# Study, Schemes and Syllabus
# of
# Doctor of Philosophy (Ph.D.)

## Department of Chemical Engineering
## SLIET, Longowal

# Reviewed on
# DATE
# 30.07.2025

# SLIET LONGOWAL

## 2.2.1 – CHEMICAL ENGINEERING (PH.D. – CE)

### COURSE WORK SUBJECT CODE & SUBJECT NAME

| SUBCODE | SUBJECTNAME | L | T | P | CREDIT |
|---|---|---|---|---|---|
| CH-10001 | Bio-based Polymers and their Degradation | 3 | 1 | 0 | 4 |
| CH-10002 | Advanced Polymer Composite Technology | 3 | 1 | 0 | 4 |
| CH-10003 | Advanced Reaction Engineering | 3 | 1 | 0 | 4 |
| CH-10004 | Advanced Energy Technology | 3 | 1 | 0 | 4 |
| CH-10005 | Advances in Environmental Engineering | 3 | 1 | 0 | 4 |
| CH-10006 | Waste Management and Recycling | 3 | 1 | 0 | 4 |
| CH-10007 | Lignocelluloses Technology | 3 | 1 | 0 | 4 |

**A candidate, with recommendation of the RAC, may also opt for a subject from the teaching scheme of M. Tech. programme of the department as the departmental coursework subject.**

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## 2.2.1 – CHEMICAL ENGINEERING (PH.D. – CE)

### CH-10001: BIO-BASED POLYMERS AND THEIR DEGRADATION

| L | T | P | CREDIT |
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| 3 | 1 | 0 | 4 |

**Unit-I** **(10)**

**Introduction to Bio-based Polymers:** Definition and Classification of bio-based polymers, Importance of Bio-based Polymers, Structure, chemistry, and properties of some biodegradable polymers like Chitosan, Starch, cellulose, Polylactic acid (PLA), Polyhydroxyalkanoates (PHAs).

**Unit-II** **(10)**

**Synthesis and Properties of Bio-based Polymers**

Synthesis (fermentation, chemical synthesis, and direct extraction from biomass), Key Properties- like mechanical, thermal, and chemical properties of bio-based polymers, flexibility, and degradation behaviour. Structure-Property Relationships.

**Unit-III** **(10)**

**Degradation Mechanisms of Bio-based Polymers**

Biodegradation- biological processes involved in polymer degradation, including the roles of microorganisms (bacteria, fungi, etc.). Hydrolytic Degradation, Enzymatic Degradation, Factors Affecting Degradation such as temperature, humidity, pH, and the presence of specific microorganisms influence the degradation rate. Environmental Degradation-such as soil, water, and compost**.**

**Unit-IV** **(10)**

**Applications of Bio-based Polymers**

Packaging-use of bio-based polymers in food packaging, films, and other packaging materials, Medical Applications-use of biocompatible and biodegradable bio-based polymers in medical devices, drug delivery, and tissue engineering, Other Applications- in textiles, automotive parts, and other industries.

**Challenges and Future Trends:** Cost and Scalability, Performance Limitations and Sustainability Considerations.

**Recommended Books:**


1. Handbook of Biodegradable Polymers by Catia Bastioli, Rapra Technology.
2. Chemistry & Technology of Biodegradable Polymers, AcademicProfessionalLondon1994, G.J.L.Griffin Blackie(ed)
3. Biopolymers: Processing and Products by Michael Niaounakis, Elsevier
4. Handbook of Biodegradable Polymers, AbrahamJ.Donb& others(ed.)

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## 2.2.1 – CHEMICAL ENGINEERING (PH.D. – CE)

### CH-10002: ADVANCED POLYMER COMPOSITE TECHNOLOGY

**L T P** **CREDIT**
**3 1 0** **4**

| Unit | Main Topics | Course outlines | Lecture(s) |
|---|---|---|---|
| Unit-1 | Iintroduction to Polymer Composites | Types: particulate, fibrous, laminated; advantages of composites over base materials; synthetic fibers (glass, carbon, aramid, ceramic, metal); natural fibers (jute, flax, coir, hemp); hybrid systems; mineral fillers; filler surface treatment; thermoplastic composites and applications; overview of nanocomposites. | 14 |
| | Mechanical & Interfacial Properties | Tensile, flexural, compressive, shear, impact, and creep behavior; dynamic mechanical analysis (DMA); fatigue resistance; effects of matrix and interface on mechanical properties; interfacial adhesion; role of coupling agents (e.g., silanes, MAPP). | 8 |
| Unit-2 | Fabrication & Processing of Composites | Hand lay-up, spray-up, autoclave, resin injection, vacuum bag moulding; filament winding, pultrusion, injection and compression moulding; advanced techniques: VARI, 3D printing of composites; thermoplastic processing: extrusion, hot press. | 12 |
| | Polymer Blends & Alloys | Types and miscibility; factors influencing blend morphology; thermodynamics of mixing; compatibilization strategies; melt flow and rheology; rubber toughening; preparation, processing and examples of commercial blends (e.g., PC/ABS). | 8 |
| | | **Total** | **=42 hrs** |

**Recommended Books:**

| **Author** | **Title** | **Publisher** |
|---|---|---|
| F.N. Cogswell | Thermoplastic Aromatic Polymer Composites | Springer |
| L.A. Utracki | Polymer Alloys and Blends | Hanser Publishers |
| P.K. Mallick | Fiber-Reinforced Composites: Materials, Manufacturing and Design | CRC Press |
| S.T. Peters | Handbook of Composites | Springer |
| J.A. Brydson | Plastics Materials | Butterworth-Heinemann |
| Ronald F. Gibson | Principles of Composite Material Mechanics | CRC Press |

# SLIET LONGOWAL

## 2.2.1 – CHEMICAL ENGINEERING (PH.D. – CE)

### CH-10003: ADVANCED REACTION ENGINEERING

**L T P** **CREDIT**
**3 1 0** **4**

**Unit-I** **(10)**

Homogeneous Reaction in Ideal Reactors: Kinetics of Homogenous reactions, Interpretation of Batch Reactor Data; Integral method of analysis and Differential Method of Analysis.

**Unit-II** **(10)**

Design of Ideal Reactors: Design of Ideal Rectors; Concept of Design; Important parameters controlling Design of fixedand varying volume reactors.

**Unit-III** **(14)**

**Non-Ideal Reactors:** Concept of non-ideal flow, Compa1tment Models, Dispersion Model, The tanks in series Model, the convection Model for Laminar flow, Earliness of mixing, Segregation and RTI.

**Unit-IV** **(10)**

**Catalytic Reactors:** Reaction Catalysed by solids: Heterogeneous reaction; The packed Bed Catalytic Reactor.

**Recommended Books:**

| Sr. No. | Title | Author | Publishers |
|---|---|---|---|
| 1. | ChemicalReactionEngg. | OctaveLeven spiel | WileyInternationalEd. |
| 2. | ElementsofChemical ReactionEngineering | Fogler,H.S. | PHI |
| 3. | AdvancedPolymerChemistry: | ManojChanda | Marshal DcccarInc. |
| 4. | Aproblem-solving guide FundamentalsofPolymers InternationalEd.1990 | AnilKumar&Rakesh K. Gupta | McGrawHill |
| 5. | PolymerReactorEngineering, FirstEd.1994 | C.McGreavy | BlackieAcademic andProfessional, |
| 6. | AnintroductiontoPolymer | Charles | Rammond B.Seymquer |

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## 2.2.1 – CHEMICAL ENGINEERING (PH.D. – CE)

### CH-10004: ADVANCED ENERGY TECHNOLGY

| L | T | P | CREDIT |
|---|---|---|---|
| 3 | 1 | 0 | 4 |

**Unit-I** **(11)**

**Introduction:** Energyscenario. Energy sources & their availability. Prospects of renewable energy sources. Classification of energy sources. Quality & concentration of an energysources. Resourcesof energy&energy usepatternindifferent regionsof theworld.

**Energy Audit:** Energy audit concepts, elements, measurements, mass& energy balances, evaluation of energy conserving opportunities, presentation of reports case study.

**Unit-II** **(10)**

**Energy Conservation:** An economic concept of energy conservation, laws of energy efficiencies, energy recovery from waste, waste heat recovery systems and applications. Energy savings by recycling & by network analysis, application of pinch technology to energy conservation.

**Unit-III** **(11)**

**Solar Energy and Wind Energy:** Solar radiation, its measurement & prediction. Solar water beating, solar dryers, solar stills, solar cooling& refrigeration. Thermal storage. Solar PY.

Basic principles of wind energy conversion. Basic components, classification. advantages & disadvantages of WECS (Wind Energy Collectors System), Types of wind machines (Wind Energy Collectors), energy storage, application of wind energy.

**Hydrogen and fuel cells:** Salient features of hydrogen as energy carrier. Hydrogen production technologies. Fuelcells, types and operation. Fuel-cells in CHP mode.

**Unit-IV** **(10)**

**Bioenergy:** Biomass as a source of energy, assessment of biomass availability using GT Sand remote sensing, biomass characterization. Biomass conversion technologies, biogas generation, classification of biogas plants, digester design considerations, thermal gasification of biomass. Classification and design of biomass gasifiers. Downstream processing of syngas. First, second and third generation biofuels, biochemical/chemical processing steps.

**RecommendedBooks:**


1. Hand bookofEnergyConservation byRobe,1andCollinsVol.1 &Vol.2.
2. Non-conventional Energy Sources by G.D. Rai.
3. Energy Technology by S.Rao
4. Solar Energy by S.P. Sukhatme

# SLIET LONGOWAL

## 2.2.1 – CHEMICAL ENGINEERING (PH.D. – CE)

### CH-10005: ADVANCES IN ENVIRNMENTAL ENGINEERING

| L | T | P | CREDIT |
|---|---|---|---|
| 3 | 1 | 0 | 4 |

**Unit-I** **(10)**

**Introduction:** Environmental pollution, monitoring & control; effects of pollutants on living systems and structure. Effluent guidelines & standards forair, water& land disposals. Conservationof material resources&energy through recycling.

**Unit-II** **(12)**

**Water Pollution:** Waste-water characterization. Waste-water treatment; primary treatment, secondary treatment, advanced waste-water treatment techniques. Industrial waste-water treatment & disposal, design of major water pollution control equipment.

**Unit-III** **(12)**

**Air Pollution:** Types of air pollutants and their effects on environment. Greenhouse effect. Depletion of ozone layer. Dispersion of air pollutants; plume characteristics. Design of chimney, setting chamber, cyclone separator, filter bag house, ESP sand snubbers.

**Unit-IV** **(08)**

**Solid Waste Pollution:** Characterization of solid waste, disposal of solid waste, solid waste management, reuseof solid waste materials, recovery of materials& metals, conversion into useful products. Landfillgasesand leachates.

**Environment impact Assessment** &**Auditing:** Environment impact assessment, project data, environment data, prediction & evaluation of impacts, environment Impact assessment in Indian context. Environment auditing and analysis ofdata, costbenefit analysisin pollution control.

**RecommendedBooks:**


1. Manual on emergency Preparedness for Chemical Hazards Ministry of environment & Forests, govt. of India.
2. Environmental engineering-G.N.Panday,G.C.Camey.TataMcGraw
3. SustainableBusiness-RegencyCorporationLtd.,
4. Wastewatertreatment"ConceptandDesignApproach"G.L.Karia,R.AChristian.
5. Air Pollution Control Engineering, Man in Crawford
6. Air Pollution Control Engineering, W.Licht
7. Environmental Engineering by Peavy, Rowe, Tchobanoglous

# SLIET LONGOWAL

## 2.2.1 – CHEMICAL ENGINEERING (PH.D. – CE)

### CH-10006: WASTE MANAGEMENT & RECYCLING

| L | T | P | CREDIT |
|---|---|---|---|
| 3 | 1 | 0 | 4 |

**Unit-I** **(10)**

Concept of Waste and circular economy, Sources, Classification and characterization of solid wastes, Legal and Regulatory Frameworks: Examining relevant legislation, policies, and guidelines for waste management at local, national, and international levels. Waste Minimization and Reduction: Strategies to reduce waste generation at the source, such as product design, packaging optimization, and promoting reusable materials. Reuse and Recycling: Concept of "6 Rs", principles of Refuse, Reduce, Reuse, Recycle, Repurpose, and Recover.

**Unit-II** **(12)**

Waste Collection and Transportation, Route Optimization and Logistics, Waste Treatment Technologies: Composting and vermicomposting, Incineration and thermal treatment for reducing waste and energy recovery, Anaerobic Digestion for biogas production, Mechanical Biological Treatment (MBT): Pulping, Shredding, and Granulating. Waste Disposal and Landfilling, Landfill Design and Operation: Principles of landfill site selection, construction, and operation, including leachate and gas management. Integrated Waste Management (IWM): Principles and strategy.

**Unit-III** **(12)**

**Special Waste Streams: (An overview)**

Argo-residues: Types and characterization of Argo-Residues; Processing of agro-residues: Gasification; Liquefaction; Bioethanol, Bio diesel; Combustion; Pyrolysis. Briquetting and Palletisation.

Biomedical Waste: Management of medical waste, including collection, treatment, and disposal.

E-waste: Challenges and opportunities associated with managing electronic waste, Management of e-waste including recycling and disposal.

Hazardous Waste: Characteristics of hazardous waste, relevant regulations, and safe handling and disposal procedures.

**Unit-IV** **(10)**

Economics of Waste Management: Analyzing the costs and benefits of different waste management options.

Analyzing real-world examples of waste management systems: Successful and unsuccessful case studies from different cities and countries.

*Students will be expected to present a seminar on Advanced topics of Waste Management and Recycling including design of a specific waste management system.

**Recommended Books:**

| Sr. No. | Title | Author | Publishers |
|---|---|---|---|
| 1. | Waste to Energy | Upender Pandel; Poonia; J. Mathur and S.Mathur | Prime Publishers |
| 2. | Prospects and Perspectives of Solid | B.B.Hosetti | New Age International Pub. |
| 3. | Waste Age and Recycling Times Recycling Handbook | Leila R. Smith Emeritus | CRC Press |
| 4. | Waste Management: A Comprehensive Guide to Sustainable Solutions | Manish R. Moroliya | New Age International Pub. |

# SLIET LONGOWAL

## 2.2.1 – CHEMICAL ENGINEERING (PH.D. – CE)

### CH-10007: LIGNOCELLULOSES TECHNOLGY

**L T P** **CREDIT**
**3 1 0** **4**

| Unit | Main Topics | Course outlines | Lecture(s) |
|---|---|---|---|
| **Unit-1** | Introduction | Lignocelluloses as sustainable raw materials. Main chemical constituents and their significance. Physical and morphological characteristics of lignocelluloses. | 5 |
| | Delignification | Alkaline delignification, acidic delignification, organosolv delignification. Process chemistry, and technology; main process parameters, and equipment. Environmental management. | 8 |
| | Saccharification and alcohol fermentation | Dilute acid hydrolysis, concentrated acid hydrolysis, and enzymatic hydrolysis of lignocelluloses. Process parameters and equipment. Ethanol fermentation from hexoses and pentoses. Butanol fermentation. | 7 |
| **Unit-II** | Cellulose | Cellulose chemistry, and macromolecular structure. Cellulose characteristics: degree of polymerization, end groups, hydrophilic character. Cellulose based products: paper and paperboard, filter media, packaging, adsorbents, fibres and yarns, composites, and nanocellulose products. | 10 |
| | Lignin | Lignin chemistry and characterization: functional groups, inter monomer linkages and substructures, and polydispersity. Lignin based polymers: adhesives, resins, foams, blends, and composites. Specialty chemicals, and carbon products from lignin. | 10 |

**Total=40 Hrs.**

**Recommended Books:**


1. Ghatak, HR. Lignin Isolation, Characterization, and Value Addition. CRC Press, Taylor and Francis. 2025.
2. Sun, R-C. Cereal Straw as a Resource for Sustainable Biomaterials and Biofuels. Elsevier. 2010.
3. Rojas, OJ (eds.) Cellulose Chemistry and Properties: Fibers, Nanocelluloses and Advanced Materials. Springer. 2016.
4. Belgacem, N, Pizzi, A (eds.) Lignocellulosic Fibers and Wood Handbook. Scrivener Publishing LLC. 2016.