
**Two-Year Postgraduate Programme**

# Master of Science

# M.Sc. Industrial Chemistry

## Faculty of Applied Sciences

### Parul University

### Vadodara, Gujarat, India

# Faculty of Applied Sciences
## Master of Science in Industrial Chemistry

1. **Vision of the Department:**
   Building foundation for excellence and spur development of the Institution as a premier Institution, by igniting and nurturing enthusiasm, interests and passion, in the study of chemistry, in professional courses, as a part of curriculum.

2. **Mission of the Department:**

| | |
|---|---|
| **M1** | Awakening the young minds and discover their talents both in theory and in practical chemistry, through dedication to teaching, commitment to students and innovative instructional methods. |
| **M2** | Supporting the developmental activities of the College and make the Department vibrant. |
| **M3** | Organizing critical contributions in areas of emphasis such as faculty, modern labs, department library and demonstrate a high level of competence in the study of Chemistry. |

3. **Program Educational Objectives**
   The statements below indicate the career and professional achievements that the Master of Science in Industrial Chemistry curriculum enables graduates to attain.

| | |
|---|---|
| **PEO 1** | To demonstrate a high level of competence and expertise in industrial chemistry, applying their knowledge to solve complex problems in chemical manufacturing, analysis, and research. |
| **PEO 2** | To exhibit leadership qualities and work effectively in multidisciplinary teams, demonstrating the ability to lead and contribute to collaborative efforts in the industrial setting. |
| **PEO 3** | To demonstrate the ability to adapt to evolving technologies, market demands, and workplace environments, showcasing flexibility in their approach to problem-solving and decision-making. |

4. **Program Learning Outcomes**
   Program Learning outcomes are statements conveying the intent of a program of study.

| | | |
|---|---|---|
| **PLO 1** | **Disciplinary Knowledge** | Execute strong theoretical and practical understanding generated from the specific programme in the area of work. |
| **PLO 2** | **Critical Thinking and Problem Solving** | Identify the problem by observing the situation closely, take actions and analytical skills to design the solutions. |
| **PLO 3** | **Social Competence** | Exhibit thoughts and ideas effectively, build effective interactive and presenting skills to meet global competencies. |
| **PLO 4** | **Research-related Skills and Scientific Temper** | Infer scientific literature, build sense of enquiry and identify and consult relevant sources to find answers. |

| | | |
|---|---|---|
| **PLO 5** | **Trans-disciplinary Knowledge** | Create new conceptual, theoretical and specific approaches to address a common problem. |
| **PLO 6** | **Personal and Professional Competence** | Execute interpersonal relationships, self-motivation and adaptability skills and commit to professional ethics. |
| **PLO 7** | **Effective Citizenship and Ethics** | Demonstrate empathetic social to professional ethics and responsibility. |
| **PLO 8** | **Environment and Sustainability** | Understand the impact of the scientific solutions in societal and environmental contexts. |
| **PLO 9** | **Self-directed and Life-long learning** | Acquire the ability to engage in independent and life-long learning in broadest context of socio-technological changes. |

## 5. Program Specific Learning Outcomes

| | | |
|---|---|---|
| **PSO 1** | **Advanced Knowledge** | Differentiate between chemistry, chemical engineering and chemical industry and identify the distinguishing features of its component |
| **PSO 2** | **Professional Development** | Explain the importance and roles of process optimization chemical engineering in intellectual ways |

## 6. Credit Framework

| **Semester wise Credit distribution of the programme** | |
|---|---|
| Semester-1 | 28 |
| Semester-2 | 28 |
| Semester-3 | 24 |
| Semester-4 | 20 |
| **Total Credits:** | **100** |

| **Category wise Credit distribution of the programme** | |
|---|---|
| **Category** | **Credit** |
| Major Core | 64 |
| Elective | 12 |
| Dissertation | 4 |
| Internship | 20 |
| **Total Credits:** | **100** |

## 7. Program Curriculum

| Semester 1 | | | | | | |
|---|---|---|---|---|---|---|
| **Sr. No.** | **Subject Code** | **Subject Name** | **Credit** | **Lect** | **Lab** | **Tut** |
| 1 | 11223101 | Advanced Petrochemical Technology | 4 | 4 | - | - |
| 2 | 11223102 | Advancement in Industrial Operations | 4 | 4 | - | - |
| 3 | 11223103 | Industrial Polymer | 4 | 4 | - | - |
| 4 | 11223104 | Introduction of Synthetic Dyes & Drugs | 4 | 4 | - | - |
| 5 | 11223130 OR 11223131 | Environmental Pollution Control Technology / OR / Entrepreneurship and Innovations *(Elective Subjects)* | 4 | 4 | - | - |
| 6 | 11223105 | Lab-1 (Petrochemical & Operational Tech) | 4 | - | 8 | - |
| 7 | 11223106 | Lab-2 (Synthesis of Dyes & Drugs) | 4 | - | 8 | - |
| | | **Total:** | **28** | **20** | **16** | **-** |
| **Semester 2** | | | | | | |
| **Sr. No.** | **Subject Code** | **Subject Name** | **Credit** | **Lect** | **Lab** | **Tut** |
| 8 | 11223151 | Materials and Utilities in Chemical Technology | 4 | 4 | - | - |
| 9 | 11223152 | Pharmaceutical Technology | 4 | 4 | - | - |
| 10 | 11223153 | Advanced Spectroscopy and Chromatography | 4 | 4 | - | - |
| 11 | 11223154 | Industrial Safety | 4 | 4 | - | - |
| 12 | 11223181 OR 11223180 | Chemical Reactor Engineering OR Green Chemistry *(Elective Subjects)* | 4 | 4 | - | - |
| 13 | 11223155 | Lab-1 (Reaction Process Control) | 4 | - | 8 | - |
| 14 | 11223156 | Lab-2 (Synthesis of Organic Chemicals) | 4 | - | 8 | - |
| | | **Total:** | **28** | **20** | **16** | **-** |
| **Semester 3** | | | | | | |
| **Sr. No.** | **Subject Code** | **Subject Name** | **Credit** | **Lect** | **Lab** | **Tut** |
| 15 | 11223201 | Industrial Process Control Technology | 4 | 4 | - | - |
| 16 | 11223202 | Process Development Technology | 4 | 4 | - | - |
| 17 | 11223203 | Basic Name Reactions in Chemistry | 4 | 4 | - | - |
| 18 | 11223204 | Intellectual Property Rights | 4 | 4 | - | - |
| 19 | 11223230 OR 11223231 | Nanomaterial Chemistry OR Medicinal Chemistry *(Elective Subjects)* | 4 | 4 | - | - |
| 20 | 11223205 | Dissertation | 4 | - | 8 | - |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | **Total:** | **24** | **20** | **08** | **-** |
| **Semester 4** | | | | | | |
| **Sr no** | **Subject Code** | **Subject name** | **Credit** | **Lect** | **Lab** | **Tut** |
| 21 | 11223251 | Industrial Internship | 20 | - | 600 | - |
| | | **Total:** | **20** | **-** | **600** | **-** |

## 8. Detailed Syllabus

# Semester: 1

- **Course Name:** Advanced Petrochemical Technology

  **Course Code:** 11223101

  **Prerequisite:** Knowledge of petroleum engineering fundamentals, including reservoir engineering, drilling engineering, production engineering, and petrophysics, is crucial for advanced studies or a career in petroleum technology.

  **Rationale:** Advanced Petrochemical Technology is rooted in the need for continuous improvement, innovation, sustainability, and adaptability in the petrochemical industry. By understanding and implementing advanced technologies, professionals in this field contribute to the efficiency, safety, and environmental responsibility of petrochemical processes and products.

**Course Learning Objective:**

| | |
|---|---|
| **CLOBJ 1** | Memorise concepts of reservoir engineering, including fluid flow in porous media, reservoir simulation techniques, enhanced oil recovery methods, and reservoir management strategies. |
| **CLOBJ 2** | Recognise topics related to oil and gas production, such as artificial lift systems, well performance analysis, production optimization, and production forecasting methods. |
| **CLOBJ 3** | Demonstration of petroleum projects, risk analysis, decision-making under uncertainty, and project valuation techniques specific to the petroleum industry. |
| **CLOBJ 4** | Examine cutting-edge technologies and trends in the petroleum industry, such as digital oilfield technologies, reservoir monitoring and surveillance, and advanced drilling and completion techniques. |
| **CLOBJ 5** | Evaluate research skills and an understanding of the importance of innovation in addressing challenges and driving advancements in the petroleum industry. |
| **CLOBJ 6** | Investigate issues related to sustainability, corporate social responsibility, and ethical decision-making in the industry. |

**Course Learning Outcomes:**

| | |
|---|---|
| **CLO 1** | Remember advanced understanding of fluid flow in porous media, reservoir simulation techniques, and enhanced oil recovery methods, and be able to apply this knowledge to real-world reservoir management scenarios. |
| **CLO 2** | Classify advanced economic evaluations of petroleum projects, perform risk analysis, and make informed decisions considering economic and risk factors. |
| **CLO 3** | Demonstrate advanced drilling techniques such as directional drilling, wellbore stability analysis, and drilling optimization, and will be able to evaluate and select appropriate drilling technologies for specific well conditions. |
| **CLO 4** | Organise well testing analysis, interpretation of well data, pressure transient analysis, and integration of well test results with reservoir modelling. |
| **CLO 5** | Support the importance of innovation in addressing challenges and driving advancements in the petroleum industry. |

| | |
|---|---|
| **CLO 6** | Develop demonstrate expertise in production optimization techniques, including artificial lift systems, well performance analysis, and production forecasting, and be able to apply these techniques to maximize hydrocarbon recovery. |

**Teaching & Examination Scheme:**

| Teaching Scheme | | | | Evaluation Scheme | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| L | T | P | C | Internal Evaluation | | | ESE | | Total |
| | | | | MSE | CE | P | Theory | P | |
| 4 | - | - | 4 | 20 | 20 | - | 60 | - | 100 |

**L-** Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

**Course Content:**

| Sr. No | Content | Weightage | Teaching Hours |
|---|---|---|---|
| 1 | **Basics of Petroleum Refinery Technology:** Introduction, importance, origin & occurrence, classification of crude oils according to their composition, basic properties of crude oil, TBP /ASTM/EFV distillation curves. **Composition of Crude oil:** Composition of paraffins, aromatic and olefins hydrocarbons, Sulphur-nitrogen-oxygen based compounds, organometallic hydrocarbons according to source, formation and composition of Kerogens (advanced source of organic compound). Natural Gas: Introduction, Composition, utilization, types of natural gas resources, physical properties, processing of LPG & CNG, uses | 25% | 15 |
| 2 | **Cracking and Reforming:** Introduction and purpose of cracking, types and different methods of cracking, effects of temperature & pressure on cracking, Introduction and purpose of reforming, differentiate thermal and catalytic reforming. **Basic and Advanced Cracking and Reforming Techniques:** Aim, objectives, process-flow utilities & technology, advantage and disadvantage of a) hydrocracking; b) platforming (Pt catalyst reforming); c) coking; d) vis-breaking; e) doctor's sweetening; f) catalytic desulfurization; g) MEROX treatment | 25% | 15 |
| 3 | **Oil Fields Brines**: Composition, Classification, Origin and alteration of Oil Field Brines, Importance of Oil Field water analysis, Effects of water circulation on Hydrocarbons Properties of Hydrocarbons: Density, Viscosity, Surface Tension, Color, Fluorescence, Cloud Point and Pour Point, Aniline Point, Optical Properties, Flash Point, Refractive Index and Calorific Value | 25% | 15 |
| 4 | **Petrochemicals Industry:** Objective, process utilities and manufacturing technology of Methanol, Formaldehyde, Ethylene dichloride, Linear Alkyl Benzene, Phenol, Petrol, Diesel, Kerosene, lubricant oil, CNG and LPG, Grease. Separation of Crude Oil: Distillation and Classification of Petroleum: First, Second and Third Generation Petrochemicals, Miscellaneous Petrochemicals, Integrated | 25% | 15 |

| | | | |
|---|---|---|---|
| | Petrochemicals Complex, Petrochemical Industry in India | | |
| | **Total** | **100%** | **60** |

**Text Book and Reference Book:**

1. Understanding Petroleum Refining Technology, R. Prasad
2. Modern Petroleum Refining Technology, B.K.B. Rao

- **Course Name:** Advancement in Industrial Operations

  **Course Code:** 11223102

  **Prerequisite:** A fundamental understanding of industrial operations, including manufacturing processes, supply chain management, quality control, and industrial systems engineering concepts, is often necessary.

  **Rationale:** Industrial systems have become increasingly complex due to factors such as globalization, technological advancements, and changing consumer demands. Advanced industrial operations aim to address this complexity by applying advanced techniques and methodologies to optimize these systems.

**Course Learning Objective:**

| | |
|---|---|
| **CLOBJ 1** | Define the principles and concepts underlying industrial systems, including manufacturing processes, supply chain management, quality control, and industrial engineering techniques. |
| **CLOBJ 2** | Identify operations management tools and techniques, such as lean manufacturing, Six Sigma, total quality management, and advanced production planning and scheduling methods, to optimize industrial operations. |
| **CLOBJ 3** | Interpret supply chain management principles and techniques, including inventory optimization, demand forecasting, logistics management, and supplier relationship management, to optimize the flow of materials and information across the supply chain. |
| **CLOBJ 4** | Differentiate in identifying, assessing, and managing risks in industrial operations, including operational, financial, and strategic risks, to ensure resilience and continuity in operations. |
| **CLOBJ 5** | Evaluate advanced project management and leadership skills necessary for leading and managing complex industrial projects, including project planning, execution, monitoring, and control. |
| **CLOBJ 6** | Develop critical thinking and problem-solving abilities to analyse complex industrial operations problems, identify root causes, and propose effective solutions. |

**Course Learning Outcomes:**

| | |
|---|---|
| **CLO 1** | Memorise advanced knowledge of industrial systems, including manufacturing processes, supply chain management, quality control, and industrial engineering principles. |
| **CLO 2** | Describe advanced operations management techniques such as Six Sigma, lean |

| | |
|---|---|
| | manufacturing, total quality management (TQM), and advanced production planning methods to optimize industrial operations. |
| **CLO 3** | Implement data analysis and interpretation to make informed decisions in industrial operations, utilizing statistical methods, data visualization, and predictive analytics. |
| **CLO 4** | Examine supply chain processes; including procurement, logistics, inventory management, and distribution, to enhance overall supply chain performance. |
| **CLO 5** | Evaluate and manage risks in industrial operations, including risks related to safety, regulatory compliance, supply chain disruptions, and market fluctuations. |
| **CLO 6** | Develop project management skills specific to industrial operations, including project planning, scheduling, budgeting, and execution within the industrial context. |

**Teaching & Examination Scheme:**

| Teaching Scheme | | | | Evaluation Scheme | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| L | T | P | C | Internal Evaluation | | | ESE | | Total |
| | | | | MSE | CE | P | Theory | P | |
| 4 | - | - | 4 | 20 | 20 | - | 60 | 0 | 100 |

**L-** Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

**Course Content:**

| Sr. No. | Content | Weightage | Teaching Hours |
|---|---|---|---|
| 1 | **Basics for Unit Operations**<br>Basic laws, stoichiometry, material and energy balances, tie substance, gas laws, equilibrium state, steady and unsteady states, dimensionless equations, dimensionless formulae, dimensionless groups, different types of graphic representation, mathematical problems. | 25% | 15 |
| 2 | **Distillation:**<br>Introduction, Basic of Distillation, Selection of Key Component, Sequencing of Distillation Column, Selection of Operating Pressure, Advanced Methods for Finding Theoretical Stages, Multicomponent Batch Distillation, Azeotropic and Extractive Distillation | 25% | 15 |
| 3 | **Heat Transfer:**<br>Source of heat, Mode of heat transfer, (i) Conduction: Principal, basic laws, Material properties of importance like Thermal Conductivity, Sp. Heat; (ii) Convection: Principal, basic laws, Natural convection & Forced convection, (iii) Radiation, Boiling & Condensation, steam and electricity as heating media Mass Transfer: Classification of mass transfer operation, choice of separation method, Methods of conducting mass transfer operations, Applications, Diffusion in Solids, Inter Phase Mass Transfer, Leaching, Mass Transfer with Chemical Reactions. | 33% | 20 |
| 4 | **Size Reduction and Particle Size Distribution:**<br>Definition, objectives of size reduction, factors affecting size reduction, laws governing energy and power requirements of a mills including ball mill, hammer mill, fluid energy mill etc, | 17% | 10 |

| | | | |
|---|---|---|---|
| | (Unit replaced with Membrane technology and Membrane separation Process | | |
| | **Total** | **100%** | **60** |

**Text Book and Reference Book:**

1. Unit Operations of Chemical Engineering, By Warren L McCabe, Julian C. Smith, Petter Harriott
2. Unit Operations, by K.A. Gavhne

- **Course Name:** Industrial Polymer

**Course Code:** 11223103

**Prerequisite:** Students requires fundamental knowledge of materials and basic of chemical compositions

**Rationale:** Polymers offer versatility in terms of their properties and can be tailored to meet specific performance requirements. This makes them highly adaptable to diverse industrial needs, allowing for customization of materials for various applications.

**Course Learning Objective:**

| | |
|---|---|
| **CLOBJ 1** | Define fundamental principles of polymer science, including polymer structure, properties, synthesis methods, and characterization techniques. |
| **CLOBJ 2** | Recognise polymer processing techniques such as extrusion, injection molding, blow molding, and thermoforming, and be able to apply these techniques to produce polymer products. |
| **CLOBJ 3** | Use polymer characterization techniques, including spectroscopy, chromatography, microscopy, and thermal analysis, and be able to interpret and analyse polymer properties based on characterization results. |
| **CLOBJ 4** | Examine polymer properties, such as mechanical, thermal, electrical, and optical properties, to select and design polymers for specific industrial applications. |
| **CLOBJ 5** | Evaluate polymer processing, material selection, and product design, and be able to apply these skills to address real-world challenges in industrial polymer applications. |
| **CLOBJ 6** | Design principles of quality control and assurance in polymer manufacturing, including testing methods, standards compliance, and quality management systems. |

**Course Learning Outcomes:**

| | |
|---|---|
| **CLO 1** | Remember a comprehensive understanding of the fundamental principles of polymer science, including polymer structure, properties, synthesis methods, and characterization techniques. |
| **CLO 2** | Identify polymer processing techniques such as extrusion, injection molding, blow molding, and thermoforming, and be able to apply these techniques to produce polymer products. |
| **CLO 3** | Examine polymer characterization techniques, including spectroscopy, chromatography, microscopy, and thermal analysis, and be able to interpret and analyse polymer properties based on characterization results. |

| | |
|---|---|
| **CLO 4** | Demonstrate knowledge of polymer properties, such as mechanical, thermal, electrical, and optical properties, to select and design polymers for specific industrial applications. |
| **CLO 5** | Evaluate polymer processing, material selection, and product design, and be able to apply these skills to address real-world challenges in industrial polymer applications. |
| **CLO 6** | Investigate principles of quality control and assurance in polymer manufacturing, including testing methods, standards compliance, and quality management systems. |

**Teaching & Examination Scheme:**

| Teaching Scheme | | | | Evaluation Scheme | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| L | T | P | C | Internal Evaluation | | | ESE | | Total |
| | | | | MSE | CE | P | Theory | P | |
| 4 | - | - | 4 | 20 | 20 | - | 60 | - | 100 |

**L-** Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation,
**CE**- Continuous Evaluation, **ESE-** End Semester Examination

**Course Content:**

| Sr. No. | Content | Weightage | Teaching Hours |
|---|---|---|---|
| 1 | **Introduction to Polymer Chemistry**<br>Introduction of polymer, nomenclature, general classification of polymer, classification based on microstructure and geometrical structure, synthesis, mechanism and thermodynamics of polymer: a) chain polymerization (free radical, cationic, anionic, coordination) and b) step polymerizations (polycondensation, poly-addition, ring opening), Difference between thermoplastics and thermosets, Difference between addition and condensation polymerization reactions, difference between cationic and anionic polymerization reactions | 25% | 15 |
| 2 | **Radical Polymerization Process**<br>Co-polymerization: Introduction, free radical co-polymerization and its kinetics aspects, copolymer equations, significance and determination of reactivity ratios, reactivity ratios and copolymerization behavior Molecular Weight (M.W.) of Polymer: Introduction of number and weight average concept and their derivation equations, equations for sedimentation and viscosity average molecular weights, M.W. and degree of polymerizartion, Polydispersity and M.W. distribution, Practical significance of polymer M.W., List of methods of determining Mn, Mw and M.W. distribution, Chromatography techniques to identify M.W. (Gel Permission Chromatography). Visometry Method: Introduction, common names of viscosity, types of capillary, viscometers, intrinsic viscosity and the use of Mark-HouwnikSakurada equation to calculate Mv, numerical | 25% | 15 |

| | | | |
|---|---|---|---|
| **3** | **Different Ingredients of Plastics**<br>Fillers, Plasticizers, Softeners Lubricants, Flow Promoters, Anti-aging agents, , Blowing Agents, Colourants, Cross linking agents, Photodegradents, Flame RetardersPolymer Processing: Introduction, Principle, working and applications of following polymer processing techniques: Injection molding, extrusion, blow molding, compression molding, rotational molding, film casting, thermoforming and vacuum forming, Fiber Spinning molding Polymer degradation: Introduction, Types of degradation: a) Chain end; b) Random, Thermal Degradation, Mechanical Degradation, Chemical Degradation, Photo degradation | **20%** | **12** |
| **4** | **Introduction of Synthesis**, Properties, Process Manufacturing Technology and Uses of different Plastics Materials: polyethylene (PE), Poly Propylene (PP), Poly Vinyl Chloride (PVC), PolyMethyl Methacrylate (PMMA), Poly Styrene (PS), Polyamide (Nylon), Poly Urethane (PU), Phenol Formaldehyde (PF), Polyester Resin | **30%** | **18** |
| | **Total** | **100%** | **60** |

**Text Book and Reference Book:**

1. Industrial Chemistry, by B.K. Sharma, Krishna Publication
2. Introduction to Polymers by Robert J. Young and Peter A. Lovell
3. Polymer Science and Technology by Joel R. Fried

- **Course Name:** Introduction of Synthetic Dyes & Drugs

  **Course Code:** 11223104

  **Prerequisite:** Knowledge of Chemistry Fundamentals, Organic Chemistry, Biochemistry, Pharmacology Basics and Analytical Chemistry

  **Rationale:** Introduction of a Synthetic Dyes & Drugs subject is justified by its relevance to industry, medicine, environmental sustainability, and the interdisciplinary nature of the field. This subject equips students with the knowledge and skills needed to address real-world challenges and contribute to advancements in science and technology.

  **Course Learning Objective:**

| | |
|---|---|
| **CLOBJ 1** | Define and explain key concepts in synthetic chemistry, including chemical bonding, molecular structure, and reaction mechanisms, with a focus on organic chemistry |
| **CLOBJ 2** | Describe the principles and methods involved in the synthesis of synthetic dyes, including the structure-activity relationship and the impact of different dye classes. |
| **CLOBJ 3** | Execute the process of drug synthesis and design, considering factors such as drug targets, pharmacokinetics, and the structure-activity relationship in drug development. |
| **CLOBJ 4** | Examine the physical and chemical properties of synthetic dyes, including color |

| | |
|---|---|
| | characteristics, stability, and applications in various industries such as textiles, cosmetics, and printing. |
| **CLOBJ 5** | Evaluate the environmental impact of synthetic dyes and drugs. Explore sustainable practices in dye and drug development, waste management, and the development of eco-friendly alternatives. |
| **CLOBJ 6** | Investigate emerging trends and technologies in synthetic dye and drug development. Understand how advances in biotechnology and nanotechnology influence these fields. |

**Course Learning Outcomes:**

| | |
|---|---|
| **CLO 1** | Remember understanding of the fundamental principles of synthetic chemistry, organic chemistry, and biochemistry as they relate to the synthesis and properties of synthetic dyes and drugs. |
| **CLO 2** | Classify synthetic dyes based on their chemical structures, properties, and applications. |
| **CLO 3** | Implement the process of drug synthesis and design, including an understanding of drug targets, structure-activity relationships, and pharmacokinetics. |
| **CLO 4** | Analyse the physical and chemical properties of synthetic dyes and drugs, and apply this knowledge to their various industrial and medical applications. |
| **CLO 5** | Evaluate proficiency in using analytical techniques such as spectroscopy and chromatography to characterize and identify synthetic dyes and drugs. |
| **CLO 6** | Develop knowledge from chemistry, biology, and pharmacology to understand the interdisciplinary nature of synthetic dyes and drugs. |

**Teaching & Examination Scheme:**

| **Teaching Scheme** | | | | **Evaluation Scheme** | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **L** | **T** | **P** | **C** | **Internal Evaluation** | | | **ESE** | | **Total** |
| | | | | **MSE** | **CE** | **P** | **Theory** | **P** | |
| **4** | **-** | **-** | **4** | **20** | **20** | **-** | **60** | **-** | **100** |

**L-** Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

**Course Content:**

| **Sr. No.** | **Content** | **Weightage** | **Teaching Hours** |
|---|---|---|---|
| **1** | **Introduction to Dyes**<br>Introduction, Definition of dye, Difference between dye and other coloring material, Requisites of true dye, Historical development from natural to synthetic dyes, Era of natural dyes, Era of synthetic dye, Nomenclature of dyes, Commercial naming of dyes, Color index and naming of dyes, Classification of Dyes, Pollution problems due to synthetic dyes | **25%** | **15** |
| **2** | **Chemistry**<br>Chemistry of the following dyes with respect to general structural features, chemistry mode of application to different fibers and classification and their manufacturing: Azo dyes, Acid dyes, Basic dyes and Mordant dyes, Reactive dyes, sulfur dye, fluorescent dye | **25%** | **15** |

| | | | |
|---|---|---|---|
| **3** | **Drug**<br>Definition, sources of drugs, requirements of an ideal drug, classification of drugs (based on therapeutic action), Nomenclature of drugs: Generic name, Brand name, Systematic name, Different drugs Introduction, Mechanism, synthesis route and manufacturing block diagram: a) Cardiovascular drugs b) Antineoplastic drugs; c) Analgesics (Narcotics and non-narcotics) and d) Antipyretics: Classification of analgesics: narcotics and non-narcotics. Morphine (phenanthrene alkaloids), Tramadol, Aspirin (salicylates), Paracetamol (p-amino phenol). | **25%** | **15** |
| **4** | **Anti-inflammatory drugs**<br>Mechanism of inflammation and various inflammatory conditions: Prednisolone, Betamethasone (steroids), Aceclofenac (aryl acetic acid), Mefenamic acid (N-aryl anthranilic acid)<br>**Anti-tubercular drugs**<br>Synthesis and application of the following i) pamino salicylic acid (PAS) ii) Isoniazide iii) Ethambutol iv) Pyrazinamide<br>**Antibiotics**<br>Definition, characteristics and properties: Amoxicillin, Cloxacillin (lactam antibiotic), Cephalexin (cephalosporins), Doxycycline(tetracyclines), Ciprofloxacin (quinolone) | **25%** | **15** |
| | **Total** | **100%** | **60** |

**Text Book and Reference Book:**


1. Introduction to Organic Chemistry by William H. Brown, Thomas Poon
2. Organic Chemistry by Paula Yurkanis Bruice
3. Medicinal Chemistry by Graham L. Patrick
4. Introduction to Spectroscopy by Donald L. Pavia, Gary M. Lampman, George S. Kriz
5. Basic Principles of Analytical Chemistry by S. M. Khopkar
6. Color Chemistry: Syntheses, Properties, and Applications of Organic Dyes and Pigments by Heinrich Zollinger
7. The Organic Chemistry of Drug Design and Drug Action by Richard B. Silverman
8. Textile Chemistry by H. R. Peters, G. D. Scudder
9. Handbook of Pharmaceutical Excipients by Paul J. Sheskey, Walter G. Cook, Sarah C. Owen
10. Chemistry and Technology of Fabric Preparation and Finishing by Charles Tomasino


- **Course Name:** Environmental Pollution Control Technology

  **Course Code:** 11223130

  **Prerequisite**: Knowledge of Environmental science up to UG science level

  **Rationale:** Basic Environmental Science knowledge is fundamental as it provides a strong foundation for various concerns disciplines, promotes problem-solving skills, supports innovation, and opens doors to diverse career opportunities.

**Course Learning Objective:**

| | |
|---|---|
| **CLOBJ 1** | Define and explain various forms of environmental pollution, including air, water, and soil pollution. |
| **CLOBJ 2** | Understand the role of regulatory bodies and compliance requirements for industries. |
| **CLOBJ 3** | Operate methods for measuring and monitoring different pollutants in air, water, and soil. |
| **CLOBJ 4** | Analyse technologies and methods for preventing and controlling pollution in different environmental media. |
| **CLOBJ 5** | Evaluate the principles and practices of controlling air pollutants, including particulate matter, gases, and volatile organic compounds. |
| **CLOBJ 6** | Develop strategies for preventing and treating water pollution, focusing on both point and non-point sources. |

**Course Learning Outcomes:**

| | |
|---|---|
| **CLO 1** | Remember comprehensive understanding of different types of environmental pollution, their sources, and their impact on ecosystems and human health. |
| **CLO 2** | Describe national and international environmental regulations and standards to assess and ensure compliance in various industrial and urban settings. |
| **CLO 3** | Apply appropriate methods to measure and monitor air, water, and soil pollutants, and analyse the collected data to assess environmental quality. |
| **CLO 4** | Analyse pollution prevention and control technologies, considering their effectiveness, feasibility, and environmental sustainability. |
| **CLO 5** | Evaluate performance of air pollution control devices and systems for mitigating emissions of particulate matter, gases, and volatile organic compounds. |
| **CLO 6** | Design and implement strategies for preventing and treating water pollution, including the operation and optimization of wastewater treatment processes. |

**Teaching & Examination Scheme:**

| Teaching Scheme | | | | Evaluation Scheme | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Internal Evaluation | | | ESE | | |
| **L** | **T** | **P** | **C** | **MSE** | **CE** | **P** | **Theory** | **P** | **Total** |
| **4** | **-** | **-** | **4** | **20** | **20** | **-** | **60** | **-** | **100** |

**L-** Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

**Course Content:**

| Sr. No | Content | Weightage | Teaching Hours |
|---|---|---|---|
| **1** | **Basics of Environmental Science and their Issues**<br>Definition, principles and scope of environment, components of environment, importance of environmental science in changing times. Brief overview on Global Environmental Issues: a) Green House Effect; b) Global Warming and climate change; c) Acid Rain; d) Ozone Layer Depletion; e) Nuclear Accidents and | **22%** | **15** |

| | | | |
|---|---|---|---|
| | Holocaust; f) Population Pressure; g) Urban Development h) Plastic and electronic waste; i) effects of different pollutants (air, water, soil, etc) on surroundings environment | | |
| **2** | **Water pollution and its Industrial Control Techniques** Definition, types and sources of pollution & their quality standards Objective, process technology, advantage and disadvantages of water pollution control techniques: a) ETP; b) oxidation ponds; c) Activated Sludge Process (ASP); d) Trickling Filters; f) fluidized bed reactors; g) up flow anaerobic sludge blanket reactor; h) fixed film reactors; i) membrane bioreactor neutralization; j) sludge management; k) digesters and solid waste management, regulatory framework overview for water pollution monitoring and control according to GPCB | **33%** | **15** |
| **3** | **Air and Soil pollution and its Industrial Control Techniques** Definition, types and sources of air and soil pollution and their quality standards. Objective, process technology, advantage and disadvantages of Air pollution control techniques: Green House Gas (GHG) emissions reduction, carbon capture and storage (CCS) technologies, Pollution reduction and removal (Flue Gas Desulfurization (FGD) methods, catalytic or thermal destruction of NOX, Fluidized Bed Combustion, Dioxins reduction and removal methods, Thermal Oxidizers or Wet Scrubbers to neutralize chemicals or heavy metals, solvent recovery systems like low volatile organic compound, Methods for removal of pollutants from gaseous effluents and particulate matter Objective, process technology, advantage and disadvantages of Air pollution control techniques: Soil waste disposal techniques, Biopesticides, Bioremediation- in-situ and ex-situ, Phyto-remediation, phyto-volatization, regulatory framework overview for air and soil pollution monitoring and control according to GPCB | **30%** | **20** |
| **4** | **Green technologies for pollution control** Definition and concepts of: green energy; sustainable consumption of resources; energy conservation; wind turbines; solar panels; recycle, reuse and reduce; use biodegradable and bio-accumulative products in environment | **15%** | **10** |
| | **Total** | **100%** | **60** |

**Text Book and Reference Book:**


1. Fair, G.M., Geyer J.C and Okun, (1969) "Water and Waste water Engineering" Vol II, John Wiley Publications.
2. Weber W.J., (1975) "Physico - Chemical Processes for Water Quality Control".
3. Peavy, H.S., Rowe and Tchobonoglous,G., (1985), "Environmental Engineering", McGraw Hill
4. Raju, B.S.N., (1995), "Water Supply and Wastewater Engineering", Tata McGraw Hill Pvt. Co. Ltd., New Delhi.
5. Benefield R.D., and Randal C.W., (1980), "Biological Process Design for Wastewater Treatment", Prentice Hall, EnglewoodChiffs, New Jersey.
6. Metcalf and Eddy Inc., (2003), "Wastewater Engineering - Treatment and Reuse", 4th

- **Course Name:** Entrepreneurship and Innovations

  **Course Code:** 11223131

  **Prerequisite:** Knowledge of Entrepreneurship and Innovations up to basic science level

  **Rationale:** Basic Entrepreneurship and Innovations knowledge is fundamental as it provides a strong foundation for various concerns disciplines, promotes problem-solving skills, supports innovation, and opens doors to diverse career opportunities.

**Course Learning Objective:**

| | |
|---|---|
| **CLOBJ 1** | Define entrepreneurship and articulate its significance in the business world |
| **CLOBJ 2** | Identify the key characteristics and traits associated with successful entrepreneurs |
| **CLOBJ 3** | Demonstrate the ability to identify and evaluate entrepreneurial opportunities in various industries and markets |
| **CLOBJ 4** | Differentiate and refine creative business ideas, demonstrating an understanding of market needs |
| **CLOBJ 5** | Evaluate effective market research to assess the feasibility and potential success of a business idea |
| **CLOBJ 6** | Develop a comprehensive business plan that includes a business model, market strategy, financial projections, and operational plan |

**Course Learning Outcomes:**

| | |
|---|---|
| **CLO 1** | State articulates a clear definition of entrepreneurship, understanding its key principles and components |
| **CLO 2** | Identify the essential characteristics and traits exhibited by successful entrepreneurs |
| **CLO 3** | Demonstrate the ability to identify potential entrepreneurial opportunities and assess their feasibility. |
| **CLO 4** | Organise and develop creative and innovative business ideas that address market needs |
| **CLO 5** | Evaluate thorough market research to gather relevant data and insights for business decision-making |
| **CLO 6** | Develop a detailed and comprehensive business plan that includes a business model, market strategy, financial projections, and operational details |

**Teaching & Examination Scheme:**

| Teaching Scheme | | | | Evaluation Scheme | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Internal Evaluation | | | ESE | | |
| **L** | **T** | **P** | **C** | **MSE** | **CE** | **P** | **Theory** | **P** | **Total** |
| **4** | **-** | **-** | **4** | **20** | **20** | **-** | **60** | **-** | **100** |

**L-** Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

**Course Content:**

| Sr. No | Content | Weightage | Teaching Hours |
|---|---|---|---|
| 1 | **Introduction to Entrepreneurship**<br>Entrepreneurs; entrepreneurial personality and intentions – characteristics, traits and behavioural; entrepreneurial challenges. Entrepreneurial Opportunities: Opportunities. Discovery/ creation, Pattern identification and recognition for venture creation: prototype and exemplar model, reverse engineering | **33 %** | **20** |
| 2 | **Entrepreneurial Process and Decision-Making**<br>Entrepreneurial ecosystem, Ideation, development and exploitation of opportunities; Negotiation, decision-making process and approaches, Effectuation and Causation. | **17 %** | **10** |
| 3 | **Crafting business models and Lean Start-ups**<br>Introduction to business models; Creating value propositions-conventional industry logic, value innovation logic; customer focused innovation; building and analyzing business models; Business model canvas, Introduction to lean startups, Business Pitching | **17 %** | **10** |
| 4 | **Organizing Business and Entrepreneurial Finance**<br>Forms of business organizations; organizational structures; Evolution of Organisation, sources and selection of venture finance options and its managerial implications. Policy Initiatives and focus; role of institutions in promoting entrepreneurship. | **33 %** | **20** |
| | **Total** | **100 %** | **60** |

**Text Book and Reference Book:**


1. S. Carter and D. Jones-Evans, Enterprise and small business- Principal Practice and Policy, Pearson Education (2006)
2. T. H. Byers, R. C. Dorf, A. Nelson, Technology Ventures: From Idea to Enterprise, McGraw Hill (2013)
3. Osterwalder, Alex and Pigneur, Yves (2010) Business Model Generation.
4. Kachru, Upendra, India Land of a Billion Entrepreneurs, Pearson
5. Bagchi, Subroto, (2008), Go Kiss the World: Life Lessons for the Young Professional, Portfolio Penguin
6. Bagchi, Subroto, (2012). MBA At 16: a Teenager's Guide to Business, Penguin Books
7. Bansal, Rashmi, Stay Hungry Stay Foolish, CIIE, IIM Ahmedabad
8. Bansal, Rashmi, (2013). Follow Every Rainbow, Westland.
9. Mitra, Sramana (2008), Entrepreneur Journeys (Volume 1), Booksurge Publishing
10. Abrams, R. (2006). Six-week Start-up, Prentice-Hall of India.
11. Verstraete, T. and Laffitte, E.J. (2011). a Business Model of Entrepreneurship, Edward Elgar Publishing

- **Course Name:** Petrochemical & Operational Technology

  **Course Code:** 11223105

  **Prerequisite:** Knowledge of different types of reactors and basic terminology

  **Rationale:** lab environment allows students to apply theoretical concepts learned in the classroom to practical scenarios, reinforcing their understanding of petrochemical processes and technologies.

**Course Learning Objective:**

| | |
|---|---|
| **CLOBJ 1** | Define a comprehensive understanding of different types of environmental pollution, their sources, and their impact on ecosystems and human health. |
| **CLOBJ 2** | Describe national and international environmental regulations and standards to assess and ensure compliance in various industrial and urban settings. |
| **CLOBJ 3** | Apply appropriate methods to measure and monitor air, water, and soil pollutants, and analyse the collected data to assess environmental quality. |
| **CLOBJ 4** | Analyse and recommend pollution prevention and control technologies, considering their effectiveness, feasibility, and environmental sustainability. |
| **CLOBJ 5** | Evaluate and assess the performance of air pollution control devices and systems for mitigating emissions of particulate matter, gases, and volatile organic compounds. |
| **CLOBJ 6** | Design and implement strategies for preventing and treating water pollution, including the operation and optimization of wastewater treatment processes. |

**Course Learning Outcomes:**

| | |
|---|---|
| **CLO 1** | Remember a solid understanding of the principles and concepts underlying petrochemical processes, including feedstock, reactions, and product synthesis. |
| **CLO 2** | Explain the key components, structures, and functions of the petrochemical industry, including the role of refineries and chemical plants. |
| **CLO 3** | Apply safety protocols, regulations, and best practices in petrochemical operations to ensure a safe working environment for oneself and others. |
| **CLO 4** | Examine process control systems, instrumentation, and automation technologies used in petrochemical plants to monitor and control processes efficiently. |
| **CLO 5** | Select and maintain common petrochemical equipment such as reactors, distillation columns, pumps, and compressors, ensuring optimal performance and reliability. |
| **CLO 6** | Design principles of process optimization to enhance efficiency, reduce energy consumption, and maximize production yields in petrochemical operations. |

**Teaching & Examination Scheme:**

| Teaching Scheme | | | | Evaluation Scheme | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Internal Evaluation | | | ESE | | Total |
| L | T | P | C | MSE | CE | P | Theory | P | |
| - | - | 6 | 4 | - | - | 40 | - | 60 | 100 |

**L-** Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

**Course Content:**

| Exp. No. | Name of the Experiment |
|---|---|
| **1** | Determine the Aniline Point of a given sample. |
| **2** | Determine the Cloud Point of a given sample. |
| **3** | Determine the Pour Point of a given sample |
| **4** | Determine the Flash Point and Fire Point of petroleum refinery product by semi-automatic Pensky & Martin apparatus |
| **5** | To determine the smoke point of a given sample |
| **6** | Determination of Viscosity of given sample using Say Bolt Viscometer |
| **7** | To determine the moisture content of the given liquid fuel sample using dean and stark apparatus |
| **8** | To determine the percentage purity of refinery products by auto distillation apparatus |
| **9** | To determine the acid number of given oil samples |
| **10** | To determine the calorific value of given samples by Bomb Calorimeter |
| **11** | To determine the thermal conductivity of metal rod |
| **12** | To determine the heat transfer from composite wall |
| **13** | To determine the thermal conductivity of insulating powder |
| **14** | To determine the critical radius of insulating material |
| **15** | Heat Transfer in Natural Convection |
| **16** | Heat Transfer in Forced Convection |
| **17** | To determine the effectiveness of pin fin in case of natural convection |
| **18** | To determine the effectiveness of pin fin in case of forced convection |
| **19** | Critical Heat Flux Apparatus |
| **20** | Parallel flow and counter current flow double pipe heat exchanger |

**Text Book and Reference Book:**

1. Understanding Petroleum Refining Technology, R. Prasad
2. Modern Petroleum Refining Technology, B.K.B. Rao

- **Course Name:** Lab -1 (Reaction Process Control)

  **Course Code:** 11223155

  **Prerequisite:** Knowledge of Chemical Engineering Fundamentals, Chemical Reaction Engineering, Process Dynamics and Control, Thermodynamics and Mathematics and Numerical Methods

  **Rationale:** Reaction Process Control laboratory plays a crucial role in the education and professional development of students, offering a dynamic and interactive environment where theoretical knowledge is translated into practical skills and insights.

**Course Learning Objective:**

| | |
|---|---|
| **CLOBJ 1** | Define proficiency in operating and understanding the instrumentation used for monitoring and controlling chemical reactions, including sensors, analysers, and control systems. |
| **CLOBJ 2** | Identify monitor chemical reactions in real-time using various analytical techniques, such as spectroscopy, chromatography, and other relevant methods. |
| **CLOBJ 3** | Demonstrate skills in collecting experimental data, analyzing results, and interpreting trends to gain insights into reaction kinetics, thermodynamics, and |

| | |
|---|---|
| | process dynamics. |
| **CLOBJ 4** | Examine safety protocols and procedures when working with chemical reagents, instrumentation, and experimental setups in the laboratory. |
| **CLOBJ 5** | Evaluate experiments to investigate reaction kinetics, optimize reaction conditions, and explore the impact of variables on reaction outcomes. |
| **CLOBJ 6** | Develop different process control strategies to maintain desired reaction conditions, such as feedback and feed forward control, cascade control, and advanced control techniques. |

**Course Learning Outcomes:**

| | |
|---|---|
| **CLO 1** | Remember statistical methods and interpret the results to draw conclusions about reaction kinetics, thermodynamics, and process dynamics. |
| **CLO 2** | Identify reaction kinetics, optimize reaction conditions, and assess the impact of variables on reaction outcomes. |
| **CLO 3** | Apply efficiency and performance of chemical reactions, considering factors such as yield, selectivity, and reaction rates. |
| **CLO 4** | Examine troubleshoot issues that may arise during reaction processes, demonstrating effective problem-solving skills and the ability to make informed decisions. |
| **CLO 5** | Select operating and calibrating instruments and equipment used for monitoring and controlling chemical reactions in a laboratory setting. |
| **CLO 6** | Design experiments involving real-time monitoring of chemical reactions using various analytical techniques, and interpret the obtained data. |

**Teaching & Examination Scheme:**

| **Teaching Scheme** | | | | **Evaluation Scheme** | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **L** | **T** | **P** | **C** | **Internal Evaluation** | | | **ESE** | | **Total** |
| | | | | **MSE** | **CE** | **P** | **Theory** | **P** | |
| **-** | **-** | **6** | **4** | **-** | **-** | **40** | **-** | **60** | **100** |

**L-** Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation,
**CE**- Continuous Evaluation, **ESE-** End Semester Examination

| **Exp. No.** | **Name of the Experiment** |
|---|---|
| **1** | Heterogeneous Liquid-Liquid Reaction in a Stirred Cell |
| **2** | Bubble Contactor |
| **3** | Industrial Reactor |
| **4** | Heterogeneous Liquid-Liquid Reaction in a Stirred Cell |
| **5** | Study in Packed Bed Reactor |
| **6** | RTD For Spiral Tube Coil Reactor |
| **7** | RTD For Tubular Reactor |
| **8** | RTD For C S T R |
| **9** | RTD For P F R |
| **10** | Interacting-Non interacting Couple tank |
| **11** | Study of control characteristics for a single tank |
| **12** | Study of control characteristics for a interacting tank system |
| **13** | Study of control characteristics for a non-interacting tank system |
| **14** | Air purge method for Level control measurement |
| **15** | Characteristic of Control valve kit |

**Text Book and Reference Book:**


1. "Chemical Reaction Engineering" by Octave Levenspiel
2. "Process Systems Analysis and Control" by Donald R. Coughanowr and Steven E. LeBlanc
3. "Elements of Chemical Reaction Engineering" by H. Scott Fogler
4. "Chemical Process Control: An Introduction to Theory and Practice" by George Stephanopoulos
5. "Handbook of Industrial Chemistry and Biotechnology" edited by James A. Kent
6. "Chemical Process Control: A First Course with MATLAB" by Pao C. Chau and Chung K. Law
7. "Chemical Engineering Design and Analysis: An Introduction" by T. Michael Duncan and Jeffrey A. Reimer
8. "Experimental Methods for Engineers" by J.P. Holman
9. "Chemical Process Control: An Overview" by B. Wayne Bequette

# Semester: 2

- **Course Name:** Materials & Utilities in Chemical Industry

  **Course Code:** 11223151

  **Prerequisite:** Students must have knowledge about materials & Utilities used in chemical industry.

  **Rationale:** Materials & Utilities in the Chemical Industry lies in its critical role in resource management, cost optimization, environmental sustainability, safety, and overall efficiency in chemical processes. It prepares students for the complex challenges and responsibilities associated with managing materials and utilities in the chemical sector.

**Course Learning Objective:**

| | |
|---|---|
| **CLOBJ 1** | Define a solid understanding of the fundamental concepts and principles related to the selection, use, and management of materials in chemical processes. |
| **CLOBJ 2** | Identify the various utility systems critical to chemical manufacturing, including energy supply, water management, steam generation, and cooling systems. |
| **CLOBJ 3** | Implement the dynamics of supply chains for raw materials and utilities, considering factors such as sourcing, transportation, and inventory management. |
| **CLOBJ 4** | Differentiate safety protocols and regulatory requirements associated with the handling, storage, and disposal of materials and utilities in accordance with industry standards. |
| **CLOBJ 5** | Evaluate cutting-edge technologies and innovations in materials science and utility management, with an emphasis on integrating technology to enhance operational efficiency. |
| **CLOBJ 6** | Develop real-world case studies and engage in practical exercises to apply theoretical knowledge to industry-specific scenarios, fostering problem-solving skills. |

**Course Learning Outcomes:**

| | |
|---|---|
| **CLO 1** | Remember and select appropriate raw materials based on properties, availability, cost, and environmental impact. |
| **CLO 2** | Identify the principles and practices involved in designing utilities infrastructure for steam generation, water treatment, and other essential services. |
| **CLO 3** | Apply techniques to optimize the use of resources, minimize waste, and reduce overall production costs in chemical processes. |
| **CLO 4** | Analyse the environmental impact of materials and utilities used in chemical processes. |
| **CLO 5** | Evaluate energy requirements for chemical processes and develop strategies to enhance energy efficiency. |
| **CLO 6** | Develop and enforce safety protocols for the handling, storage, and transportation of materials in the chemical industry. |

**Teaching & Examination Scheme:**

| Teaching Scheme | | | | Evaluation Scheme | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| L | T | P | C | Internal Evaluation | | | ESE | | Total |
| | | | | MSE | CE | P | Theory | P | |
| 4 | - | - | 4 | 20 | 20 | - | 60 | - | 100 |

**L-** Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

**Course Content:**

| Sr. No. | Content | Weigh tage | Teachin g Hours |
|---|---|---|---|
| 1 | **Introduction of Materials & Utilities in Chemical Industries**<br>Introduction, List of various materials and utilities in chemical plant and their difference, Role of utilities, Applications<br>**Steam Generator**<br>Objectives, Classification and selection of boilers, distribution and utilization, design of efficient steam heating systems, steam economy, condensate utilization, steam traps and their characteristics, waste heat utilization | 25% | 15 |
| 2 | **Compressor and Vacuum Pump**<br>Objectives, types of compressors & vacuum pumps according to their performance characteristics, Methods of vacuum development and their limitations, materials and piping systems handling under vacuum, lubrication and oil removal in compressor pump. | 17% | 10 |
| 3 | **Refrigeration Systems**<br>Introduction, Principle and characteristics of refrigeration, Types of refrigerants, Methods of Refrigeration, humidification and de humidification equipment's, drying and cooling tower, air blending, exhaust, ventilation, cryogenics characteristics and production of liquid N2 and O2, Describe COP and TOR for refrigeration | 25% | 15 |
| 4 | **Insulation**<br>Importance, insulation material, effects of insulation on piping, fitting and valves equipment, insulation for high, intermediate, low and sub-zero temperatures including cryogenic insulation, determination of optimum insulation thickness<br>**Inert Gases**<br>Introduction, properties of inert gases & their use, sources and methods of | 33% | 20 |
| | **Total** | 100% | 60 |

**Text Book and Reference Book:**


1. Introduction to Materials Science and Engineering: A Balanced Approach by William D. Callister Jr. and David G. Rethwisch
2. Chemical Process Safety: Fundamentals with Applications by Daniel A. Crowl and Joseph F. Louvar
3. Plant Design and Economics for Chemical Engineers by Max S. Peters and Klaus D. Timmerhaus
4. Shreve's Chemical Process Industries by George T. Austin and Randolph Norris Shreve

5. Perry's Chemical Engineers' Handbook edited by Robert H. Perry, Don W. Green, and James O. Maloney
6. Handbook of Chemical Engineering Calculations by Nicholas P. Chopey

- **Course Name:** Pharmaceutical Technology

  **Course Code:** 11223152

  **Prerequisite:** Knowledge of Pharmaceutical Technology up to UG science level

  **Rationale:** Basic Pharmaceutical Technology knowledge is fundamental as it provides a strong foundation for various concerns disciplines, promotes problem-solving skills, supports innovation, and opens doors to diverse career opportunities.

**Course Learning Objective:**

| | |
|---|---|
| **CLOBJ 1** | Remember the stages of drug development, from drug discovery to market approval. |
| **CLOBJ 2** | Understand the factors influencing the selection of a specific dosage form for a given drug. |
| **CLOBJ 3** | Analyse the advantages and disadvantages of various drug delivery methods. |
| **CLOBJ 4** | Implement the principles of Good Manufacturing Practices (GMP) and quality control in pharmaceutical manufacturing. |
| **CLOBJ 5** | Evaluate the documentation and compliance processes necessary for drug approval and marketing. |
| **CLOBJ 6** | Formulate knowledge of quality assurance and quality control principles in pharmaceutical manufacturing. |

**Course Learning Outcomes:**

| | |
|---|---|
| **CLO 1** | Define comprehend the stages of drug development, from initial discovery to market approval, and the regulatory pathways involved. |
| **CLO 2** | Identify and choose appropriate pharmaceutical dosage forms based on the characteristics of the drug and patient needs. |
| **CLO 3** | Demonstrate knowledge and skills in pharmaceutical manufacturing processes, adhering to Good Manufacturing Practices (GMP) and ensuring product quality. |
| **CLO 4** | Differentiate in implementing quality assurance and control measures, including testing, validation, and compliance with industry standards. |
| **CLO 5** | Evaluate principles of pharmacokinetics and pharmacodynamics and apply them to optimize drug dosages for different patient populations. |
| **CLO 6** | Develop and interpret biopharmaceutical factors influencing drug absorption, distribution, and bioavailability. |

**Teaching & Examination Scheme:**

| **Teaching Scheme** | | | | **Evaluation Scheme** | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **L** | **T** | **P** | **C** | **Internal Evaluation** | | | **ESE** | | **Total** |
| | | | | **MSE** | **CE** | **P** | **Theory** | **P** | |
| **4** | **-** | **-** | **4** | **20** | **20** | **-** | **60** | **-** | **100** |

**L-** Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

**Course Content:**

| Sr. No. | Content | Weightage | Teaching Hours |
|---|---|---|---|
| 1 | **Introduction of Pharmaceutical Technology**<br>Introduction, Preparation and applications of different form of medicaments in formulation of drugs: Liquid oral, tablet, injectable, aerosol, capsule, ointment, eye drops, suppositories, lozenges. | 17% | 10 |
| 2 | **Tablets**<br>Introduction, types, additives, production technology and different tablet production process on a large scale: a) granulation and pelletization equipment; b) continuous and batch mixing; c) rapid mixing granulators; d) rota granulators; e) spheronizers and marumerisers; f) drying equipment, evaluation of tablets, problems in tableting.<br>**Coating of Tablets**<br>Objective, formulation of coating solution, types of coating: a) particle coating; b) fluidized bed coating; c) film forming materials, evaluation of coated tablets, stability and quality of coated tablet | 33% | 20 |
| 3 | **Capsules**<br>Objective, raw material for production of hard gelatin capsules, capsule process manufacturing technology, size of capsules, method of capsule filling, capsule shell and its content, quality and stability of capsule, storage of capsule dosage forms, advantages and disadvantages of capsule dosage form | 25% | 15 |
| 4 | **Sustained and controlled release formulations**<br>Principles and dose calculations, preformulation, Preclinical screening / testing and clinical trials of new substances for the pharmacological activity using in vitro and in vivo, and other possible animal alternative models, Sustained Release and Controlled Release formulations. | 25% | 15 |
| | **Total** | 100% | 60 |

**Text Book and Reference Book:**


1. Shayne Cox Gad, Handbook of pharmaceutical manufacturing, Willey interscience, USA.
2. A.R. Gennaro, Remington: The science and practice of pharmacy, 19th edition, Mack pub. Co.
3. G.S.Banker, Modern pharmaceutics, Informa healthcare.
4. H.C.Ansel, Lippincott Williams, Ansel's Pharmaceutical dosage forms and drug delivery systems, 8th edition, wilkins publisher.
5. Y W. Chien, Novel Drug Delivery Systems, 2nd edition, revised and expanded, Marcel Dekker, Inc., New York, 1992.
6. Robinson, J. R., Lee V. H. L, Controlled Drug Delivery Systems, Marcel Dekker,Inc., New York, 1992.
7. X. Li, B.R. Jasti, Design of Control Release Drug Delivery system, McGraw Hill, California, 2006.

- **Course Name:** Green Chemistry

  **Course Code:** 11223180

  **Prerequisite:** Knowledge of Green Chemistry & sustainable chemistry up to UG science level

  **Rationale:** Basic Green Chemistry knowledge is fundamental as it provides a strong foundation for various concerns disciplines, promotes problem-solving skills, supports innovation, and opens doors to diverse career opportunities.

**Course Learning Objective:**

| | |
|---|---|
| **CLOBJ 1** | Define life cycle assessment methodologies to evaluate the environmental impact of chemical processes and products from cradle to grave |
| **CLOBJ 2** | Describe and optimize chemical processes for energy efficiency, including the use of alternative energy sources and reduction of energy-intensive steps. |
| **CLOBJ 3** | Operate renewable feedstocks in chemical processes and understand the importance of moving away from reliance on finite resources. |
| **CLOBJ 4** | Distinguish strategies to minimize waste generation in chemical processes, emphasizing the principles of atom economy and the reduction of by-products |
| **CLOBJ 5** | Evaluate the role of catalysis in green chemistry and evaluate the use of green catalysts to enhance reaction efficiency while minimizing environmental impact. |
| **CLOBJ 6** | Develop regulatory frameworks related to green chemistry and consider ethical implications in the design and implementation of sustainable chemical processes. |

**Course Learning Outcomes:**

| | |
|---|---|
| **CLO 1** | Define and explain the twelve principles of green chemistry and their significance in promoting sustainability and reducing the environmental impact of chemical processes. |
| **CLO 2** | Assess the use of renewable feedstocks in chemical processes and justify the importance of transitioning from non-renewable to renewable resources. |
| **CLO 3** | Apply life cycle assessment methodologies to analyse and assess the environmental impact of chemical processes and products throughout their life cycle. |
| **CLO 4** | Develop strategies to minimize waste generation in chemical processes, applying the principles of atom economy and green synthesis |
| **CLO 5** | Evaluate and select environmentally benign solvents or solvent-free methods, considering their impact on health and the environment |
| **CLO 6** | Apply green analytical techniques to monitor and quantify chemicals in an environmentally friendly manner, minimizing the use of hazardous reagents |

**Teaching & Examination Scheme:**

| **Teaching Scheme** | | | | **Evaluation Scheme** | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **L** | **T** | **P** | **C** | **Internal Evaluation** | | | **ESE** | | **Total** |
| | | | | **MSE** | **CE** | **P** | **Theory** | **P** | |
| **4** | **-** | **-** | **4** | **20** | **20** | **-** | **60** | **-** | **100** |

**L-** Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

**Course Content:**

| Sr. No | Content | Weightage | Teaching Hours |
|---|---|---|---|
| 1 | **Introduction of Green Chemistry**<br>Introduction, Need for Green Chemistry, Goals of Green Chemistry, Twelve principles of Green Chemistry with their explanations, Limitations/ Obstacles in the pursuit of the goals of Green Chemistry, roots of innovations. | **17%** | **10** |
| 2 | **Conditions of Green Chemistry – 1**<br>Designing a Green Synthesis using principles; Prevention of Waste/ byproducts; maximum incorporation of the materials used in the process into the final products, Atom Economy, calculation of atom economy of the rearrangement, addition, substitution and elimination reactions, Prevention/ minimization of hazardous/ toxic products, Energy requirements for reactions – alternative sources of energy: use of microwaves and ultrasonic energy | **33%** | **20** |
| 3 | **Conditions of Green Chemistry – 2**<br>Selection of starting materials, avoidance of unnecessary derivatization – careful use of blocking/protecting groups, use of catalytic reagents (wherever possible) in preference to stoichiometric reagents; catalysis and green chemistry, comparison of heterogeneous and homogeneous catalysis, bio catalysis, asymmetric catalysis and photo catalysis. | **33%** | **20** |
| 4 | **Reactions of Green Chemistry**<br>Microwave assisted reactions in organic solvents Diels-Alder reaction and Decarboxylation reaction, an efficient, green synthesis of a compostable and widely applicable plastic (poly lactic acid) made from corn, Ultrasound assisted reactions: Sono chemical Simmons-Smith Reaction (Ultrasonic alternative to Iodine), solvent or water-based reactions | **17%** | **10** |
| | **Total** | **100%** | **60** |

**Text Book and Reference Book:**


1. V. Kumar, "An Introduction to Green Chemistry" Vishal publishing Co. Reprint Edition 2010
2. Rashmi Sanghi, M.M Srivastava "Green Chemistry" Fourth Reprint – 2009
3. Anastas & Warner, Green Chemistry: Theory & Practice, Oxford Univ. Press, New York,1998

- **Course Name:** Chemical Reaction Engineering

  **Course Code:** 11223181

  **Prerequisite:** Knowledge of Green Chemistry & sustainable chemistry up to UG science level

  **Rationale:** Basic Green Chemistry knowledge is fundamental as it provides a strong foundation for various concerns disciplines, promotes problem-solving skills, supports innovation, and opens doors to diverse career opportunities.

**Course Learning Objective:**

| | |
|---|---|
| **CLOBJ 1** | Understand the fundamental principles of chemical reaction kinetics, including rate laws, reaction mechanisms, and factors affecting reaction rates. |
| **CLOBJ 2** | Learn about different types of chemical reactors, such as batch reactors, continuous stirred-tank reactors (CSTRs), plug flow reactors (PFRs), and their characteristics and applications. |
| **CLOBJ 3** | Gain knowledge of reactor design principles, including reactor sizing, residence time distribution, heat and mass transfer considerations, and reactor configuration selection. |
| **CLOBJ 4** | Understand the application of mass and energy balances to chemical reactors, including the design and analysis of reaction systems under various conditions. |
| **CLOBJ 5** | Understand the principles of multiphase reactors, including gas-liquid, gas-solid, and liquid-solid reactions, and their design considerations. |
| **CLOBJ 6** | Gain insights into the application of reaction engineering principles in industrial processes, including petrochemicals, pharmaceuticals, polymers, and environmental engineering. |

**Course Learning Outcomes:**

| | |
|---|---|
| **CLO 1** | Understand the fundamental principles of chemical reaction kinetics, thermodynamics, and transport phenomena as they apply to chemical reactor design and operation. |
| **CLO 2** | Gain knowledge of different types of chemical reactors, including batch reactors, continuous flow reactors (such as plug flow and mixed flow reactors), and various types of catalytic reactors. |
| **CLO 3** | Understand the role of chemical reactors in industrial processes, including their applications in the production of fuels, petrochemicals, pharmaceuticals, and other chemical products. |
| **CLO 4** | Learn how to design and analyse chemical reactors for specific reactions, considering factors such as reaction kinetics, heat and mass transfer, and reactor configuration. |
| **CLO 5** | Develop an understanding of chemical reaction kinetics and how to determine rate laws experimentally, including the use of techniques such as differential and integral reactor analysis. |
| **CLO 6** | Gain knowledge of multiphase reactors, including gas-liquid, liquid-solid, and gas-solid reactors, and understand the complexities of reactions involving multiple phases. |

**Teaching & Examination Scheme:**

| Teaching Scheme | | | | Evaluation Scheme | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| L | T | P | C | Internal Evaluation | | | ESE | | Total |
| | | | | MSE | CE | P | Theory | P | |
| 4 | - | - | 4 | 20 | 20 | - | 60 | - | 100 |

**L-** Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

**Course Content:**

| Sr. No | Content | Weightage | Teaching Hours |
|---|---|---|---|
| 1 | **Introduction of Chemicals Reactors and Selection**<br>Introduction to Chemical Reactors and Material Balances, Batch Reactors, Continuous Stirred Tank Reactors (CSTRs), Semi-Batch Reactors, Plug Flow Reactors, Multiple Reactions and Reactor Selection, Defining Rate Laws, Overall Energy Balance for Reactors, Reactions, types and reaction rates for homogenous reactions, Differential and integral method of analysis, ideal and non-ideal reactors, RTD studies | 17% | 10 |
| 2 | **Introduction to Reactor Design**<br>Industrial reactors, Space time and Space velocity, Design of single ideal reactor - Batch, CSTR, PFR using graphical procedure, Multiple reactor system and optimum reactor size, Recycle reactors, temperature and Pressure effects, Adiabatic and Non adiabatic reaction conditions and conversion, Reactor design for complex reactions, design for optimal selectivity, optimal temperature policy | 25% | 15 |
| 3 | **Thermodynamics and Kinetics of Reactor**<br>Batch reactor, CSTR, PFR, kinetics; Stoichiometry, rate equations, thermodynamics; Fundamental heat and mass balance equations, ideal PFR, perfectly mixed reactors, recycle, Non-ideality in continuous flow reactors, Pseudo-steady-state assumption, kinetics, LH kinetics, deactivation, internal and external transport limitations; Non-catalytic reaction fundamentals, Fixed bed, fluidized bed and trickle bed reactors | 33% | 20 |
| 4 | **Multiple Reactor System**<br>Introduction of Multiple reactors, Independent, Parallel and Series reactors, Instantaneous and over all fractional yield, Choice of reactors for simple and complex reactions and multiple reactor system, Introduction to thermal stability of reactors, Product distribution in multiple reaction system, temperature dependence and vessel size for maximum production | 25% | 15 |
| | **Total** | 100% | 60 |

**Text Book and Reference Book:**


1. Chemical Reactor Analysis and Design by Gilbert F. Froment, Kenneth B. Bischoff, and Juray De Wilde
2. Elements of Chemical Reaction Engineering by H. Scott Fogler

- **Course Name:** Advanced Spectroscopy & Chromatography

  **Course Code:** 11223153

  **Prerequisite:** Knowledge of basic principles of chemistry and instrumental analysis

  **Rationale:** Advanced spectroscopy and chromatography is not only intellectually rewarding but also provides practical skills that are highly valued across scientific and industrial sectors. The ability to apply these techniques contributes to advancements in knowledge, technology, and the improvement of products and processes.

**Course Learning Objective:**

| | |
|---|---|
| **CLOBJ 1** | Gain a deep understanding of the underlying principles of advanced spectroscopy and chromatography techniques, including the theory and concepts that govern these analytical methods. |
| **CLOBJ 2** | Acquire knowledge about the instrumentation used in advanced spectroscopy and chromatography, including the operation, components, and maintenance of relevant equipment. |
| **CLOBJ 3** | Explore advanced spectroscopic techniques such as nuclear magnetic resonance (NMR), mass spectrometry (MS), infrared (IR) spectroscopy, and ultraviolet-visible (UV-Vis) spectroscopy. Understand the principles behind each technique and their applications. |
| **CLOBJ 4** | Study various chromatographic techniques, including gas chromatography (GC), liquid chromatography (LC), and high-performance liquid chromatography (HPLC). Learn about column selection, mobile phases, and detection methods. |
| **CLOBJ 5** | Develop skills in interpreting complex spectral and chromatographic data. Learn how to analyse and extract meaningful information from experimental results. |
| **CLOBJ 6** | Understand the principles of quantitative analysis using spectroscopy and chromatography. Learn methods for calibration, standardization, and determining concentrations of analytes. |

**Course Learning Outcomes:**

| | |
|---|---|
| **CLO 1** | Students will demonstrate a deep understanding of the theoretical principles underlying advanced spectroscopy and chromatography techniques. |
| **CLO 2** | Students will be able to operate and troubleshoot advanced spectroscopic and chromatographic instruments with proficiency. |
| **CLO 3** | Students will apply advanced spectroscopy techniques, including NMR, MS, IR, and UV-Vis, as well as chromatographic techniques such as GC, LC, and HPLC, to analyse various types of samples. |
| **CLO 4** | Students will interpret complex spectra and chromatograms, extracting relevant information and identifying key features. |
| **CLO 5** | Students will demonstrate the ability to perform quantitative analysis using spectroscopy and chromatography, including calibration and determination of analyte concentrations. |
| **CLO 6** | Students will develop and optimize analytical methods for specific applications, considering factors such as sensitivity, selectivity, and efficiency. |

**Teaching & Examination Scheme:**

| Teaching Scheme | | | | Evaluation Scheme | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| L | T | P | C | Internal Evaluation | | | ESE | | Total |
| | | | | MSE | CE | P | Theory | P | |
| 4 | - | - | 4 | 20 | 20 | - | 60 | - | 100 |

**L-** Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

**Course Content:**

| Sr. No | Content | Weightage | Teaching Hours |
|---|---|---|---|
| 1 | **Advanced Chromatographic Techniques**<br>Fundamental principles, theory, instrumentation and application of GC & HPLC<br>**GC-MS**<br>Main concepts about GC-MS, Instrumentation of GC-MS, Ionization methods, analysers and applications<br>**LC-MS**<br>Main concepts about LC-MS, Fundamental principles, Instrumentation and applications<br>**New Chromatographic Techniques**<br>Principle, importance and applications of multidimensional chromatography, Plasma chromatography, super critical fluid chromatography | 25% | 15 |
| 2 | **Nuclear Magnetic Resonance (NMR / PMR)**<br>Spectroscopy: Introduction, Instrumentation of NMR, Magnetic properties of nuclei. Theory of NMR Spectroscopy. Chemical Shift. Factors affecting Chemical Shift. Shielding Mechanism. Spin Spin Splitting & its Mechanism. Vicinal coupling. Karpus equation. Coupling constant & conformation, Simplification of complex spectra: Shift reagents, Spin decoupling, Applications of 1H NMR for structure elucidation | 33% | 20 |
| 3 | **13C NMR Spectroscopy**<br>Introduction, 13C NMR Spectra - Scale, Solvents, Solvent signals & their positions, multiplicity, Chemical shift values for different functional groups in 13C NMR, Applications of 13C NMR for structure elucidation<br>**2D NMR Spectroscopy**<br>Nuclear Overhauser Effect (NOE), DEPT, NOESY, COSY, HETCOR, Applications of 2D NMR to elucidate molecular structure & stereoisomers | 25% | 15 |
| 4 | **Atomic Absorption Spectroscopy (AAS)**<br>Principle, Theoretical spects of atomic absorption spectroscopy, Instrumentation: Radiation sources, filters, detector, analyser, Limitations in atomic absorption, Interferences<br>**Flame Emission Spectroscopy (FES)**<br>Principle, Theory of flame emission spectroscopy, | 17% | 10 |

| | | | |
|---|---|---|---|
| | Instrumentation: Radiation sources, filters, types of flames, detector, analyser, Limitations, Interferences, Comparison of AAS and FES | | |
| | **Total** | **100%** | **60** |

**Text Book and Reference Book:**


1. "Principles of Instrumental Analysis" by Douglas A. Skoog, F. James Holler, and Stanley R. Crouch
2. "Spectrometric Identification of Organic Compounds" by Robert M. Silverstein, Francis X. Webster, and David J. Kiemle
3. "Introduction to Spectroscopy" by Donald L. Pavia, Gary M. Lampman, George S. Kriz, and James R. Vyvyan
4. "Introduction to Modern Liquid Chromatography" by Lloyd R. Snyder, Joseph J. Kirkland, and John W. Dolan
5. "Gas Chromatography and Mass Spectrometry: A Practical Guide" by O. David Sparkman and Zelda Penton
6. "Interpretation of Mass Spectra" by Fred W. McLafferty and František Tureček
7. "NMR Spectroscopy Explained: Simplified Theory, Applications and Examples for Organic Chemistry and Structural Biology" by Neil E. Jacobsen
8. "High-Performance Liquid Chromatography: Advances and Perspectives" by Csaba Horváth and Jack Melander
9. "UV-Visible Spectrophotometry of Water and Wastewater" by Kenneth S. M. Sutherland
10. "Capillary Electrophoresis: Principles, Practice, and Applications" by Serban C. Moldoveanu and Victor David


- **Course Name:** Lab -1 (Reaction Process Control)

  **Course Code:** 11223155

  **Prerequisite:** Knowledge of Chemical Engineering Fundamentals, Chemical Reaction Engineering, Process Dynamics and Control, Thermodynamics and Mathematics and Numerical Methods

  **Rationale:** Reaction Process Control laboratory plays a crucial role in the education and professional development of students, offering a dynamic and interactive environment where theoretical knowledge is translated into practical skills and insights.

  **Course Learning Objective:**

| | |
|---|---|
| **CLOBJ 1** | Develop proficiency in operating and understanding the instrumentation used for monitoring and controlling chemical reactions, including sensors, analysers, and control systems. |
| **CLOBJ 2** | Learn to monitor chemical reactions in real-time using various analytical techniques, such as spectroscopy, chromatography, and other relevant methods. |
| **CLOBJ 3** | Acquire skills in collecting experimental data, analyzing results, and interpreting trends to gain insights into reaction kinetics, thermodynamics, and process dynamics. |
| **CLOBJ 4** | Understand and adhere to safety protocols and procedures when working with chemical reagents, instrumentation, and experimental setups in the laboratory. |
| **CLOBJ 5** | Design and plan experiments to investigate reaction kinetics, optimize reaction conditions, and explore the impact of variables on reaction outcomes. |

| | |
|---|---|
| **CLOBJ 6** | Implement and assess different process control strategies to maintain desired reaction conditions, such as feedback and feedforward control, cascade control, and advanced control techniques. |

**Course Learning Outcomes:**

| | |
|---|---|
| **CLO 1** | Analyse experimental data using statistical methods and interpret the results to draw conclusions about reaction kinetics, thermodynamics, and process dynamics. |
| **CLO 2** | Design, plan, and execute experiments to investigate reaction kinetics, optimize reaction conditions, and assess the impact of variables on reaction outcomes. |
| **CLO 3** | Apply optimization techniques to improve the efficiency and performance of chemical reactions, considering factors such as yield, selectivity, and reaction rates. |
| **CLO 4** | Identify and troubleshoot issues that may arise during reaction processes, demonstrating effective problem-solving skills and the ability to make informed decisions. |
| **CLO 5** | Demonstrate proficiency in operating and calibrating instruments and equipment used for monitoring and controlling chemical reactions in a laboratory setting. |
| **CLO 6** | Successfully conduct experiments involving real-time monitoring of chemical reactions using various analytical techniques, and interpret the obtained data. |

**Teaching & Examination Scheme:**

| **Teaching Scheme** | | | | **Evaluation Scheme** | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **L** | **T** | **P** | **C** | **Internal Evaluation** | | | **ESE** | | **Total** |
| | | | | **MSE** | **CE** | **P** | **Theory** | **P** | |
| **-** | **-** | **6** | **4** | **-** | **-** | **40** | **-** | **60** | **100** |

**L-** Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

| **Exp. No.** | **Name of the Experiment** |
|---|---|
| **1** | Heterogeneous Liquid-Liquid Reaction in a Stirred Cell |
| **2** | Bubble Contactor |
| **3** | Industrial Reactor |
| **4** | Heterogeneous Liquid-Liquid Reaction in a Stirred Cell |
| **5** | Study in Packed Bed Reactor |
| **6** | RTD For Spiral Tube Coil Reactor |
| **7** | RTD For Tubular Reactor |
| **8** | RTD For C S T R |
| **9** | RTD For P F R |
| **10** | Interacting-Non interacting Couple tank |
| **11** | Study of control characteristics for a single tank |
| **12** | Study of control characteristics for a interacting tank system |
| **13** | Study of control characteristics for a non-interacting tank system |
| **14** | Air purge method for Level control measurement |
| **15** | Characteristic of Control valve kit |

**Text Book and Reference Book:**


1. "Chemical Reaction Engineering" by Octave Levenspiel
2. "Process Systems Analysis and Control" by Donald R. Coughanowr and Steven E.

LeBlanc

3. "Elements of Chemical Reaction Engineering" by H. Scott Fogler
4. "Chemical Process Control: An Introduction to Theory and Practice" by George Stephanopoulos
5. "Handbook of Industrial Chemistry and Biotechnology" edited by James A. Kent
6. "Chemical Process Control: A First Course with MATLAB" by Pao C. Chau and Chung K. Law
7. "Chemical Engineering Design and Analysis: An Introduction" by T. Michael Duncan and Jeffrey A. Reimer
8. "Experimental Methods for Engineers" by J.P. Holman
9. "Chemical Process Control: An Overview" by B. Wayne Bequette

- **Course Name:** Lab -2 (Synthesis of Organic Chemicals)

  **Course Code:** 11223156

  **Prerequisite:** Knowledge of organic chemicals and use of glassware.

  **Rationale:** Provides students with hands-on experience in conducting organic chemical synthesis, which is essential for understanding the principles and techniques of organic chemistry.

**Course Learning Objective:**

| | |
|---|---|
| **CLOBJ 1** | Develop fundamental laboratory skills such as proper handling of chemicals, use of laboratory equipment, and adherence to safety protocols. |
| **CLOBJ 2** | Gain hands-on experience in organic synthesis techniques, including methods for preparing organic compounds such as esters, alcohols, ethers, and aromatic compounds. |
| **CLOBJ 3** | Learn various purification methods for organic compounds, including techniques such as distillation, recrystallization, chromatography, and extraction. |
| **CLOBJ 4** | Acquire skills in using spectroscopic and analytical techniques such as IR spectroscopy, NMR spectroscopy, and mass spectrometry for the identification and characterization of organic compounds. |
| **CLOBJ 5** | Understand the importance of laboratory safety and hazard management in organic synthesis, including handling of hazardous chemicals, waste disposal, and emergency procedures. |
| **CLOBJ 6** | Develop the ability to design and plan experiments effectively, including selecting appropriate reaction conditions, controlling reaction parameters, and troubleshooting experimental setups. |

**Course Learning Outcomes:**

| | |
|---|---|
| **CLO 1** | Gain hands-on experience in a variety of organic synthesis techniques, including classical organic reactions such as esterification, hydrolysis, oxidation, reduction, and multistep synthesis. |
| **CLO 2** | Understand and follow safety protocols and procedures specific to organic synthesis laboratories, including proper handling of reagents, waste disposal, and use of personal protective equipment (PPE). |
| **CLO 3** | Learn how to monitor and analyse reactions using techniques such as thin-layer chromatography (TLC), gas chromatography (GC), high-performance liquid chromatography (HPLC), and spectroscopic methods (NMR, IR, UV-Vis). |

| | |
|---|---|
| **CLO 4** | Learn how to characterize the products of organic reactions using spectroscopic methods (NMR, IR, UV-Vis) and interpret the spectral data to identify the structure of organic compounds. |
| **CLO 5** | Develop skills in experimental design and optimization of reaction conditions to maximize yield and selectivity in organic synthesis. |
| **CLO 6** | Practice maintaining a detailed laboratory notebook, recording experimental procedures, observations, and results in a clear and organized manner. |

**Teaching & Examination Scheme:**

| Teaching Scheme | | | | Evaluation Scheme | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| L | T | P | C | Internal Evaluation | | | ESE | | Total |
| | | | | MSE | CE | P | Theory | P | |
| - | - | 6 | 4 | - | - | 40 | - | 60 | 100 |

**L-** Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

| Exp. No. | Name of the Experiment |
|---|---|
| **1** | Synthesis of Acridone from Anthranilic acid |
| **2** | Heterocyclic compound: Synthesis of 7-Hydroxy-4-methylcoumarin from resorcinol |
| **3** | Acetylation: Synthesis of Mannitol hex acetyl from mannitol |
| **4** | Synthesis of Gilman's reagent |
| **5** | Synthesis of stilbene by Heck coupling reaction between Iodo benzene and styrene |
| **6** | Synthesis of ester from ketone by Buyer villager reaction |
| **7** | Synthesis of Bromobenzene from aniline by Sandmayer reaction |
| **8** | Synthesis of alcohol and carboxylic acid from aldehyde by Canizzaro Reaction |
| **9** | Synthesis of Amine from amide by Hoffmann Rearrangement |
| **10** | Synthesis of Ethyl Acetoacetate by Claisen Condensation |
| **11** | Synthesis of N-Phenylanthranilic Acid by the Ullmann Condensation |
| **12** | Synthesis of Dimethylaminopropiophenone Hydrochloride by Mannich Reaction |
| **13** | Synthesis of 5,5-Dimethyl-cyclohexan-i,3-dione by Michael Reaction |
| **14** | Synthesis of 9,10-Dihydroanthracene-9,10-end-succinic Anhydride by The Diels-Alder Reaction |
| **15** | Synthesis of Dibenzal-acetone by Claisen Reaction |
| **16** | Rearrangement of Pinacolone by the Pinacol-Pinacolone Rearrangement |
| **17** | Synthesis of 1-nitroso-2-napthanol |
| **18** | Separation of a mixture of O and P-nitroaniline in column chromatography |
| **19** | Experiment on Thin Layer Chromatography of a given sample |
| **20** | Experiment on Paper Chromatography of a given sample |

**Text Book and Reference Book:**


1. Organic Chemistry Laboratory Notebook by Cengage
2. Experimental Organic Chemistry: A Mini scale and Microscale Approach by John C. Gilbert and Stephen F. Martin

# Semester: 3

- **Course Name:** Industrial Process Control Technology

  **Course Code:** 11223201

  **Prerequisite:** Knowledge of basic principles of process control and valve.

  **Rationale:** Instrumentation and process control play a vital role in optimizing industrial processes for maximum efficiency, productivity, and product quality. By monitoring and controlling various process parameters, engineers can optimize production and minimize resource consumption.

**Course Learning Objective:**

| | |
|---|---|
| **CLOBJ 1** | Remember the fundamental principles of instrumentation and process control, including concepts such as sensors, transducers, measurement techniques, control loops, and feedback control systems. |
| **CLOBJ 2** | Identify different instrumentation techniques used in industrial processes, including measurement of temperature, pressure, flow, level, and composition, as well as the selection and calibration of instruments |
| **CLOBJ 3** | Demonstrate the dynamic behaviour of processes and systems, including the response of processes to changes in input variables, and how to model and analyse process dynamics. |
| **CLOBJ 4** | Differentiate the components of control systems, including controllers, actuators, final control elements, and the role of each component in the control loop. |
| **CLOBJ 5** | Evaluate design control systems for different industrial processes, including the selection of control strategies, tuning of controllers, and implementation of control algorithms. |
| **CLOBJ 6** | Investigate safety and reliability in instrumentation and process control, including considerations for fail-safe systems, alarm management, and risk assessment. |

**Course Learning Outcomes:**

| | |
|---|---|
| **CLO 1** | Define the fundamental principles of instrumentation and process control, including sensors, transducers, signal conditioning, and control systems. |
| **CLO 2** | Understand different types of instrumentation systems used in industrial processes, including measurement devices, control valves, actuators, and final control elements. |
| **CLO 3** | Interpret selection of appropriate sensors for different process variables and how to calibrate them for accurate measurements. |
| **CLO 4** | Analyse how signals from sensors are conditioned, transmitted, and processed to provide meaningful data for process control. |
| **CLO 5** | Evaluate components of control systems, including controllers, actuators, control valves, and feedback loops. |
| **CLO 6** | Design dynamic behaviour of industrial processes and learn how to model them for control system design and analysis. |

**Teaching & Examination Scheme:**

| Teaching Scheme | | | | Evaluation Scheme | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| L | T | P | C | Internal Evaluation | | | ESE | | Total |
| | | | | MSE | CE | P | Theory | P | |
| 4 | - | - | 4 | 20 | 20 | - | 60 | - | 100 |

**L-** Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

**Course Content:**

| Sr. No | Content | Weightage | Teaching Hours |
|---|---|---|---|
| 1 | **Basic of Advanced Control System**<br>Introduction, process control objectives and benefits, importance, the control system and its basic components, process dynamics, controller and final control elements Basic Introduction of Pneumatic System: Types and Mechanism of controllers (P, PD, PI, PID), effect of different modes of control, Pneumatic control valve and application, Pneumatic versus electronic controllers | 33% | 20 |
| 2 | **Advanced Control System**<br>Introduction, Feedback, feed forward, ratio, cascade, adaptive, inferential control system, multivariable control strategies, effects of interaction, performance analysis, variable structure and constraint control, centralized multivariable control | 17% | 10 |
| 3 | **Distributed Control System (DCS)**<br>Introduction & History, structure, typical applications, analog & digital control, distributed process control, DCS configurations, local control units, basic components, communication between components, maintenance considerations, System Integration with PLC and computers | 25% | 15 |
| 4 | **Supervisory control & Data Acquisition (SCADA)**<br>Overview, Basics of SCADA, SCADA key features, remote terminal units, PLC used as remote terminal units, SCADA software packages, Application example of SCADA | 25% | 15 |
| | **Total** | 100% | 60 |

**Text Book and Reference Book:**

1. Process Control: Modeling, Design, and Simulation by B. Wayne Bequette
2. Process Control Instrumentation Technology by Curtis D. Johnson
3. Instrument Engineers' Handbook, Volume One: Process Measurement and Analysis by Bela G. Liptak

- **Course Name:** Process Development Technology

  **Course Code:** 11223202

  **Prerequisite:** Knowledge of Process Development Technology up to UG science level

**Rationale:** Fundamentals knowledge of Process Development Technology is a basic as it provides a strong foundation for various concerns disciplines, promotes problem-solving skills, supports innovation, and opens doors to diverse career opportunities.

**Course Learning Objective:**

| | |
|---|---|
| **CLOBJ 1** | Describe fundamental principles and concepts of chemical processes, including reaction kinetics, thermodynamics, and mass transfer. |
| **CLOBJ 2** | Understand the principles and challenges involved in scaling up laboratory-scale processes to industrial production, considering factors like heat transfer and mixing. |
| **CLOBJ 3** | Apply optimization techniques to improve the efficiency and yield of chemical processes, considering factors such as reaction conditions, catalysts, and process parameters |
| **CLOBJ 4** | Identify and mitigate potential safety hazards associated with chemical processes, applying principles of process safety engineering |
| **CLOBJ 5** | Understand and apply PAT tools and techniques for real-time monitoring and control of chemical processes, improving product quality and process efficiency |
| **CLOBJ 6** | Use modelling and simulation tools to predict and optimize process performance, considering variables such as temperature, pressure, and reaction kinetics. |

**Course Learning Outcomes:**

| | |
|---|---|
| **CLO 1** | Demonstrate a thorough understanding of the fundamental principles and concepts of chemical processes, including reaction kinetics, thermodynamics, and mass transfer. |
| **CLO 2** | Apply principles and methodologies for scaling up laboratory-scale processes to industrial production, considering factors such as heat transfer, mixing, and equipment compatibility. |
| **CLO 3** | Identify potential safety hazards associated with chemical processes and implement safety measures to mitigate risks, ensuring a secure working environment. |
| **CLO 4** | Select and justify the use of appropriate materials and equipment for chemical processes, considering factors such as corrosion resistance, material compatibility, and reliability. |
| **CLO 5** | Implement Quality by Design (QbD) principles to develop robust and reproducible manufacturing processes, ensuring consistent product quality and regulatory compliance. |
| **CLO 6** | Understand and adhere to regulatory requirements for chemical manufacturing processes, ensuring compliance with industry standards and regulations |

**Teaching & Examination Scheme:**

| **Teaching Scheme** | | | | **Evaluation Scheme** | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | **Internal Evaluation** | | | **ESE** | | |
| **L** | **T** | **P** | **C** | **MSE** | **CE** | **P** | **Theory** | **P** | **Total** |
| **4** | **-** | **-** | **4** | **20** | **20** | **-** | **60** | **-** | **100** |

**L-** Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

**Course Content:**

| Sr. No | Content | Weightage | Teaching Hours |
|---|---|---|---|
| 1 | **Introduction to process development**<br>Goals of Process development, Stages in process development: Lab scale; pilot scale; industrial scale, Scope and Limitations of Project development. | 17% | 10 |
| 2 | **Development of a preliminary Process System**<br>Modular approach, Multiple process synthesis, selection of process, basic economic evaluation, Sequencing of operations and integration in processes, Batch *vs* continuous *vs* semi-batch processes- Scale up, Concept of dedicated and multiproduct plant facilities, pilot plant, mini plants, Development and evaluation of alternative flow sheets | 33% | 20 |
| 3 | **Scale Up Aspects**<br>Identification of controlling steps of process, Green Engineering principles, Utilization of energy; cost of utilities, heat exchange networks, Preparation of process specifications for typical equipment and instrumental diagram, Safety and Risk of chemical processes, Learn from mistakes | 25% | 15 |
| 4 | **Designing of Process**<br>Hierarchy of process design, Principle and approaches to process synthesis, Large scale low cost processing systems, Reaction path synthesis, Choice of reactors and separators, Process selection, Study of alternate process scale-up methods, Flow Sheet preparation, Sketching, Equipment numbering, Stream designation. | 25% | 15 |
| | **Total** | 100% | 60 |

**Text Book and Reference Book:**


1. Joseph Mizrahi, Developing an Industrial chemical process, Taylor and Francis Pub.
2. N. G. Anderson, Practical process research and development, Science direct.
3. Designing and operating safe chemical reaction process, HSE publishers
4. D. L. Erwine , Industrial Chemical Process Design
5. N. Anderson, Laboratory Chemical Process Development


- **Course Name:** Basic Name Reactions in Chemistry

  **Course Code:** 11223203

  **Prerequisite:** A basic understanding of general chemistry knowledge, Organic chemistry fundamentals, Reaction mechanisms Chemical bonding, stereochemistry, Functional group chemistry

**Rationale:** Basic name reactions represent fundamental processes in organic chemistry. Mastery of these reactions is crucial for building a strong foundation in the field and understanding more complex reactions that may build upon them.

**Course Learning Objective:**

| | |
|---|---|
| **CLOBJ 1** | Analyse and comprehend the underlying mechanisms of name reactions, including the movement of electrons, intermediates formed, and the driving forces behind the reactions. |
| **CLOBJ 2** | Develop the ability to predict the products of basic name reactions based on given reactants, reaction conditions, and knowledge of reaction mechanisms. |
| **CLOBJ 3** | Apply the principles of basic name reactions to propose synthetic routes for the preparation of specific organic compounds, demonstrating problem-solving skills. |
| **CLOBJ 4** | Correlate the structure of organic compounds with their reactivity in the context of name reactions, emphasizing the influence of functional groups on reaction outcomes. |
| **CLOBJ 5** | Apply stereochemical concepts to predict and understand the stereoselectivity and stereochemistry of products formed in name reactions |
| **CLOBJ 6** | Critically review and analyse scientific literature to identify instances where basic name reactions are applied in research, demonstrating an ability to interpret and apply acquired knowledge |

**Course Learning Outcomes:**

| | |
|---|---|
| **CLO 1** | Remember and identify important name reactions in organic and inorganic chemistry. |
| **CLO 2** | Explain the role of catalysts, intermediates, and reaction conditions in the reaction pathways. |
| **CLO 3** | Apply Stereo chemistry and Regio chemistry when predicting reaction outcomes. |
| **CLO 4** | Examine influence of reaction conditions, such as temperature, pressure, and solvent, on the outcomes of name reactions. |
| **CLO 5** | Evaluate the synthetic utility of name reactions in organic synthesis. |
| **CLO 6** | Investigate to proper safety protocols when conducting experiments related to name reactions. |

**Teaching & Examination Scheme:**

| Teaching Scheme | | | | Evaluation Scheme | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Internal Evaluation | | | ESE | | |
| **L** | **T** | **P** | **C** | **MSE** | **CE** | **P** | **Theory** | **P** | **Total** |
| **4** | **-** | **0** | **4** | **60** | **20** | **-** | **60** | **-** | **100** |

**L-** Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

**Course Content:**

| Sr. No | Content | Weightage | Teaching Hours |
|---|---|---|---|
| **1** | **Reagents in Organic Synthesis** | **25%** | **15** |

| | | | |
|---|---|---|---|
| | Alluminium-isoprpoxide, OsO4, LiAlH4, lithium diisopropylamide (LDA)SeO2, NBS, PCC (pyridinium chlorochromate), m-CPBA, TPP, lithium diisopropylamide (LDA), crown ethers, Gilman¶s reagent, tri-n-butyltin hydride | | |
| **2** | **Michael reaction**<br>Mannich reaction, Shapiro reaction, Barton reaction, Hoffman-Loffler Freytag reaction, Bayer- Villager reaction, Chichibarin reaction, Oppenauer oxidation, Heck reaction | **25%** | **15** |
| **3** | **Ullmann reaction**<br>Suzuki cross-coupling reaction, Sandmeyer reaction, Reimer-Tiemann reaction, Knoevenagel condensation, Gabriel synthesis, Diels-Alder reaction, Cannizzaro reaction, Birch reduction, Claisen condensation | **33%** | **20** |
| **4** | **Molecular Rearrangements**<br>Hoffman, Schmidt, Cartius, Beckman, Fries, Benzilic acid, Lossen cope, Claisen, Sommelet, Pinacole- Pinacolone, Wagner±Meerwein and Wolff Rearrangement | **17%** | **10** |
| | **Total** | **100%** | **60** |

**Text Book and Reference Book:**

1. Organic Chemistry by Paula Yurkanis Bruice
2. Organic Chemistry by Jonathan Clayden, Nick Greeves, and Stuart Warren
3. Organic Chemistry by Francis A. Carey and Robert M. Giuliano
4. March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure by Michael B. Smith and Jerry March
5. Advanced Organic Chemistry: Part A: Structure and Mechanisms by Francis A. Carey and Richard J. Sundberg

- **Course Name:** Intellectual Property Rights

**Course Code:** 11223204

**Prerequisite:** Knowledge of Legal Foundations, Foundations of Business Law, Introduction to Law and Legal Systems, Literary and Artistic Background, Research Skills and Writing and Communication Skills

**Rationale:** Intellectual Property Rights is not only relevant for legal professionals but also for individuals across various disciplines who seek to understand the intersection of innovation, creativity, and legal protection in today's interconnected and rapidly evolving world.

**Course Learning Objective:**

| | |
|---|---|
| **CLOBJ 1** | Define and explain the concept of intellectual property and identify the various forms of intellectual property rights, including patents, trademarks, copyrights, and trade secrets |
| **CLOBJ 2** | Understand the legal framework for intellectual property protection and explore the international aspects of intellectual property, including treaties and agreements |

| | |
|---|---|
| **CLOBJ 3** | Demonstrate processes involved in applying for and obtaining intellectual property rights and evaluate the criteria for registration and the implications of the registration process. |
| **CLOBJ 4** | Analyse the relationship between intellectual property and technological advancements and analyse the role of intellectual property in promoting scientific research and development. |
| **CLOBJ 5** | Evaluate skills in analysing intellectual property cases and enhance legal research skills to understand precedents, legal opinions, and evolving legal interpretations. |
| **CLOBJ 6** | Design implications of intellectual property laws on public policy and evaluate the role of intellectual property in addressing societal challenges. |

**Course Learning Outcomes:**

| | |
|---|---|
| **CLO 1** | Define comprehensive understanding of the different forms of intellectual property rights, including patents, trademarks, copyrights, and trade secrets. |
| **CLO 2** | Explain the legal framework and international aspects of intellectual property protection. |
| **CLO 3** | Apply the principles of intellectual property law to analyse and assess real-world cases of infringement. |
| **CLO 4** | Examine the ability to critically evaluate legal issues related to intellectual property and propose effective solutions. |
| **CLO 5** | Evaluate research to analyse relevant statutes, regulations, and case law pertaining to intellectual property rights. |
| **CLO 6** | Construct legal documents, such as patent applications, trademark registrations, and cease-and-desist letters. |

**Teaching & Examination Scheme:**

| Teaching Scheme | | | | Evaluation Scheme | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Internal Evaluation | | | ESE | | |
| **L** | **T** | **P** | **C** | **MSE** | **CE** | **P** | **Theory** | **P** | **Total** |
| **4** | **-** | **-** | **4** | **20** | **20** | **-** | **60** | **-** | **100** |

**L-** Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

**Course Content:**

| Sr. No. | Content | Weightage | Teaching Hours |
|---|---|---|---|
| **1** | **Introduction to Law**<br>Meaning of Law and Sources of Law, Classification of Law, Introduction to Legal Systems, Introduction to the Constitution of India, Law of Contract, Meaning of Property, Possession, Ownership - Principles of Criminal liability, Meaning of Theft, Fraud, Misrepresentation and other offences | **20%** | **12** |
| **2** | **Introduction to IP rights and International regime:**<br>Meaning of Intellectual Property and its Scope - Need for Protection - Evolution of IP Law - International Conventions UPOV, PCT, Budapest Treaty etc. - International Agencies | **20%** | **12** |

| | | | |
|---|---|---|---|
| | WIPO, WTO-TRIPS<br>**Copyright**<br>Meaning, Nature and Scope - Determination of Ownership and Rights of Owner - Registration of Copyright - Infringement and Enforcement<br>**Trade Marks**<br>Basic features - Service Marks, Collective Marks, Certification Trade Marks, Well-known Trade Marks, Internet Domain Name - Registration, Rights of Trade Mark Holder - Infringement and Passing off Action, and Remedies | | |
| **3** | **Patents**<br>Meaning of Patent and its Characteristics - Patentability of Inventions - Procedure for obtaining Patent - Rights and Obligations of Patentee - Transfer of Patent - Surrender, Revocation and Restoration of Patent - Infringement of Patent and Remedies thereof | **23%** | **14** |
| **4** | **Geographical Indications**<br>Meaning, GI and Trade Mark - Registration of GI - Infringement and Legal remedies<br>Biological Diversity and Traditional Knowledge: - Convention on Biological Diversity - Biological Diversity Act, 2002 - Meaning of Traditional Knowledge and Need for Protection of plant varieties, the rights of farmers and plant breeders: - UPOV Convention - PPV & FR Act, 2001 - GMOs, Breeder's Rights | **37%** | **22** |
| | **Total** | **100%** | **60** |

**Text Book and Reference Book:**


1. Principles of Intellectual Property by Peter Goodhart
2. Intellectual Property: A Very Short Introduction by Siva Vaidhyanathan
3. Intellectual Property Law by Lionel Bently and Brad Sherman
4. Intellectual Property: Patents, Copyrights, Trademarks & Allied Rights by William Cornish, David Keeton, and Martin Kretschmer
5. McCarthy on Trademarks and Unfair Competition by J. Thomas McCarthy
6. Chisum on Patents by Donald S. Chisum, Michael A. Jacobs, and Tyler T. Ochoa
7. Nimmer on Copyright" by David Nimmer
8. Frischmann, Lemley, and Strandburg's Intellectual Property: Cases and Materials by Michael J. Madison, Brett M. Frischmann, Mark A. Lemley, and Rochelle Cooper Dreyfuss


- **Course Name:** Nanomaterial Chemistry

**Course Code:** 11223230

**Prerequisite:** Knowledge of Colloidal Science up to UG science level

**Rationale:** Fundamentals knowledge of Nanomaterial Chemistry is a basic as it provides a strong foundation for various concerns disciplines, promotes problem-solving skills, supports innovation, and opens doors to diverse career opportunities.

**Course Learning Objective:**

| | |
|---|---|
| **CLOBJ 1** | Remember fundamental principles of nanomaterial chemistry, including quantum mechanics, surface chemistry, and unique properties of materials at the nanoscale. |
| **CLOBJ 2** | Identify various synthesis methods for nanomaterials, such as chemical vapor deposition, sol-gel processes, and bottom-up and top-down approaches |
| **CLOBJ 3** | Apply skills in using advanced characterization techniques, including electron microscopy, X-ray diffraction, and spectroscopy, to analyse nanomaterial structures and properties. |
| **CLOBJ 4** | Analyse techniques for surface functionalization of nanomaterials to tailor their properties for specific applications, including biomolecule attachment and surface modification |
| **CLOBJ 5** | Evaluate an application of nanomaterials in catalysis, understanding their unique catalytic properties and how they enhance reaction rates and selectivity. |
| **CLOBJ 6** | Develop the design and applications of nanocomposites, combining nanomaterials with other materials to achieve enhanced mechanical, thermal, or electrical properties. |

**Course Learning Outcomes:**

| | |
|---|---|
| **CLO 1** | Define a comprehensive understanding of the fundamental principles of nanomaterial chemistry, including quantum mechanics, surface phenomena, and unique properties at the nanoscale. |
| **CLO 2** | Identify advanced characterization techniques, such as electron microscopy, X-ray diffraction, and spectroscopy, to analyse the structural and chemical properties of nanomaterials. |
| **CLO 3** | Interpret and apply nanomaterials in catalysis, understanding their unique catalytic properties and mechanisms to enhance reaction rates and selectivity. |
| **CLO 4** | Analyse nanocomposites, combining nanomaterials with other materials to achieve synergistic properties for specific applications. |
| **CLO 5** | Evaluate the principles of nano-electronics and apply nanomaterials in electronic devices, including nanowires, quantum dots, and carbon-based materials. |
| **CLO 6** | Formulate nanomaterials in the field of nanomedicine, including drug delivery systems, imaging agents, and therapeutics. |

**Teaching & Examination Scheme:**

| **Teaching Scheme** | | | | **Evaluation Scheme** | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **L** | **T** | **P** | **C** | **Internal Evaluation** | | | **ESE** | | **Total** |
| | | | | **MSE** | **CE** | **P** | **Theory** | **P** | |
| **4** | **-** | **-** | **4** | **20** | **20** | **-** | **60** | **-** | **100** |

**L-** Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

**Course Content:**

| **Sr. No** | **Content** | **Weightage** | **Teaching Hours** |
|---|---|---|---|
| **1** | **Introduction of Nanomaterials**<br>Definition of Nano, Atomic Structure and atomic size, | **23%** | **14** |

| | | | |
|---|---|---|---|
| | emergence and challenges of nanoscience and nanotechnology, carbon age-new form of carbon (Quantam dots to CNT to Graphene), influence of nano over micro/macro, size effects and crystals, large surface to volume ration, surface effects on the properties, Types and properties of nanomaterials: One dimensional, Two dimensional and Three dimensional, Quantum Dots shell structures, metal oxides, semiconductors, composites. | | |
| **2** | **Synthetic Routes of Nanomaterials**<br>Principle and relative merits of each technique for production of Nano-structures including ultra-thin films and multilayer by: (a) Laser Ablation technique, (b) Arc Discharge technique, (c) Mechanical Milling and (d) Physico-chemical methods such as Chemical Vapor Deposition (CVD), Plasma, Sputtering, Self-assembly technique. | **27%** | **16** |
| **3** | **Chemical Methods of Nanomaterials**<br>Synthesis of nanomaterials by precipitation and co-precipitation methods, Sol-Gel synthesis, Microemulsions synthesis, Hydrothermal and Solvothermal methods, Microwave synthesis, Sonochemical assisted synthesis. Metal nanocrystals synthesis by polyol, and borohydrate reduction methods, Photochemical synthesis, Synthesis in supercritical fluids, Electrochemical synthesis, Synthesis of Core-Shell nanostructure, Organic–Inorganic Hybrids, Quantum dots (QDs), Carbon Nanotubes, Graphene nanosheets. | **30%** | **18** |
| **4** | **Properties, Characterization And Applications of Nanomaterials**<br>Properties and size effect of nanomaterials, electrical, Mechanical, Magnetic, Optical and catalytic properties, Characterization methods, Applications of nanotechnology in sustainable development and technology. | **20%** | **12** |
| | **Total** | **100%** | **60** |

**Text Book and Reference Book:**


1. G. A. Ozin, A. C. Arsenault, L. Cademartiri, Nanochemistry: A Chemical Approach to Nanomaterials, 2nd Edition, The Royal Society of Chemistry, Cambridge, 2009.
2. C. N. R Rao, A. Muller, A. K Cheetham, Nanomaterials Chemistry, 1st Edition, Wiley-VCH, 2007.
3. G. Cao, Nanostructures & Nanomaterials: Synthesis, Properties, and Applications, 1st Edition, Imperial College Press, London, 2004.
4. M. Hosokawa, K. Nogi, M. Naito, Y. Yokoyama, Nanoparticles Technology Handbook, 1st Edition, Elsevier, 2007.
5. T. Pradeep, NANO The Essentials: Understanding Nanoscience and Nanotechnology, 1st Edition, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2007.

- **Course Name:** Medicinal Chemistry

  **Course Code:** 11223231

  **Prerequisite:** Knowledge of Chemistry, Biology, Physics, Maths, Pharmacology, Microbiology, Anatomy and Physiology

  **Rationale:** Medicinal Chemistry is motivated by the desire to advance medical science, improve healthcare outcomes, and contribute to the development of innovative and effective therapeutics. It offers a dynamic and challenging field for individuals passionate about making a positive impact on human health.

**Course Learning Objective:**

| | |
|---|---|
| **CLOBJ 1** | State the various biological targets, such as enzymes, receptors, and nucleic acids, that are relevant to drug action. |
| **CLOBJ 2** | Explain the principles of drug-receptor interactions and understand the factors influencing binding affinity and specificity. |
| **CLOBJ 3** | Demonstrate a solid understanding of the chemical principles underlying drug design, including structure-activity relationships (SAR) and quantitative structure-activity relationships (QSAR). |
| **CLOBJ 4** | Examine the processes of drug metabolism, pharmacokinetics, and bioavailability, and understand their implications for drug development. |
| **CLOBJ 5** | Evaluate synthetic organic chemistry techniques relevant to the design and synthesis of medicinal compounds. |
| **CLOBJ 6** | Investigate analytical techniques, such as spectroscopy and chromatography, for the identification and characterization of medicinal compounds. |

**Course Learning Outcomes:**

| | |
|---|---|
| **CLO 1** | Remember comprehensive understanding of the fundamental principles of medicinal chemistry, including the chemical and biological basis of drug action. |
| **CLO 2** | Identify and assess relevant biological targets for drug intervention, considering their significance in disease pathways. |
| **CLO 3** | Interpret structure-activity relationships to predict and rationalize the effects of chemical modifications on drug potency and selectivity. |
| **CLO 4** | Demonstrate designing and executing synthetic routes for the preparation of medicinal compounds, demonstrating sound knowledge of synthetic organic chemistry. |
| **CLO 5** | Analyse the molecular interactions between drugs and their target receptors, understanding the factors influencing binding affinity. |
| **CLO 6** | Investigate various analytical techniques, such as spectroscopy and chromatography, for the identification and characterization of medicinal compounds. |

**Teaching & Examination Scheme:**

| **Teaching Scheme** | | | | **Evaluation Scheme** | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **L** | **T** | **P** | **C** | **Internal Evaluation** | | | **ESE** | | **Total** |
| | | | | **MSE** | **CE** | **P** | **Theory** | **P** | |
| **4** | **-** | **-** | **4** | **20** | **20** | **-** | **60** | **-** | **100** |

**L-** Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

**Course Content:**

| Sr. No | Content | Weightage | Teaching Hours |
|---|---|---|---|
| 1 | **Biological Molecules**<br>Introduction, structure and their nomenclature with examples of some biological molecules; 1) amino acids; 2) peptides and proteins; 3) carbohydrates; 4) lipids; 5) nucleic acids | 17% | 10 |
| 2 | **Introduction of Drugs and their Actions**<br>Introduction, what are drugs and why do we need new ones? Drug discovery and design, a historical outline, Sources of drugs and lead compounds, Classification of drugs, Routes of administration, the pharmaceutical phase, Drug metabolism and Concepts of Prodrugs, Introduction to drug action: a) The pharmacokinetic phase; b) Bioavailability of a drug; c) The pharmacodynamics phase | 33% | 20 |
| 3 | **Introduction of Drugs Discovery**<br>Introduction, Stereochemistry and drug design: a) Structurally rigid groups; b) Conformation and configuration, Solubility and drug design (Importance of Water Solubility), Solubility and drug structure, Salt formation, The incorporation of water solubilizing groups in a structure<br>**Principles of Drug & Drug Delivery System**<br>Introduction, Principles, Fundamentals and Mechanism of Drug Delivery, Types, Activation; Modulated Drug Delivery Systems; Mechanically activated, pH activated, Enzyme activated, and Osmotic activated Drug Delivery Systems, Feedback regulated Drug Delivery Systems<br>**Pharmacotherapy**<br>Basic concepts of Pharmacotherapy, Clinical and individualization of Drug Therapy, Drug Delivery Systems and their Biopharmaceutics & Therapeutic Considerations | 33% | 20 |
| 4 | **Drug Action**<br>General Anesthetics, Local Anesthetics, Hypnotics and Sedatives, Opioid analgesics, antitussives, anti convulsants, Antiparkinsonism drugs, CNS stimulants, Psychopharmacological agents (neuroleptics, antidepressants, anxiolytics), Drug Use During Infancy and in the Elderly (Pediatries & Geriatrics), Drug use during Pregnancy, Drug induced Diseases, General Principles of Clinical Toxicology | 17% | 10 |
| | **Total** | 100% | 60 |

**Text Book and Reference Book:**


1. Medicinal Chemistry by Thomas Nogrady and Donald F. Weaver
2. Medicinal Chemistry: The Modern Drug Discovery Process by Erland Stevens and William W. Fleming
3. Wilson and Gisvold's Textbook of Organic Medicinal and Pharmaceutical Chemistry by John M. Beale Jr. and John H. Block
4. Principles of Medicinal Chemistry by William O. Foye, Thomas L. Lemke, and

David A. Williams
5. Medicinal Chemistry: A Molecular and Biochemical Approach by Thomas Nogrady and Donald F. Weaver
6. Burger's Medicinal Chemistry, Drug Discovery and Development edited by Donald J. Abraham
7. Comprehensive Medicinal Chemistry III edited by David J. Triggle, Alexander S. MacDonald, and Michael J. E. Sternberg
8. Handbook of Medicinal Chemistry: Principles and Practice edited by Andrew Davis and Simon Campbell
9. Foye's Principles of Medicinal Chemistry edited by David A. Williams, Thomas L. Lemke, and Victoria F. Roche
10. Textbook of Drug Design and Discovery by K.C. Joshi and N.P. Mehta

# Semester: 4

- **Course Name:** Industrial Internship

  **Course Code:** 11223251

  **Prerequisite:** Core concepts related to their field of study (e.g., chemical processes, engineering design, material analysis, etc.). Familiarity with theoretical and laboratory practices related to their academic curriculum.

  **Rationale:** The An Industrial Internship bridges the gap between academic knowledge and real-world applications.

**Course Learning Objectives:**

| | |
|---|---|
| **CLOBJ1** | Provide students with first-hand experience in an industrial setting. |
| **CLOBJ2** | Enable students to understand and contribute to real-world projects and processes. |
| **CLOBJ3** | Develop professional skills such as teamwork, problem-solving, and effective communication. |
| **CLOBJ4** | Expose students to workplace safety, sustainability practices, and ethical considerations. |
| **CLOBJ5** | Encourage students to identify areas of improvement and innovation in industrial operations. |

**Course Learning Outcomes:**

| | |
|---|---|
| **CLO1** | Apply theoretical knowledge to solve practical problems in an industrial context. |
| **CLO2** | Demonstrate competency in working with industrial tools, equipment, and software relevant to their field. |
| **CLO3** | Analyze and document industrial processes, highlighting areas for efficiency and innovation. |
| **CLO4** | Communicate effectively through professional reports and presentations. |
| **CLO5** | Reflect on their internship experience, identifying personal growth and future career goals. |

**Teaching & Examination Scheme:**

| Teaching Scheme | | | | Evaluation Scheme | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Internal Evaluation | | | ESE | | Total |
| L | T | P | C | MSE | CE | P | Theory | P | |
| - | - | 600 | 20 | - | - | 150 | - | 250 | 400 |

**L-** Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

1. **Students are going compulsory for an Internship (in Industry) in the last (4th ) Semester.**
2. **At the end of the semester, all students have to submit their internship reports.**