Board of Studies

Restructuring of ICD Programme (CPT-DCT) - 2024

DATE

22.05.2024

रसायनअभियांत्रिकीविभाग
Department of Chemical Engineering
संतलौंगोवालअभियांत्रिकीएवंप्रौद्योगिकीसंस्थान
SANT LONGOWAL INSTITUTE OF ENGINEERING AND TECHNOLOGY
(भारतशासन, शि. म. अधीन, समविश्वविद्यालय)
(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.

Program Outcomes (PO's) for ICD programme

1. **Basic And Discipline specific Knowledge:** Apply knowledge of basic mathematics, science and engineering fundamentals and engineering specialization to solve engineering problems.

2. **Problem Analysis:** identify and analyse well-defined engineering problems using codified standard methods.

3. **Design/development of solutions:** Design solution for well-defined technical problems and assist with the design of systems components or processes to meet specified needs.

4. **Engineering tools, Experimentation and Testing:** Apply modern engineering tools and appropriate techniques to conduct standard tests and measurements.

5. **Engineering practices for society, sustainability, and environment:** Apply appropriate technology in context of society, sustainability, environment, and ethical practices.

6. **Project Management:** Use engineering management principals individually, as a team member or a leader to manage projects and effectively communicate about well-defined engineering activities.

7. **Life-long learning:** ability to analyse individual needs and engage in updating in the context of technological changes.

Study Scheme of Integrated Certificate Diploma Programme (CPT-DCT):

Semester-I							
Sr. No	**Code No.**	**Course Title**	**Hrs per week**			**Hrs.**	**Credits**
			L	**T**	**P**		
1.	BSMA101	Mathematics-I	3	1	0	4	4
2.	BSPH103	Applied Physics - I	2	1	0	3	3
3.	BSCY105	Applied Chemistry	2	1	0	3	3
4.	HSMH101	Communication Skills in English	2	0	0	2	2
5.	BSPH107	Applied Physics – I Lab	0	0	2	2	1
6.	BSCY109	Applied Chemistry Lab	0	0	2	2	1
7	HSMH105	Communication Skills in English Lab	0	0	2	2	1
8.	ESME101	Engineering Graphics	0	0	2	2	1
9	ESWS103	Engineering Workshop Practice	0	0	4	4	2
10	HSSP103	Sports & Yoga	0	0	2	2	1
			9	**3**	**14**	**26**	**19**
11.	**QPCH101**	**Raw material characterization**	**0**	**0**	**08**	**08**	**1**

Semester-II							
Sr. No	**Code No.**	**Course Title**	**Hrs per week**			**Hrs.**	**Credits**
			L	**T**	**P**		
1.	BSMA102	Mathematics-II	3	1	0	4	4
2.	BSPH104	Applied Physics - II	2	1	0	3	3
3.	ESCS102	Introduction to IT Systems	2	0	0	2	2
4.	ESEE104	Fundamentals of Electrical Engineering	2	0	0	2	2
5.	ESEC108	Fundamentals of Electronics Engineering	2	0	0	2	2
6.	ESME106	Engineering Mechanics	2	1	0	2	2
7.	BSPH106	Applied Physics-II Lab	0	0	2	2	1
8.	ESCS110	Introduction to IT Systems Lab	0	0	2	2	1
9.	ESEE112	Fundamentals of Electrical Engineering Lab	0	0	2	2	1
10.	ESEC114	Fundamentals of Electronics Engineering Lab	0	0	2	2	1
11.	ESME116	Engineering Mechanics Lab	0	0	2	2	1
			13	**3**	**10**	**25**	**20**
12	**QPCH102**	**Pulping, beating and refining of pulp**	**0**	**0**	**08**	**08**	**1**
13	EAA 102	Extra Academic Activity (A/B/C)	-	-	-	-	**1 S/US**

Summer-I							
Sr. No	**Code No.**	**Course Title**	**Hrs per week**			**Hrs**	**Credits**
			L	**T**	**P**		
1	**QPCH103**	**On Job Training (QP) (6Weeks)**	**0**	**0**	**24**	**24**	**3**

Semester-III							
Sr. No	**Code No.**	**Course Title**	**Hrs per week**			**Hrs**	**Credits**
			L	**T**	**P**		
1.	PCCH201	Fluid Flow	3	1	0	4	4
2.	PCCH203	Pulping and Bleaching Technology	3	1	0	4	4
3.	PCCH205	Chemical Engineering Thermodynamics	3	0	0	3	3
4.	PCCH207	Pulp Washing & Chemical Recovery	3	0	0	3	3
5.	PCCH209	Industrial Stoichiometry	3	0	0	3	3
6.	PCCH211	Bleaching Process lab	0	0	2	2	1
7.	PCCH213	Pulping Process lab	0	0	2	2	1
8.	PCCH215	Pulp Washing & Chemical Recovery Lab	0	0	2	2	1
9.	AUCH201	Environmental Science	2	0	0	2	0 (S/US)
			17	**2**	**6**	**25**	**20**
10.	**QPCH201**	**Wastewater treatment**	**0**	**0**	**08**	**08**	**1**
11.	EAA201	Extra Academic Activity (A/B/C)	-	-	-	-	**1 S/US**

Semester-IV							
Sr. No	**Code No.**	**Course Title**	**Hrs. Per week**			**Hrs**	**Credits**
			L	**T**	**P**		
1.	PCCH202	Heat Transfer	3	1	0	4	4
2.	PCCH204	Mechanical Operations	3	1	0	4	4
3.	PCCH206	Stock preparation & Paper Making	3	0	0	3	3
4.	PECH202	Professional Elective -I	3	1	0	4	4
5.	OECH202	Open Elective - I	3	0	0	3	3
6.	PCCH208	Paper making Lab	0	0	2	2	1
7.	PCCH210	Paper Testing Lab	0	0	2	2	1
8.	AUMH202	Essence of Indian Knowledge and Tradition	2	0	0	2	0 (S/US)
			17	**3**	**4**	**24**	**20**
9.	**QPCH202**	**Process Instrumentation**	**0**	**0**	**08**	**08**	**1**
10	EAA202	Extra Academic Activity (A/B/C)	-	-	-	-	**1 S/US**

Summer-II							
Sr. No	**Code No.**	**Course Title**	**Hrs per week**			**Hrs**	**Credits**
			L	**T**	**P**		
1.	TPID301	Summer Internship–II (4-6 weeks)	0	0	08	08	1
2 .	**QPCH203**	**On Job Training (QP) (6Weeks)**	**0**	**0**	**16**	**16**	**2**
							3

Semester-V							
Sr. No	**Code No.**	**Course Title**	**Hrs per week**			**Hrs**	**Credits**
			L	**T**	**P**		
1.	HSMH301	Entrepreneurship and Starts-ups	3	1	0	4	4
2.	PCCH301	Mass Transfer	3	0	0	3	3
3.	PCCH303	Chemical Process Industries	3	0	0	3	3
4.	PECH301	Professional Elective -II	3	1	0	4	4
5.	OECH301	Open Elective - II	3	0	0	3	3
6.	PCCH305	Chemical Engineering Lab-1	0	0	2	2	1
7.	PRCH301	Minor Project	0	0	4	4	2
			15	**2**	**6**	**23**	**20**
8.	**QPCH301**	**Chemical Process Technology**	**0**	**0**	**08**	**08**	**1**

Semester-VI							
Sr. No	**Code No.**	**Course Title**	**Hrs per week**			**Hrs**	**Credits**
			L	**T**	**P**		
1.	AUMH302	Indian Constitution	2	0	0	2	0
2.	PCCH302	Chemical Reaction Engineering	3	0	0	3	3
3.	PECH302	Professional Elective - III	3	1	0	4	4
4.	PECH304	Professional Elective - IV	3	1	0	4	4
5.	OECH302	Open Elective -III	3	0	0	3	3
6.	PCCH306	Chemical Engineering Lab-2	0	0	2	2	1
7.	PRCH302	Major Project	0	0	8	8	4
8.	SECH302	Seminar	1	0	0	1	1
			15	**2**	**10**	**27**	**20**
9.	**QPCH302**	**Solid waste management**	**0**	**0**	**08**	**08**	**1**

List of Professional Electives

Professional Elective-I			
Sr. No	**Sub. Code**	**Subject Name**	
1	PECH202A	Process Instrumentation	
2	PECH202B	Polymer Technology	
3	PECH202C	Energy Technology	
Professional Elective -II			
Sr. No	**Sub. Code**	**Subject Name**	
1	PECH301A	Petroleum Technology	
2	PECH301B	Electrochemical Engineering	
3	PECH301C	Thermo-chemical Engineering	
Professional Elective -III			
Sr. No	**Sub. Code**	**Subject Name**	
1	PECH302A	Process Equipments	
2	PECH302B	Biochemical Engineering	
3	PECH302C	Green Technology	
Professional Elective -IV			
Sr. No	**Sub. Code**	**Subject Name**	
1	PECH304A	Pollution Control	
2	PECH304B	Fertilizer Technology	
3	PECH304C	Separation Techniques	

List of Open Electives

Open Elective-I			
Sr. No	**Sub. Code**	**Subject Name**	
1	OECH202 A	Pollution Control	
2	OECH202 B	Energy Technology	
Open Elective-II			
Sr. No	**Sub. Code**	**Subject Name**	
1	OECH301A	Bioresource Technology	
2	OECH301B	Green Technology	
Open Elective-III			
Sr. No	**Sub. Code**	**Subject Name**	
1	OECH302 A	Biochemical Engineering	
2	OECH302 B	Thermo-chemical Engineering	

Title of the course: Raw material characterization
Subject Code: QPCH101
Weekly load: 0-0-8
Credit: 1
Course Outcomes: At the end of the course, the student will be able to comprehend:

CO1	Study of physical characteristics of cellulosic raw materials
CO2	Study of Chemical characteristics of cellulosic raw materials
CO3	Study of characteristics of fillers, resins, alum, and dyes
CO4	Study of characteristics of internal and external sizing chemicals

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

List of Experiments:

1. Determination of the moisture content in cellulosic raw material.
2. Determination of 1% NaOH solubility of cellulosic raw material.
3. Determination of ash and silica in cellulosic raw material.
4. Determination of alcohol benzene solubility of cellulosic raw material.
5. Determination of Bulk density of cellulosic raw material.
6. Determination of klaxon lignin in cellulosic raw material.
7. Determination of holocellulose in cellulosic raw material.
8. Water solubility of cellulosic raw material.
9. Determination of colour and brightness of fillers and dyes.
10. Determination of density and particle size of fillers.
11. Preparation of solutions of resin for addition in pulp slurry.
12. Preparation of solutions of alum for addition in pulp slurry.
13. Preparation of solutions of internal sizing chemical for addition in pulp slurry.
14. Preparation of solutions of different dyes for addition in pulp slurry.

Title of the course: Pulping, beating and refining of pulp
Subject Code: QPCH102
Weekly load: 0-0-8
Credit: 1
Course Outcomes: At the end of the course, the student will be able to comprehend:

CO1	Study of pulping processes parameters
CO2	Study of different types of beating and refining processes
CO3	Measurement of pulping effect on pulp characteristics
CO4	Measurement of beating effect on pulp characteristics

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

List of Experiments:

1. Calculation of chemical requirement for chemical pulping.
2. Preparation of pulping chemical solution of different concentration.
3. Determination of pulp kappa number.
4. Effect of pulping chemical dosing on pulp kappa number.
5. Effect of pulping temperature on pulp kappa number.
6. Effect of pulping time on pulp kappa number.
7. Fractionation of pulp based on the size of fibres.
8. Determination of average weight fibre length of pulp.
9. Study of lab valley beater.
10. Study of different types of refiners.
11. Beating and refining of pulp in lab Valley Beater.
12. Measurement of ^{0}SR of pulp slurry after beating and refining.
13. Effect of load increase on pulp ^{0}SR.
14. Effect of time increase on pulp ^{0}SR.
15. Effect of consistency increase on pulp ^{0}SR.

Title of the course: Fluid Flow
Subject Code: PCCH-201
Weekly load: 3-1-0
Credit: 4

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

CO1	Ability to understand fluid behaviour.
CO2	Comprehend the various flows measuring device.
CO3	Comprehend the flow of fluids through fluid transport 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**
CO1	S	S	M	W	M	M	S
CO2	S	S	M	W	M	M	S
CO3	S	S	M	W	M	M	S

Unit	**Course outlines**	**Lecture**
Unit I	Units and dimensions ,Various types of flow: steady and unsteady flow, uniform and non-uniform flow, stream line flow, laminar and turbulent flow	10
Unit II	Types of fluids: compressible and incompressible fluid, Newtonian and non-Newtonian fluid. Physical properties of fluids. Dimensionless numbers and their physical significance.	10
Unit III	Flow through the pipes and channels, concept of boundary layer. Continuity equation, Bernoulli's theorem and its application (without correction factor) and Reynolds number, Skin friction and form friction, Fanning factor, frictional losses in pipes and fittings.	10
Unit IV	Fluid pressure, various types of manometers, Pitot tube, Introduction to variable head meters and variable area meters. Wet gas meter, magnetic flow meter and anemometer, Simple numerical problems related to these topics. Pumps, reciprocating pump, rotary pump, characteristics curves of centrifugal pump, cavitations, Net positive suction Head & Priming.	10

Recommended Books:

1. Warren L McCabe, Julian C Smith, Peter Harriott, Unit Operations Of Chemical Engineering McGraw Hill Chemical Engineering Series, Tata McGraw Hill Publications, 2005.
2. K.A.Gavhane, Unit Operations -1, Nirali Publications, Third edition.
3. G.C.Sekhar , unit operations in Chemical Engineering, Pearson education , 2005.

Title of the course: Pulping and Bleaching technology
Subject Code: PCCH-203
Weekly load: 3-1-0
Credit: 4
Course Outcomes: At the end of the course, the student will be able to comprehend:

CO1	Pulping process and raw material preparation.
CO2	Working of different pulping equipment.
CO3	Pulp bleaching process.
CO4	Operations of bleaching 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**
CO1	S	S	S	M	S	M	S
CO2	S	S	S	M	S	M	S
CO3	S	S	S	M	S	M	S
CO4	S	S	S	M	S	M	S

Unit	**Course outlines**	**Lecture**
Unit-1	**Introduction** Definition of pulping as a fibre separation process, classification of raw materials used in paper making process (wood, non wood and agricultural residues)	05
	Raw material preparation Brief study of debarking, chipping and chip screening operations, operating procedures and safeguards of chipper and chip screens.	05
Unit-II	**Pulping equipments** Different types of digesters: Batch and continuous digesters, difference between batch and continuous digesters, Heating methods: Direct and Indirect Methods, Digester room operations like Chip filling, liquor charging, digester relief and blow down operations.	05
	Pulping Methods Different pulping processes like chemical, mechanical and semi chemical pulping. Alkaline Pulping: Description of soda and Kraft pulping processes, pulping of non wood raw materials, Introduction to semi chemical pulping processes like CMP and CTMP.	05
Unit-III	**Bleaching of Pulp** Fundamentals of pulp bleaching, important bleaching agents; their advantages and disadvantages. Brightness as a measure of pulp bleaching. Storage, handling and safety of chlorine and chlorine based bleaching agents, introduction to chlorine free bleaching.	10
Unit-IV	**Bleaching equipments and sequences** Introduction of common bleaching sequences, Flow sheets for important bleaching sequences like CE, CEHDED, CEDED, OCEDED, CEHP, CED, CEHH, CEHD with emphasis on operational measures and equipments used.	10

Recommended Books:

1. G.A. Smook, Handbook of Pulp and Paper Technologists.
2. J.P. Casey, Pulp & Paper Chemistry and Chemical Technology Vol. I.
3. Rydholm, Pulping Processes.
4. Libbey, Textbook of Pulp and paper Making.
5. C. Biermann, Handbook of Pulp and Paper Technologists.
6. R.P. Singh, Bleaching of Pulp.

Title of the course: Chemical Engineering Thermodynamics
Subject Code: PCCH-205
Weekly load: 3-0-0
Credit: 3

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

CO1	Develop a fundamental understanding of the basic Chemical Engineering thermodynamics and calculations
CO2	Comprehend phase equilibria and chemical reaction equilibria
CO3	Comprehend Refrigeration and Liquefaction

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

Unit	**Course outlines**	**Lecture**
Unit I	**Basic Concepts of Thermodynamics** Concept of Enthalpy, Internal Energy, Entropy, Free Energy and Equilibrium. Laws of Thermodynamics. Volumetric Properties of Fluids, Heat Effects, Heat Conduction in Gases and Liquids. Thermal Conductivity of Gases and Liquids.	10
Unit II	**Thermodynamics Properties of Fluids** Ideal Gas Law and Equations of States, Thermodynamic Properties of pure fluids: Properties of homogeneous mixtures; Concept of partial molar properties, fugacity, fugacity coefficient, chemical potential and activity coefficient.	10
Unit III	**Phase Equilibria and Chemical Reaction Equilibria** Vapour Pressure, Ideal Solutions and Ideal Gas Mixtures, Vapour liquid equilibria - Dew point and bubble point calculations for ideal solutions, Gibbs Duhem equation. Chemical Reaction Equilibria, Criteria of Chemical Reaction Equilibria, Clausius-Clapeyron equation.	10
Unit IV	**Refrigeration and Liquefaction** Various cycles of refrigeration – Carnot, Vapour compression, Vapour absorption. Concept of solar refrigeration. Liquefaction process cycles, coefficient of performance. Properties of refrigerant**.**	10

Recommended Books:

1. Introduction to Chemical Engineering Thermodynamics, Smith & Van Ness, Tata McGraw Hill Pub.
2. Chemical & Process Thermodynamics, Kyle, Prentice Hall (I) Publications
3. Chemical Engineering Thermodynamics, K V Narayanan, Prentice Hall (I) Publications
4. Chemical Engineering Thermodynamics, YVC Rao, Tata McGraw Hill Pub.

Title of the course: Pulp Washing and Chemical Recovery
Subject Code: PCCH-207
Weekly load: 3-0-0
Credit: 3

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

CO1	Pulp washing on multistage rotary vacuum filters.
CO2	Operation different washing equipments used in paper industry.
CO3	Working of Black liquor concentration & incineration.
CO4	Understand Concepts and operation of chemical recovery 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**
CO1	S	S	W	M	S	S	S
CO2	S	S	W	M	S	S	S
CO3	S	S	W	M	S	S	S
CO4	S	**S**	W	**M**	**S**	**S**	**S**

Unit	**Course outlines**	**Lecture**
Unit I	**Brown Stock Washing** Requirement of pulp washing after pulping. Study of pulp washing on multistage rotary vacuum filters. Construction and working of a rotary vacuum filter. Operating procedures including start-up and shutdown. Generation and maintenance of vacuum. Factors affecting brown stock washing. Concept of dilution factor and elementary calculations. Washing equipment other than rotary vacuum filters like horizontal belt washers and diffusion washers (only working principles and operational aspects).	10
Unit II	**Black liquor evaporation** Black liquor as an asset rather than a liability, its importance as an energy source, overview of recovery process. Black liquor characteristics. Classification of evaporators and their objectives in chemical recovery process, Introduction to multiple effect evaporations of Black liquor, Brief description of types of evaporators, condensate systems, vacuum devices, feeding arrangement. Operation of evaporators and operational troubles. high concentration black liquor	10
Unit III	**Black liquor incineration** General description of recovery boiler, flue passes, boiler feed water and steam flow. Major reactions. Combustion air and its control. Draft control. Black liquor firing. Smelt flow and dissolving. Operating procedures including start-up and shutdown. Control of air pollution.	12
Unit IV	**Causticizing Operations and lime cycle** Green liquor and its characteristics. The causticizing reaction. Causticizing efficiency. Operation of slakers, causticizers, mud washers and mud filters. Lime mud reburning; construction and working of lime kiln.	8

Recommended Books:

1. Handbook of Pulp and Paper Technology. K.W. Britt.
2. Handbook for Pulp and Paper Technologist. G.A. Smook.
3. Kraft Recovery Boilers. T.N. Adams, W.J. Frederick, T.M Grace, M. Hupa, A.K Jones, W. B. A. Sharp, D. Singbeil, H. Tran.

Title of the course: Industrial Stoichiometry
Subject Code: PCCH-209
Weekly load: 3-0-0
Credit: 3

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

CO1	Perform basic chemical calculations, conversion factors.
CO2	Perform Material balance (steady state):with and without chemical reactions
CO3	Perform elementary energy balance (steady State)

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

Unit	**Course outlines**	**Lecture**
Unit I	**Basic Chemical Engineering Calculations** Units and dimensions, conversion of units, calculation of composition/ concentration, chemical stoichiometric equations, gas laws (for ideal and real gases), Raoult's Law for ideal solutions, Henry's Law, Dalton's Law.	10
Unit II	**Material Balance** Material Balance (Steady State): Key components, techniques of problem solving, material balance problems without or with chemical reactions, concepts of bypass, recycle and purge systems.	10
Unit III	**Energy Balance** Energy Balance (Steady State), First Law of thermodynamics, heat effects, heat capacities of solid, liquid, gases and solutions, heat of formation, heat of combustion, heat of dissolution, heat of reaction, heat of fusion, heat of vaporization.	10
Unit IV	**Application of Stoichiometry** Applications of stoichiometric calculations to chemical engineering processes/operations such as distillation, humidification, evaporation, crystallization, drying and batch reactors.	10

Recommended Books:

1. Basic Principles and Calculation in Chemical Engineering, Himmelblau, Prentice Hall (I) Publications
2. Industrial Stoichiometry, Bhatt & Vora, Tata McGraw Hill
3. Industrial Stoichiometry, Lewis & Lewis, Tata McGraw Hill
4. Solved Examples in Chemical Engineering, G.K. Roy, Khanna Publications

Title of the course : Bleaching Process Lab
Subject Code : PCCH-211
Weekly load : 0-0-2
Credit: 01

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

CO1	Perform calculations of Pulping Process
CO2	Perform cooking procedure for pulping of raw-material
CO3	Carryout bleach liquor preparation, bleaching of pulp and calculations.
CO4	Comprehend with test of raw-materials.

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

List of Experiments:

1. Preparation of hypochlorite bleach liquor.
2. Calculation of volume of hypochlorite bleach liquor required for given quantity of pulp.
3. Bleaching of Pulp by sodium hypochlorite.
4. Bleaching of Pulp using hydrogen peroxide.
5. Washing of bleached pulp and calculation of Yield percentage.
6. Measurement of bleaching effect by brightness testing.
7. Bleaching of Pulp using chlorine dioxide.

Title of the course : Pulping Process Lab
Subject Code : PCCH-213
Weekly load : 0-0-2
Credit: 1

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

CO1	Perform calculations of Pulping Process
CO2	Perform cooking procedure for pulping of raw-material
CO3	Carryout bleach liquor preparation, bleaching of pulp and calculations.
CO4	Comprehend with test of raw-materials.

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

List of Experiments:

1. Preparation of 100 gpl NaOH solution for cooking.
2. Calculation of amount of raw material required for pulping in batch digester.
3. Study of Pulping Process parameters in lab digester.
4. Washing and screening of Pulp
5. Preparation of KRAFT pulping liquor.
6. Preparation of organosolv pulping liquor
7. Pulping of agro residue using organosolv pulping
8. Measurement of fibre length in fibre classifier

Title of the course: Pulp Washing and Chemical Recovery Lab
Subject Code: PCCH-215
Weekly load: 0-0-2
Credit: 1

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

CO1	Pulp washing on multistage rotary vacuum filters
CO2	Operation different washing equipments used in paper industry
CO3	Working of Black liquor concentration & incineration
CO4	Concepts and operation of chemical recovery 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**
CO1	S	M	M	S	S	S	S
CO2	S	M	M	S	S	S	S
CO3	S	M	M	S	S	S	S
CO4	S	M	M	S	S	S	S

List of experiments

1. Study of Rotary Drum Pulp Washer.
2. Laboratory washing of pulp by vacuum filtration.
3. Determination of specific gravity of Black liquor.
4. Measurement of degree twaddle (^{O}TW) of black liquor at different concentrations.
5. Determination of Total solids in black liquor.
6. Determination of viscosity of black liquor at different concentrations.
7. Flow sheet of a Chemical Recovery System.
8. Determination of specific gravity of lime mud.
9. Determination of moisture content in lime mud.
10. Size reduction of lime in jaw crusher.

Title of the course: Environmental Science
Subject Code: AUCH-201
Weekly load: 2-0-0
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**
CO1	S	S	M	M	S	S	S
CO2	S	S	M	M	S	S	S
CO3	S	S	M	M	S	S	S
CO4	S	S	M	M	S	S	S

Unit	**Course outlines**	**Lecture**
Unit – I	**Introduction to Environmental studies:** Environment, scope and importance of environmental studies, need for public awareness.	10
Unit – II	**Introduction to Environmental studies:** Introduction to forest resources, water resources, mineral resources, food resources, energy resources. Equitable use of resources for sustainable life styles. Role of individual in conservation of natural resources.	10
Unit – III	**Ecosystem and Biodiversity:** Ecosystem. Classification of ecosystem. Structural and functional components of an ecosystem. Energy flow in ecosystem. Forest ecosystem. Grass-land ecosystem. Biodiversity, types of biodiversity, function of biodiversity. Conservation of biodiversity.	10
Unit – IV	**Environmental pollution and social issues:** Environmental pollution, types of pollution. Municipal solid waste management. Role of an individual in pollution prevention. Water conservation. Climate change. Global warming. Acid rain. Ozone layer depletion. Water and Air Act.	10

Recommended Books:

1. A.Kaushik and C.P. Kaushik, Perspectives in Environmental Studies; New Age International Publisher.
2. P. Anandan and R. Kumaravelan, Environmental Science and Engineering; SCITECH Publications.
3. Pollution Control Acts, Rules and Notifications; CPCB Publication.
4. E. Bharucha, Textbook for Environmental Studies; UGC Publication.

Title of the course: Wastewater treatment
Subject Code: QPCH-201
Weekly load: 0-0-8
Credit: 1
Course Outcomes: At the end of the course, the student will be able to comprehend:

CO1	Important physical and chemical characteristics of wastewater
CO2	Important experimental techniques for wastewater characterization
CO3	Unit operations used in wastewater treatment
CO4	Working in wastewater treatment plant

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

List of experiments:

1. Determination of total solids, dissolved solids, and suspended solids in wastewater.
2. Determination of pH and fixed solids of wastewater sample.
3. Determination of volatile solids in wastewater.
4. Determination of dissolved oxygen of wastewater by titration method.
5. Determination of acidity/alkalinity of wastewater by titration method.
6. Determination of BOD of wastewater sample.
7. Determination of COD of wastewater sample.
8. Microscopic evaluation of wastewater.
9. Wastewater treatment by sedimentation and filtration and comparison of methods.
10. Use of different flocculants in wastewater treatment.
11. Study of effect of different flocculants on sedimentation in wastewater treatment.
12. Visit to the Institute wastewater treatment plant and demonstration of unit operations and unit processes involved.

Title of the course: Heat Transfer
Subject Code: PCCH-202
Weekly load: 3-1-0
Credit: 4

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

CO1	Gain knowledge of different Heat Transfer Processes.
CO2	Comprehend concepts of insulations and their properties.
CO3	Comprehend different heat exchanging equipment their operations, basic calculations
CO4	Use the different laws of Heat Transfer in problem solving.

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

Unit	**Course outlines**	**Lecture**
Unit I	**Introduction** Modes of heat transfer: Conduction, Convection, Radiation **Conduction** Fourier's Law, thermal conductivity of materials, one dimensional steady state heat conduction through composite walls, cylinders, spheres, Insulation and insulating materials, critical thickness of insulation, physical properties of insulating materials. Concept of unsteady state heat transfer.	10
Unit II	**Convection** Concept of heat transfer coefficient, Free and forced convection, Significance of dimensionless groups such as Reynolds number, Prandlt's number, Nusselt's Number and Grashof's number. Empirical correlations for free and forced convection. Heat transfer with phase change.	10
Unit III	**Radiation** Laws of radiation, Black body, Grey body, angle factor, view factor. Exchange of radiant heat between black bodies. Radiation from gas and vapor, Radiant exchange between gray surfaces, Radiant flux, Radiation intensity.	10
Unit IV	**Heat Exchange Equipments** General discussion about various types of heat exchangers, evaporators, condensers, and furnaces.	10

Recommended Books:

1. D.S. Kumar, Heat & Mass Transfer, S.K. Kataria & Sons, 2013.
2. B. K. Dutta, Heat Transfer Principles and Applications, PHI Learning, 2015
3. Y. A. Cengel, Heat Transfer A Practical Approach, McGraw Hill, 2002.

Title of the course: Mechanical Operations
Subject Code: PCCH 204
Weekly load: 3-1-0
Credit: 4

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

CO1	Comprehend the unit operation and their role in Chemical Engineering industries
CO2	Comprehend the Characteristics of particulate solids, Principles of size reduction, crushing and grinding equipment
CO3	Comprehend the Mixing of solids and separation methods for different types of mixtures like solid-solid, solid-gas, solid-liquid
CO4	Comprehend the Size enlargement: scope and applications, size enlargement techniques

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

Unit	**Course outlines**	**Lecture**
Unit I	**Introduction** Introduction to mechanical operation, Classification of solid particles, properties of particulate masses, storage of solids, transportation of solid materials, hydraulic and pneumatic conveying equipment	10
Unit II	Principles of size reduction, determination of mean particles size, size distribution equations, laws of crushing and grinding, Kick's Law, Bond's Law and Rittinger's Law. Classification of industrial mills such as ball mill, fluid energy mill, jaw crusher and Blake crusher; chippers, choppers and cutters.	10
Unit III	**Separation techniques** Industrial screening, effectiveness of screen, methods of solid, solid, solid-liquid, solid-gas separation, mixing of solids and pastes, filtration, centrifugation and cyclone separators.	10
Unit IV	Elutriation, classification and sedimentation, flow of fluids past solid; fluidization, Stoke's Law, free and hindered setting, Types of thickness; batch and continuous and their industrial applications.	10

Recommended Books:

1. Warren L Mccabe, Julian C Smith, Peter Harriott, Unit Operations Of Chemical Engineering Mcgraw Hill Chemical Engineering Series, Tata McGraw Hill Publications , 2005
2. Badger, W.L. and Banchero, J.T, Introduction to Chemical Engineering, Tata McGraw Hill Pub. Co. Ltd,1997
3.K.A.Gavhane, Unit Operations -1, Nirali Publications, Third edition
4.G.C.Sekhar , unit operations in Chemical Engineering, Pearson education , 2005
5. A.K.Swain, G.K.Roy , mechanical operations, , tata McGraw Hill Education Private Limited, 2011

Title of the course: Stock Preparation & Paper Making
Subject Code: PCCH-206
Weekly load: 3-0-0
Credit: 3

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

CO1	Comprehend pulp and paper industry operations, products, process variables
CO2	Comprehend how one part of the mill affects another.
CO3	Comprehend equipment working and to interact more knowledgeably with process engineers and operators

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

Unit	**Course outlines**	**Lecture**
Unit-1	**Introduction** General block diagram of a paper industry post brown stock washing. Important operations.	2
	Stock Preparation Different processes during stock preparation. Introduction to mechanical treatment of pulp fibres. Equipments used for mechanical treatment. Concept of freeness and its measurement. Operating procedures for refiners and beaters. Different internal sizing agents. Preparation and storage of size solution and alum. Brief study of wet end additives like starches, gums, dyes, fillers and strength improvement resins.	8
Unit-II	**Screening, Cleaning, and secondary fibres** Study of pulp screening systems, working of knotters, vibrating screens, pressure screens and centri-cleaners batteries. Classification of secondary fibres. Pulpers and pulper additives. Operation of pulpers. Different deinking processes; equipments.	10
Unit-III	**Approach flow and wet end operations** Various stock distribution systems. Operation and maintenance of open and air cushion type roll headboxes. Introduction to hydraulic headboxes. Introduction to different parts of a Fourdrinier paper machine. Operating procedures and practices. Maintenance and troubleshooting. Brief study of drainage elements. Concept of basis weight and its control. Introduction to twin wire forming. Start-up and shutdown procedures. Tackling a web break.	10
Unit-IV	**Pressing, Drying, and Finishing** Transfer of sheet from the wire part to the press part. Types of draws. Brief study of different types of presses and felts. Loading and unloading procedures. Web break events. Arrangement and operation of multi-cylinder dryers and yanki dryers. Dryer felts. Grouping of dryers. Working procedures for steam and condensate removal systems. Start-up and shutdown procedures. Operation of calendars and pope reels. Working and maintenance of rewinders cutters and guillotines.	10

Recommended Books:

1. M.J. Kocurrek, Pulp & Paper manufacture, TAPPI Publication.
2. J.P. Casey, Pulp and Paper chemistry and chemical Technology, Wiley.
3. K.W. Britt, Handbook of Pulp and paper Technology, Wiley.
4. G.A. Smook, Handbook of Pulp and paper Technology, TAPPI Publication.

Title of the course: Process Instrumentation
Subject Code: PECH 202A
Weekly load: 3-1-0
Credit: 4

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

CO1	Comprehend basic of instrumentation needed to implement process control.
CO2	Comprehend Process instrumentation diagrams
CO3	Comprehend various process control schemes

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

Unit	**Course outlines**	**Lecture**
Unit I	**Introduction** Importance of instruments in chemical process industries, general classification of instrument. Indicating and recording type instrument. Description and construction details, working principle, range and application of following instruments. Pressure and Vacuum Gauge: Liquid column gauge, bourdon tube gauge. Thermometer and Pyrometer: Liquid expansion thermometer, bimetallic thermometer, thermocouple, resistance thermometer, optical and radiation pyrometer.	10
Unit II	**Liquid level meters, Flow Meters and Analyzers** Liquid Level Meter: visual indicators, float actuated level meter, static pressure instrument. Flow meter orifice, venture, pitot tube, rotameter. Analyzer: pH meter, chemical composition analyzer, various types of analyzers, oxygen analyzer and infra-red analyzer, orsat analysis.	10
Unit III	**Transmission & Instrumentation Diagram** Transmission: Pneumatic and electrical transmission (inductance transmission only) and their fields of application. Process instrumentation, recording instruments, indicating and recording instruments, transmission of instrument reading, control centre, instrumentation diagram, instrumentation in modern chemical plant	10
Unit IV	**Controllers & control valves** Basic concept of process control, types of controllers and control valves.	10

Recommended Books:

1. S.K. Singh, Industrial Instrumentation and Control. Tata McGraw-Hill Publication.
2. D. Patranabis, Principles of Industrial Instrumentation, Tata McGraw Hill Publication.
3. D. Patranabis, Principles of Process Control, Tata McGraw Hill Publication.
4.Eckman, Industrial Instrumentation, Wiley Eastern Publication.
5. Coughnour, Process System Analysis and Control, McGraw Hill Publication.

Title of the course: Polymer Technology
Subject Code: PECH-202B
Weekly load: 3-1-0
Credit: 4

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

CO1	Comprehend the relationships between polymer molecular weight, molecular weight distribution, and the properties of polymeric materials.
CO2	To distinguish different polymerization reactions and their mechanisms/kinetics
CO3	To 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**
CO1	S	M	W	M	S	S	S
CO2	S	M	W	M	S	S	S
CO3	S	M	W	M	S	S	S

Unit	**Course outlines**	**Lecture**
Unit-I	Polymer Science: Classification of polymers, description and measurement of average molecular weight, number average, weight average, viscosity average, z average, Relationship with degree of polymerization, various polymerization techniques.	10
Unit-II	Polymer Material Technology: introduction to polymer materials, classification and structure, industrial manufacturing of important polymers such as polyolefin, poly vinyl chloride, epoxy, polystyrene, Teflon etc. Fibres: properties, applications and manufacturing of fiber forming polymers, spinning technology.	10
Unit-III	Polymer Processing: Curing of polymers, injection moulding, extrusion moulding, compression moulding, blow moulding, rotational moulding, calendaring, thermoforming etc. Rubbers: properties, applications and manufacturing of important elastomeric polymers NR, BR, SBR , NBR, EPDM etc.	10
Unit-IV	Polymer testing & Characterization: Mechanical- tensile, compressive, impact etc., Thermal- TGA, DSC, Tg, thermal conductivity etc., SEM, XRD, FTIR, NMR, GPC	10

Reference Books:

1. V.R. Gowarikar,"Text book of Polymer Science"New age international (P) Ltd.
2. F.W. Billmeyer," Text book of Polymer Science", 3rd Ed., Wiley,1984.
3. IRI," Rubber Technology", Tata McGraw- Hill, 1998.
4. S.L. Rosen," Fundamental principles of polymeric materials," 2nd Ed.,Wiley, 2007.

Title of the course: Energy Technology
Subject Code: PECH-202C
Weekly load: 3-1-0
Credit: 4

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

CO1	Appraise the importance, requirement and conservation of energy and fuels for sustainability
CO2	Develop basic insight of conventional and non-conventional sources of energy
CO3	Appreciate the development of energy technology devices (conventional and alternative)

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

Unit	Course outlines	Lecture
Unit I	Concept of Energy, units of energy, conversion factors, general classifications of Energy, world energy resources and energy consumption, Indian energy resources and energy consumption	**10**
Unit II	Conventional energy resources, Thermal, hydel and nuclear reactors, thermal, hydel and nuclear power plants, efficiency, merits and demerits of the above power plants, Solid fuels: principal solid fuel, coal preparation, storage of coal, introduction of coal to liquid technology (CTL).	**10**
Unit III	Liquid fuels: gasoline, Naphtha, Kerosene, diesel. Gaseous fuel: Natural Gas, Producer Gas, Water Gas, LPG, LNG.	**10**
Unit IV	Combustion processes calculations, Biomass, solar energy , wind energy, energy conservation	**10**

Recommended Books :

1. Rai.G.D. , Non-conventional Energy Sources, Khanna Publishers
2. Sarkar Sameer, Fuel and Combustion, Orient Longman
3. Gupta. O.P, Fuel Furnaces and Refractories, Khanna Publishers

Title of the course: Pollution Control
Subject Code: OECH-202A
Weekly load: 3-0-0
Credit: 3
Course Outcomes: At the end of the course, the student will be able to:

CO1	Analyse the nature of pollution and effect of various pollutants in different industries
CO2	Comprehend the principles and working of various processes and devices used for waste treatment and pollution control
CO3	Appreciate the design of pollution control devices
CO4	Develop the insight for municipal and industrial waste management and treatment

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

Unit	**Course outlines**	**Lecture**
Unit I	**Water Pollution Control** Wastewater characterization - Physical characteristics of wastewater, Chemical characteristics of wastewater, inorganic and organic pollutants and their harmful effects. Wastewater treatment - Primary treatment of wastewater; Flow equalization, Primary clarifiers - construction and working. Secondary treatment of wastewater - biological treatment methods, working of aerobic lagoons, activated sludge process, trickling filters. Tertiary Treatment of Wastewater – concept and working of the processes.	10
UnitII	**Air Pollution Control** 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. Air pollution control devices: Basic principles, construction and working of Settling chambers, cyclone separators, bag filters, wet scrubbers and electrostatic precipitators.	10
Unit III	**Solid Waste Management** Municipal solid waste management – Collection, Transportation, segregation, processing - Biochemical and Thermo-chemical treatment, Land-filling. Industrial solid waste management – Types of industrial wastes, Basic treatment methods.	10
Unit IV	**Pollution control in industries and Case Studies** Pollution and the control strategies in various polluting industries (basic plans), case studies of pollution hazards in India as well as abroad. Concept of common effluent treatment plant, medical waste management, and hazardous waste management.	10

Recommended Books:

1. Environmental Pollution Control Engineering, C.S.Rao, New Age International Publishers
2. Metcalf & Eddy, Wastewater Engg. - Treatment, Disposal, Reuse, Tata McGraw Hill
3. M.Crawford, Air Pollution Control Engg, Tata McGraw Hill
4. N. Schobanoglous,Environmental Engg, John Wiley and Sons

Title of the course: Energy Technology
Subject Code: OECH-202B
Weekly load: 3-0-0
Credit : 3

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

CO1	Appraise the importance, requirement and conservation of energy and fuels for sustainability
CO2	Develop basic insight of conventional and non-conventional sources of energy
CO3	Appreciate the development of energy technology devices (conventional and alternative)

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

Unit	**Course outlines**	**Lecture**
Unit I	Concept of Energy, units of energy, conversion factors, general classifications of Energy, world energy resources and energy consumption, Indian energy resources and energy consumption	**10**
Unit II	Conventional energy resources, Thermal, hydel and nuclear reactors, thermal, hydel and nuclear power plants, efficiency, merits and demerits of the above power plants, Solid fuels: principal solid fuel, coal preparation, storage of coal, introduction of coal to liquid technology (CTL).	**10**
Unit III	Liquid fuels: gasoline, Naphtha, Kerosene, diesel. Gaseous fuel: Natural Gas, Producer Gas, Water Gas, LPG, LNG.	**10**
Unit IV	combustion processes calculations, Biomass, solar energy , wind energy, energy conservation	**10**

Recommended Books:

1. Rai.G.D. , Non-conventional Energy Sources, Khanna Publishers
2. Sarkar Sameer, Fuel and Combustion, Orient Longman
3. Gupta. O.P, Fuel Furnaces and Refractories, Khanna Publishers

Title of the course : Paper Making Lab
Subject Code : PCCH-208
Weekly load : 0-0-2
Credit : 1

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

CO1	Gain the different operational steps of Paper Making.
CO2	Gain the practical knowledge of mechanical treatment on fibre surface.
CO3	Calculation and knowledge of different additives used in paper makings.
CO4	Gain the practical knowledge of consistency of pulp slurry and calculations based on them.

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

List of Experiments:

1. Beating of Pulp for different time interval at constant load.
2. Measurement of freeness of pulp (^{0}SR) & study of equipment.
3. Study of Bauer McNett fibre classifier.
4. Study of lab sheet former & preparation of 80 & 100 GSM sheets.
5. Addition of internal sizing chemical & study of its effect.
6. Study of filler addition in paper & its effect on paper properties.
7. Measurement of filler retention in paper.
8. Study of alum addition on pH of Pulp stock.
9. Study of effect of ^{0}SR on drainage rate of pulp.
10. Measurement of consistency of Pulp slurry.

Title of the course : Paper Testing Lab
Subject Code : PCCH-210
Weekly load :0-0-2
Credit : 1

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

CO1	Test the GSM bulk, and Calliper of Paper in paper industry and research labs
CO2	Test the Burst strength and Gurley porosity of paper in paper industry and research labs
CO3	Determine smoothness, folding strength, Cobb value of paper in paper industry and research labs
CO4	Determine brightness, opacity and gloss of paper in paper industry and research labs

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

List of Experiments:

1. Measurement of GSM and bulk of Paper.
2. Measurement of Calliper of Paper.
3. Determination of Burst strength of paper
4. Determination of Gurley porosity of paper
5. Determination of smoothness of paper
6. Determination of folding strength of paper
7. Measurement of brightness of paper
8. Measurement of opacity of paper
9. Measurement of Cobb value of paper
10. Measurement of gloss of paper

Title of the course: Process Instrumentation
Subject Code: QPCH202
Weekly load: 0-0-8
Credit: 1
Course Outcomes: At the end of the course, the student will be able to comprehend:

CO1	Basic understanding of concepts and principles related to different instrumentations used in chemical process industries.
CO2	To acquire knowledge and associated skills for selecting and using instruments in the process industry.
CO3	To measure the steady state response and dynamic response of a process.
CO4	Ability to read and interpret process instrumentation and control diagrams related to process plant layout, equipment, and components.

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

List of Experiments:

1. To study the control valve characteristics.
2. Calibration of mercury glass thermometer and draw the calibration curve.
3. The purpose of this study is to study the construction, working principle, and characteristics of thermocouples and RTDs and compare their performance for temperature measurement.
4. Study of different parts of a C-type Bourdon tube pressure gauge and calibration of the Bourdon tube pressure gauge using a dead weight tester.
5. Low pressure/vacuum measurement using Macleod gauge and mercury column manometer.
6. Pressure sensor calibration using mercury column manometer.
7. Evaluate performance characteristics of capacitive/ resistive/ air purge method for level measurement.
8. To study the construction and operation of Orifice Meter and Venturi Meter. Compare their performance for flow measurement.
9. To study the construction and operation of Pitot tube and Rotameter. Compare their performance for flow measurement.
10. Measurement of fluid flow using an electromagnetic flow meter.
11. Study and Calibration of I/P and P/I converter.
12. Study of pH in various samples of water.
13. Study of UV-visible spectrophotometer and HPLC.

14. To study and analyze the steady-state and dynamic response of first-order systems using step and ramp input.
15. Draw symbols for the instrumentation layout: flow rate indicator, flow recorder, level indicator, pH recorder, and level controller.
16. Representation of instruments for control loop configurations for chemical process variables a) Level control b) pressure control c) temperature control d) flow control e) pH control f) Composition control.

Title of the course: Mass Transfer
Subject Code: PCCH-301
Weekly load: 3-0-0
Credit: 3

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

CO1	Comprehend the various Mass Transfer operations, different types of diffusion and their applications.
CO2	Comprehend the vapour liquid equilibrium and various distillation methods with different types of distillation columns.
CO3	Comprehend the principles and equipments for absorptions, extraction, leaching and humidification, crystallization and drying.

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

Unit	**Course outlines**	**Lecture**
Unit-I	**Introduction** Mass Transfer operations and their applications, molecular diffusion, eddy diffusion, diffusion of solids	05
	Diffusion Molecular diffusion, eddy diffusion, diffusion of solids	05
Unit-II	**Distillation** Relative volatility, vapour liquid equilibrium, various distillation methods: flash distillation, batch distillation, continuous distillation, steam distillation. Introduction to azeotropic, extractive distillation. Different types of distillation columns, concept of flooding, weeping, entrainment and loading in distillation columns.	10
Unit-III	**Gas-Liquid, Liquid-Liquid and Solid-Liquid Operations** Principles and equipments for absorptions, extraction, leaching and humidification.	10
Unit-IV	**Crystallization** Study of various factors effecting crystallization. Nucleation, crystal growth, size and shape variation of different materials during crystallization, types of crystallizers.	06
	Drying Principles of drying operations and drying equipments, industrial applications of drying	04

Reference Books:

1. Treybal ,R.E, Mass Transfer Operation, Tata McGraw Hill Chemical Engineering Series.
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: Chemical Process Industries
Subject Code: PCCH-303
Weekly load: 3-0-0
Credit: 3
Course Outcomes: At the end of the course, the student will be able to:

CO1	Comprehend the process description and process flow sheet in the manufacturing of oils & fats.
CO2	Comprehend various types of paints and their constituents.
CO3	Comprehend the process description and process flow sheet of polymer & sugar industries.
CO4	Comprehend the process description and process flow sheet of rubber, petroleum and paper sugar 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**
CO1	S	W	W	W	S	S	S
CO2	S	W	W	W	S	S	S
CO3	S	W	W	W	S	S	S
CO4	S	W	W	W	S	S	S

Unit	**Course outlines**	**Lecture**
Unit I	**Oils & Fats** Fats & Oils: Chemical composition and physical properties of oils and fats. Process description of solvent extraction with flow sheet. Flow sheet, chemical reaction, raw material required, process description and major engineering problems associated with hydrogenation of oil.	06
	Paints Paint & Varnish: Definition of paint & varnish, Constituents of paints and varnishes. Enamel and its constituents. Special paints wiz Luminescent paint, heat resistant paint and fire-retardant paint.	04
Unit II	**Polymers & Sugar Industries** Polymer: Definition, degree of polymerization, types of polymerization, physical properties of polymers, classification of polymers, process description of manufacture of polyethylene, PCV and Teflon. Sugar Industry: Process description, flow sheet and major engineering problems associated with the manufacturing of sugar from sugarcane, sugar by-product utilization	10
Unit III	**Rubber and Petroleum** Rubber: Classification of rubber, pertinent properties of rubber polymers, vulcanization of rubber manufacture of Butadiene and Styrene, Butadiene Rubber (SBR), Manufacture of Nylon 66 with flow sheets. Industrial applications of rubber. Petroleum: Introduction, origin and composition of petroleum, classification of crude petroleum, refining of petroleum, uses of petroleum products, petroleum refining in India, definition of Octane number and Cetane number. Operations with examples (excluding design calculations).	10
Unit IV	**Paper Industry** Paper Industry: Definition, types of paper product, raw materials required like bamboo, agricultural waste residue, bagasse, and recycled fibres. Various additives and speciality chemicals like sizing materials, sizing materials, dry and wet strength additives, surface treatment additives and fillers used for paper making	10

Recommended Books:
1. Dryden, Outlines of chemical Technology, East west press.
2. Shreve, Chemical process industries, McGraw Hill.
3. G.N. Pandey, A Textbook of chemical Technology, Vol.- II, Vikas publications

Title of the course: Petroleum Technology
Subject Code: PECH-301A
Weekly load: 3-1-0
Credit: 4

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

CO1	Introduction with the petroleum refinery worldwide
CO2	Develop knowledge of different refining processes
CO3	Develop knowledge of safety and pollution control in the refining 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**
CO1	S	W	W	W	S	S	S
CO2	S	W	W	W	S	S	S
CO3	S	W	W	W	S	S	S

Unit	**Course outlines**	**Lecture**
Unit – I	**Introduction to Petroleum Refining** Indian Refineries, Their location and capacity Global crude oil producers Characteristics of crude, Composition, constituents of crude oil	**10**
Unit – II	**Refining processes** Process of refining of crude oil to obtain various fractions. Unit operations used in separation processes- Fractionation, Vacuum Distillation, List of Hydrocarbons/fractions obtained based on their boiling ranges and their uses.	**10**
Unit – III	**Unit Processes in Refineries** Hydrogeneration, Cracking, Alkylation, Polymerization, Hydrocracking. Isomerisation, Reforming, Esterification & Hydrations, Waste Treatment	**10**
Unit – IV	**Evaluation of oil stock** Power number, Octane number , cetane number, Flash point, Fire point, Viscosity index, Pour point, cloud point, inorganic acidity, organic acidity, Evaluation of crude oil – T.B.P. apparatus. ASTM distillation, EFV. **Hazard & Safety in Hydrocarbon Industries:** Case study in Hazards & Safety in hydrocarbon Industry.	**10**

Recommended Books:

1. W. L. Nelson Petroleum Refinery Engineering McGraw-Hill series in chemical engineering.
2. R. J. Hengsbeck Petroleum Processing Mcgraw Hill Book Company Inc.
3. Dr. B.K. Bhaskara Rao, Modern Petroleum refining Processes (5th Edition).
4. Dr. Ram Prasad, Petroleum Refining Technology, Khanna Publishers.
5. James Cameron, Petroleum Refining Technology, Atlantic Publishers and Distributor.

Title of the course: Electrochemical Engineering
Subject Code: PECH 301B
Weekly load: 3-1-0
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 behaviour
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**
CO1	S	W	W	W	S	S	S
CO2	S	W	W	W	S	S	S
CO3	S	W	W	W	S	S	S

Unit	**Course outlines**	**Lecture**
Unit I	**Introduction** Electrochemistry basics; Thermodynamics of ideally polarisable and non-polarisable interfaces. Electrochemical cells; reversible and irreversible cells, EMF.	10
Unit II	**Electrode kinetics** Equilibrium potential, Nernst equation, over potential and its different types. Equilibrium exchange current density; Butler-Volume 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
Unit III	**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	10
Unit IV	**Electrodes and electrolytic membranes** Electrodes for 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

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. Pletcher, D., and Walsh, F.C., Industrial Electrochemistry, Chapman

Title of the course: Thermo-chemical Engineering
Subject Code: PECH-301C
Weekly load: 3-1-0
Credit: 4

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

CO1	Introduction of concepts of thermochemical transformations.
CO2	Biomass characterization in terms of proximate analysis and elemental analysis.
CO3	Applications of thermochemical engineering in Pyrolysis, Gasification and Incineration Technologies.

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

Unit	**Course outlines**	**Lecture**
Unit I	**Introduction** Chemical transformation of biomass at elevated temperature. Classification of thermochemical processes. Important products from thermochemical processes. Major industrial applications. **Biomass characteristics** Biomass characteristics important for thermochemical processes: Proximate analysis, elemental analysis, ash characteristics, particle size.	10
Unit II	**Pyrolysis** Pyrolysis fundamentals. Important reactions. Pyrolysis products; pyrolysis oil characteristics and applications; biochar characteristics and applications. Major process parameters. Types of pyrolizers; their construction and working. Catalytic pyrolysis.	10
Unit III	**Gasification** Gasification fundamentals. Important reactions. Syngas characteristics. Major process parameters. Types of gasifiers; their construction and working. Energy from syngas.	10
Unit IV	**Incineration** Incineration fundamentals. Important reactions. Major process parameters. Combustion air and flue gases. Energy recovery from incineration. Brief introduction to biomass fired boilers.	10

Recommended Books:

1. Pyrolysis and Gasification. G.L. Ferrero, K. Maniatis, A. Buekens, A.V. Bridgwater
2. Biomass Gasification, Pyrolysis and Torrefaction. P. Basu
3. Steam Generation from Biomass. E.K. Vakkilainen

Title of the course: Bio-resource Technology
Subject Code: OECH 301A
Weekly load: 3-0-0
Credit: 3

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

CO1	Various types of bio-resources available and their characterization
CO2	Thermochemical processes
CO3	Pelletization technology

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

Unit	**Course outlines**	**Lecture**
Unit I	**Introduction** Appraisals about bio-resources available due to farming, food processing and other bio-based industries.	10
Unit II	**Types of bio-resources** Agricultural wastes, Forestry wastes, Characterization of bio-resources for various applications.	10
Unit III	**Thermo chemical processes** Pyrolysis Processes, Gasification Processes, Liquefaction Processes and Combustion Processes.	10
Unit IV	**Pelletization Technology** Parameters controlling pelletization, Various pelletization technologies, Economic evaluations of pelletization technologies	10

Recommended Books:

1. M.P. Poonia J. Mathur, S.Mathur, (Eds.), Waste *to*. Energy. Prime Publishing House, New Delhi.
2. B.B.Hosetti, Prospects and Perspectives of Solid, New Age International Publications, 2002.
3. A. Nag, K. Vijaykumar, Environment Education and Solid, New Age International Publications, 2005.

Title of the course: Green Technology
Subject Code: OECH-301B
Weekly load: 3-0-0
Credit: 3

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

CO1	Understand concepts of green technologies.
CO2	Understand concepts of green materials.
CO3	Apply green technologies in energy, environment and pollution abetment.

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

Unit	**Course outlines**	**Lecture**
Unit I	**Introduction** Sustainable development and green technology. Need for paradigm shift in industry, government, and institutions. Concept of circular economy and cleaner production. Principles of green chemistry and engineering.	10
Unit II	**Green materials and processes** Green solvents, ionic liquids, deep eutectic solvents, supercritical and subcritical fluids. Bioplastics and biopolymers. Green processes for synthesis, separation, and purification. Green catalysts.	10
Unit III	**Green energy technologies** Renewable vs non-renewable sources. Solar thermal and solar photovoltaic. Wind. Energy from biomass, second and third generation biofuels. Green hydrogen, production, and storage.	10
Unit IV	**Green technology in pollution abatement** Zero discharge approach to pollution. Advanced oxidation techniques, electrochemical, photochemical, sonochemical, peroxide, and ozone treatments.	10

Recommended Books:

1. Renewable Energy and Green Technology. A.K Sahoo, S.P. Nanda
2. Green Technology: An Approach For Sustainable Environment. S.S. Purohit
3. Green Engineering and Sustainable Development. B.C. Samanta

Title of the course: Chemical Engineering Lab-1
Subject Code: PCCH-305
Weekly load: 0-0-2
Credit:1

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

CO1	To understand the principles of Fluid Flow, Heat Transfer and Mass Transfer equipments.
CO2	Calibration of various equipments available in labs of Fluid Flow, Heat Transfer and Mass Transfer equipments
CO3	Study of various operations related to transport phenomena

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

List of Experiments:

1. Study the Shell and Tube Heat Exchanger
2. To find out the thermal conductivity of liquids.
3. To find out the thermal conductivity of metal rod apparatus
4. To study the temperature distribution in the composite cylinder.
5. To study the double pipe heat exchanger.
6. To determine the thermal resistance of composite wall.
7. To find out the least count of Hg Glass thermometer
8. To calibrate the given Rotameter
9. To Calibrate a Thermostat.
10. To Calibrate Orificemeter
11. To Calibrate Venturimeter
12. To Calibrate pH meter
13. To Calibrate Pressure Gauge
14. To study the process of diffusion
15. To study the process of adsorption
16. To study the process of liquid-liquid extraction
17. To study the process of distillation

Note: Students are expected to perform any eight experiments (08) from the list based on the availability of the infrastructure and slots in the time-table.

Title of the course: Minor Project
Subject Code: PRCH-301
Weekly load: 0-0-4
Credit: 2

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

CO1	Review the literature
CO2	Develop the ideas based of the acquired knowledge in the ICD programme.
CO3	Convert the idea into a working 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**
CO1	S	S	S	S	S	S	S
CO2	S	S	S	S	S	S	S
CO3	S	S	S	S	S	S	S

Students are expected to:

a) Identify and Select the project problem related to process/social /professional world.

b) Apply fundamentals of courses studied during the program.

Title of the course: Chemical Process Technology
Subject Code: QPCH-301
Weekly load: 0-0-8
Credit: 1
Course Outcomes: At the end of the course, the student will be able to comprehend:

CO1	Use of apparatus, glassware, and Instrumentation in Process Technology Lab.
CO2	Safety Procedures in Process Technology Lab.
CO3	Application of various Unit Operations and processes to the Chemical Industries.
CO4	Manufacturing techniques of various Chemical Engineering products at laboratory scale.

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

Laboratory experiments and related works:

1. Standard apparatus and glassware used in the process technology lab and their appropriate use.
2. Safety in process technology lab.
3. Use of Process Flow Diagrams.
4. The iodine value of oil.
5. The Saponification value of a vegetable oil.
6. The Density and viscosity of a liquid/ oil.
7. Determination of properties of fuel oils (petrol/ diesel).
8. Determination of Acid value of vegetable oil.
9. Preparation of Soap.
10. Crystallization of Copper sulphate.
11. Crystallisation of sugar.
12. Preparation of urea formaldehyde.
13. Reducing and non-reducing sugars.
14. Analysis of cement.
15. Preparation of aspirin.
16. Preparation of dyes and pigments.
17. Analysis of fertilizers.
18. Preparation of biodiesel.
19. Preparation of ethanol from bio-residues.

Title of the course: Chemical Reaction Engineering
Subject Code: PCCH-302
Weekly load: 3-0-0
Credit: 3

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

CO1	Comprehend the kinetics of homogeneous reactions.
CO2	Comprehend the importance of various variables affecting reaction rate.
CO3	Comprehend the principles of single and multiple reactions, different types of reactors and their applications
CO4	Comprehend the principles of Steady state flow 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**
CO1	S	S	M	M	S	S	S
CO2	S	S	M	M	S	S	S
CO3	S	S	M	M	S	S	S
CO4	S	S	M	M	S	S	S

Unit	**Course outlines**	**Lecture**
Unit I	**Introduction** Introduction to different types of chemical reactions, fundamentals of Chemical reaction equilibrium, effect of temperature and pressure on equilibrium constant, kinetics of homogeneous reactions, order and molecularity of a reaction.	10
Unit II	**Reaction Kinetics &Rate Laws** Relative rates of reaction, elementary rate law, reaction orders, irreversible and reversible reactions, rate law representation for non-elementary reactions, reaction rate constant, activation energy and temperature dependency.	10
Unit III	**Mole Balances** Different types of chemical reactors and their applications and limitations, General mole balance on batch reactor and continuous flow reactors. Exposure to non-ideal reactors.	10
Unit IV	**Ideal Reactor Design and Performance** Ideal batch reactor, steady state continuous stirred tank reactor, steady state plug flow reactor, limiting reactant & conversion, space time and space velocity for flow systems, introduction to multiple reactions.	10

Recommended Books:

1. Fogler, S., Essentials of Chemical Reaction Engineering, 2e. Pearson Education India, 2020.
2. Lenenspiel O., Chemical Reaction Engineering, Wiley India, 2006.
3. Ghatak, H. R., Reaction Engineering Principles, CRC Press, 2016.

Title of the course: Process Equipment
Subject Code: PECH-302A
Weekly load: 3-1-0
Credit: 4

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

CO1	Understand various types of equipment in process industries.
CO2	Understand different types of process pipelines and pumps.
CO3	Understand & working of different types of Heat Transfer equipment.
CO4	Understand & working of different types of Mass Transfer 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**
CO1	S	S	W	W	S	S	S
CO2	S	S	W	W	S	S	S
CO3	S	S	W	W	S	S	S
CO4	S	S	W	W	S	S	S

Unit	**Course outlines**	**Lecture**
Unit-I	**Introduction**: Codes and standards, equipment selection and specification.	04
	Pressure vessels: Factors influencing the design of pressure vessels, types of cylindrical and spherical vessels.	06
Unit-II	**Process Pipelines & Pumps:** Piping classification, important fittings and their use, symbols, layouts and colour codes for pipeline, Selection & design of various pumps.	10
Unit-III	**Heat transfer equipment:** Shell and tube heat exchangers. Classification, specifications and sketches of heat transfer equipment.	10
Unit-IV	**Mass transfer equipment:** Tray towers: Shell & Trays, Tray Spacing, tower diameter, downspouts, weirs etc, Bubble cap trays, Sieve (perforated) trays, General pressure drops correlation, Packed towers: types of packing.	10

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: Biochemical Engineering
Subject Code: PECH-302B
Weekly load: 3-1-0
Credit: 4

Course Outcomes: At the end of the course, the student 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 analyze 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**
CO1	S	M	W	M	S	S	S
CO2	S	M	W	M	S	S	S
CO3	S	M	W	M	S	S	S
CO4	S	M	W	M	S	S	S

Unit	**Course outlines**	**Lecture**
Unit I	**Introduction** Historical background, Integrated biochemical systems, Unit Operations in Biochemical process, Microbial Cells and its Constituents, Chemicals for Life.	08
Unit II	**Fermentation process** Fermentation process description, sterilization techniques, microbial cell growth cycle and growth kinetics. Components and controlling parameters of fermentation process. Enzyme and cell immobilization techniques and their application in fermentation process.	12
Unit III	**Bioreactors** Introduction, types and characterization of batch and continuous bioreactors and their basic design equations	10
Unit IV	**Purification of fermentation products** Introduction to different methods like Disruption of cells, precipitation, filtration, Centrifugation, Liquid-Liquid Extraction, Chromatography, Membrane processes, Drying, and Crystallization.	10

Recommended Books:

1. J.E. Bailey & D. F. Ollis, Biochemical Engineering Fundamentals. McGraw Hill Book Company, 1986.
2. Shuler M., Kargi F., Bioprocess Engineering: Basic Concepts, PHI, 2012.
3. Weith, John W.F., Biochemical Engineering - Kinetics, Mass Transport, Reactors and Gene Expression, Wiley and Sons Inc., 1994.
4. Stanbury P. F., Whittaker, A. and Hall, S. J., Principles of Fermentation Technology, Butterworth-Heinemann2007.
5. M. L.Shuler&F.Kargi, Bioprocess Engineering (Basic Concepts). Prentice Hall of India, 2003

Title of the course: Green Technology
Subject Code: PECH-302C
Weekly load: 3-1-0
Credit: 4
Course Outcomes: At the end of the course, the student will be able to:

CO1	Understand concepts of green technologies.
CO2	Understand concepts of green materials.
CO3	Apply green technologies in energy, environment and pollution abetment.

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

Unit	**Course outlines**	**Lecture**
Unit I	**Introduction** Sustainable development and green technology. Need for paradigm shift in industry, government, and institutions. Concept of circular economy and cleaner production. Principles of green chemistry and engineering.	10
Unit II	**Green materials and processes** Green solvents, ionic liquids, deep eutectic solvents, supercritical and subcritical fluids. Bio plastics and biopolymers. Green processes for synthesis, separation, and purification. Green catalysts.	10
Unit III	**Green energy technologies** Renewable vs non-renewable sources. Solar thermal and solar photovoltaic. Wind. Energy from biomass, second and third generation biofuels. Green hydrogen, production, and storage.	10
Unit IV	**Green technology in pollution abatement** Zero discharge approach to pollution. Advanced oxidation techniques, electrochemical, photochemical, sonochemical, peroxide, and ozone treatments.	10

Recommended Books:

1. Renewable Energy and Green Technology. A.K Sahoo, S.P. Nanda
2. Green Technology: An Approach For Sustainable Environment. S.S. Purohit
3. Green Engineering and Sustainable Development. B.C. Samanta

Title of the course: Pollution Control
Subject Code: PECH-304A
Weekly load: 3-1-0
Credit: 4
Course Outcomes: At the end of the course, the student will be able to:

CO1	Analyse the nature of pollution and effect of various pollutants in different industries
CO2	Comprehend the principles and working of various processes and devices used for waste treatment and pollution control
CO3	Develop the insight for municipal and industrial waste management and treatment

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

Unit	**Course outlines**	**Lecture**
Unit I	**Water Pollution Control** Wastewater characterization - Physical characteristics of wastewater, Chemical characteristics of wastewater, inorganic and organic pollutants and their harmful effects. Wastewater treatment - Primary treatment of wastewater; Flow equalization, Primary clarifiers - construction and working. Secondary treatment of wastewater - biological treatment methods, working of aerobic lagoons, activated sludge process, trickling filters. Tertiary Treatment of Wastewater – concept and working of the processes.	10
Unit II	**Air Pollution Control** 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. Air pollution control devices: Basic principles, construction and working of Settling chambers, cyclone separators, bag filters, wet scrubbers and electrostatic precipitators.	10
Unit III	**Solid Waste Management** Municipal solid waste management – Collection, Transportation, segregation, processing - Biochemical and Thermo-chemical treatment, Land-filling. Industrial solid waste management – Types of industrial wastes, Basic treatment methods.	10
Unit IV	**Pollution control in industries and Case Studies** Pollution and the control strategies in various polluting industries (basic plans), case studies of pollution hazards in India as well as abroad. Concept of common effluent treatment plant, medical waste management, and hazardous waste management.	10

Recommended Books:

1. Environmental Pollution Control Engineering, C.S.Rao, New Age International Publishers
2. Metcalf & Eddy, Wastewater Engg. - Treatment, Disposal, Reuse, Tata McGraw Hill
3. M.Crawford, Air Pollution Control Engg, Tata McGraw Hill
4. N. Schobanoglous, Environmental Engg, John Wiley and Sons

Title of the course: Fertilizer Technology
Subject Code: PECH-304B
Weekly load: 3-1-0
Credit: 4

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.

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

Unit	**Course outlines**	**Lecture**
Unit I	**Overview of Fertilizer** Role of essential Elements in plant Growth, Application of fertilizers considering Nutrient, Development of fertilizer industry; Fertilizer production and consumption in India. Classification of fertilizers. Synthetic vs. Organic/ bio-fertilizers, advantages and challenges. Action of fertilizers.	10
Unit II	**NitrogenousFertilizers** **Ammonia:** Physical & chemical properties and uses. Kellog manufacturing process including chemical reactions, major raw material requirements with detailed flow sheets. **Urea:** Physical & chemical properties and uses, manufacturing process from ammonium carbamate including chemical reactions, major raw material requirements with detailed flow sheets. **Ammonium sulphate (AS):** Physical & chemical properties and uses, manufacturing process from synthetic ammonia and sulphuric acid including chemical reactions, major raw material requirements with detailed flow sheets. **Calcium ammonium nitrate (CAN):** Physical & chemical properties and uses, manufacturing process from limestone and concentrated nitric acid including chemical reactions, major raw material requirements with detailed flow sheets. **Ammonium chloride:** Physical & chemical properties and uses, modified Solvay process including chemical reactions, major raw material requirements with detailed flow sheets.	10
Unit III	**Phosphorousfertilizer** **Diammonium Phosphate (DAP):** Physical & chemical properties and uses, manufacturing process from ammonia and phosphoric acid including chemical reactions, major raw material requirements with detailed flow sheets. **Single Super Phosphate (SSP):** Physical & chemical properties and uses, manufacturing process from phosphate rock with sulphuric acid including chemical reactions, major raw material requirements with detailed flow sheets.	10
Unit IV	**Complex Fertilizer (NPK)** History, Physical & chemical properties and uses, manufacture of Urea ammonium Phosphate, ammonium Phosphate sulphate, nitro phosphate with potash including chemical reactions, major raw material requirements with detailed flow sheets. **Bio-fertilizer**s: Types of Bio-fertilizers, Nitrogen fixing bio-fertilizers, Phosphate- solubilising bio-fertilizers, Preparation of a Bio Fertilizers	10

Recommended Books:

1. Shreve's Chemical Process Industries, George T. Austin, McGraw Hill Pub.
2. Dryden's Outlines of Chemical Technology, M. Gopala Rao, Affiliated East-West Press
3. Chemical Technology, Volume I & II,2ndEdition, Pandey & Shukla,Vani Books Company.
4. Bio fertilizers in Agriculture, NS Subba Rao, Oxford& IBH Publishing Company
5. Handbook of Fertilizer Association of India, New Delhi

Title of the course: Separation Techniques
Subject Code: PECH-304C
Weekly load: 3-1-0
Credit: 4

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

CO1	Understand modern separation techniques in chemical & biochemical industry.
CO2	Understand the novel membranes for various applications.
CO3	Understand 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**
CO1	S	S	W	S	S	S	S
CO2	S	S	W	S	S	S	S
CO3	S	S	W	S	S	S	S

Unit	**Course Outlines**	**Lecture**
Unit-I	**Introduction:** Separation process in chemical and biochemical Industry, Categorization of separation processes. **New Separation Techniques:** Introduction to various new separation techniques e.g. Membrane separation, Ion-exchange foam separation etc.	10
Unit-II	**Membrane based Separation Techniques:** Historical background, physical and chemical properties of membranes, Techniques of membrane preparation, membrane characterization.	10
Unit-III	**Osmosis and osmotic pressure:** Working principle, operation and design of Reverse osmosis, Ultra filtration, Microfiltration, Electro dialysis and Pervaporation. Gaseous separation by membranes.	10
Unit-IV	**Miscellaneous Separation Techniques:** Introduction to foam separation, micellar separation, supercritical fluid extraction, liquid membrane permeation and chromatographic separation.	10

Recommended Books:

1. King, C.J., "Separation Processes", Tata McGraw-Hill.
2. Sourirajan, S. and Matsura, T., "Reverse Osmosis and Ultra filtration 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. MunirCherion, Ultrafilteration Handbook, Technomic Publishi

Title of the course: Biochemical Engineering
Subject Code: OECH-302 A
Weekly load: 3-0-0
Credit: 3
Course Outcomes: At the end of the course, the student 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 analyze 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
CO1	S	M	W	M	S	S	S
CO2	S	M	W	M	S	S	S
CO3	S	M	W	M	S	S	S
CO4	S	M	W	M	S	S	S

Unit	Course outlines	Lecture
Unit I	**Introduction** Historical background, Integrated biochemical systems, Unit Operations in Biochemical process, Microbial Cells and its Constituents, Chemicals for Life.	08
Unit II	**Fermentation process** Fermentation process description, sterilization techniques, microbial cell growth cycle, Components and controlling parameters of fermentation process. Enzyme and cell immobilization techniques and their application in fermentation process.	12
Unit III	**Bioreactors** Introduction, types and characterization of batch and continuous bioreactors and their basic operation techniques.	10
Unit IV	**Purification of fermentation products** Introduction to different methods like Disruption of cells, precipitation, filtration, Centrifugation, Liquid-Liquid Extraction, Chromatography, Membrane processes, Drying, and Crystallization.	10

Recommended Books:

1. J.E. Bailey & D. F. Ollis, Biochemical Engineering Fundamentals. McGraw Hill Book Company, 1986.
2. Shuler M., Kargi F., Bioprocess Engineering: Basic Concepts, PHI, 2012.
3. Weith, John W.F., Biochemical Engineering - Kinetics, Mass Transport, Reactors and Gene Expression, Wiley and Sons Inc., 1994.
4. Stanbury P. F., Whittaker, A. and Hall, S. J., Principles of Fermentation Technology, Butterworth-Heinemann2007.
5. M. L. Shuler & F.Kargi, Bioprocess Engineering (Basic Concepts). Prentice Hall of India, 2003

Title of the course: Thermo-chemical Engineering
Subject Code: OECH-302B
Weekly load: 3-0-0
Credit: 3

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

CO1	Introduction of concepts of thermo-chemical transformations.
CO2	Biomass characterization in terms of proximate analysis and elemental analysis.
CO3	Applications of thermo-chemical engineering in Pyrolysis, Gasification and Incineration Technologies.

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

Unit	Course outlines	Lecture
Unit I	**Introduction** Chemical transformation of biomass at elevated temperature. Classification of thermo-chemical processes. Important products from thermo-chemical processes. Major industrial applications. **Biomass characteristics** Biomass characteristics important for thermo-chemical processes: Proximate analysis, elemental analysis, ash characteristics, particle size.	10
Unit II	**Pyrolysis** Pyrolysis fundamentals. Important reactions. Pyrolysis products; pyrolysis oil characteristics and applications; biochar characteristics and applications. Major process parameters. Types of pyrolyzers; their construction and working. Catalytic pyrolysis.	10
Unit III	**Gasification** Gasification fundamentals. Important reactions. Syngas characteristics. Major process parameters. Types of gasifiers; their construction and working. Energy from syngas.	10
Unit IV	**Incineration** Incineration fundamentals. Important reactions. Major process parameters. Combustion air and flue gases. Energy recovery from incineration. Brief introduction to biomass fired boilers.	10

Recommended Books:

1. Pyrolysis and Gasification. G.L. Ferrero, K. Maniatis, A. Buekens, A.V. Bridgwater
2. Biomass Gasification, Pyrolysis and Torrefaction. P. Basu
3. Steam Generation from Biomass. E.K. Vakkilainen

Title of the course: Chemical Engineering Lab-2
Subject Code: PCCH-306
Weekly load: 0-0-2
Credit: 1

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

CO1	Comprehend the kinetics of homogeneous reactions.
CO2	Comprehend the importance of various variables affecting reaction rate.
CO3	Comprehend the principles of single and multiple reactions, different types of reactors and their applications
CO4	Comprehend the principles of Steady state flow 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**
CO1	S	S	M	S	S	S	S
CO2	S	S	M	S	S	S	S
CO3	S	S	M	S	S	S	S
CO4	S	S	M	S	S	S	S

List of Experiments:

1. To Study Isothermal Batch Reactor.
2. To Study Isothermal Continuous Stirred Tank Reactor (CSTR).
3. To Study Plug Flow Reactor.
4. To Study Isothermal Semi-Batch Reactor.
5. To Study CSTR's in Series (Cascade CSTR).
6. To calibrate the thermostat on Isothermal Plug Flow Reactor.
7. To calibrate the thermostat on Isothermal CSTR.
8. To calibrate the thermostat on Isothermal Batch Reactor.
9. To calibrate the thermostat on Isothermal Semi-batch Reactor.
10. To calibrate the selected rotameter on Isothermal Plug Flow Reactor.
11. To calibrate the selected rotameter on Isothermal CSTR.
12. To find out the calorific value of a given oil (Petrol/Diesel)
13. To find out saponification value of (Petrol/Diesel)
14. To find out the Iodine value of (Petrol/Diesel)
15. To find out the density of (Petrol/Diesel)
16. To find out kinematic viscosity of (Petrol/Diesel)
17. To find out Flash Point of (Petrol/Diesel)

Note: Students are expected to perform any eight experiments (08) from the list based on the availability of the infrastructure and slots in the time-table.

Title of the course: Major Project
Subject Code: PRCH-302
Weekly load: 0-0-8
Credit: 4

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

CO1	Understand a specific chemical engineering problem well.
CO2	Setup a working model explaining a specific concept.
CO3	Conceptualize design/fabrication.
CO4	Present and communicate effectively regarding any chemical engineering problem.

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

Students are expected to:

a) Identify and Select project problems related to process/social /professional world.
b) Apply fundamentals of various courses studied during the Program.
c) Effectively communicate solution and future scope of work.

Title of the course: Seminar
Subject Code: SECH-302
Weekly load: 1-0-0
Credit: 1

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

CO1	Appreciate various chemical engineering problems and their solutions.
CO2	Write a literature review on various chemical engineering topics.
CO3	Present and communicate effectively any chemical engineering concept before knowledgeable audience.

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

Students are expected to present a seminar (Power point presentation) on a Specific topic assigned by the teacher concern. They will also submit the review report on the presentation topic.

Title of the course: Solid Waste Management
Subject Code: QPCH302
Weekly load: 0-0-8
Credit: 1
Course Outcomes: At the end of the course, the student will be able to comprehend:

CO1	Classification of Solid wastes.
CO2	Characterization of Agricultural waste for their utilization
CO3	Reuse of Solid waste as value-added products.

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

List of Experiments:

1. Classification of Solid wastes.
2. Study any five agro-residues available in the region.
3. Determination of Moisture content of an agro-residue.
4. Determination of Ash Content of an agro-residue.
5. Determination of Fixed carbon of an agro-residue.
6. Determination of Volatile Matter of an agro-residue.
7. Determination of Bulk density of an agro-residue.
8. Study of Pyrolysis of any agro-residue available.
9. Study of Size Reduction of Biomass Sample.
10. Sieve analysis of powder obtained from biomass sample.
11. Classification & utilization of Kitchen waste.
12. Classification & utilization of Municipal waste.
13. Classification & utilization of Electronic waste.