Newton‘s Law of Viscosity, Non-Newtonian Fluids, Pressure & Temperature dependence of viscosity, Velocity distributions in laminar flow: Shell momentum balance, Flow of a falling film, Flow through a circular tube, flow through an annulus, Adjacent flow of two immiscible fluids, Creeping flow around a solid sphere, Equation of Change for isothermal system, Equation of continuity, equation of motion, equation of mechanical energy.	10
Unit-II	Energy Transport	Thermal conductivity and mechanism of energy transport. Fourier‘s Law of Heat Conduction, Temperature & Pressure dependence of thermal conductivity in Gas and Liquids. Temperature distribution in solids and in Laminar Flow, shell energy balance, Heat conduction with an electrical Heat source, Heat conduction with a nuclear heat source, Heat conduction with a viscous heat source, heat conduction with a chemical heat source, Heat conduction through composite walls (addition of resistances), Heat conduction in a cooling fin.	11
	Mass Transport and Transport Property	Diffusivity and Mechanisms of Mass transport, definition of concentration velocities, Mass fluxes, Fick‘s law of diffusion, temperature and pressure dependence of mass diffusivity. Concentration distribution in solids and in Laminar flow, shell mass balance, diffusion through a stagnant gas film, diffusion with homogenous chemical reaction, diffusion with heterogeneous chemical reaction, Measurement of Transport properties, viscosity measurement, Thermal conductivity measurement, diffusion coefficient measurement. Non-Newtonian phenomena: (a) Rheological characteristics of materials, Time independent behaviour, Time dependent behaviour, visco-elastic behaviour. (b) Rheological measurement, capillary viscometer, Rotational viscometers.	11

Total = 42 Hrs.

Recommended Books:

1. Transport Phenomena, by R. Byron Bird, Warren E. Stewart and Edwin N Lightfoot, 2nd Edition, Wiley, 2001.
2. Transport Processes and Unit operations, by Christie John Geankoplis, 4th Edition, PHI Learning Private Limited., New Delhi.
3. Transport Phenomena Fundamentals", by Joel Plawsky, CRC Press, 2nd edition, Taylor and Francis Group, New York.
4. Introduction to Transport Phenomena, by William J. Thomson, Pearson Education Asia, Delhi, 2001.
5. Fundamentals of Momentum, Heat and Mass Transfer, by J. R. Welty, C. E Wicks and R. E. Wilson, 3rd Ed., 1984.
6. Fundamentals of Heat and Mass Transfer, by Frank P. Incropera, David P. DeWitt, 6th edition, John Wiley & Sons (Asia) Pvt. Ltd.

Title of the Course : **Chemical Reaction Engineering – II** **L T P : 3 0 0**
Subject Code : **PCCH-622** **Weekly Load : 3 Hrs**
Course Category : **Professional Core** **Credit : 3**

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

CO1	Understand and analyze non ideal flow patterns in real reactors.
CO2	Appraise the kinetics of non-catalytic solid fluid reactions and apply them in preliminary design.
CO3	Appraise the kinetics of non-catalytic fluid-fluid reactions and apply them in preliminary design.
CO4	Appraise the kinetics of solid catalyzed reactions and apply them in preliminary 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	PO12	PSO1	PSO2
CO1	**S**	**M**	**M**	**M**	**W**				**W**	**W**			**M**	**M**
CO2	**S**	**M**	**M**	**M**						**W**			**M**	**M**
CO3	**S**	**M**	**M**	**W**	**W**		**M**			**W**			**W**	**M**
CO4	**M**	**M**	**M**	**W**		**W**			**M**	**W**		**W**	**M**	**W**

Unit	Main Topics	Course Outlines	Lectures
Unit-I	Non- ideal flow reactors	Residence time distribution of fluid in vessels; ideal reactors and real reactors. Experimental determination of RTD; pulse and step tracer input. The convolution integral. Properties of RTD function. Conversion from RTD. Models for non-ideal flow, dispersion model (dispersed plug flow)	**10**
	Non-catalytic solid fluid reactions	Kinetics of industrially important non-catalytic solid fluid reactions. The shrinking core model; process steps and deduction of rate law. Rate controlling step and limiting cases. Process parameters. Concept of enhancement factor; dominant resistance in overall rate	**11**
Unit-II	Non-catalytic fluid-fluid reactions	Concept of reactive absorption and reactive extraction and their industrial applications. Process steps and deduction of rate law. Comparison with straight mass transfer. Enhancement factor; determination and use in kinetics.	**10**
	Fluid solid catalytic reactions	Classification of catalysts, preparation and physical characteristics of solid catalysts, concept of physical and chemical adsorption, kinetics of solid catalyzed gas phase reaction, Langmuir-Hinshelwood rate equation. Design and performance evaluation of fixed-bed catalytic reactors.	**11**

TOTAL = 42Hrs

Recommended Books :

1. Ghatak, H.R., Reaction Engineering Principles, CRC Press, Taylor and Francis Group
2. Levenspiel, O., Chemical Reaction Engineering, Wiley
3. Fogler, H.S., Elements of Chemical Reaction Engineering, Prentice Hall
4. Hill, G.C.; and Root, T.W., Introduction to Chemical Engineering kinetics and Recator Design, Wiley
5. Schmal. M., Chemical Reaction Engineering: Essentials, Exercises, and Examples, CRC Press, Taylor and Francis Group

Title of the Course : **Agro Residue Utilization** **L T P : 3 0 0**
Subject Code : **OECH-621A** **Weekly Load : 3 Hrs**
Course Category : **Open Elective-3** **Credit : 3**

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

CO1	Classify and appraise about the use of agro-residues
CO2	Analyze the characteristics of agro-residues for utilization and sustainability
CO3	Appraise the technologies and processes for effective utilization of agro-residues

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	PO12	PSO1	PSO2
CO1		**M**				**S**	**S**	**M**						
CO2	**S**	**M**	**M**	**M**		**M**	**S**	**M**		**M**	**M**			
CO3	**S**	**M**				**M**	**M**	**M**		**M**	**M**			

Unit	**Main Topics**	Course outlines	**Lecture(s)**
Unit-1	Production and utilization scenario of agro-residue	Availability of different agro residues in India and other countries; Agro-residues as bio-renewable materials; Current utilization scenario at national and international level; Introduction to Conversion technologies– biochemical, thermochemical, chemical and physical.	10
	Constituents of agro residue and production of combustible materials	Physical and chemical characteristics of various agro-residues available in India; Important constituents and their possible uses in industries; The similarity and difference among different agro-residues; Charcoal production, Briquetting; Bio-gas generation technologies for fuel.	11
Unit-II	Processing of biomass	Biochemical Conversion- Anaerobic digestion to methane, Ethanol fermentation; Thermo-chemical Conversion- Pyrolysis, Gasification, Liquefication, combustion.	10
	Utilisation of agro-residues for value-added products	Utilization of agro-residues as adsorbents ; Utilization of agro-residues for paper manufacture; Utilization of agro-residues for bio-diesel production; Utilization of agro-residues as building materials	11

Total = 42 Hrs.

Recommended Books:

1. Robert C. Brown. 2003. Bio-renewable Resources: Engineering New Products from Agriculture. Iowa state Press, Blackwell Publishing.
2. D. O. Hall, G. N. Barnard, and P. A. Moss, Biomass for energy in the developing countries, current roles, potential, problems, prospects, Pergamon Press Ltd.
3. L.P. White, L.G. Claskett, Biomass as Fuel, Academic Press
4. M. J. Kocurek, Pulp and Paper manufacture, Vol. 2, 3 & 4; TAPPI Publication.

Title of the Course : **Corrosion Engineering** **L T P : 3 0 0**
Subject Code : **OECH-621 B** **Weekly Load : 3 Hrs**
Course Category : **Open Elective-III** **Credit : 3**

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

CO1	To understand the principles of corrosion and engineering methods used to reduce and prevent the corrosion.
CO2	Appraise the engineering problems and solve these problems involving various types of corrosion.
CO3	Selection of corrosion resistant materials for a given application.
CO4	Selection of appropriate techniques for corrosion prevention.

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	PO12	PSO1	PSO2
CO1	**M**	**S**	**M**		**W**	**M**	**M**		**M**		**S**			
CO2		**M**	**W**		**W**	**M**			**M**		**M**			
CO3	**M**	**M**	**W**			**W**								
CO4	**M**	**S**			**W**	**W**					**M**			

Unit	**Main Topics**	Course outlines	**Lecture(s)**
Unit-I	Basic concepts	Definition and importance, Electrochemical nature and forms of corrosion, Corrosion rate and its determination.	03
	Electrochemical thermodynamics and kinetics	Electrode potentials, Potential-pH (Pourbiax) diagrams, Reference electrodes and experimental measurements, Faraday's laws, Instrumentation and experimental procedure.	04
	Galvanic and concentration cell corrosion	Basic concepts, Experimental measurements, and determination of rates of galvanic corrosion, Concentration cells.	04
	Corrosion measurement through polarization techniques	Tafel extrapolation plots, Polarization resistance method, Commercial corrosion probes, Other methods of determining polarization curves.	04
	Passivity	Basic concepts of passivity, Properties of passive films, Experimental measurement, Applications of Potentiostatic Anodic Polarization, Anodic protection	04
Unit-II	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.	05
	Environmental induced cracking	Stress corrosion cracking, Corrosion fatigue cracking, Hydrogen induced cracking, Methods of prevention and testing, Erosion, Fretting and Wear.	05
	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.	05
	Atmospheric and elevated temperature corrosion:	Atmospheric corrosion and its prevention, Oxidation at elevated temperatures, Alloying, Oxidizing environments.	05
	Prevention and control of corrosion:	Cathodic protection, Coatings and inhibitors, Material selection and design.	03
		Total	**42**

Recommended Books:

1. Fontana, M.G., Corrosion Engineering, 3rd Ed., Tata McGraw-Hill, 2008.
2. Jones, D.A., Principles and Prevention of Corrosion, Prentice-Hall, 1996.
3. Pierre R. Roberge, Corrosion engineering: principles and practice, McGraw-Hill, 2008.
4. Sastri, V.S., Ghali, E., El boujdaini, M., Corrosion prevention and protection: Practical solutions, John Wiley and Sons, 2007.

Title of the Course : **Industrial Pollution Control** **L T P : 3 0 0**
Subject Code : **OECH-622A** **Weekly Load : 3 Hrs**
Course Category : **Open Elective-4** **Credit : 3**

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

CO1	Characterize liquid, solid, and gaseous pollutants emanating from different industries
CO2	Understand the working principles of physical, chemical, and biological treatment of wastewater and use them in preliminary design
CO3	Understand and apply air pollution mitigation strategies through meteorological factors and control devices
CO4	Understand the working principles of different solid waste treatment and disposal techniques and use them in preliminary 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	PO12	PSO1	PSO2
CO1		**M**		**M**	**W**	**M**	**S**	**M**	**W**			**W**		
CO2	**S**	**M**	**M**		**W**		**M**		**M**			**W**		
CO3	**S**	**M**	**S**	**M**	**W**				**W**			**M**		
CO4	**S**	**S**	**M**	**M**	**W**	**M**	**S**		**M**			**S**		

Unit	**Main Topics**	Course outlines	**Lecture(s)**
Unit-1	**Introduction**	Pollution due to industries with reference to chemical process industries.	04
	Wastewater characterization	Solids analysis of wastewater. Physical characteristics of wastewater. Chemical characteristics of wastewater; inorganic pollutants, organic pollutants; their harmful effects. Waste water discharge standards and regulations.	08
	Wastewater treatment	Primary treatment of wastewater; Flow equalization, Primary clarifiers, construction and working. Secondary treatment of wastewater; biological treatment methods; aerobic suspended growth processes, attached growth processes. Working of aerobic lagoons, activated sludge process, trickling filters. Wastewater treatment by adsorption, membrane separation.	08
Unit-II	Air pollutants	Natural and anthropogenic sources of air pollutants such as particulates, oxides of sulphur, oxides of nitrogen, carbon monoxide, hydrocarbons etc. Secondary air pollutants. Environmental impacts of air pollutants. Ambient and emission standards for air pollutants.	06
	Meteorological factors in Air pollution	Atmospheric turbulence. Lapse rate and atmospheric stability. Wind velocity and distribution, windrose diagram. Plume behaviour.	06
	Air pollution control	Air pollution control devices; settling chambers, cyclone separators, bag filters, electrostatic precipitators; construction and working. Control of gaseous pollutants.	06
	Solid waste management	Biochemical treatment. Thermo-chemical treatment. Land-filling.	04

Total = 42 hrs

Recommended Books:

1. Metcalf & Eddy, Wastewater Engg. Treatment, Disposal, Reuse, Tata McGraw Hill
2. M.Crawford, Air Pollution Control Engg, Tata McGraw Hill
3. N. Schobanoglous, Environmental Engg, John Wiley and Sons
4. N.L. Nemerow, Liquid wastes of industry, Addision Wesley Pub.co.

Title of the Course : **Energy Audit and Management** **L T P : 3 0 0**
Subject Code : **OPCH-622B** **Weekly Load : 3 Hrs**
Course Category : **Open Elective-4** **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	Comprehend 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	PO12	PSO1	PSO2
CO1		**M**	**M**			**M**	**M**					**S**		
CO2						**S**	**M**				**M**			
CO3	**S**	**S**	**S**	**S**	**M**	**M**	**M**		**M**		**M**	**M**		
CO4	**S**	**S**			**M**		**M**		**M**		**M**			

Unit	**Main Topics**	**Course outlines**	**Lecture(s)**
Unit-1	Energy scenario and basics of Energy Audit	Primary and Secondary Energy, Conventional and non-conventional energy, 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, Basic concepts of cogeneration.	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, a 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	07

		conservation opportunities in pumping system.	
	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.	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. Guide book for National Certification Examination for Energy managers and Auditors- Book 1 to 3, Bureau of Energy efficiency, 2005.

Title of the Course : **Pulping and Bleaching Technology** **L T P : 3 0 0**
Subject Code : **PECH-621A** **Weekly Load : 3 Hrs**
Course Category : **Professional Elective-2** **Credit : 3**

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

CO1	Understand different chemical and high yield pulping processes used in paper industry
CO2	Understand different bleaching processes used in paper industry
CO3	Design and optimize operating condition of brown stock washing equipments
CO4	Comprehend safety and environmental impacts of pulping and bleaching.

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	PO12	PSO1	PSO2
CO1	**S**	**M**	**M**				**M**		**W**			**M**	**M**	**S**
CO2	**S**	**M**	**M**	**W**		**M**	**S**					**M**	**M**	**S**
CO3	**S**	**S**	**S**	**M**					**W**			**M**	**M**	**S**
CO4	**S**	**M**				**M**	**M**					**M**	**W**	**S**

Unit	**Main Topics**	Course outlines	**Lecture(s)**
Unit-1	Introduction	Pulping and bleaching processes in the context of papermaking.	06
	Chemical Pulping	The soda process; its advantages and disadvantages. The kraft process. Composition of kraft pulping liquors; different industrial terms. Alkaline pulping reactions. Pulping process parameters; active alkali charge, chip size, liquor to wood ratio, time to temperature, time at temperature. The 'H' factor and Kappa number. Additives like anthraquinone, polysulfide. Study of the batch and continuous versions. Construction and working of different types of digesters.	08
	High Yield Pulping	Introduction to Mechanical pulping; refiner mechanical pulping and its variations, principle and operation of refiners. Thermo mechanical pulping. CRMP processes. The cold soda process, sulfite based semi chemical pulping process. Peroxide based CRMP processes.	08
Unit-II	Brown stock washing	Importance of washing & details of washing processes, lignin removal in washing, brown stock washing systems, performance of washers, Displacement ratio, Norden efficiency, dilution factor, washing losses, washing equipments.	10
	Pulp bleaching and Environmental Aspects	Role of bleaching in paper making for different grades of paper. Chemistry of bleaching & its measurement (brightness, brightness reversion); Single and multistage bleaching processes; chlorination, extraction, hypochlorite, chlorine dioxide, oxygen, ozone, peroxide bleaching stages. Bleaching for non-wood fibres & secondary fibers. Brief study of Biobleaching. Safety aspects. Environmental impacts of pulping and bleaching	10

Total=42 hrs

Recommended Books:

1. M.J. Kocurrek, Pulp & Paper manufacture Vo.1,3,4 & 5, TAPPI Publication
2. J.P. Casey, Pulp and Paper chemistry and chemical Technology, Wiley
3. Dence, Bleaching of pulp, TAPPI Publication
4. G.A. Smook, Handbook for pulp and paper tech, TAPPI Publication

Title of the Course : Biochemical Engineering **L T P : 3 0 0**
Subject Code : PECH-621B **Weekly Load : 3 Hrs**
Course Category : Professional Elective-2 **Credit : 3**

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

CO1	Present unit operations together with the fundamental principles for basic methods in production technique for biochemical based products.
CO2	Calculate and analyse the kinetic parameters for microbial growth and enzymatic reactions.
CO3	Calculate the need for oxygen and oxygen transfer in a biological production process
CO4	Give an account of important microbial industrial processes and fermenter 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	PO12	PSO1	PSO2
CO1	**M**	**S**		**M**		**M**	**S**	**M**	**M**	**M**		**S**	**S**	**S**
CO2	**M**	**S**	**S**	**S**	**M**	**M**	**M**	**S**		**W**		**S**	**S**	**S**
CO3	**S**	**S**	**S**	**S**		**M**	**M**	**M**		**W**			**S**	**S**
CO4	**S**	**M**	**W**		**M**	**M**	**M**	**M**		**W**	**M**	**M**	**S**	**S**

Theory

Unit	Main Topics	Course outlines	Lecture(s)
Unit-1	Introduction to Biochemical Engineering	Historical background, interdisciplinary approach, Integrated bioprocess systems, Unit Operations in Bioprocess, Diversity in Microbial Cells, Cell Constituents, Chemicals for Life.	04
	Microbial Growth Kinetics	Fermentation and its classification, Growth-cycle phases (for batch cultivation), Continuous culture, Biomass production in cell culture, Mathematical modeling of batch growth, Product synthesis kinetics, Overall kinetics and thermal death kinetics of cells and spores.	06
	Kinetics of Enzyme Catalysis.	Enzyme Kinetics with one or two substrates, modulation and regulation of enzyme activity, Industrial application of enzymes.	05
	Immobilized Enzymes	Immobilization Techniques, Effects of intra and inter-phase mass transfer on enzyme kinetics.	06
Unit-II	Bioreactors	Classification and characterization of different bioreactors e.g. batch and continuous, mechanically and non-mechanically agitated, CST type, tower, continuous, rotating, anaerobic etc., Design and analysis of Bioreactors - batch reactor, CSTR and plug flow reactor	08
	Transport Phenomenon in Bioprocess Systems	Agitation and aeration-gas-liquid mass transfer, oxygen transfer rates, determination of kLa, Heat balance and heat transfer correlations-sterilization etc.	08
	Basic Outline of downstream fermentation process and purification of fermentation products	Introduction, Range of fermentation process, Components of fermentation process, Disruption of cells, precipitation, filtration, Centrifugation, Liquid-Liquid Extraction, Chromatography, Membrane processes, Drying, Crystallization	06

Total = 42 hrs

Recommended Books:

1. Biochemical Engineering Fundamentals by J.E. Bailey & D. F. Ollis, McGraw Hill Book Company, 1986.
2. Shuler M., Kargi F., Bioprocess Engineering: Basic Concepts, PHI (2012).
3. Doran, P.M Bioprocess Engineering Principles, Academic Press (2012)
4. Aiba, S., Humphrey, A.E and Millis, N.F., Biochemical Engineering, Academic Press (1973)
5. Weith, John W.F., Biochemical Engineering - Kinetics, Mass Transport, Reactors and Gene Expression, Wiley and Sons Inc. (1994).
6. Stanbury P. F., Whittaker, A. and Hall, S. J., Principles of Fermentation Technology, Butterworth-Heinemann (2007)
7. Biochemical Engineering by H. W. Blanch & D.S. Clark, Marcel Dekker, Inc., 1997.
8. Bioprocess Engineering (Basic Concepts) by M. L.Shuler & F.Kargi, Prentice Hall of India, 2003

Title of the Course : Polymer Technology **L T P : 3 0 0**
Subject Code : PECH-621C **Weekly Load : 3 Hrs**
Course Category : Professional Elective-1 **Credit : 3**

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

CO1	Learn the fundamentals used in the polymer industries
CO2	Better coordination will be there amongst the persons of mechanical engg and chemical engg since persons from these discipline are working together.
CO3	Applications of these materials will be sought in day to day life.

CO/PO Mapping : (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation):														
COs	**Program me Outcomes (POs)**													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	**S**	**S**	**M**	**M**	**M**	**-**	**-**	**M**	**S**	**S**	**-**	**S**	**M**	**M**
CO2	S	**S**	**M**	**M**	**-**	**S**	**W**	**S**	**S**	**S**	**-**	**M**	**M**	**M**
CO3	**M**	**M**	**S**	**S**	**S**	**S**	**M**	**S**	**S**	**S**	**M**	**S**	**-**	**M**

Unit	**Main Topics**	**Course outlines**	**Lecture(s)**
Unit-1	Polymer Chemistry	Concept of functionality and Poly dispersity, Classification of polymers, Average molecular weight averages and their measurement by Osmometry, Light scattering, Viscosity method, Ultracentrifugation, Methods of polymerization such as Bulk , Solution, Suspension and Emulsion, Mechanism and kinetics of free radical and chain growth polymerization reactions, Concept of Polymer degradation, Glass transition, and Crystallization melting temperatures.	10
	Polymer Testing	Identification of polymers, Polymer testing and Characterization, Mechanical properties tensile, flexural, compressive, fatigue, shear, hardness, Thermal properties: heat deflection temperature, Vicat softening temperature, coefficient of thermal expansion, Underwriter Laboratories (UL) temperature index, Low temperature brittleness test, Thermal analysis techniques: Thermo grave metric analysis (TMA), Thermo mechanical analysis (TMA), Differential scanning . calorimetry (DSC), Electrical properties	10
Unit-II	Polymer processing and Rheology:	Viscosity and Polymer processing, Melt flow index, Maxwell and Voigt models, Common additives used in polymers and mixing equipments, Processing techniques: Extrusion, Injection molding, Blow molding, Rotational molding, Compression molding and Calendaring, Spinning techniques for fibers. Common methods for fabrication of Composites, Introduction of Stretch blow moulding, Gas injection moulding, Common faults and remedies in processing	14
	Polymer applications	Application of polymers in electrical, automobile, agriculture and packaging, sports, electrical, sports, optical, marine, medical, aerospace fields	08

Total = 42 Hrs.

Recommended Books:

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

Title of the Course : Modeling and Simulation **L T P : 3 0 0**
Subject Code : PECH-621D **Weekly Load : 3 Hrs**
Course Category : Professional Elective-2 **Credit : 3**

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

CO1	Comprehend the important physical phenomena from the problem statement
CO2	Develop of process models based on conservation principles and process data
CO3	Demonstrate the model solving ability for various processes/unit operations
CO4	Simulate the chemical processes and different parts of the 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	PO12	PSO1	PSO2
CO1	**S**	**S**							**M**			**M**	**M**	**M**
CO2	**S**	**S**	**M**		**M**				**M**			**M**	**M**	**M**
CO3	**S**	**S**	**S**	**S**	**M**				**M**			**M**	**M**	**M**
CO4	**S**		**S**	**S**	**S**				**M**			**M**	**M**	**M**

Unit	Main Topics	Course outlines	Lectures
Unit-I	Fundamentals	Mathematical models for chemical engineering systems: Introduction, Use of mathematical models, Scope of coverage, Principles of formation, Fundamental laws, Continuity equation, Energy equation, Equations of motions, Transport equations, Equations of state, Equilibrium, Chemical kinetics.	4
	Numerical Methods (Iterative Convergence Methods)	Interval halving, Newton Raphson method, False Position, Explicit convergence method, weignsten, Muller method, Numerical integration algorithm; Euler method, Runga-Kutta Algorithm, Implicit methods.	5
	Models in Fluid Flow Operations	The continuity equation, Flow through Packed bed column, Laminar Flow in narrow Slit, Flow of Film on the outside of circular tube, Momentum fluxes for creeping flow in to slot.	6
	Model for Heat Transfer and other Equipments	Two heated tanks, double pipe heat exchanger, shell and tube heat exchanger, cooling towers Single effect and multi effect evaporators, agitated vessels, pressure change equipments, mixing process, fluid - solid operations.	7
Unit-II	Models for Mass Transfer Equipments	Flash distillation, differential distillation, and continuous binary distillation in tray and packed column, vaporizers, single phase and multiphase separation, multi-component separation, drying equipments, adsorption, absorbers and strippers. Batch liquid- liquid extraction, Mixer-Settler Extraction Cascades, Staged Extraction Columns.	7
	Models for Reaction Equipments	Batch reactor, Semi batch reactor, Continuous stirred tank reactor, Plug flow reactor, Slurry reactor, Trickle bed reactor, Bubble column reactor, Packed column reactor, Bioreactors, Reactors used in effluent treatments, Fluidized bed reactor.	6
	Simulation Examples	Gravity flow tank, Three CSTRs in series, Non-isothermal CSTR, Binary distillation column, Multi-component distillation column, Batch reactor, Biochemical reactors and absorption.	7

Total=42 hrs

Recommended Books:

1. B. Wayer, “Chemical Engineering Process Dynamics”, Prentice Hall.
2. Bequette, “Analysis and Simulation”, Prentice Hall.
3. Computational Methods for Process Simulation, W. Fred Ramirez.
4. Luyben W.L., “Process Modeling Simulation and Control for Chemical Engineers, McGraw Hill,
5. Davis M. E., “Numerical Methods and Modeling for Chemical Engineers”, Wiley, New York
6. Finlayson B. A., “Nonlinear analysis in Chemical Engineering”, McGraw Hill, New York, 1980.
7. Chapra S.C., R.P. Canale, “Numerical Methods for Engineers”, Tata-McGraw Hill Publications
8. Franks R.E.G., “Modeling and Simulation in Chemical Engineering”, Wiley Intrscience, NY
9. John Ingam, Irving J.Dunn., Chemical Engineering Dynamic Modeling with PC Simulation, VCH Publishers.
10. Kayode Coker A., Chemical Process Design, Analysis and Simulation, Gulf Publishing Company.
11. Himmelblau D., K.B. Bischoff, “Process Analysis and Simulation”, John wiley & Sons.
12. Wayne Blackwell, “Chemical Process Design on a Programmable Calculator”, McGraw Hill.

Title of the Course : Fuel cells **L T P : 3 0 0**
Subject Code : PECH-621E **Weekly Load : 3 Hrs**
Course Category : Professional Elective-2 **Credit : 3**

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

CO1	Understand the energy dynamics of fuel cell operation.
CO2	Comprehend the kinetics and current voltage relationship for fuel cell operation.
CO3	Understand the cell design for different types of fuel cells.
CO4	Select fuel cells for different applications.

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	PO12	PSO1	PSO2
CO1	**S**	**W**				**S**	**S**			**W**				**S**
CO2	**S**	**M**			**M**		**W**			**W**				**S**
CO3	**S**	**S**	**S**	**M**	**M**		**W**			**W**			**W**	**M**
CO4	**S**	**S**		**M**	**S**	**M**	**M**	**W**		**W**	**W**	**W**	**M**	**M**

Unit	**Main Topics**	**Course outlines**	**Lecture(s)**
Unit-1	Thermodynamics and electrochemistry of fuel cells	Electrochemical half cell reactions for different fuel cells. Free energy changes and enthalpy changes in fuel cell reactions; relationship with cell potential; Nernst equation for fuel cell. Effects of temperature and pressure. Overpotential; its different types and relationship with current density. Efficiency of fuel cell.	07
	Alkaline fuel cells	Reactions involved; and efficiency. The electrolyte; poisoning of electrolyte. Anion exchange membranes. Type of electrodes. Basis design and construction; static and flowing electrolyte types. Applications of alkaline fuel cells.	07
	PEM fuel cells	Reactions involved; and efficiency. Components of PEM fuel cell. Working of proton exchange membrane. Electrocatalysts for PEM fuel cells and the construction of electrodes. Gas diffusion. Applications of PEM fuel cells.	07
Unit-II	Solid oxide fuel cells	Reactions involved; and efficiency. Working of solid oxide or ceramic electrolyte; different materials used. Electrodes and the construction of cell; tubular and planar designs. Operating temperatures. Application of solid oxide fuel cells.	07
	Molten carbonate fuel cells	Reactions involved; and efficiency. Electrolyte and electrolyte support. Electrodes and the cell design. Internal reforming of fuel. Operating temperatures. Applications of molten carbonate fuel cells.	07
	Direct methanol fuel cells	Reactions involved; and efficiency. Electrolyte membrane and electrodes. Operating temperatures. Applications of direct methanol fuel cells.	07

Total = 42 Hrs.

Recommended Books:

1. Fuel Cell Systems Explained, J. Larminie and A. Dicks, 2nd Edition, John Wiley & Sons Inc., 2000.
2. PEM Fuel Cells Theory and Practice, Frano Barbir, Elsevier Academic Press, 2005.
3. Fuel Cell Technology Handbook, Gregor Hoogers, SAE International, 2003.
4. Fuel Cell Principles and Applications, B Viswanathan and M A. Scibioh, Universities Press, 2006.

Title of the Course : Design and Simulation Lab **L T P : 0 0 2**
Subject Code : PCCH-623 **Weekly Load : 2Hrs**
Course Category : Professional Core **Credit : 1**

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

CO1	demonstrate ability to reduce of models into set of equations solvable by numerical methods
CO2	understand and develop the simulation techniques for solving mathematical models of chemical engineering processes
CO 3	Exhibit the skill of writing the code and usage of software for simulating Chemical engineering problems by means of computer programming.
CO4	Handle the design of various typical chemical based equipment like heat exchangers, distillation columns etc.

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	PO12	PSO1	PSO2
CO1	**M**	**M**	**M**		**S**			**W**	**M**	**M**	**W**	**M**		**W**
CO2	**M**	**M**	**W**		**S**			**M**	**M**	**M**	**M**		**M**	**W**
CO3	**M**	**M**	**M**	**S**	**S**		**M**		**M**	**M**	**S**		**M**	**M**
CO4	**M**		**S**	**S**	**M**		**S**	**M**	**M**	**S**	**S**	**M**	**M**	**S**

List of Experiments:

1. Modelling & Simulation of single CSTR, from the data taken from the standard literature.
2. Modelling & Simulation of open loop CSTRs in series, from the data taken from the standard literature.
3. Modelling & Simulation of close loop CSTRs in series, from the data taken from the standard literature.
4. Modelling & Simulation of gravity flow tank, from the data taken from the standard literature.
5. Modelling & Simulation of counter current heat exchanger from the data taken from the standard literature.
6. Modelling & Simulation of Binary distillation column, from the data taken from the standard literature.
7. Modelling & Simulation of Multi-component distillation column, from the data taken from the standard literature.
8. Computer aided Design of Sieve tray distillation column.
9. Computer aided Design of Shell and tube Heat exchanger.

Note: Minimum 08 Experiments must be conducted.

Title of the Course :	**Chemical Process Industries**	**L T P : 3 0 0**
Subject Code :	**PCCH-711**	**Weekly Load : 3 Hrs**
Course Category :	**Departmental Core**	**Credit : 3**

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

CO1	Apply engineering knowledge to manufacturing processes of various inorganic and organic chemical products
CO2	Apply various unit operations and processes to the chemical industries
CO3	Understand the engineering problems and their remedies associated with manufacturing processes in chemical industries

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	PO12	PSO 1	PSO 2
CO1	**S**	**M**				**W**						**W**	**M**	**M**
CO2	**S**	**M**				**M**			**M**	**M**		**W**	**M**	**M**
CO3	**S**	**M**	**M**			**M**	**M**	**M**	**M**	**M**		**M**	**M**	**M**

Unit	**Main Topics**	**Course outlines**	**Lecture(s)**
Unit-I	1. Inorganic Acids	Manufacturing Process of sulphuric acid, Hydrochloric acid, Phosphoric acid and Nitric acid.	05
	2. Chlor alkali industries	Manufacturing of soda ash. Working of Diaphragm, Mercury and Membrane cells.	03
	3. Cement and Ceramics	Portland cement production. (details of manufacturing process with flow chart), Basic ceramic chemistry, Structural clay products, Refractories, Vitreous enamel, Kilns.	05
	4.Polymer Industry	Scope of Polymerization Industries, Types of polymerization, Manufacture of Polyethylene and Polypropylene, Nylon, Rubber	05
	5. Pulp and Paper	Scope of Pulp and paper industries, Manufacturing of pulp and manufacturing of paper	03
Unit-2	6. Oils & Fats	Methods of extracting vegetable oils, Refining and Hydrogenation of oils	03
	7.Pharmaceutical industries	Drug design, formulation, packaging (with flow diagram).	03
	8.Fermentation industry	Fermentation process, Manufacture of ethyl alcohol from molasses by fermentation.	03
	9.Sugar	Manufacture and refining of sugar	03
	10.Fertilizers	Major components of fertilizers and their significance, Manufacturing of Triple superphosphate (Wet process), Urea, Ammonium nitrate	05
	11.Soap & Detergents	Chemistry of soaps & detergents, types and manufacturing of soaps and detergents.	04

Total=42 hrs

Recommended Books:

1. Dryden, Outlines of Chemical Technology, East West Press
2. Shreves's Chemical Process Industries by George T. Austin, McGraw Hill
3. M. Gopala Rao, Marshall Sitting, Outlines of Chemical Technology, East West Press

Title of the Course :	**Process Instrumentation and Control**	**L T P : 3 1 0**
Subject Code :	**PCCH-712**	**Weekly Load : 4 Hrs**
Course Category :	**Professional Core**	**Credit : 4**

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

CO1	Comprehend and discuss the importance of process instrumentation & control
CO2	Have knowledge of various instruments for the measurements of process parameters
CO3	Implement dynamic models with or without controllers
CO4	Analyse properties (stability, speed of response, frequency response etc.) of dynamic models & processes
CO5	Design controllers and use of basic knowledge of advanced control strategies

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	PO12	PSO1	PSO2
CO1		**W**				**W**			**W**			**M**	**M**	**M**
CO2	**S**	**S**	**M**						**M**			**S**	**M**	**M**
CO3	**S**	**S**	**S**	**M**					**M**			**S**	**W**	**M**
CO4	**S**	**S**	**S**	**W**	**W**				**M**			**M**	**W**	**M**
CO5	**S**	**S**	**S**	**M**	**M**				**M**			**M**	**W**	**S**

Unit	**Main Topics**	**Course outlines**	**Lectures**
Unit-1	Temperature, Pressure and level Measuring Instruments	Importance of instruments in chemical process industries, classification of instruments, static and dynamic characteristics of instruments, Principle, construction and working of Resistance thermometer, thermocouple, optical and radiation pyrometer. Principle , construction and working of manometers, bourdon gauge, Macleod gauge, vacuum and pressure transducers, liquid level measurement.	08
	Miscellaneous measurements	Principle , construction and working of nucleonic devices , gas analysers, measuring instruments for viscosity, conductivity, humidity and pH, industrial weighing and feeding systems	04
	Dynamic behaviour of simple processes	Objectives of Chemical Process Control, Mathematical modeling of chemical processes, State variables and state equations, Input-Output model, Linearization of nonlinear systems, Types of Forcing functions, dead-time systems, Laplace transform of simple functions, transforms of derivatives, solution of differential equations, inversion by partial fractions: partial fractions First order systems/processes – Thermometer, Liquid level tank, Liquid level tank with constant outlet (pure capacitive), Dynamic response of first order system to sinusoidal, impulse and step inputs.	09
Unit-II	Design of single-loop feedback control systems	Second order systems/processes – Damped vibrator, Interacting and Non-interacting systems, Step response of second order system, Characteristics of under-damped system. Classical controllers - P, PI, PD, PID and ON- OFF controllers. Concept of feed-back control system, Servo & Regulatory problem, Block diagram reduction of complicated control systems, and Dynamic behaviour of feed-back control processes.	10
	Stability Analysis of feed-back	Notion of stability, Characteristic equation, stability analysis of feedback control system using Routh-Hurwitz criteria, Root locus.	

	systems		04
	Frequency response analysis of linear processes	Response of first order system to sinusoidal input, Frequency response characteristics of general linear system, Bode diagrams, Bode stability criteria, Gain margin, Phase Margin, Nyquist Stability criteria, Ziegler Nicholes Tuning technique	04
	Advanced control system	Cascade control, ratio control, feed forward control, Override control Cascade control for: jacketed CSTR, heat exchanger, distillation column.	03

Total=42 hrs

Recommended Books:

1. Eckman, D.P., Industrial instrumentation; Wiley eastern
2. Weber, Introduction to Process Dynamics and Control; John Wiley
3. George Stephanopoulos, Chemical Process Control, PHI publication
4. Donald R. Coughanour, Process System Analysis & Control, Mc Graw Hill
5. B. Wayne Bequette, Process Control – Modelling, Design & Control, PHI Publication
6. Dale E. Seborg, Thomal F. Edgar, Process Dynamics & Control, Dancan A. Mellichamp
7. Babatunde A. Ogunnaike, W. Harmon Ray, Process Dynamics, Modeling & Control, Oxford University Press
8. M. Chindambaram, Computer Control of Processes, Alpha Science Internatinal Ltd
9. Bella G. Liptak, Elsevier, Instrument Engineers Handbook (Process Control)

Title of the Course : Optimization Techniques for Engineers **L T P : 3 0 0**
Subject Code : OECH-711A **Weekly Load : 3 Hrs**
Course Category : Open Elective-5 **Credit : 3**

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

CO1	Understand the basic concept of engineering optimization.
CO2	Distinguish various optimization techniques with their advantages and disadvantages
CO3	Understand the flow pattern of parameters in multivariable optimization techniques
CO4	Developed the ability for selecting the suitable techniques for optimization of selected process parameters.
CO5	Understanding the application of these 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	PO12	PSO1	PSO2
CO1	**S**	**M**									**M**	**S**		
CO2	**S**				**S**				**M**	**W**	**M**	**M**		
CO3		**M**			**S**	**M**				**M**		**M**		
CO4		**S**	**M**	**M**		**M**	**S**	**S**		**M**	**S**			
CO5	**S**	**M**					**S**				**S**	**S**		

Unit	**Main Topics**	**Course Outlines**	**Lectures**
Unit-1	Introduction	Optimization and calculus based classical optimization techniques.	04
	One Dimensional Minimization 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.	08
	Linear Programming	Graphical representation, simplex and revised simplex methods, duality and transportation problems. Unconstrained- univariate method, Powell's method, simplex method, rotating coordinate method	08
Unit-2	Multivariable Non-Linear Programming	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.	08
	Dynamic Programming:	Multistage processes- acyclic and cyclic, suboptimization, principle of optimality and applications.	06
	Geometric Programming (GP)	Differential calculus and Arithmetic-Geometric inequality approach to unconstrained GP; Constrained GP minimization; GP with mixed inequality constraints and Complementary GP.	08

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.

Title of the Course : Polymer Technology **L T P : 3 0 0**
Subject Code : OECH-711B **Weekly Load : 3 Hrs**
Course Category : Open Elective-5 **Credit : 3**

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

CO1	Learn the fundamentals used in the polymer industries
CO2	Students will be encouraged to set up his own business related to plastics products
CO3	Better coordination will be there amongst the persons of mechanical engg and chemical engg since persons from these disciplines are working together.
CO4	New applications of these materials will be sought in day to day life.

CO/PO Mapping: (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation):														
COs	**Program me Outcomes (POs)**													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	**S**	**S**	**M**	**M**	**M**	**-**	**-**	**M**	**S**	**S**	**-**	**S**		
CO2	**S**	**S**	**S**	**S**	**M**	**S**	**-**	**S**	**S**	**S**	**S**	**M**		
CO3	S	**S**	**M**	**M**	**-**	**S**	**W**	**S**	**S**	**S**	**-**	**M**		
CO4	**M**	**M**	**S**	**S**	**S**	**S**	**M**	**S**	**S**	**S**	**M**	**S**		

Unit	**Main Topics**	**Course outlines**	**Lecture(s)**
Unit-1	Polymer Chemistry	Concept of functionality and Poly dispersity, Classification of polymers, Average molecular weight averages and their measurement by Osmometry, Light scattering , Viscosity method, Ultracentrifugation, Methods of polymerization such as Bulk , Solution , Suspension and Emulsion, Mechanism and kinetics of free radical and chain growth polymerization reactions, Concept of Polymer degradation, Glass transition and Crystallization melting temperatures.	10
	Polymer Testing	Identification of polymers, Polymer testing and Characterization, Mechanical properties tensile, flexural, compressive, fatigue, shear, hardness, Thermal properties: heat deflection temperature, Vicat softening temperature, coefficient of thermal expansion, Underwriter Laboratories (UL) temperature index, Low temperature brittleness test, Thermal analysis techniques: Thermo grave metric analysis (TMA), Thermo mechanical analysis (TMA), Differential scanning, calorimetry (DSC), Electrical properties	10
Unit-II	Polymer processing and Rheology:	Viscosity and Polymer processing, Melt flow index, Maxwell and Voigt models, Common additives used in polymers and mixing equipments, Processing techniques: Extrusion, Injection molding, Blow molding, Rotational molding, Compression molding and Calendaring, Spinning techniques for fibers. Common methods for fabrication of Composites, Introduction of Stretch blow moulding, Gas injection moulding, Common faults and remedies in processing	16
	Polymer applications	Application of polymers in electrical, automobile, agriculture and packaging, sports, electrical, sports, optical, marine, medical, aerospace fields	06

Total = 42 Hrs.

Recommended Books:

1. F. W. Billmeyer, Jr, Textbook of Polymer Science, John Wiley & Sons, New York,
2. Sinha S., Kumar V., Polymeric Systems and Applications, Studium Press, New Delhi.
3. Shah, V., Handbook of Plastics Testing Technology, John Wiely and Sons.
4. Morton - Jones, D.H. Polymer Processing, Chapman and Hall,

5. Chanda M, Roy, S.K., Plastics Technology Handbook, Marcel Dekker.

Title of the Course : Paper Technology **L T P : 3 0 0**
Subject Code : OECH-711C **Weekly Load : 3 Hrs**
Course Category : Open Elective-5 **Credit : 3**

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

CO1	Understand different paper making processes used in paper industry
CO2	Understand different pulping and paper making processes used in paper industry
CO3	Design and optimize operating condition of pulping, bleaching, stock and paper making process
CO4	Comprehend safety and environmental impacts of paper making 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	PO12	PO13	PO14
CO1	**S**	**M**	**M**				**M**						**M**	**S**
CO2	**S**	**M**	**M**				**S**						**M**	**S**
CO3	**S**	**S**	**S**	**M**								**M**	**M**	**M**
CO4	**S**	**M**				**M**	**M**					**M**	**S**	**S**

Unit	Main Topics	Course outlines	Lecture(s)
Unit-1	1. Introduction	Paper manufacturing processes, current paper production and consumption trends in India and other countries.	03
	2.Pulping Processes	Mechanical pulping; refiner mechanical pulping and its variations, thermo-mechanical pulping. CRMP processes. Chemical Pulping Processes like soda process, sulphite pulping process, Kraft process. Alkaline pulping reactions. Pulping process parameters; The 'H' factor and Kappa number. Study of the batch and continuous digesters. Construction and working of different types of digesters. Environmental & Safety aspects.	10
	3. Washing and Bleaching	Details of washing processes, brown stock washing systems, performance of washers, washing equipments. Chemistry of bleaching & its measurement. Single and multistage bleaching processes; Bio-bleaching and environment friendly processes and safety concerns.	08
Unit-II	4.Stock Preparation and Paper Making	Stock distribution and drainage, Approach flow system, head box type & role in paper making, Principle, working & calculation of different drainage elements on fourdrinier wire, Different types of paper machines (twin wire, top former etc.), Wire design & its type, Types & theory of pressing, Types of dryers, basic calculation on wire, press & dryer section.	10
	5.Chemical Recovery Process	Black liquor Properties, The recovery cycle of alkaline pulping. Impact of pulping on chemical recovery process. Black liquor evaporation; Process chemistry, types of recovery boiler and accessories, effect of design and operating parameters .Green liquor clarification, slaking & causticizing reactions, variables affecting its efficiency, Environmental & Safety requirements.	11

Total=42

Recommended Books:

1. M.J. Kocurrek, Pulp & Paper manufacture Vo.1,3,4 & 5,6,7,8 TAPPI Publication
2. J.P. Casey, Pulp and Paper chemistry and chemical Technology, Wiley
3. Green, R.P., and Hough, G. Chemical Recovery in Alkaline Pulping Processes TAPPI Press
4. G.A. Smook, Handbook for pulp and paper tech, TAPPI Publication

Title of the Course : **Novel Separation Techniques** **L T P : 3 1 0**
Subject Code : **PECH-711-A** **Weekly Load : 4 Hrs**
Course Category : **Professional Elective-3** **Credit : 4**

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 design novel membranes for various applications.
CO3	Analyze and design pervaporation, chromatography, ion exchange and dialysis 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	PO12	PSO1	PSO2
CO1	**S**	**S**				**S**	**S**					**M**	**S**	**S**
CO2	**S**	**S**	**S**	**S**									**S**	**S**
CO3	**S**	**S**	**S**	**S**		**W**	**W**		**W**				**S**	**S**

Unit	Main Topics	Course Outlines	Lectures
Unit-1	Introduction	Separation process in chemical and biochemical Industry, Categorization of separation processes, equilibrium and rate governed processes.	07
	New Separation Techniques	Introduction to various new separation techniques e.g. Membrane separation, Ion-exchange foam separation, supercritical extraction, liquid membrane permeation, PSA & Freeze drying.	07
	Membrane based Separation Techniques	Historical background, physical and chemical properties of membranes, Techniques of membrane preparation, membrane characterization, various types of membranes and modules.	07
Unit-II	Osmosis and osmotic pressure.	Working principle, operation and design of Reverse osmosis, Ultrafiltration, Microfiltration, Electrodialysis and Pervaporation. Gaseous separation by membranes.	06
	Ion Exchange	History, basic principle and mechanism of separation, Ion exchange resins, regeneration and exchange capacity. Exchange equilibrium, affinity, selectivity and kinetics of ion exchange. Design of ion exchange systems and their uses in removal of ionic impurities from effluents.	09
	Miscellaneous Separation Techniques	Introduction to foam separation, micellar separation, supercritical fluid extraction, liquid membrane permeation and chromatographic separation.	06

Total = 42 Hrs.

Recommended Books:

1. King, C.J., "Separation Processes", Tata McGraw-Hill.
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", Butterworths, Boston, 1985.
6. Munir Cherion, Ultrafilteration Handbook, Technomic Publishing.

Title of the Course : **Electrochemical Engineering** **L T P : 3 1 0**
Subject Code : **PECH-711B** **Weekly Load : 4 Hrs**
Course Category : **Professional Elective-3** **Credit : 4**

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

CO1	Analyze the electrochemical processes to ascertain their kinetic and thermodynamic behavior
CO2	Comprehend electrode preparation and characterization and their industrial applications.
CO3	Select and utilize appropriate electrode materials under optimized process conditions for industrial applications.

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**	**PO12**	**PSO1**	**PSO2**
CO1	S	M					M		W	W				M
CO2	S	M	W			M			W	W		W	W	M
CO3	S	S	S	M			M		W	W	W	W		M

Unit	**Main Topics**	**Course Outlines**	**Lectures**
Unit-1	Introduction	Electrochemistry basics; Thermodynamics of ideally polarizable and non-polarizable interfaces. Electrochemical cells; reversible and irreversible cells, EMF.	3
	Electrode kinetics	Equilibrium potential, Nernst equation, overpotential and its different types. Equilibrium exchange current density; Butler-Volmer equation; high field and low field approximations; charge transfer resistance and polarizability of the interface. Rate determining step, stoichiometric number, reaction order. Determination of kinetic parameters.	9
	Electro-analytical techniques	Potentiometry and amperometry. Linear sweep voltammetry and cyclic voltammetry. Analysis of cyclic voltammograms. Potential steps under mass transfer control; Cottrell equation for a planar and spherical electrode. Faradaic impedance	9
Unit-2	Electrodes and electrolytic membranes	Electrodes for the electrochemical reactors. Preparation, characteristics and applications of graphite, magnetite, lead dioxide coated anodes, noble metal coated anodes, noble metal oxide coated anodes, steel cathodes, coated cathodes, diaphragms and ion exchange membranes.	10
	Industrial applications	Chlor alkali industry. Manufacture of potassium and ammonium persulphates, hydrogen peroxide, potassium permanganate. Production of hydrogen by water electrolysis. Electrodialysis and electrochemical incineration. Batteries and fuel cells. Electrometallurgy.	11

Total = 42 Hrs.

Recommended Books:

1. Bockris, J.O.M.; and Reddy, A.K.N. Modern, Electrochemistry, Plenum Press
2. Bard, A.J., and Faulkner, L.R., Electrochemical Methods Fundamentals and Applications, Wiley
3. Scott, K., Electrochemical Reaction Engineering, Academic Press
4. Linden, D., and Reddy, T.B., Hand Book on Batteries and Fuel Cell, McGraw Hill
5. Pletcher, D., and Walsh, F.C., Industrial Electrochemistry, Chapman

Title of the Course : Polymer Composites **L T P : 3 1 0**
Subject Code : PECH-711C **Weekly Load : 4 Hrs**
Course Category : Professional Elective-3 **Credit : 4**

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

CO1	Learn the fundamentals used in the composite industries
CO2	Students will be encouraged to set up his own business
CO3	Better coordination will be there amongst the persons of material science, mechanical engineering and chemical engineering since persons from these disciplines are engaged in this work
CO4	New applications of these materials will be sought in building, automotive, sport and other industries.

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	PO12	PSO1	PSO2
CO1	**S**	**S**	**S**	**S**	**W**	**-**	**M**	**S**	**W**	**-**	**-**	**S**	**-**	**S**
CO2	**S**	**S**	**S**	**S**	**W**	**S**	**W**	**M**	**S**	**S**	**S**	**S**	**W**	**S**
CO3	S	**S**	**S**	**S**	**M**	**S**	**-**	**S**	**S**	**M**	**S**	**S**	**-**	**W**
CO4	**S**	**S**	**S**	**M**	**S**	**S**	**W**	**-**	**S**	**-**	**S**	**S**	**S**	**M**

Unit	**Main Topics**	**Course outlines**	**Lectures**
Unit-1	Introduction	Naturally available composites, Composites and need for the additive; Fibre reinforcement; long fibre vs short fibre; natural fibre reinforcement; Mineral powder filler; surface treatments, interfacial adhesion and coupling agents.	06
	Thermoplastics composites:	Important thermoplastics as polymer matrix, commonly used fillers, compatibility between thermoplastics and filler, effect of filler shape and size on the properties of composites, filler vs. fibre.	08
	Natural fibre reinforced composites	Properties of common cellulosic materials such as rice husk, wood flour, bagasse, hemp, flex, hemp, kneaf, pineapple, cotton, jute, banana fibres, chemical treatment of fibres, commonly used thermoplastic materials such as low density poly ethylene, High density poly ethylene, poly propylene, poly styrene	08
Unit-II	Thermoset composites	Important thermosetting resins (Polyester, epoxy, vinyl ester, PF, bismaleimide, polyamide etc.; fibres for reinforcements (glass, carbon, aramid, Kevlar ceramic, metallic) bulk moulding compound (BMC), sheet moulding compound (SMC), prepreg. Effect of fibre length and orientation on composite properties.	10
	Fabrication Methods:	Manual (Hand layup, 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.	06
	Polymer Alloy/ Blends	Blend, 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;	04

		development of thermoplastic alloys.	

Total = 42 Hrs.

Recommended Books:

1. C, Baillie, Green Composites, Wood head Publishing Limited.
2. M W Heyer, Stress analysis of fibre Reinforced Composite Materials, Tata McGraw Hill, N Delhi
3. F.N. Cogswell, Thermoplastic Aromatic Polymer Composites, Butterworth-Heinemann.
4. L. A. Ultracki, Polymer Alloys & Blends, Hanser Gardener Publications.
5. S.T. Peters, Handbook of Composites, Springer-Science- Business Media.
6. R. W. Dysen, Engg. Polymers, Chapman and Hall New York.

Title of the Course : **Industrial Pollution Control** **L T P : 3 1 0**
Subject Code : **PECH-711D** **Weekly Load : 3 Hrs**
Course Category : **Professional Elective-3** **Credit : 3**

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

CO1	Characterize liquid, solid, and gaseous pollutants emanating from different industries
CO2	Understand the working principles of physical, chemical, and biological treatment of wastewater and use them in preliminary design
CO3	Understand and apply air pollution mitigation strategies through meteorological factors and control devices
CO4	Understand the working principles of different solid waste treatment and disposal techniques and use them in preliminary 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	PO12	PSO1	PSO2
CO1		**M**		**M**	**W**	**M**	**S**	**M**	**W**			**W**	**M**	**S**
CO2	**S**	**M**	**M**		**W**		**M**		**M**			**W**	**M**	**S**
CO3	**S**	**M**	**S**	**M**	**W**				**W**			**M**	**M**	**S**
CO4	**S**	**S**	**M**	**M**	**W**	**M**	**S**		**M**			**S**	**M**	**S**

Unit	**Main Topics**	Course outlines	**Lecture(s)**
Unit-1	**Introduction**	Pollution due to industries with reference to chemical process industries.	04
	Wastewater characterization	Solids analysis of wastewater. Physical characteristics of wastewater. Chemical characteristics of wastewater; inorganic pollutants, organic pollutants; their harmful effects. Waste water discharge standards and regulations.	08
	Wastewater treatment	Primary treatment of wastewater; Flow equalization, Primary clarifiers, construction and working. Secondary treatment of wastewater; biological treatment methods; aerobic suspended growth processes, attached growth processes. Working of aerobic lagoons, activated sludge process, trickling filters. Wastewater treatment by adsorption, membrane separation.	08
Unit-II	Air pollutants	Natural and anthropogenic sources of air pollutants such as particulates, oxides of sulphur, oxides of nitrogen, carbon monoxide, hydrocarbons etc. Secondary air pollutants. Environmental impacts of air pollutants. Ambient and emission standards for air pollutants.	06
	Meteorological factors in Air pollution	Atmospheric turbulence. Lapse rate and atmospheric stability. Wind velocity and distribution, windrose diagram. Plume behaviour.	06
	Air pollution control	Air pollution control devices; settling chambers, cyclone separators, bag filters, electrostatic precipitators; construction and working. Control of gaseous pollutants.	06
	Solid waste management	Biochemical treatment. Thermo-chemical treatment. Land-filling.	04

Total = 42 hrs

Recommended Books:

1. Metcalf & Eddy, Wastewater Engg. Treatment, Disposal, Reuse, Tata McGraw Hill
2. M.Crawford, Air Pollution Control Engg, Tata McGraw Hill
3. N. Schobanoglous, Environmental Engg, John Wiley and Sons

4. N.L. Nemerow, Liquid wastes of industry, Addision Wesley Pub.co.

Title of the Course : Biorefineries **L T P : 3 1 0**
Subject Code : PECH-711E **Weekly Load : 4 Hrs**
Course Category : Professional Elective-3 **Credit : 4**

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

CO1	Comprehend the relevance of biorefineries as replacement for petroleum refineries.
CO2	Understand the availability, economics, and characteristics of different biomass sources.
CO3	Understand the process engineering of different types of biorefiberies.
CO4	Perform basic equipment design for different types of biorefiberies.

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	PO12	PSO1	PSO2
CO1		**M**				**S**	**S**	**M**		**W**		**W**	**S**	**S**
CO2		**M**			**M**	**S**	**S**	**M**		**W**	**M**	**M**	**S**	**S**
CO3	**S**	**S**		**M**	**M**	**M**	**S**		**W**	**W**			**S**	**S**
CO4	**S**	**S**	**S**	**M**	**S**	**M**	**M**		**W**	**W**			**M**	**M**

Unit	**Main Topics**	**Course outlines**	**Lecture(s)**
Unit-1	Introduction	Sustainability challenge for fossils based sourcing of energy and chemicals; global and national outlook. The definition of a biorefinery and classification.	04
	Biomass sources	Woody and non-woody biomass; perennial and annual biomass; aquatic and algal biomass. Overview of polysaccharide chemistry. Overview of lignin chemistry. Overview of protein and lipids chemistry. Morphology and physical structure of biomass sources.	08
	First generation bio refineries	Conversion of starchy biomass to first generation bioethanol. Transesterification of fats to biodiesel. Process chemistry; engineering aspects; equipments. Conflict with food security and resource utilization.	08
Unit-II	Second generation biorefineries	Conversion of lignocelluloses to second generation bioethanol; physical pre-treatment methods; acid hydrolysis; enzymatic hydrolysis; converted sugars to bioethanol. Process chemistry; engineering aspects; equipments. Lignin utilization. Biobutanol production.	08
	Thermochemical bio refineries	Thermochemical conversion processes for biomass; torrefaction; pyrolysis; gasification; hydrothermal treatment. Process chemistry; engineering aspects; equipments. Fischer Tropsch synthesis of biofuels.	08
	Marine bio refineries	Microalgae and macroalgae cultivation and harvesting. Biochemical and physiochemical processes. Product spectrum from algal biomass and value addition.	06

Total = 42 Hrs.

Recommended Books :

1. Biorefinery: From biomass to chemicals and fuels. Michele Aresta, Angela Dibenedetto, Franck Dumeignil. DeGruyter, 2012.
2. Platform Chemical Biorefinery. Satinder Kaur Brar, Saurabh Jyoti Sarma, Kannan Pakshirajan. 1st Edition, Elsevier, 2016.
3. Algal Biorefinery: An Integrated Approach. Debabrata Das (Ed.). Springer, 2015.
4. Integrated Biorefineries: Design, Analysis, and Optimization. Paul R. Stuart and M.M. El-Halwagi. CRC Press, 2012.

Title of the Course : **Molecular Simulation** **L T P : 3 1 0**
Subject Code : **PECH-711 F** **Weekly Load : 4 Hrs**
Course Category : **Professional Elective-3** **Credit : 4**

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

CO1	Understand how different models can be used to describe chemical reactions and chemical problems
CO2	Explain strengths and weaknesses of different models (molecular mechanics, semi-empirical, wave function based and density functional theory).
CO3	Apply the principles of Molecular Simulation to the chemical reactions.
CO4	Apply modern molecular-level software on different chemical engineering problems.

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	PO12	PSO1	PSO2
CO1	**S**	**M**	**S**	**S**	**S**		**S**	**M**		**M**	**S**		**M**	**M**
CO2	**S**	**M**	**M**	**W**	**M**		**M**	**M**			**M**		**W**	**W**
CO3	**S**	**S**	**W**		**S**	**W**	**S**	**M**		**M**	**M**		**W**	**W**
CO4	**S**	**S**	**S**	**W**	**S**	**W**	**S**	**S**	**S**		**M**		**M**	**W**

Unit	Course outlines	**Lecture(s)**
Unit-I	Fundamentals of molecular simulations : Ab-initio Methods, Basis Sets, HartreeFock Theory, Density Functional Theory, Geometry Optimization, Vibrational Analysis	06
	Elementary, classical statistical mechanics, elementary concepts of temperature, ensembles and fluctuations, partition function, ensemble averaging, ergodicity.	06
	Molecular Dynamics Methodology - Force Field, Integrating Algorithms, Periodic Box and Minimum Image Convention. Interaction.	05
	Long Range Forces, Non Bonded Interaction, Temperature Control, Pressure Control, Estimation of Pure Component Properties,Radial Distribution Function; Molecular Dynamics Packages	05
Unit-II	Monte Carlo simulation - Monte Carlo integration, simple biasing methods, importance sampling, Markov chain, transition-probability matrix, detailed balance, Metropolis algorithm	11
	Monte Carlo simulation in different ensembles; Monte Carlo simulation for gas, liquid and polymers; Advanced applications	09
	Total	**42**

Recommended Books:

1. Daan F., Berend, S., Understanding Molecular Simulation: From Algorithms to Applications, 2nd Ed., Academic Press, New York, 2002.
2. Allen, M.P., Tildesley, D.J., Computer Simulation of Liquids, Clarendon Press, Oxford, 1987.
3. Binder, K., The Monte-Carlo Method in Condensed Matter Physics, Berlin : Springer-verlag, 1992.
4. McQuarrie, D. A., Statistical Mechanics, Harper and Row, New York, 1976.
5. Leach, A.R., Molecular modelling: principles and applications, 2nd Ed., Pearson, New Delhi, 2001.

Title of the Course : Stock Preparation & Paper Making **L T P : 3 0 0**
Subject Code : PECH-712A **Weekly Load : 3 Hrs**
Course Category : Professional Elective-4 **Credit : 3**

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

CO1	Appraise about pulp and paper industry operations, products, process variables
CO2	Analyse the performance of machinery of the plant
CO3	Comprehend the working of equipments and related engineering problems

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	PO12	PSO1	PSO2
CO1	**S**					**S**					**M**		**M**	**M**
CO2	**S**			**M**							**M**		**M**	**W**
CO3	**S**	**S**	**M**	**M**		**M**	**W**					**W**	**S**	**M**

Unit	**Main Topics**	Course outlines	**Lecture(s)**
Unit-1	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	08
	Types of paper machine	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.	06
	Wire and press	Wire design & its type, Types & theory of pressing, types of press felts & their structure, functions of press felts, basic calculation on press section	06
Unit-II	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	08
	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	10
	Paper Finishing	Working of re-winders, cutters, coating, machine calendaring & super calendaring, Finishing plant defects of paper.	04

Total=42 Hrs.

Recommended Books:

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

Title of the Course : **Polymer Materials** **L T P : 3 0 0**
Subject Code : **PECH-712B** **Weekly Load : 3 Hrs**
Course Category : **Professional Elective-4** **Credit : 3**

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

CO1	Describe the methods of preparation and the properties of polymer materials
CO2	Appraise about the structure and properties of mineral filled thermoplastics & thermosets
CO3	Analyze the processing techniques for fiber formation

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	PO12	PSO1	PSO2
CO1	**S**	**M**	**M**									**S**	**W**	**M**
CO2	**S**	**M**	**M**	**W**	**M**	**M**				**M**		**M**	**M**	**W**
CO3	**S**	**M**	**M**	**W**			**M**	**W**			**W**	**M**	**M**	**W**

Unit	**Main Topics**	Course outlines	**Lecture(s)**
Unit-1	Introduction	Need of additives, Rule of mixtures for composites, Aspect ratio and shape of fillers	03
	Thermoset composites	Matrices: Polyester, Epoxy, Vinyl ester, Phenol formaldehyde, Poly urethane, Silicone, Polyimide, Bis maleimide. Fibers: Glass, Carbon, Aramid, Forms of fibers: Short, Long, Roving , Mat etc.	06
	Other Thermo- set Composites	Dough moulding compound (DMC), Sheet moulding compound (SMC), Glass mat thermoplastics (GMT), Applications	04
	Fiber characteristics	Fiber volume fraction, Dispersion of fiber, fiber aspect ratio, fiber orientation, fiber matrix adhesion	03
	Thermoplastics Composites	Matrices: Poly ethylene (high and low density) , Poly propylene, Poly styrene, Poly vinyl chloride, Poly carbonate, Poly ethylene terephthalate, Acrylo nitrile butadiene styrene, Poly ether ether ketone, Poly phenylene sulfide	05
Unit-II	Fillers	Fillers: Silica, Talc, Mica, Kaolin, Fly ash, Zirconia, Wollastonite, Calcium carbonate , Effect of their shape, size , surface area and their compatibility with matrix	04
	Important Natural Fibers	Flax, Hemp, Kenaf, Jute, Pineapple, Banana, Sisal, Cotton, Wood, Bamboo, Bagasse, Coir, Rice husk	04
	Applications and Advantages	Applications of composites in building, automobile, sports and other sectors	04
	Compatabilizer &Coupling Agents	Fatty acids and anhydrides, Silanes, Zirconate, Titanate and Isocyanates	04
	Processing Techniques	Hand layup, Spray up, Filament winding, Pultrusion, Pressure/ Vacuum bag moulding, Auto clave moulding, Resin transfer moulding	04

Total=42 hrs

Recommended Books:

1. Zweifel, Maier, Schiler, Plastics Additives Handbook, Hanser Munich
2. R J Crawford, Plastic Engineering, Maxwell Macmillan International Publication
3. Arends, Polymer Blends and Alloys
4. Dyson, Engineering Polymers , PHI Publication
5. McW Richardson, Polymer Engineering Composites, Applied Science Publishers

Title of the Course : **Petroleum Refining & Petrochemicals** **L T P : 3 0 0**
Subject Code : **PECH-712C** **Weekly Load : 3 Hrs**
Course Category : **Professional Elective-4** **Credit : 3**

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

CO1	Comprehend the importance of petroleum and petroleum products to meet the global demand
CO2	Appreciate the application of various operations and processes involved in handling and refining of petroleum refinery products
CO3	Apply the principles of sciences to the manufacturing processes of petrochemical products
CO4	Appraise the engineering problems and their remedies associated with the 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	PO12	PSO1	PSO2
CO1						**M**	**M**			**M**			**S**	**M**
CO2	**S**	**M**	**W**	**W**			**M**						**M**	**M**
CO3	**S**		**W**			**W**	**M**				**W**		**M**	**M**
CO4	**S**	**S**	**S**	**W**			**M**						**M**	**W**

Unit	**Main Topics**	Course outlines	**Lecture(s)**
Unit-I	Petroleum Refining	Origin, Formation and Evaluation of Crude Oil. Testing of Crude and Petroleum Products. Refining of Petroleum, Atmospheric and Vacuum Distillation. Various types of crudes, Crude Oil characterization, interpretation of Crude Assays. ASTM-D86/D1160, TBP distillation Hydrotreating, Catalytic reforming, isomerisation, , Fluidized Catalytic Cracking (FCC), Hydro Cracking, Coking and Air Blowing of Bitumen, ATF Merox, Naphtha/Gas cracker for the production of Ethylene, Propylene, Isobutylene and Butadiene. Treatment Techniques: Removal of Sulphur Compounds from Petroleum Fractions to improve performance /taking into account environment considerations, Solvent Treatment Processes, Dewaxing, Clay Treatment and Hydrofining. Introduction to advanced cleaner technologies for meeting future stringent fuel specifications	21
Unit-II	Petrochemicals	Production of Petrochemicals like Dimethyl Terephathalate (DMT), Ethylene Glycol, Synthetic Glycerine, Linear Alkyl Benzene (LAB), Acrylonitrile, Methyl Methacrylate (MMA), Vinyl Acetate Monomer, Phthalic Anhydride, Maleic Anhydride, Phenol and Acetone, Methanol, Formaldehyde, Acetaldehyde, Pentaerythritol, propylene, ethylene and Production of Carbon Black.	21

Total: 42 hrs

Recommended Books:

1. Nelson, W. L., "Petroleum Refinery Engineering", 4th Edn., McGraw Hill, New York, 1985.
2. Bhaskara Rao, B. K., "Modern Petroleum Refining Processes", 2nd Edn., Oxford and IBH Publishing Company,
3. Bhaskara Rao, B. K. "A Text on Petrochemicals", 1st Edn., Khanna Publishers, New Delhi, 1987.
4. Wiseman. P., Petrochemicals, UMIST Series in Science and Technology.
5. H. Steiner, Introduction to petrochemicals Industry', Pergamon, 1961.
6. Norman P. Liberman, Troubleshooting Process Operations, Pennwell Books, 2009

Title of the Course : Fluidization Engineering **L T P : 3 0 0**
Subject Code : PECH-712D **Weekly Load : 3 Hrs**
Course Category : Professional Elective-4 **Credit : 3**

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

CO1	Understand basic of fluidization
CO2	Understand different regimes of fluidization and their importance
CO3	Able to design a fluidized bed

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	PO12	PSO1	PSO2
CO1	S	M	M		W	W	W		W			W	W	W
CO2	S	M	M	W	W	W	W		W			W	W	W
CO3	S	M	M	W	W	W	M		W			W	M	M

Unit	Main Topics	Course outlines	Lecture(s)
Unit-1	Introduction	Phenomena of fluidization, importance of fluidization in process industry, comparison of fluidized beds with other modes of contacting, advantages and disadvantages, industrial applications, terminology for fluid- particle system, fluidization quality, Characteristics of particles, effect of temperature and pressure on fluidized bed behavior	05
	Mechanics of flow around single particles	Flow around single particle, force balance, Review of packed beds, force balance and Ergun Equation, Fixed bed of particles of mono and mixed sizes, and varying shapes.	07
	Mechanics of homogenous fluidization	Homogenous fluidized beds, minimum fluidization velocity-measurement, prediction and correlations, stability aspects- qualitative and quantitative-wave propagation.	08
Unit-II	Heterogeneous fluidization	Geldan classification and mapping of regimes, bubbling bed (heterogeneous fluidized) bed models, Davidson model for a bubble in a fluidized bed, and its implications, turbulent and fast fluidization-mechanics, flow regimes and design equations, entertainment and elutriation, pneumatic transport, Free boards behaviour, slugging, spouted beds, dilute and dense phase transport-circulating fluidized beds, bubbling bed fluidization.	10
	Complexities in fluidized bed operation	Mixed particle system-mixed sized particles, Particles of different densities and shapes, particle to particle and particle to gas heat transfer, Mass transfer in fluidized systems, mixing in fluidized systems-measurements and mixing models, reactions in fluidized beds and models, FCC reactor introduction.	8
	Dense bed	Distributions , Gas jets, and pumping power, Ideal Distribution, Tuyeres and caps, designing of gas distributor	04

Total Hours: 42 hrs

Recommended Books:

1. Kunii D. and Levenspiel O., " Fluidization Engineering", 2nd Ed., Butterworth-Heinemann.1991
2. Davidson D. and Harrison J. F., " Fluidization Engineering",2nd Ed., Academic Press. 2003
3. Yang W. C., " Handbook of fluidization and Fluid particle system", 3rd Ed., CRC. 2003
4. Rhodes, M., Introduction to Particle Technology , 2nd Ed., Wiley, 2008
5. Jackson, R., The Dynamics of fluidized Particles, Cambridge University Press. 2000.
6.

Title of the Course : **Renewable Energy Sources** **L T P : 3 0 0**
Subject Code : **PECH-712E** **Weekly Load : 3 hrs**
Course Category : **Professional Elective-4** **Credit : 3**

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

CO1	Compare between Renewable & non-renewable energy sources.
CO2	Appraise the fundamentals and applications of , biomass, bio-diesel, ethanol, geothermal, solar, wind as sources of energies
CO3	Energy generation technologies from biomass, ethanol, geo-thermal, solar and wind.
CO4	Assess the environmental issues related with utilization of biomass, bio-diesel, ethanol, geothermal, solar and wind as sources of energies.

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	PO12	PSO1	PSO2
CO1	M	W				S	S	M				M	M	M
CO2	S	S	S			S	M	M		M	W	S	S	M
CO3	S	M	M	W		S	M	M	W	M	W	S	S	M
CO4	S	S	M	W		S	S	M	W	M	M	S	S	M

Unit	Main Topics	Course Outlines	Lectures
Unit-1	Introduction	Introduction to Energy Science & Technology, Law of conservation of energy, Energy calculations, energy demand, various resources of non-conventional energy.	05
	Biomass, bio-diesel and ethanol as sources of energy	Introduction to biomass energy; Thermo-chemical conversion of biomass; Anaerobic digestion to methane for bio-gas generation; Ethanol production. Environmental considerations.	10
	Geo-Thermal Energy	Introduction to geo-thermal energy; Vapour dominated (stream) geothermal electrical power plant; Liquid dominated (hot-water) geo-thermal electrical power plant; Energy generations processes through various types of geo-thermal energy plants; Environmental considerations.	07
Unit-II	Solar Energy	Introduction to fundamentals and applications of Solar thermal energy conversion systems: Solar Collectors, Solar thermal power plants, Solar photovoltaic systems-Prospects of solar PV systems, principles of a photo voltaic cell, V-I characteristics of a solar cell, efficiency of a solar cell; Environmental considerations.	10
	Wind Energy	Introduction to wind energy. Basic principles of Wind Energy Conservation: The nature of the wind, the power in the wind, forces on blades, wind energy conservation; Site selection considerations; Basic components of a WECS (Wind Energy Conservation System); Advantages and disadvantages of WECS; Types of Wind Machines-Horizontal-Axial machines, Vertical –Axis Machines.	10

Total = 42hrs

Recommended Books:

1. Saha, S.N., Food Combustion Energy Technology; Dhanpat Rai Pub.
2. Rai, G.D., Non-conventional Energy Sources; Khanna Publishers.
3. Gupta, O.P., Elements of Fuels, Furnaces and Refractories, Khanna Publishers

Title of the Course : Process Instrumentation and control Lab **L T P : 0 0 2**
Subject Code : PCCH-713 **Weekly Load : 2 hrs**
Course Category : Professional Core **Credit : 2**

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

CO1	Understand operating principles of various parameters measuring instruments
CO2	Determine the dynamics of level, temperature measurement process, two capacity liquid level process without interaction and with interaction and U-tube manometer
CO3	have knowledge on the development and use of right type of control dynamics for process control under different operative conditions.
CO4	Determine the performance of controllers for a flow process, pressure process, level process, temperature process and evaluate the performance of cascade 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	PO12	PSO1	PSO2
CO1	**S**	**M**	**S**	**M**	**--**	**M**	**M**	**W**	**S**	**M**	**M**	**S**	**M**	**M**
CO2	**M**								**M**	**W**			**W**	**W**
CO 3	**M**								**M**	**W**			**W**	**M**
CO 4	**M**								**M**	**W**			**M**	**M**

List of Experiments

1. To study the dynamic characteristics of Hg in glass thermometer, thermocouple and RTD.
2. To calculate the viscosity of carbon tetra chloride at different concentration using standard solution viscometer.
3. To detect the conductivity value of given solution by using the conductivity meter.
4. To study air purge level measurement method
5. To study about manometer and. Bourdon's tube pressure gauge.
6. To study the level and flow sensors.
7. To Study the IP to PI converter.
8. To find out the time constant for 1st order system.
9. To find the transient response of single tank for step and impulse change.
10. Step and impulse response of a non-interacting system..
11. Step and impulse response of a interacting system.
12. To study the response of 2nd order system..
13. To study the control valve operation and its flow and inherent characteristics.
14. Multi process Trainer for flow and level control
15. Study of open loop response (manual control)
16. Study of on/off controller.
17. Study of proportional controller.
18. Study of proportional integral controller.
19. Study of proportional integral Derivative controller.

Note: Minimum 08 Experiments have to be conducted.

Title of the Course :	**Energy Audit and Management**	**L T P : 3 0 0**
Subject Code :	**PECH-721A**	**Weekly Load : 3 Hrs**
Course Category :	**Professional 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	Comprehend 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	PO12	PSO1	PSO2
CO1		**M**	**M**			**M**	**M**					**S**	**M**	**S**
CO2						**S**	**M**				**M**		**W**	**S**
CO3	**S**	**S**	**S**	**S**	**M**	**M**	**M**		**M**		**M**	**M**	**W**	**S**
CO4	**S**	**S**			**M**		**M**		**M**		**M**		**W**	**S**

Unit	**Main Topics**	**Course outlines**	**Lecture(s)**
Unit-1	Energy scenario and basics of Energy Audit	Primary and Secondary Energy, Conventional and non-conventional energy, 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, Basic concepts of cogeneration.	08
	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.	06
	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.	08
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	08
	Energy Conservation in Fans, Blowers and Pumps	Difference between fans, blowers and compressors, Fan types, a 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	06

		conservation opportunities in pumping system.	
	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.	06

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. Guide book for National Certification Examination for Energy managers and Auditors – Book 1 to 3, Bureau of Energy efficiency, 2005.

Title of the Course : Nano-science and Nano-technology **L T P : 3 0 0**
Subject Code : PECH-721B **Weekly Load : 3 Hrs**
Course Category : Professional Elective-5 **Credit : 3**

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

CO1	Describe the basic concepts of nanoscience and nanotechnology
CO2	Appraise different nano-materials along with their fabrication techniques & characterization.
CO3	Summarize the applications of nano-materials & nano-composites 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	PO12	PSO1	PSO2
CO1	**S**	**S**		**W**							**M**	**M**	**M**	**M**
CO2	**S**	**S**	**S**		**W**		**W**	**M**		**W**	**S**	**M**	**M**	**M**
CO3	**S**	**M**	**W**			**W**	**W**	**W**		**W**	**M**		**M**	**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.	04
	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.	10
	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,	08
	Microscopy	Microscopy - Scanning Tunnelling Microscope, Atomic Force Microscope, Scanning Electron Microscopy, Principles of Noncontact Atomic Force Microscope (NCAFM).	04

Total = 42 Hrs.

Recommended Books:

1. B. Bhushan, (in Eds.) "Springer handbook of nanotechnology", Springer – Verlag, 2004.
2. Charles P. Poole; Frank K. J Owens," Introduction to Nanotechnology", John Wiley

Title of the Course : **Chemical Plant utilities and Safety** **L T P : 3 0 0**
Subject Code : **PECH-721C** **Weekly Load : 3 Hrs**
Course Category : **Professional Elective** **Credit : 3**

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

CO1	Appraise and analyse hazards and their prevention methods
CO2	Analyse specialized personal protective equipment for safety in process industries
CO3	Understand and Analyse fire protection methods, prevailing safety standards and key elements of Process safety Management
CO4	Design and analyse standard process plant utilities

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	PO12	PSO1	PSO2
CO1	**S**					**M**	**M**		**M**	**M**	**M**		**W**	**W**
CO2	**S**					**M**	**M**		**M**	**M**	**M**		**W**	**M**
CO3	**S**	**S**	**M**			**M**	**M**		**M**	**M**		**W**	**W**	**W**
CO4	**S**	**S**	**M**			**M**	**M**		**M**	**M**			**M**	**M**

Unit	**Main Topics**	Course outlines	**Lecture(s)**
Unit-1	1. Key Process Plant Utilities	Plant Air, Instrument air and cryogenic nitrogen generation system. Raw water treatment, water softening /demineralization process, Type of Cooling Towers, typical cooling water network	10
	Boilers	Boilers, Typical steam handling and distribution systems	06
	2. Introduction to hazards and safety	Identification and classification of various types of hazards in work-place environment, Hazard analysis techniques, pre-incident plans, General personal protective equipment (PPEs) used in chemical process industries, PSVs, consideration of safety in design (Inherent), Occupational Health and Safety Management System (OHSMS).	03
	2 Process Safety Management	Awareness and significance of elements of Process Safety Management in Chemical Process industry,	02
Unit-II	2. Hazardous Chemicals	Maximum allowable concentrations, flammable (LEL/UEL), toxic and biological threshold limit values (TLV). MSDS of chemicals/hazardous materials, General chemical handling precautions.	05
	3. Chemical, Mechanical and Electrical hazards	Various types of preventive measures and specialised personal protective equipment (PPEs) to avoid risk of direct exposure to chemical, mechanical and electrical hazards	06
	4. Radioactive hazards	Introduction to radioactive substances, associated hazards and their prevention.	04
	5. Fire prevention and control	Various methods of fire prevention and control methods in chemical process industries, different type of hydrocarbon / toxic gas detectors, Types of fire extinguishers and industrial classification of fires, typical fire water network systems in chemical process industries. Good housekeeping practices.	06

Total = 42 hrs

Recommended Books :

1. G.L.Wills ; Safety in Process Plant Design;Halsted Press .
2. F.P.Less; Loss Prevention in Process Industries; 3rd Revised edition
3. Safety for Chemical Engineers A.I.Ch.E. Publications
4. N.De Nevers; Air Pollution Control, McGraw Hill
5. Lyle, O. : Efficient Use of Steam, HMSO, 1963.
6. Jouganson, R. : Fan Engineering, Buffalo Rorge Co., 1970.
7. Crowl & Louver, Chemical Process Safety, Prentice Hall
8. Kletz, What Went Wrong, Gulf
9. Herausgeg von P.M.Goodall, The Efficient use of Steam, IPC Science and Technology Press Ltd, Guildford

Title of the Course : **Pharmaceutical Formulations** **L T P : 3 0 0**
Subject Code : **PECH-721D** **Weekly Load : 3 Hrs**
Course Category : **Professional Elective-5** **Credit : 3**

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

CO1	Understand the methods of preparation of various liquid, semi solid, solid dosage forms.
CO2	Understand the factors influencing the development of various dosage forms.
CO3	Understand the formulation concepts and evaluate different dosage forms to meet out the compendial requirements.

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	PO12	PSO1	PSO2
CO1	**S**	**M**				**W**	**S**			**W**		**M**	**S**	**S**
CO2	**S**	**M**	**S**		**M**	**W**	**S**				**M**	**M**	**W**	**S**
CO3	**S**	**S**	**S**	**M**	**M**		**M**	**M**		**W**		**M**	**W**	**S**

Unit	**Main Topics**	**Course Outlines**	**Lectures**
UNIT 1	Pre-formulation studies and monophasic liquid dosage forms	Physical/physicochemical properties of drugs - physical form, particle size, shape, density, wetting, dielectric constant, solubility, polymorphism, dissolution, organoleptic properties and their effect on formulation, stability and bioavailabilty. Dissolution process – Solubility and Physical characters of liquid dosage forms – Liquid formulations for internal use – external use.	08
	Biphasic systems and semi solid dosage forms	Emulsions – formulation of emulsions – stability – evaluation of emulsions – Suspensions – Formulations – problems in suspension – evaluation of suspensions – Suppositoreis – Suppository bases – formulation and packaging– Ointments – skin structure and drug absorption – ointment bases – additives – special type of ointments – processing and evaluation of ointments. Creams- formulation and evaluation	08
	Role of natural polymers in drug formulation	Concept- advantages and disadvantages- Physicochemical and biological properties of natural polymers relevant to sustained release formulations.	06
UNIT I	Solid dosage forms	Types of tablets - Tabletting equipments – Granulation technology – Formulation of Tablets – Processing problem of tablets and evaluation of tablets. Tablets Coating – Principles – Tablet coating process – Sugar coating – Film Coating – Specialized coating – Evaluation of coated tablets. Hard gelatin Capsules – Raw materials – Manufacture – Formulations – Filling equipments – Evaluations – Soft gelatin capsule – Rationale – Manufacture – Formulation – Evaluation.	10
	Parenteral products	Diversities of parenteral products – Formulation of parenteral products – Sustained action parenteral products – Processing and Packaging– Evaluation of parenteral products – specialized parentral products.	06
	Pharmaceutical aerosols	Components of aerosol package – Formulation, Stability testing, Manufacture, Quality control and Testing of pharmaceutical aerosols.	04

TOTAL = 42 Hrs

Recommended books:

1.Lachman, L. “The Theory and Practice of Industrial Pharmacy”, Varghese Publishing House, 1987.
2. Aulton, Michael E. “Pharmaceutics: The Science of Dosage Form Design”, Churchill Livingstone, 2002.
3. Allen, Loyd V. et al. “Ansel’s Pharmaceutical Dosage Forms and Drug Delivery Systems”., Wolters Kluver/Lippin Cott Williams & Wilkins, 2011.
4.Avis, K.E. et al. “Pharmaceutical Dosage Forms: Parenteral Medications” Vol.1-3, Marcel Dekker, 2005.
5.Libermann, H.A. et al. “Pharmaceutical Dosage Forms: Tablets” Vol.1-3, 2nd Ed., Marcel Dekker, 2005.
6.Libermann, H.A. et al., “Pharmaceutical dosage forms: Disperse Systems” Vol. 1-3, Marcel dekker, 2005.

Title of the Course : **Fertilizer Technology** **L T P : 3 0 0**
Subject Code : **PECH-721E** **Weekly Load : 3 Hrs**
Course Category : **Professional Elective-5** **Credit : 3**

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

CO1	Understand each fertilizer product, its flow diagram for industry production
CO2	Understand arranging treatment, reaction and separation steps in a flow diagram for variety of fertilizers including Nitrogenous fertilizers, Phosphatic fertilizer, Potash Fertilizer, Complex fertilizer and Bio fertilizers
CO3	Understand the major process engineering problems of different types of fertilizer.
CO4	Understand the uses of variety of fertilizers.

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	PO12	PSO1	PSO2
CO1	**S**	**M**				**S**	**S**			**M**		**W**	**S**	**S**
CO2	**S**	**M**			**M**	**S**	**S**						**S**	**S**
CO3		**M**		**M**	**M**	**M**	**S**			**M**			**S**	**S**
CO4		**M**	**S**	**M**	**S**	**M**	**M**			**W**	**W**		**M**	**M**

Unit		**Topic to be covered**	Lectures
UNIT 1	Introduction	**Overview of Fertilizer Synthetic fertilizers**: Classification of fertilizers, Role of essential Elements in plant Growth, Application of fertilizers considering Nutrient, Development of fertilizer industry; Fertilizer production and consumption in India;	4
	Nitrogenous Fertilizers	**Introduction to Ammonia:** History, Physical & chemical properties, Kellog manufacturing process including chemical reactions, major raw material requirements with detailed flow sheets. Major engineering problems encountered during process and uses **Urea:** History, Physical & chemical properties, manufacturing process from ammonium carbamate including chemical reactions, major raw material requirements with detailed flow sheets. Major engineering problems encountered during process and uses **Ammonium sulphate (AS):** History, Physical & chemical properties, manufacturing process from synthetic ammonia and sulphuric acid including chemical reactions, major raw material requirements with detailed flow sheets. Major engineering problems encountered during process and uses **Calcium ammonium nitrate (CAN):** History, Physical & chemical properties, manufacturing process from limestone and concentrated nitric acid including chemical reactions, major raw material requirements with detailed flow sheets. Major engineering problems encountered during process and uses **Ammonium chloride:** History, Physical & chemical properties modified Solvay process including chemical reactions, major raw material requirements with detailed flow sheets. Major engineering problems encountered during	18

		process and uses	
UNIT 2	Phosphorous fertilizer	**Diammonium Phosphate (DAP):** History, Physical & chemical properties, manufacturing process from ammonia and phosphoric acid including chemical reactions, major raw material requirements with detailed flow sheets. Major engineering problems encountered during process and uses **Single Super Phosphate (SSP):** History, Physical & chemical properties, manufacturing process from phosphate rock with sulphuric acid including chemical reactions, major raw material requirements with detailed flow sheets. Major engineering problems encountered during process and uses	10
	Complex Fertilizer (NPK)	History, Physical & chemical properties, manufacture of Urea ammonium Phosphate, ammonium Phosphate sulphate, nitro phosphate with potash including chemical reactions, major raw material requirements with detailed flow sheets. Major engineering problems encountered during process and uses	5
	Bio Fertilizers	Biofertilizers, Types of Biofertilizers, Nitrogenfixing biofertilizers, Phosphate-solubilizing biofertilizers, Preparation of a Bio Fertilizers	5

Total = 42 hrs

Recommended books:

1. Shreve's Chemical Process Industries
2. Dryden's Outlines of Chemical Technology
3. Pandey & Shukla, Chemical Technology, Volume I & II, 2nd Edition, Vani Books Company.
4. N S Subba Rao, Bio fertilizers in Agriculture, Oxford & IBH Publishing Company
5. Hand book of Fertilizer Association of India, New Delhi

Title of the Course : **Hazardous Waste Management** **L T P : 3 0 0**
Subject Code : **PECH-721F** **Weekly Load : 3 Hrs**
Course Category : **Professional Elective-5** **Credit : 3**

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

CO1	Analyse the concept, need and classification of hazardous waste from various sources.
CO2	Analyse the characteristics and remedies for hazardous wastes specifically for nuclear, e-waste, biomedical and chemical waste.
CO3	Appraise the various aspects of hazardous waste management and the challenges
CO4	Design the treatment and disposal system for hazardous waste.

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	PO12	PSO 1	PSO 2
CO1	**M**					**S**	**S**					**M**		**M**
CO2	**M**	**S**	**S**	**M**		**M**	**S**		**W**		**M**	**S**	**W**	**M**
CO3	**M**			**S**					**W**				**W**	**M**
CO4	**M**		**S**		**M**		**S**		**W**		**M**		**W**	**M**

Unit	**Main Topics**	**Course outlines**	**Lecture(s)**
Unit-1	Introduction	Need for hazardous waste management – Sources of hazardous wastes – Effects on community – terminology and classification – Storage and collection of hazardous wastes – Problems in developing countries – Protection of public health and the environment.	04
	Nuclear wastes and e-waste	Characteristics – Types – Nuclear waste – Uranium mining and processing – Power reactors – Refinery and fuel fabrication wastes – spent fuel – Management of nuclear wastes – Decommissioning of Nuclear power reactors – Health and environmental effects.	08
	Biomedical and chemical wastes	Biomedical wastes – Types – Management and handling – control of biomedical wastes Chemical wastes – Sources – Domestic and Industrial - Inorganic pollutants – Environmental effects – Need for control – Treatment and disposal techniques – Physical, chemical and biological processes – Health and environmental effects.	10
Unit-II	Scientific landfill	Concept – function – site selection and approval – acceptable wastes – Design and construction – Liners: clay, geomembrane, HDPE, geonet, geotextile – Treatment and disposal of leachate – Combined and separate treatment. Site remediation – Remedial techniques.	10
	Management of hazardous wastes	Identifying a hazardous waste – methods – Quantities of hazardous waste generated – Components of a hazardous waste management plan – Hazardous waste minimization – Safe disposal of pyrophoric material - Disposal practices in Indian Industries – Future challenges,	10

Total=42 Hrs

Recommended Books:

1. J. Glynn Henry and Gary. W. Heinke, "Environmental Science and Engineering", Pretice Hall of India, 2004.
2. A. D.Bhide and B.B.Sundaresan, "Solid Waste Management – Collection, Processing and disposal" Mudrashilpa Offset Printers, Nagpur, 2001.
3. Biomedical waste (Management and Handling) Rules, 1998.

Title of the Course : **Chemical Recovery Processes in Pulp and Paper Industry** **L T P : 3 0 0**

Subject Code : **PECH-722A** **Weekly Load : 3 Hrs**

Course Category : **Professional Elective -6** **Credit : 3**

Course outcomes : At the end of the course, student must be able to

CO1	Appraise significance of black liquor in the economic and environmental performance of paper mills.
CO2	Analyze the unit operations and processes used in the processing of black liquor
CO3	Characterize black liquor for optimal chemical recovery
CO4	Make process calculations for the optimal operation of equipments used in chemical recovery

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	PO12	PSO1	PSO 2
CO1		**S**				**S**	**S**					**W**	**S**	**S**
CO2	**S**	**S**	**M**	**W**			**M**				**W**	**W**	**M**	**M**
CO3	**S**	**S**	**W**	**W**								**W**	**M**	**M**
CO4	**S**	**S**	**S**	**M**		**M**	**S**				**W**	**W**	**M**	**M**

Unit	Main Topics	Course Outlines	Lectures
Unit-1	Introduction	The recovery cycle of alkaline pulping. Impact of pulping on chemical recovery process.	04
	Black liquor Properties	Chemical and rheological properties of black liquor and their effect on evaporator operations, evaporator scales, overview of liquid effluents & gaseous emissions; black liquor characteristics influencing furnace operations.	08
	Concentration of black liquor	Black liquor evaporation; multiple effect evaporation, types of evaporators used in paper industries and auxiliary equipments, direct contact evaporators, finisher effects, and exclusion of DCE. Mechanical vapour recompression.	10
Unit-II	Incineration of black liquor	Process chemistry, types of recovery boiler and accessories, effect of design and operating parameters; combustion air and its distribution; fire side deposits; their effect on performance and control measures. Suspended particulate matter & gaseous emissions and their control.	08
	Causticizing	Green liquor clarification, slaking & causticizing reactions, variables affecting its efficiency. White liquor clarification and equipment details, mud washer, calculation of soda loss in lime sludge. Lime mud reburning & lime recovery	08
	Black liquor gasification	Chemistry and process parameters. Chemical Recovery process; MTCI process	04

Total = 42 Hrs.

Recommended Books :

1. Kocurrek, M.J. Pulp & Paper manufacture Vol. 5 TAPPI Press
2. Casey, J.P. Pulp and Paper chemistry and chemical Technology Wiley
3. Green, R.P., and Hough, G. Chemical Recovery in Alkaline Pulping Processes TAPPI Press
4. Smook, G.A. Handbook for pulp and paper technologists TAPPI Press

Title of the Course : **Rubber Technology** **L T P : 3 0 0**
Subject Code : **PECH-722B** **Weekly Load : 3 Hrs**
Course Category : **Professional Elective-6** **Credit : 3**

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

CO1	Classify natural rubber and other synthetic elastomers.
CO2	Appraise about the rubber compounding and vulcanization and rubber products manufacturing.
CO3	Compare the natural rubber and various synthetic rubbers and their processing

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	PO12	PSO1	PSO2
CO1	**M**	**M**											**S**	
CO2	**S**	**S**	**S**	**M**									**M**	**W**
CO3	**S**	**S**	**M**			**M**	**M**						**M**	**M**

Unit	**Main Topics**	Course outlines	**Lecture(s)**
Unit-1	General Introduction	Basic concept & definition, Rubber Plantation & Production of Natural Rubber, Degradation & Aging of rubbers.	10
	Compounding	Types of additive used, Mastication, Carbon black, Rubber compounding & mixing, Plasticizers, Accelerators.	10
Unit-II	Vulcanization	Vulcanization system and Mechanism of Vulcanization.	10
	Synthetic Rubber	Chloroprene Rubber, Silicone Rubber, SBR, Nitrile Rubber, Butyl rubber, Poly isobutylene; PU elastomer; Floro elastomer, Ethylene Propylene-Diene Elastomer. Formation of Rubber products for Industrial and Domestic uses.	12

Total = 42 Hrs.

Recommended Books:

1. M. Morton; Rubber Technology; Van Nostrand Reinhold Co. ACS
2. G. Alliger ; I. J. Sjothun; Vulcanization of Elastomers; Robert E. Krieger Pub. Co., New York

Title of the Course : **Advance Process control** **L T P : 3 0 0**
Subject Code : **PECH-722C** **Weekly Load : 3 Hrs**
Course Category : **Professional Elective-6** **Credit : 3**

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

CO1	Comprehend and discuss the importance of process control in process operation and the role of process control engineers
CO2	Develop fundamental and empirical models for dynamic processes.
CO3	Implement dynamic models with or without controllers
CO4	Analyse properties (stability, speed of response, frequency response etc.) of dynamic models & processes
CO5	Design controllers and use of basic knowledge of advanced control strategies

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	PO12	PSO1	PSO2
CO1		**W**				**W**								
CO2	**S**	**S**	**M**						**M**			**M**		**M**
CO3	**S**	**S**	**S**	**M**					**M**			**M**		**W**
CO4	**S**	**S**	**S**	**W**					**M**			**W**		**W**
CO5	**S**	**S**	**S**	**M**					**M**			**M**		**M**

Unit	Main Topics	Course outlines	Lectures
Unit-1	Development of Empirical Models From Process Data	Review of Laplace transformation, Dynamic behaviour of first order and higher order system. and control system design for linear closed loop systems. Fitting First and Second Order Models Using Step Tests, Development of Discrete Time Dynamic Models, Identifying Discrete Time Models From Experimental Data.	03
	Analysis and Design of Advanced Control Systems:	Feedback control of systems with large dead time, Cascade control, Feedforward control, Ratio control, Feedforward-Feedback control, Adaptive control, Inferential Control	04
	Multiple-Input, Multiple-Output (MIMO) Systems	Introduction to MIMO systems, degrees of freedom and number of controlled and manipulated variables, generation of alternative loop configurations, extension to interacting systems	05
	Matrix properties and state variables	Matrix mathematics, matrix properties, Representation of multivariable processes, open loop and close loop systems.	05
Unit-1I	Analysis of multivariable systems.	Review of RGA and introduction to singular value analysis. Frequency response techniques for control system design. Bode and Nyquist plots for SISO systems, singular value analysis for MIMO systems	05
	Multiloop and Multivariable Control:	Process and Control Loop Interactions, Pairing of Control and Manipulated Variables, Singular Value Analysis, Tuning of Multi-loop PID Control Systems, Decoupling and Multivariable Strategies, Strategies for Reducing Control Loop Interactions	05
	Design of controllers for multivariable processes	Introduction to model predictive control (MPC). continuous-time Internal Model Control (IMC), and IMC-based PID.	05

	Discrete- Time control systems	Sampling and Z-Transform, Open-Loop and Closed-Loop response, Stability analysis of discrete-time control systems	05
	Digital control system	Introduction to digital control. Implementation of digital PID algorithms. Identification of discrete models for digital control. Digital model-based control - IMC and Dahlin's method	05

Total=42 hrs

Recommended Books:

1. Weber, Introduction to Process Dynamics and Control; John Wiley
2. George Stephanopoulos, Chemical Process Control, PHI publication
3. Donald R. Coughanour, Process System Analysis & Control, Mc Graw Hill
4. B. Wayne Bequette, Process Control – Modelling, Design & Control, PHI Publication
5. Dale E. Seborg, Thomal F. Edgar, Process Dynamics & Control, Dancan A. Mellichamp
6. Babatunde A. Ogunnaike,W. Harmon Ray, Process Dynamics, Modeling & Control,,Oxford University Press
7. M. Chindambaram, Computer Control of Processes, Alpha Science Internatinal Ltd
8. Bella G. Liptak, Elsevier, Instrument Engineers Handbook (Process Control)

Title of the Course : **Combustion Technology** **L T P : 3 0 0**
Subject Code : **PECH-722D** **Weekly Load : 3 Hrs**
Course Category : **Professional Elective -6** **Credit : 3**

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

CO1	characterize the fuels
CO2	Understand and analyze the combustion mechanisms of various fuels
CO3	Appreciate the importance of draft in control of furnace

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	PO12	PSO1	PSO2
CO1	**M**					**M**	**S**					**M**	**M**	**M**
CO2	**M**	**S**					**S**		**W**			**W**	**M**	**M**
CO3		**S**				**S**	**M**						**M**	**M**

Unit	**Main Topics**	**Course outlines**	**Lecture(s)**
Unit-1	Fundamental concepts	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. Classification of fuel, Origin, Composition, Characteristics and analysis of coal washing & storage of coal, Physical & chemical processing of coal, Various classification systems of coal briquetting, Carbonization, Gasification of coal. Fuel Combustion Calculation, Fundamentals of various combustion calculations with numerical examples	20
Unit-II	Application of combustion technology	Flame, Calculation of theoretical and actual flame temperatures Draught, Limits of Inflammability, Types of combustion Process- Surface, Submerged, Pulsating, Furnaces: General classification and description of different types of furnaces with special reference to furnaces used in ceramic, petroleum and pharmaceutical industries. Slow combustion, Energy Conservation , fluidised bed combustion, combustion of non-conventional fuels in energy efficient furnaces, role and control of draft in furnaces, insulation , material of construction , shanky diagram	22

Total=42 Hrs

Recommended Books:

1. Samir Sarkar Fuels and combustion, orient longman
2. O.P. Gupta Elements of Fuels, furnaces and Refractories
3. Wilson, P.J., Wells, G.H. Coke, cake and coal chemicals, McGraw Hill
4. Griswold, J. Fuels, combustion and Furnaces, McGraw Hill
5. Francis, W. Fuels and fuel Technology, Vol. I and II Pergarnon Press
6. McNeil D Coal combustion products, peragamen Press
7. Haslam, R.T. Russal, R.P Fuels and their combustion, McGraw Hill

Title of the Course : **Environmental Impact Assessment** **L T P : 3 0 0**
Subject Code : **PECH-722E** **Weekly Load : 3 Hrs**
Course Category : **Professional Elective-6** **Credit: 3**

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

CO1	Conversant with the legal framework of EIA
CO2	Prepare and comprehend EIA reports of greenfield and extension projects
CO3	Carry out Life Cycle Assessment of projects

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	PO12	PSO1	PSO2
CO1	**M**			**S**	**W**	**S**	**S**	**M**			**M**		**M**	**M**
CO2	**M**	**S**	**S**	**S**	**W**	**S**	**S**	**M**		**S**	**M**	**M**	**M**	**S**
CO3	**M**	**M**	**M**	**S**	**W**	**M**	**S**	**M**			**M**	**W**	**M**	**M**

Unit	**Main Topics**	**Course Outlines**	**Lectures**
Unit-1	Scope and Significance	Salient features of Environmental Impact Assessment Notification under Environment Protection Act. The process of granting environmental clearance for designated projects.	10
	Preparation of EIA report	Essential elements of EIA report. Comparative study of different assessment methodology, Adhoc procedures, overlay techniques, checklist, matrices and networks.	08
Unit-2	Impact assessment for natural environment	Evaluation of the possible impacts of a proposed action on the air, water, and land environment at meso and micro scale.	08
	Impact assessment for Biological and Socio-cultural Environment	Evaluation of the possible impact of a proposed action on biodiversity and functional balance of the ecosystem. Possible impact on the existing socio-cultural and economic patterns of the surrounding population.	08
	Life Cycle Assessment	Life Cycle Assessment of projects; illustrative examples of thermal power plant, roads and highways.	08

Total = 42 hrs.

Recommended Books :

1. Pollution Control Acts, Rules, and Notifications , CPCB
2. Canter, L.W., Environmental Impact Assessment, McGraw Hill
3. Gilpin, A., Environmental Impact Assessment: Cutting Edge for the 21st Century, Cambridge University Press
4. Marriott, B.B., Practical Guide to Environmental Impact Assessment, McGraw Hill

Title of the Course : **Environmental Impact Assessment** **L T P : 3 0 0**
Subject Code : **PECH-722E** **Weekly Load : 3 Hrs**
Course Category : **Professional Elective-6** **Credit: 3**

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

CO1	Conversant with the legal framework of EIA
CO2	Prepare and comprehend EIA reports of greenfield and extension projects
CO3	Carry out Life Cycle Assessment of projects

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	PO12	PSO1	PSO2
CO1	**M**			**S**	**W**	**S**	**S**	**M**			**M**		**M**	**M**
CO2	**M**	**S**	**S**	**S**	**W**	**S**	**S**	**M**		**S**	**M**	**M**	**M**	**S**
CO3	**M**	**M**	**M**	**S**	**W**	**M**	**S**	**M**			**M**	**W**	**M**	**M**

Title of the Course : **Project stage 1 and seminar** **L T P : 0 0 4**
Subject Code : **PRCH-711** **Weekly Load : 4 Hrs**
Course Category: **Professional Core** **Credit: 2**

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

CO1	Identify and finalize the project problems
CO2	Demonstrate the technical/engineering/professional knowledge to selected project problem
CO3	Effectively communicate and present the project findings in written and oral form

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	PO12	PSO1	PSO2
CO1	**S**	**S**	**W**	**S**	**S**	**M**	**S**	**S**	**S**	**S**	**M**	**M**	**M**	**S**
CO2	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**M**	**S**	**S**	**M**	**M**	**M**	**S**
CO3	**S**	**M**	**M**	**S**	**S**	**M**	**S**	**S**	**S**	**S**	**M**	**M**	**M**	**S**

Preliminary work:

a) Identification and Selection of project problem related to process/social /professional world.

b) Application of fundamental knowledge acquired during the period of UG program study.

Comprehensive work:

a) Feasibility study f proposed project work.

b) Effective communication of selected problem for the proposed project work

Title of the Course : **Project stage II** **L T P : 0 0 12**
Subject Code : **PRCH-721** **Weekly Load : 12 Hrs**
Course Category : **Professional Core** **Credit: 6**

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

CO1	Demonstrate the knowledge, skills and attributes of professional Engineers
CO2	Provide engineering solution to industrial/social problems
CO3	Demonstrate team spirit, ethical practices, managerial skill and economical aspects.
CO4	Effectively communicate and present the project findings in written and oral form.

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	PO12	PSO1	PSO2
CO1	**S**	**W**	**M**	**S**	**M**	**S**	**S**	**S**	**S**	**M**	**M**	**S**	**M**	**M**
CO2	**M**	**S**	**S**	**S**	**M**	**S**	**S**	**S**	**M**	**M**	**S**	**S**	**M**	**S**
CO3	**M**	**M**	**M**	**S**	**M**	**M**	**S**	**S**	**S**	**M**	**S**	**S**	**M**	**M**
CO4	**S**	**W**	**M**	**M**	**M**	**M**	**M**	**S**	**S**	**S**	**S**	**M**	**M**	**M**

a) Identification and Selection of project problem related to process/social /professional world.

b) Application of fundamental knowledge acquired during the period of UG program study.

c) Provide the possible solutions of the problem.

d) Feasibility study of selected solution

e) Effective communication of optimum solution and future scope of work.

Board of Studies

(UG PROGRAMME in CHEMICAL ENGINEERING (HONS.))

DATE

02.07.2021

रसायन अभियांत्रिकी विभाग
Department of Chemical Engineering
संत लौंगोवाल अभियांत्रिकी एवं प्रौद्योगिकी संस्थान
ANT LONGOWAL INSTITUTE OF ENGINEERING AND TECHNOLOG
(भारत शासन, शि. म. अधीन, सम विश्वविद्यालय)
(Deemed to be University under MoE, Government of India)
लौंगोवाल – १४८१०६. संगरूर (पंजाब) भारत
Longowal -148106. Sangrur (Punjab) India

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.

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Program Educational Objectives (PEOs)

PEO 01: To prepare students for successful professional career in Indian and multinational Chemical process and allied industries, design and consultancy organizations and relevant government agencies.

PEO 02: To build up capacity in students for problem analysis, interpretation and solution related to application of Chemical engineering for sustainable development.

PEO 03: To prepare students who can provide leadership and companionship in multidisciplinary teams.

PEO 04: To inculcate in students qualities that enable them to apply their domain knowledge as enlightened citizens for the upliftment of society.

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Program Outcomes (POs)

PO 01: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO 02: Problem analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO 03: Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO 04: Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO 05: Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

PO 06: The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO 07: Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO 08: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO 09: Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO 10: Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO 11: Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and Leader in a team, to manage projects and in multidisciplinary environments.

PO 12: Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

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Longowal -148106. Sangrur (Punjab) India

Program Specific Outcomes (PSOs)

PSO 01: Natural Resource Utilization: The candidate should have sufficient technical knowledge to cater to the need of existing and upcoming chemical industry and efficient utilization of natural resources.

PSO 02: Cleaner production: Applying Chemical Engineering fundamentals for green and energy efficient processes.

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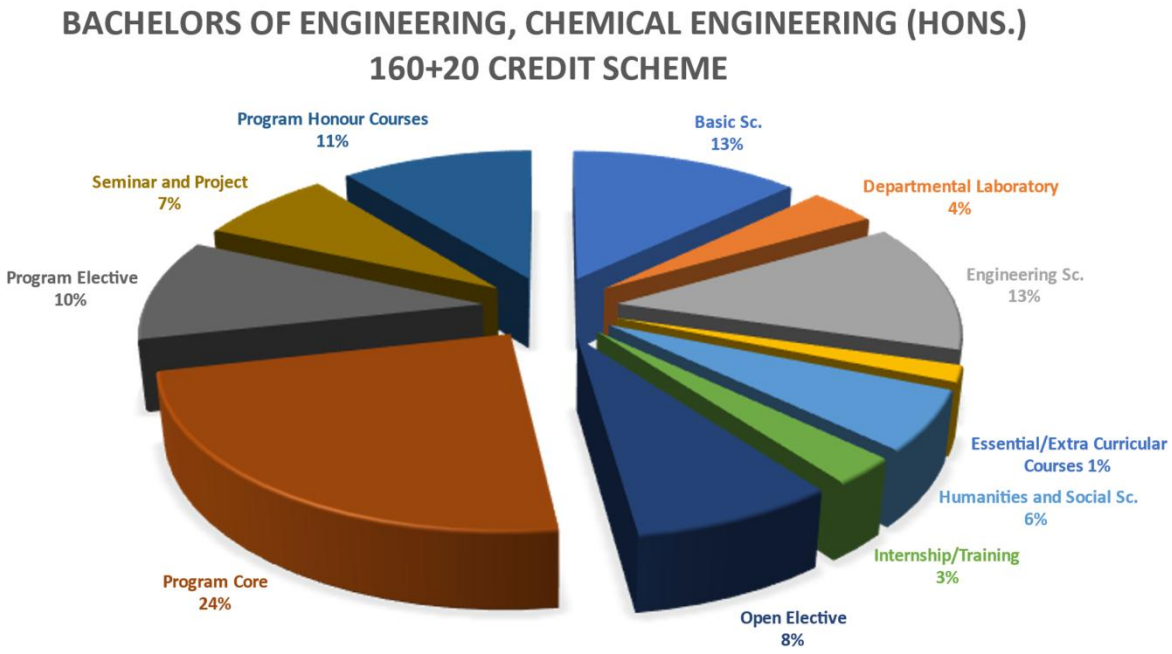
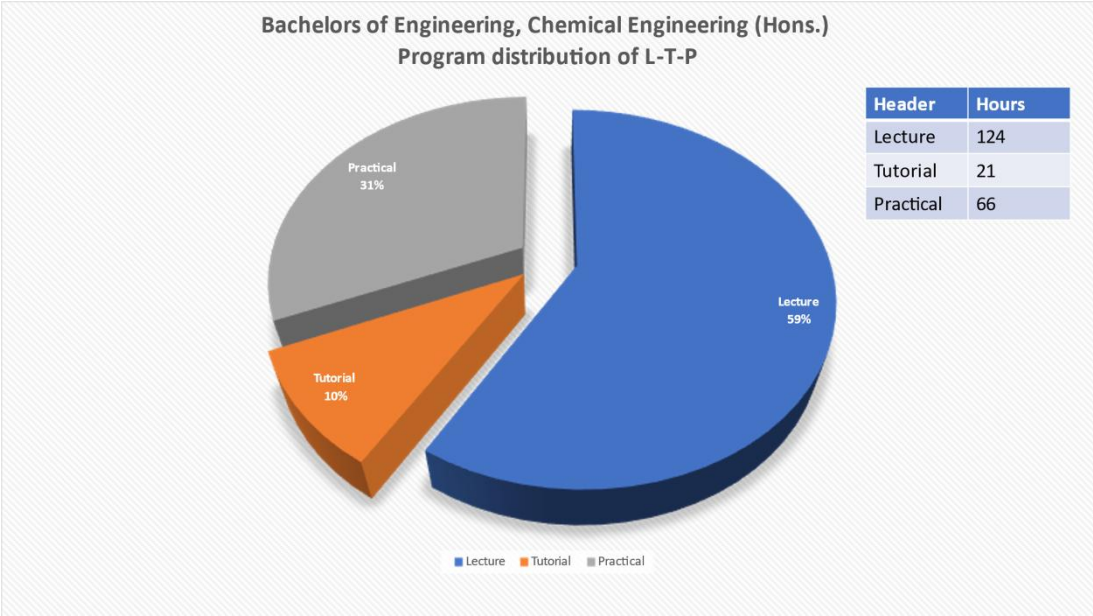
Bachelor of Engineering, Chemical Engineering (Hons.) 160+ 20 Credit scheme





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संत लौंगोवाल अभियांत्रिकी एवं प्रौद्योगिकी संस्थान
ANT LONGOWAL INSTITUTE OF ENGINEERING AND TECHNOLOG
(भारत शासन, शि. म. अधीन, सम विश्वविद्यालय)
(Deemed to be University under MoE, Government of India)
लौंगोवाल – १४८१०६. संगरूर (पंजाब) भारत
Longowal -148106. Sangrur (Punjab) India

Study Scheme for Bachelor of Engineering in Chemical Engineering (Hons.)

(In addition to 160 Credit scheme of major degree of Bachelor of Engineering in Chemical Engineering)

Semester-VA							
S No	**Sub Code**	**Subject Name**	**L**	**T**	**P**	**Hrs.**	**Credits**
1.	HDCH-611	Process Equipment Design	2	2	0	4	4
2.	HDCH-612	Optimization of Chemical Processes	3	1	0	4	4
		Total	5	3	0	8	8
	Semester-VI A						
S No	**Sub Code**	**Subject Name**	**L**	**T**	**P**	**Hrs.**	**Credits**
1.	HDCH-621	Process Energy Integration	3	1	0	4	4
		Total	3	1	0	4	4
Semester-VII							
S No	**Sub Code**	**Subject Name**	**L**	**T**	**P**	**Hrs.**	**Credits**
1.	HDCH-711	Computational Transport Phenomena	3	1	0	4	4
		Total	3	1	0	4	4
Semester-VIII							
S No	**Sub Code**	**Subject Name**	**L**	**T**	**P**	**Hrs.**	**Credits**
4	PHCH-721	Project Hons	0	0	08	08	4
		Total	0	0	08	08	4

Title of the Course : **Process Equipment Design** **L T P : 2 2 0**
Subject Code : **HDCH-611** **Weekly Load : 4 Hrs**
Course Category : **Honors** **Credit : 4**

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

CO1	Apply fundamental principles of chemical engineering design to chemical industry equipment.
CO2	Appraise the process piping design and design of pumps used in chemical industries
CO3	Design and optimize operating conditions of Mass transfer equipment like distillation columns
CO4	Appreciate safety and economical aspects during designing of process equipment

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	PO12	PSO1	PSO2
CO1	**S**	**S**	**S**	**M**	**W**				**S**	**M**		**M**	**M**	**M**
CO2	**S**	**S**	**S**	**M**	**W**				**S**	**M**		**M**	**M**	**M**
CO3	**S**	**S**	**S**	**M**	**W**				**S**	**M**		**M**	**M**	**M**
CO4	**M**	**S**	**S**		**W**	**S**			**M**	**M**		**M**	**M**	**M**

Unit	**Main Topics**	Course outlines	**Lecture(s)**
Unit-1	Design preliminaries	Introduction, nature of design, codes and standards, equipment selection and specification.	03
	Pressure vessel design (Unfired)	Factors influencing the design of vessels, criteria in vessel design, design of cylindrical and spherical vessels under internal pressure, IS 803-strong tank vessel design, design of thick-walled high-pressure vessels, design of heads and closures. Different safety features.	06
	Piping & pump design	Piping classification, important fittings and their use, symbols, layouts and color codes for pipelines, process piping design and pipe size selection, selection & design of various pumps.	05
Unit-II	Heat transfer equipment	Design of shell and tube heat exchangers, TEMA exchangers, Evaporators. Classification, specifications and sketches of heat transfer equipment, Economical aspects of designing.	07
	Mass transfer equipment	Process design calculations for mass transfer equipment: tray towers, sieve tray layout and hydraulic design, column diameter and height. General pressure drop correlation, packed towers, column internals, types of packing,	07

Total = 28 Hrs.

Recommended Books

1. Sinnot R.K., Coulson & Richardson's Chemical Engg; Elsevier
2. Bhattacharya B.C., Introduction to Chemical Equipment Design; CBS Pub.
3. Lloyd E.Brownell &Edwin H.Young, Process Equipment Design; Wiley Pub.
4. Ludwig E.E., Applied Process Design Vol.2; Gulf Publishing Company
5. Douglas J.M., Conceptual Design Of Chemical Process; Mcgraw-Hill
6. Norman P. Liberman, Troubleshooting Process Operations, Pennwell Books, 2009

Title of the Course: **Optimization of Chemical Processes** **L T P : 3 1 0**
Subject Code : **HDCH-612** **Weekly Load: 4 Hrs**
Course Category : **Honors** **Credit : 4**

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

CO1	Understand the basic concept of engineering optimization.
CO2	Distinguish various optimization techniques with their advantages and disadvantages
CO3	Understand the flow pattern of parameters in multivariable optimization techniques
CO4	Select the suitable techniques for optimization of selected process parameters.
CO5	Understand the application of these 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	PO12	PSO1	PSO2
CO1	**S**	**M**									**M**	**M**		**M**
CO2	**S**				**S**				**M**	**W**	**M**	**M**		**W**
CO3	**M**	**M**	**S**		**S**					**W**	**W**	**M**		**W**
CO4		**S**	**M**	**M**						**W**	**W**	**W**		
CO5	**S**	**S**	**S**	**M**	**S**				**M**	**W**	**S**	**M**		**M**

Unit	Main Topics	Course Outlines	Lectures
Unit-1	Introduction	Optimization and calculus based classical optimization techniques.	05
	One Dimensional Minimization 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
	Linear Programming	Graphical representation, simplex and revised simplex methods, duality and transportation problems.	05
	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 methods.	12
Unit-2	Dynamic Programming:	Multistage processes- acyclic and cyclic, sub optimization, principle of optimality and applications.	05
	Geometric Programming (GP)	Differential calculus and Arithmetic-Geometric inequality approach to unconstrained GP; Constrained GP minimization; GP with mixed inequality constraints and Complementary GP	08

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

Title of the Course: **Process Energy Integration** **L T P: 3 1 0**
Subject Code: **HDCH-621** **Weekly Load: 4 Hrs**
Course Category: **Departmental Core (Honors)** **Credit: 4**

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

CO1	Understand of the fundamentals of process integration for industrial application.
CO2	Perform pinch analysis of actual industrial problems.
CO3	Apply the principles of sciences to analyze and design heat exchanger networks.
CO4	Appraise the engineering problems and minimize the water consumption and waste generation.

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	PO12	PSO1	PSO2
CO1	**S**	**S**				**W**	**S**				**S**			**S**
CO2	**S**	**S**	**S**	**M**	**M**	**W**	**S**				**S**			**S**
CO3	**S**	**S**	**S**	**M**	**M**	**W**	**M**				**M**			**S**
CO4	**S**	**S**	**S**	**M**	**M**	**W**	**S**				**S**			**S**

Unit	**Main Topics**	**Course outlines**	**Lecture(s)**
Unit-I	1. Process Integration – Introduction	Definition of Process Integration (PI), School of thoughts, Areas of application and Techniques available for PI, Onion diagram.	06
	2. Pinch Technology – An Overview	Introduction, Basic concept, how it is different than energy auditing, Role of thermodynamic laws, Problem addressed by Pinch technology.	07
	3. Steps of Pinch Technology:	Data extraction, Targeting, Designing, Optimization-Super targeting	05
	4. Elements of Pinch Technology	Grid diagram, Composite curve, Problem table algorithm, Grand composite curve	05
Unit-II	5. Heat Exchanger Network Targeting:	Energy targeting, Area targeting, Number of units targeting, Shell targeting, cost targeting.	05
	6. Designing of Heat Exchanger Network	Pinch design methods, Heuristic rules, Stream splitting, Design of maximum energy recovery (MER), Design of multiple utilities and pinches, Design for threshold problem, Loops and Paths.	06
	7. Heat Integration of Equipment	Heat engine, Heat pump, Distillation column, Reactor, Evaporator, Drier, Refrigeration systems.	04
	8. Heat and Power Integration	Co-generation, Steam turbine, Gas turbine.	03
		Total	**42**

Recommended Books:

1. Kemp, I. C., "Pinch Analysis and Process Integration: A user Guide on Process Integration for the Efficient Use of Energy", 2nd Ed., Butterworth-Heinemann, 2007.
2. Smith R.., "Chemical Process Design and Integration", 2nd Ed., Wiley, 2005.
3. Shenoy U. V., "Heat Exchanger Network Synthesis", Gulf Publishing Company.
4. El Halwagi, M. M., "Process Integration", 7th Ed., Academic Press, 2006.

Title of the Course :	**Computational Transport Phenomena**	**L T P : 3 1 0**
Subject Code :	**HDCH-711**	**Weekly Load : 4 Hrs**
Course Category :	**Honors**	**Credit : 4**

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

CO1	Access various discretization techniques with their applications in transport phenomena.
CO2	Compute engineering problems pertaining simultaneous transport.
CO3	Develop solution to the transport phenomena-based model.

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	PO12	PSO1	PSO2
CO1	**S**	**S**	**M**	**W**						**M**	**S**	**W**		**M**
CO2	**S**	**S**	**S**	**M**	**S**					**M**	**M**	**W**		**M**
CO3	**S**	**S**	**S**	**M**	**S**					**M**	**W**	**W**		**M**

Unit	Main Topics	Course Outlines	Lectures
Unit-I	Introduction	Governing equations for momentum, energy and mass transport, Review of ODE and PDE, Initial and Boundary conditions, classification of PDE, various methods to solve PDE numerically along with their advantages and disadvantages, Finite difference formulation, various aspects of finite difference equation, error and stability analysis, dissipation, and dispersion errors, modified equations. Unwinding of convective terms and its significance, Transportive and conservative properties. Upwind biased difference schemes and its significance. Solutions of simultaneous equations: iterative and direct methods, TDMA, ADI;	12
	Computational Momentum Transport	Solution of incompressible N-S equation: Stream function and vorticity formulation; Primitive variable methods: Application of SIMPLE, SIMPLER and MAC algorithm to solve fluid flow problems.	10
Unit-II	Computational Energy Transport	One- and Two-dimensional steady heat conduction and their solutions, extension to three-dimensional; Unsteady heat conduction, explicit and implicit methods, solution of boundary layer equation, upwinding.	8
	Simultaneous Transport and advanced Computational Techniques	Simulation of coupled transport problems, Concepts of boundary layer theory and its simulation algorithm, Study on Grid generation and Stability criterion, QUICK and exponential scheme. Preliminary concepts of Finite Element Method and Finite Volume Method for simultaneous energy and momentum transport problems. Comparison of finite difference, finite element, and finite volume approaches to discretization of a model problem.	12

Total = 42 Hrs.

Recommended Books:

1. Transport Phenomena, by R. Byron Bird, Warren E. Stewart and Edwin N Lightfoot, 2nd Edition, Wiley, 2001.
2. Fundamentals of Heat and Mass Transfer, by Frank P. Incropera, David P. DeWitt, 6th edition, John Wiley & Sons (Asia) Pvt. Ltd.
3. K. Muralidhar and T. Sundararajan, Computational Fluid Flow and Heat Transfer, 2nd ed., Narosa, 2011.
4. P. S. Ghoshdastidar, Computer Simulation of Flow and Heat Transfer, 4th ed., Tata McGraw-Hill), 1998.

5. S. V. Patankar, Numerical Heat Transfer and Fluid Flow, Hemisphere Series on Computational Methods in Mechanics and Thermal Science.

Title of the Course: **Project Hons** **L T P: 0 0 8**
Subject Code: **PHCH-721** **Weekly Load: 8 Hrs**
Course Category: **Professional Core** **Credit: 4**

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

CO1	Demonstrate the knowledge, skills, and attributes of professional Engineers for designing & development of chemical process plant/engineering equipment/product
CO2	Provide engineering solution to selected industrial/societal problem.
CO3	Demonstrate team spirit, ethical practices, managerial skill, and economical aspects.
CO4	Effectively communicate and present the project findings in written and oral form.

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	PO12	PSO1	PSO2
CO1	**S**	**S**	**S**	**S**	**M**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**M**	**M**
CO2	**S**	**S**	**S**	**S**	**M**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**M**	**S**
CO3					**M**	**S**	**M**	**S**	**S**	**M**	**S**	**S**	**M**	**M**
CO4					**M**	**M**		**S**	**S**	**S**	**M**	**M**	**M**	**M**

The project work must include:

f) Identification and Selection of project problem related to process/ societal /professional world for demonstration of knowledge of chemical engineering.

g) Application of fundamental knowledge and skills to design & develop chemical process plant/engineering equipment/product

h) Provide the possible solutions of the problem.

i) Feasibility study of selected solution

j) Effective communication of optimum solution and future scope of work.

(UG PROGRAMME in CHEMICAL ENGINEERING)

(Minor Degree)

DATE

02.07.2021

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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.

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Program Educational Objectives (PEOs)

PEO 01: To prepare students for successful professional career in Indian and multinational Chemical process and allied industries, design and consultancy organizations and relevant government agencies.

PEO 02: To build up capacity in students for problem analysis, interpretation and solution related to application of Chemical engineering for sustainable development.

PEO 03: To prepare students who can provide leadership and companionship in multidisciplinary teams.

PEO 04: To inculcate in students qualities that enable them to apply their domain knowledge as enlightened citizens for the upliftment of society.

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Program Outcomes (POs)

PO 01: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO 02: Problem analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO 03: Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO 04: Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO 05: Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

PO 06: The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO 07: Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO 08: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO 09: Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO 10: Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO 11: Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and Leader in a team, to manage projects and in multidisciplinary environments.

PO 12: Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

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Program Specific Outcomes (PSOs)

PSO 01: Natural Resource Utilization: The candidate should have sufficient technical knowledge to cater to the need of existing and upcoming chemical industry and efficient utilization of natural resources.

PSO 02: Cleaner production: Applying Chemical Engineering fundamentals for green and energy efficient processes.

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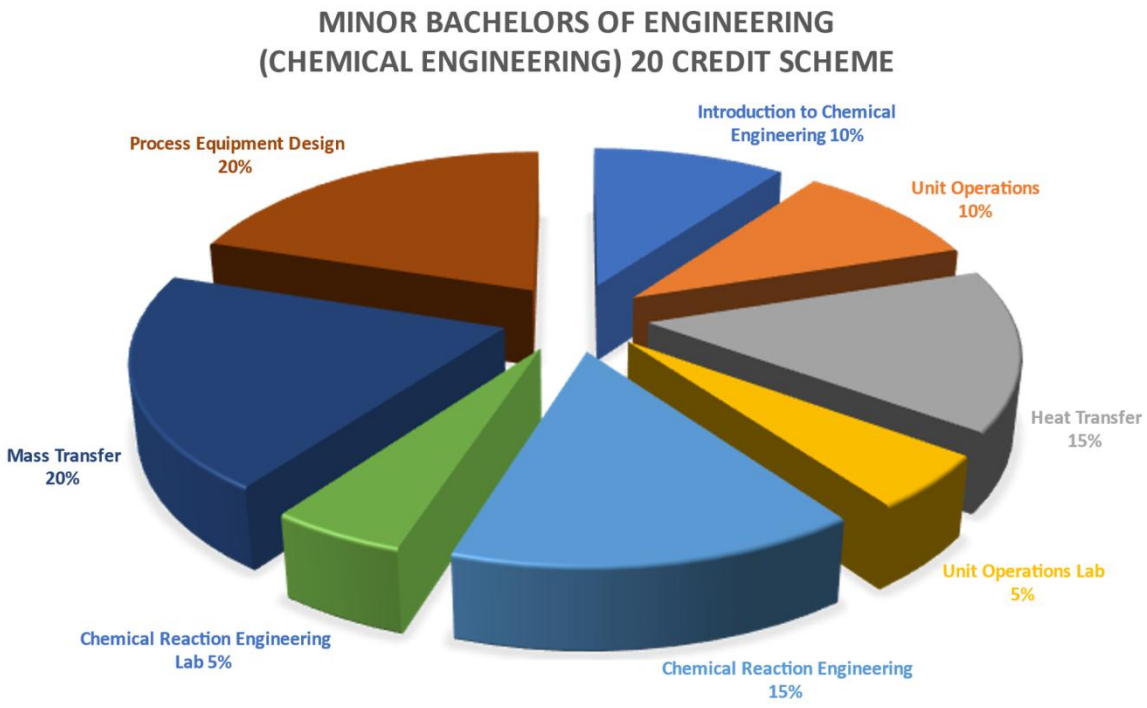
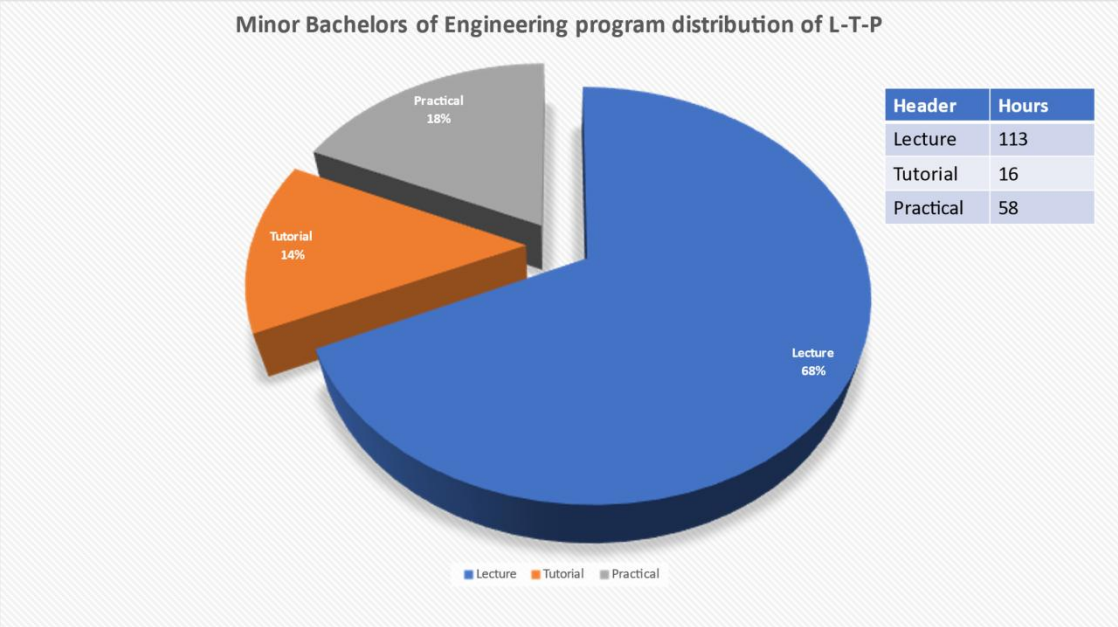
Minor Bachelor of Engineering Degree (Chemical Engineering) 20 Credit scheme





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Study Scheme for Minor Bachelor of Engineering Degree in Chemical Engineering

	Semester-III						
S No	**Sub Code**	**Subject Name**	**L**	**T**	**P**	**Hrs.**	**Credits**
1.	MDCH-511	Introduction to Chemical Engineering	2	0	0	2	2
2.	MDCH-512	Unit Operations	2	0	0	2	2
		Total	4	0	0	4	**4**
	Semester-IVA						
S No	**Sub Code**	**Subject Name**	**L**	**T**	**P**	**Hrs.**	**Credits**
1.	MDCH-521	Heat Transfer	2	1	0	3	3
2.	MDCH-522	Unit Operations Lab	0	0	2	2	1
		Total	2	1	2	5	**4**
	Semester-VA						
S No	**Sub Code**	**Subject Name**	**L**	**T**	**P**	**Hrs.**	**Credits**
1.	MDCH-611	Chemical Reaction Engineering	3	0	0	3	3

2.	MDCH-612	Chemical Reaction Engineering Lab	0	0	2	2	1
		Total	3	0	2	5	**4**
	Semester-VI A						
S No	**Sub Code**	**Subject Name**	**L**	**T**	**P**	**Hrs.**	**Credits**
1.	MDCH-621	Mass Transfer	3	1	0	4	4
		Total	3	1	0	4	**4**
Semester-VII							
S No	**Sub Code**	**Subject Name**	**L**	**T**	**P**	**Hrs.**	**Credits**
1.	MDCH-711	Process Equipment Design	3	1	0	4	4
		Total	3	1	0	4	**4**

Title of the Course: **Chemical Process Calculation** **L T P: 2 0 0**
Subject Code: **MDCH-511** **Weekly Load: 2 Hrs**
Course Category: **Minor Degree** **Credit: 2**

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

CO1	Apply/ use the units and dimensions, dimensional analysis, concentration calculations
CO2	Apply the stoichiometric calculations to the industrial chemical reactions
CO3	Formulate and solve the material and energy balance problems applicable to chemical 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	PO12	PSO1	PSO2
CO1	**S**	**S**	**M**							**W**				
CO2	**S**	**S**	**S**							**W**				
CO3	**S**	**S**	**S**	**M**	**M**				**S**	**W**		**S**		

Unit	**Main Topics**	**Course outlines**	**Lecture(s)**
Unit-1	Introduction and Techniques of problem solving	Concept of unit operations and unit processes, Types of problems in chemical engineering, various steps of techniques of problem solving, barriers to problem solving, comparison between problem solving habits of novice and an expert, Process flow sheet.	03
	Basic Calculations	Units and dimensions, Dimensional analysis, Mole concept, Concentration calculations, stoichiometry, and stoichiometric calculations, Limiting and excess reactants, Gas laws (for ideal and real gases) and equations of state, Concept of vapor pressure and partial pressure, Raoult's Law for ideal solutions, Henry's Law, Dalton's Law for gaseous mixtures	07
	Material Balance	Material balance without and with chemical reactions, Recycle, bypass and purge operations with and without chemical reactions.	04

Unit-II	Energy Balance	Concept of Thermodynamic properties, Law of conservation of energy, heat capacities of solid, liquid, gases and solutions, latent heat, heat of formation, heat of combustion, heat of reaction, theoretical flame temperature, Use of steam tables, formulation, and solution of energy balance problems to chemical processes (steady state)	08
	Applications of material and energy balance	Degree of freedom analysis, Applications of material and energy balance to various chemical plant operations. Basic calculations using chemical flow sheet simulator.	06

Total=28 Hrs.

Recommended Books:

1. Himmelblau, Basic Principles and Calculations in Chemical Engineering, Prentice Hall (I)
2. Hougen & Watson, Chemical Process Principles, Wiley International Edition.
3. Bhatt & Vora, Industrial Stoichiometry, Tata McGraw Hill
4. G.K. Roy, Solved Examples in Chemical Engineering, Khanna Publications.

Title of the Course: **Chemical Process Industries** **L T P: 2 0 0**
Subject Code: **MDCH-512** **Weekly Load: 2 Hrs**
Course Category: **Minor Degree** **Credit: 2**

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

CO1	Apply engineering knowledge to manufacturing processes of various inorganic and organic chemical products
CO2	Apply various unit operations and processes to the chemical industries
CO3	Analyze the engineering problems associated with the manufacturing processes in chemical industries

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	PO12	PSO1	PSO2
CO1	**S**	**M**				**M**	**W**		**M**			**W**	**M**	**M**
CO2	**S**	**M**				**M**	**W**		**M**	**M**		**W**	**M**	**M**
CO3	**S**	**M**	**M**			**M**	**M**	**M**	**M**	**M**		**W**	**M**	**M**

Unit	**Main Topics**	**Course outlines**	**Lecture(s)**
Unit-I	Inorganic Acids	Manufacturing Process of sulphuric acid, Hydrochloric acid, and Nitric acid.	03
	Cement and Ceramics	Portland cement production. (Details of manufacturing process with flow chart), Basic ceramic chemistry, Refractories, Vitreous enamel, Kilns.	04
	Polymer Industry	Scope of Polymerization Industries, Types of polymerizations, Manufacture of Polyethylene and Polypropylene, Nylon, Rubber	04
	Pulp and Paper	Scope of Pulp and paper industries, Manufacturing of pulp and manufacturing of paper	03
Unit-II	Oils & Fats	Methods of extracting vegetable oils, Refining and Hydrogenation	03

		of oils	
	Fermentation industry	Fermentation process, Manufacture of ethyl alcohol from molasses by fermentation.	03
	Sugar	Manufacture and refining of sugar	02
	Fertilizers	Major components of fertilizers and their significance, Manufacturing of Triple superphosphate (Wet process), Urea.	03
	Soap & Detergents	Chemistry of soaps & detergents, types and manufacturing of soaps and detergents.	03

Total=28 hrs

Recommended Books:

1. Dryden, Outlines of Chemical Technology, East West Press
2. Shreves's Chemical Process Industries by George T. Austin, McGraw Hill
3. M. Gopala Rao, Marshall Sitting, Outlines of Chemical Technology, East West Press

Title of the Course: **Heat Transfer** **L T P: 2 1 0**
Subject Code: **MDCH-521** **Weekly Load: 3 Hrs**
Course Category: **Minor Degree** **Credit: 3**

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

CO1	Understand the fundamentals of modes of heat transfer i.e., conduction, convection, and radiation
CO2	Overview the performance of heat exchangers and evaporators in process industries
CO3	Recognize the applications of heat transfer principles and equipment to the process industries

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	PO12	PSO1	PSO2
CO1	**S**	**S**										**W**		**M**
CO2	**S**	**M**	**M**	**W**		**W**			**W**			**W**		**M**
CO3	**S**	**M**	**S**	**M**	**M**	**W**			**W**	**W**		**W**		**W**

Unit	**Main Topics**	**Course outlines**	**Lecture(s)**
Unit-I	Conduction	Review of Fourier's Law, one-dimensional heat conduction through composites having plane wall. Steady state heat flow with heat source through plane wall surface. Thermal conductivity of materials. Fins and their applications.	10
	Convection	free and forced convection, concept of thermal boundary layer, concept of overall heat transfer coefficient for laminar and turbulent flow, heat transfer inside & outside tubes with significance of Nusselt, Prandtl, Reynold, Biot, Fourier and Peclet number.	08

	Radiation	Distribution of radiant energy, Definition of emissivity, absorptivity, Reflectivity and Transmissivity, concept of Black and Grey bodies, Plank's Law of monochromatic radiation, Kirchhoff's Law, Wein's displacement law, Stefan-Boltzmann law	08
Unit -II	Heat Transfer with Phase Change	Boiling, Condensation, Heat Exchangers and Evaporators: Drop wise and Film wise condensation, Nucleate & Film boiling.	06
	Heat Transfer Equipment	Heat Exchangers: Theory & design of Double Pipe Heat Exchanger, Shell and Tube Exchangers, Selection of passes of 1-2, 2-4 Shell-and-Tube Heat Exchangers, Overview of plate type heat exchanger, reboiler, condensers and evaporators.	10

Total=42 hrs

Recommended Books:

1. Kumar D.S., Heat and Mass Transfer, S.K. Kataria & Sons
2. McCabe & Smith, Unit Operations of Chemical Engg, McGraw Hill
3. Kreith, Principles of Heat Transfer, Harper & Row
4. Kern, D.Q., Process Heat Transfer, Tata McGraw Hill

Title of the Course: **Unit Operation Lab** **L T P: 0 0 2**
Subject Code: **MDCH-522** **Weekly Load: 2 Hrs**
Course Category: **Minor Degree** **Credit: 1**

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

CO1	Understand various modes of heat transfer.
CO3	Understand the principles and analyze liquid-solid mass transfer operations.
CO4	Discuss the operation of the process equipment like extraction, diffusion, and crystallization.

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	PO12	PSO1	PSO2
CO1	**S**	**M**	**M**	**M**					**S**	**W**	**W**	**M**		**-**
CO3	**S**	**M**	**-**	**M**					**S**	**W**	**W**	**M**		**W**
CO4	**S**	**M**	**-**	**M**					**S**	**W**	**W**	**M**		**W**

List of experiments:

1. To find out heat transfer coefficient of vertical cylinder in natural convection.
2. To determine the total thermal resistance & thermal conductivity of composite wall and also plot temperature gradient along with composite wall structure.
3. To find out the thermal conductivity of metal rod apparatus.
4. To determine the emissivity of gray surface.
5. To determine the value of Stefan Boltzmann apparatus constant for radiation heat transfer.
6. To find out the thermal conductivity of liquids.
7. To study the mass transfer coefficient for sublimation of naphthalene balls in air using a packed bed of spherical particles of naphthalene.

8. Determination of the diffusion coefficient of an organic vapor in air and study the effect of temperature on the diffusion coefficient.
9. To study the drying characteristics of the given wet material (forced convection).
10. To study liquid-solid equilibria.

Note: Minimum 08 Experiments have to be conducted.

Title of the Course: **Chemical Reaction Engineering** **L T P: 3 0 0**
Subject Code: **MDCH-611** **Weekly Load: 3 Hrs**
Course Category: **Minor degree** **Credit: 3**

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

CO1	Develop rate laws for homogeneous reactions
CO2	Design the ideal reactors for single and multiple reactions
CO3	Design the non-isothermal reactors and the heat exchange equipment required
CO4	Develop skills to choose the right reactor among single, multiple, recycle reactor, etc.

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	PO12	PSO1	PSO2
CO1	**S**	**M**												
CO2	**S**	**M**	**S**	**M**	**M**				**W**			**W**		
CO3	**S**	**M**	**S**	**S**	**M**				**W**			**W**		
CO4	**S**	**S**	**W**	**M**		**W**		**W**	**W**		**M**	**M**		**W**

Unit	**Main Topics**	**Course Outlines**	**Lectures**
Unit-I	Kinetics of homogeneous reaction	Concept of reaction rate, rate equation, single and multiple reactions, elementary and non-elementary reactions, molecularity and order of reactions, concept of rate constant k, and representation of reaction rate.	11
	Reactors	Concepts of Batch reactor, Semi batch reactor, Continuous stirred tank reactor, plug flow reactor, Slurry reactor, Trickle bed reactor, Bubble column reactor, Packed column reactor, Bioreactors, Reactors used in effluent treatments, Fluidized bed reactor.	11
Unit-II	Kinetics of heterogeneous reactions	Introduction to Kinetics (Gas solid non-catalytic reaction), Heterogeneous rate of reactions and different types of kinetic models for non-catalytic reactions, Inter & Intra-phase Mass transfer, Concept of reactive absorption and reactive extraction and their industrial applications. Process steps and deduction of rate law. Comparison with straight mass transfer.	10
	Catalytic reactions	Industrially important non-catalytic solid fluid reactions, the shrinking core model; process steps and deduction of rate law. Rate controlling step and limiting cases. Process parameters. Concept of enhancement factor; dominant resistance in overall rate Classification of catalysts, preparation and physical characteristics of solid catalysts, concept of physical and chemical adsorption, and kinetics of solid catalyzed gas phase reaction	10

Total = 42 hrs

Recommended Books:

1. Ghatak, H. R., Reaction Engineering Principles, CRC Press, Taylor and Francis Group
2. Levenspiel, O., Chemical Reaction Engineering, Wiley
3. Fogler, H .S., Elements of Chemical Reaction Engineering, Prentice Hall
4. Hill, G. C.; and Root, T.W., Introduction to Chemical Engineering kinetics and Recator Design, Wiley
5. Schmal, M, Chemical Reaction Engineering: Essentials, Exercises and Examples, CRC Press, Taylor and Francis Group

Title of the Course:	**Chemical Reaction Engineering Lab**	**L T P: 0 0 2**
Subject Code:	**MDCH-612**	**Weekly Load: 2 Hrs**
Course Category:	**Minor degree**	**Credit: 1**

Course outcomes: At the end of the course, the students will

CO1	Understand the basic concepts of chemical reaction engineering.
CO2	Attain a sound working knowledge on different types of reactors.
CO3	Analyze the performance of reactors and determine kinetics of chemical reactions progressed in 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	PO12	PSO1	PSO2
CO1	**S**	**S**							**S**	**S**		**W**		
CO2	**S**	**M**	**M**		**M**				**S**	**S**		**W**		
CO3	**S**	**M**	**M**	**M**	**M**				**S**	**S**	**W**	**W**		

Lists of Experiments:

13. To determine the order of reaction (n) and the reaction rate constant (k) for the given saponification reaction in an isothermal batch reactor.
14. To perform kinetic studies to established rate constant (K) using a series of reactors i.e., PFR followed by a CSTR.
15. To determine the kinetic constants k, n for saponification of ethyl-acetate with NaOH in isothermal CSTR at room temperature.
16. Study of RTD (Residence time distribution) in packed bed reactor by experiment & also plot Exit Age Distribution E.
17. To determine the rate constants k, and order of reaction, n in plug flow reactor.
18. To determine the rate constant (k) for a 2nd order saponification reaction of ethyl acetate in aqueous NaOH solution in isothermal Semi-Batch Reactor.
19. To determine the space time τ_1, τ_2 and τ_3 of CSTR's in series (Cascade CSTR) & also evaluate kinetic constants (k, n) at ambient temperature.
20. Study of catalytic homogenous reaction in a batch reactor under adiabatic condition.
21. Study the effect of temperature on kinetic parameters k, n in isothermal batch reactor.
22. Study the effect of temperature on kinetic parameters k, n in isothermal CSTR.
23. Study the effect of temperature on kinetic parameters k, n in isothermal Plug flow reactor.
24. Study the effect of temperature on kinetic parameters k, n in isothermal Semi-batch reactor.

Note: Minimum 08 Experiments must be conducted.

Title of the Course: **Mass Transfer** **L T P: 3 1 0**
Subject Code: **MDCH-621** **Weekly Load: 4 Hrs**
Course Category: **Minor degree** **Credit: 4**

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

CO1	Compute diffusivities and mass transfer coefficients and describe their applications
CO2	Apply the fundamentals of process design to various mass transfer operations
CO3	Carryout process design of distillation columns, humidifiers, absorbers
CO4	Apply the engineering fundamentals to the complexities of 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	PO12	PSO1	PSO2
CO1	**S**	**S**	**S**	**M**					**M**	**W**		**W**		**M**
CO2	**S**	**S**	**S**	**M**					**M**	**W**		**W**		**M**
CO3	**S**	**S**	**S**	**M**					**M**	**W**		**W**		**M**
CO4	**S**	**S**	**S**	**S**					**M**	**W**		**W**		**M**

Unit	**Main Topics**	Course outlines	**Lecture(s)**
Unit-1	Introduction	Classifications of mass transfer operations, choice of separation methods, design principles. Steady state molecular diffusion in fluids at rest and laminar flow, mass transfer coefficients in laminar and turbulent flow, mass, heat, and momentum transfer analogies.	10
	Inter phase Mass Transfer and gas-liquid contacting operations	Equilibrium between phases, local and overall mass transfer coefficients, General characteristics and operational features of tray towers and packed towers, types of trays, packed towers, tray towers, scrubbers.	10
Unit-II	Humidification Operations	VLE & enthalpy of pure substance, vapor-gas mixtures, Fundamental relationship for adiabatic and non-adiabatic operations for air-water system for humidification and dehumidification. Cooling towers-construction, operation, and process calculations.	8
	Separation Processes	Overview of distillation, absorption, extraction, adsorption, leaching, drying and crystallization	14

Total = 42 hrs

Recommended Books:

1. Treybal, Robert, Mass Transfer Operations, McGraw Hill
2. Sherwood, Thomas Mass transfer McGraw Hill
3. Badger & Banchero Introduction to Chemical Technology McGraw Hill
4. Dutta, B.K, Principles of Mass Transfer and Separation Processes, Prentice Hall of India
5. McCabe, Smith & Harriot, Unit Operations of Chemical Engineering, McGraw Hill

Title of the Course: **Process Equipment Design** **L T P: 3 1 0**
Subject Code: **MDCH-711** **Weekly Load: 4 Hrs**
Course Category: **Minor degree** **Credit: 4**

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

CO1	Apply fundamental principles of chemical engineering design preliminaries of chemical industry equipment
CO2	Appraise the process piping design and design of pumps used in chemical industries
CO3	Design and optimize operating conditions of Mass transfer equipment like distillation columns
CO4	Appreciate safety and environmental aspects during designing of process equipment

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	PO12	PSO1	PSO2
CO1	**S**	**S**	**S**	**M**	**W**				**S**	**M**		**M**	**M**	**M**
CO2	**S**	**S**	**S**	**M**	**W**				**S**	**M**		**M**	**M**	**M**
CO3	**S**	**S**	**S**	**M**	**W**				**S**	**M**		**M**	**M**	**M**
CO4	**M**	**S**	**S**		**W**	**S**			**M**	**M**		**M**	**M**	**M**

Unit	**Main Topics**	**Course outlines**	**Lecture(s)**
Unit-1	Design preliminaries	Introduction, nature of design, codes and standards, equipment selection and specification.	2
	Pressure vessel design (Unfired)	Factors influencing the design of vessels, criteria in vessel design, design of cylindrical and spherical vessels under internal pressure, IS 803-strong tank vessel design, design of thick-walled high-pressure vessels, design of heads and closures. Different safety features.	6
	Piping design	Piping classification, important fittings and their use, symbols, layouts and color codes for pipelines, process piping design and pipe size selection,	10
Unit-II	Heat transfer equipment	Design of shell and tube heat exchangers, TEMA exchangers, classification specifications and sketches of heat transfer equipment, Evaporators Economical aspects of designing.	12
	Mass transfer equipment	Process design calculations for mass exchange equipment: tray towers, sieve tray layout and hydraulic design, column diameter and height. Packed towers, column internals, types of packing, general pressure drop correlation	12

Total = 42 Hrs.

Recommended Books

7. Sinnot R.K., Coulson & Richardson's Chemical Engg; Elsevier
8. Bhattacharya B.C., Introduction to Chemical Equipment Design; CBS Pub.
9. Lloyd E.Brownell &Edwin H.Young, Process Equipment Design; Wiley Pub.
10. Ludwig E.E., Applied Process Design Vol.2; Gulf Publishing Company
11. Douglas J.M., Conceptual Design of Chemical Process; Mcgraw-Hill
12. Norman P. Liberman, Troubleshooting Process Operations, Pennwell Books, 2009