

GU/Acad –PG/BoS -NEP/2025-26/441

Date: 01.10.2025

### CIRCULAR

The Academic Council & Executive Council of the University has approved Ordinance OA-35A relating to PG Programmes offered at the University campus and its affiliated Colleges based on UGC 'Curriculum and Credit Framework for Postgraduate Programmes'. Accordingly, the University has proposed introduction of Ordinance OA-35A from the Academic year 2025-2026 onwards.

The Programme structure and syllabus of Semester I and II of the **Post Graduate Diploma in Chemical Industrial Techniques** Programme approved by the Academic Council in its meeting held on 13<sup>th</sup> September 2025 is attached.

The Dean & Vice-Dean (Academic) of the School of Chemical Sciences of the affiliated College offering the **Post Graduate Diploma in Chemical Industrial Techniques** are requested to take note of the above and bring the contents of the Circular to the notice of all concerned.

(Ashwin V. Lawande)  
Deputy Registrar – Academic

To,

1. The Dean, School of Chemical Sciences, Goa University.
2. The Vice-Dean (Academic), School of Chemical Sciences, Goa University.
3. Principal of affiliated College offering the Post Graduate Diploma in Chemical Industrial Techniques Programme.

Copy to:

1. Chairperson, BoS in Chemistry, Goa University.
2. Controller of Examinations, Goa University.
3. Assistant Registrar Examinations (PG), Goa University.
4. Director, Directorate of Internal Quality Assurance, Goa University for uploading the Syllabus on the University website.

# GOA UNIVERSITY

## POST GRADUATE DIPLOMA IN CHEMICAL INDUSTRIAL TECHNIQUES

(Effective from the Academic Year 2025-2026)

### ABOUT THE PROGRAMME

The primary goal of the Post Graduate Diploma in Chemical Industrial Techniques course is to provide students with the foundational knowledge and practical skills necessary for success in various chemical industries and research institutions. This includes a thorough understanding of the application of chemical principles in industrial processes, the development of problem-solving abilities, and an appreciation for both historical and contemporary trends in the field. Additionally, the course will address the ethical and environmental considerations associated with industry, promoting an understanding of sustainable practices and responsible chemical production.

### OBJECTIVES OF THE PROGRAMME

The objective is to equip students for careers in sectors such as pharmaceuticals, polymers, petrochemicals, and manufacturing, as well as opportunities in research and development. Students will also establish a solid foundation for pursuing advanced studies or research in industry. Students will examine both basic and advanced concepts in chemistry, encompassing the principles of inorganic, organic, and physical chemistry, in addition to materials science and analytical techniques. With an emphasis on hands-on laboratory experience, the course will prepare students to conduct experiments, analyse data, and develop innovative chemical processes. They will enhance their ability to resolve challenges related to chemical reactions, process optimization, and product development in an industrial setting. Furthermore, the course will provide insights into the diverse chemical industries, their products, and the challenges they face.

### ELIGIBILITY/ PRE-REQUISITES FOR THE PROGRAMME

**B. Sc (3 years) Chemistry/Chemical Sciences, Life Sciences, Earth Sciences**

**B. Pharm, B. Sc Industrial Chemistry, B.E/ BTECH Chemical Engineering**

| <b>PROGRAMME SPECIFIC OUTCOMES (PSO)</b> |                                                                                                                                                                                                                                                                                       |
|------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>PSO 1.</b>                            | Students will acquire a comprehensive understanding of the fundamental concepts of chemistry.                                                                                                                                                                                         |
| <b>PSO 2.</b>                            | Students will be equipped to utilize modern instrumentation techniques for designing experiments, along with a thorough knowledge of standard operating procedures and safety regulations necessary for the effective handling and use of chemicals.                                  |
| <b>PSO 3.</b>                            | By applying critical thinking and the scientific method, students will design, conduct, document, and analyse chemical experiments, gaining insight into the effects of chemistry on both the environment and society.                                                                |
| <b>PSO 4.</b>                            | Through hands-on laboratory work and practical activities, students will develop the problem-solving skills essential for successful careers in various fields, including pharmaceuticals, the chemical industry, education, research, environmental monitoring, and product quality. |
| <b>PSO 5.</b>                            | Students will foster an awareness of how chemistry impacts the environment, society, and broader developmental issues beyond the confines of the scientific community.                                                                                                                |

**PROGRAMME STRUCTURE**  
**Post Graduate Diploma in Chemical Industrial Techniques**  
**Effective from Academic Year 2025-26**

| <b>SEMESTER I</b>                                            |                    |                                               |                |              |
|--------------------------------------------------------------|--------------------|-----------------------------------------------|----------------|--------------|
| <b>Discipline Specific Core (DSC) Courses (16 credits)</b>   |                    |                                               |                |              |
| <b>Sr. No.</b>                                               | <b>Course Code</b> | <b>Title of the Course</b>                    | <b>Credits</b> | <b>Level</b> |
| 1                                                            | CIT-5000           | Introduction to Chemical Industries           | 4              | 400          |
| 2                                                            | CIT-5001           | Calibration & Validation (QA/QC Compliances)  | 4              | 400          |
| 3                                                            | CIT-5002           | Chemical Safety and Ethics of Research        | 4              | 400          |
| 4                                                            | CIT-5003           | Laboratory Course in Chemical Techniques - I  | 2              | 400          |
| 5                                                            | CIT-5004           | Laboratory Course in Chemical Techniques - II | 2              | 400          |
| <b>Total Credits for DSC Courses in Semester I</b>           |                    |                                               | <b>16</b>      |              |
| <b>Discipline Specific Elective (DSE) Course (4 credits)</b> |                    |                                               |                |              |
| <b>Sr. No.</b>                                               | <b>Course Code</b> | <b>Title of the Course</b>                    | <b>Credits</b> | <b>Level</b> |
| 1                                                            | CIT-5201           | Concepts in Nanotechnology                    | 4              | 400          |
| 2                                                            | CIT-5202           | Materials in Chemical Industries              | 4              | 400          |
| 3                                                            | CIT-5203           | Modern Characterization Techniques            | 4              | 400          |
| 4                                                            | CIT-5204           | Fundamentals of Industrial Catalysis          | 4              | 400          |
| <b>Total Credits for DSE Courses in Semester I</b>           |                    |                                               | <b>4</b>       |              |
| <b>Total Credits in Semester I</b>                           |                    |                                               | <b>20</b>      |              |



| SEMESTER II                                                                     |             |                                                |         |       |
|---------------------------------------------------------------------------------|-------------|------------------------------------------------|---------|-------|
| Discipline Specific Core (DSC) Courses                                          |             |                                                |         |       |
| Sr. No.                                                                         | Course Code | Title of the Course                            | Credits | Level |
| 1                                                                               | CIT-5005    | Data analysis & Analytical Method Development  | 4       | 500   |
| 2                                                                               | CIT-5006    | Drug development & Pharmacopeial Aspects       | 4       | 500   |
| 3                                                                               | CIT-5007    | Process Safety and Pollution management        | 4       | 500   |
| 4                                                                               | CIT-5008    | Instrumental Techniques                        | 4       | 500   |
| Total Credits for DSC Courses in Semester II                                    |             |                                                | 16      |       |
| Discipline Specific Elective (DSE) Courses (4 credits)/ Internship <sup>#</sup> |             |                                                |         |       |
| Sr. No.                                                                         | Course Code | Title of the Course                            | Credits | Level |
| 1                                                                               | CIT-5205    | Laboratory Course in Chemical Techniques - III | 2       | 500   |
| 2                                                                               | CIT-5206    | Laboratory Course in Chemical Techniques - IV  | 2       | 500   |
| 3                                                                               | CIT-5207    | Laboratory Course in Chemical Techniques - V   | 2       | 500   |
| Total Credits for DSE Courses in Semester II                                    |             |                                                | 4       |       |

| Industrial Internship        |             |                     |                |       |
|------------------------------|-------------|---------------------|----------------|-------|
| Sr. No.                      | Course Code | Title of the Course | Credits        | Level |
| 1                            | CIT-5208    | Internship          | 4 <sup>#</sup> | 500   |
| Total Credits in Semester II |             |                     | 20             |       |

Note: - <sup>#</sup> 4 Credit Internship can be opted in lieu of 4(2+2) credit DSE practicals.

| Blooms Taxonomy Cognitive Levels |               |
|----------------------------------|---------------|
| Cognitive Level                  | Notations     |
| K1                               | Remembering   |
| K2                               | Understanding |
| K3                               | Applying      |
| K4                               | Analyzing     |
| K5                               | Evaluating    |
| K6                               | Create        |

## SEMESTER I

### Discipline Specific Core Courses

|                                              |                                     |
|----------------------------------------------|-------------------------------------|
| <b>Title of the Course</b>                   | Introduction to Chemical Industries |
| <b>Course Code</b>                           | CIT-5000                            |
| <b>Number of Credits</b>                     | 04                                  |
| <b>Theory/Practical</b>                      | Theory                              |
| <b>Level</b>                                 | 400                                 |
| <b>Effective from AY</b>                     | 2025-26                             |
| <b>New Course</b>                            | Yes                                 |
| <b>Bridge Course/<br/>Value added Course</b> | No                                  |
| <b>Course for advanced learners</b>          | No                                  |

|                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|---------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Pre-requisites for the Course:</b> | Nil                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <b>Course Objectives:</b>             | <ol style="list-style-type: none"><li>1. To provide students with a comprehensive understanding of the fundamental principles, processes, and operations involved in various chemical industries.</li><li>2. To cover both inorganic and organic chemical manufacturing processes.</li><li>3. To emphasize on raw materials, reaction mechanisms, process flow diagrams, major equipment, and product applications.</li><li>4. To introduce safety, environmental considerations, and recent trends in the chemical industry.</li></ol> |

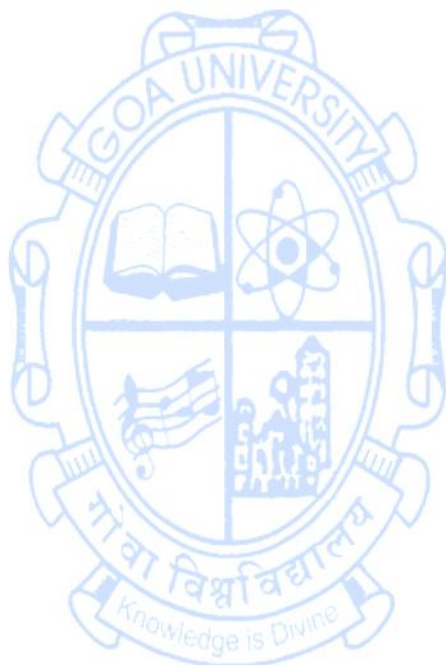
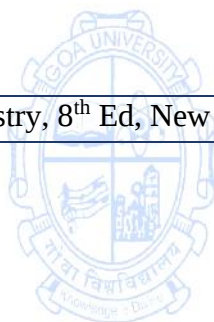
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|-------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|---------------------|------------------------|
| <b>Course Outcomes:</b> | Students will be able to                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>Mapped to PSO</b> |                     |                        |
|                         | CO 1. explain different aspects of a chemical Industry.                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <b>PSO1, PSO2</b>    |                     |                        |
|                         | CO 2. distinguish between different Inorganic, Organic Chemical and electronic Industries                                                                                                                                                                                                                                                                                                                                                                                                                 | <b>PSO1, PSO4</b>    |                     |                        |
|                         | CO 3. apply quality requirements of Industrial water and different treatment processes.                                                                                                                                                                                                                                                                                                                                                                                                                   | <b>PSO4, PSO5</b>    |                     |                        |
|                         | CO 4. analyze the relationship between safety and sustainability in industrial operations.                                                                                                                                                                                                                                                                                                                                                                                                                | <b>PSO3, PSO5</b>    |                     |                        |
| <b>Content:</b>         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <b>No of hours</b>   | <b>Mapped to CO</b> | <b>Cognitive Level</b> |
| <b>Module 1:</b>        | <b>Safety and Environmental Aspects in Chemical Industries</b><br>Overview of industrial hazards (chemical, physical, mechanical, electrical); Key safety regulations, standards, and the use of Personal Protective Equipment (PPE); Hazard identification and risk assessment.; Emergency preparedness and response; Brief overview of environmental pollution from chemical industries (air, water, soil) and basic pollution control measures; Sustainable practices and green chemistry initiatives. | <b>04</b>            | CO4                 | K1, K2, K3             |
| <b>Module 2:</b>        | <b>Introduction to Chemical Industries</b><br>Definition and scope of the chemical industry. Classification of chemical industries (based on raw materials, products, scale of operation). Importance of the chemical industry in the national economy. Interdisciplinary nature of chemical industrial techniques. Overview of major chemical sectors (basic chemicals, speciality chemicals, pharmaceuticals, agrochemicals, etc.). Factors influencing the location of chemical industries.            | <b>06</b>            | CO1                 | K1, K2                 |
| <b>Module 3:</b>        | <b>Inorganic Chemical Industries - Part I</b><br><b>Heavy Inorganic Chemicals: Sustainable Process Design &amp; Optimization in Chemical Industries</b><br><b>Sulfuric Acid:</b> Raw materials, manufacturing processes (Contact process), reactions involved, major equipment, applications, safety considerations.<br><b>Nitric Acid:</b> Raw materials, manufacturing processes (Ostwald process), reactions                                                                                           | <b>10</b>            | CO2                 | K1, K2, K3, K4         |

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|------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|-----------------|----------------|
|                  | <p>involved, major equipment, applications, safety considerations.</p> <p><b>Phosphoric Acid:</b> Raw materials, manufacturing processes, reactions involved, major equipment, applications, safety considerations.</p> <p><b>Ammonia:</b> Raw materials, manufacturing processes (Haber-Bosch process), reactions involved, major equipment, applications, safety considerations.</p> <p><b>Caustic Soda and Chlorine:</b> Raw materials, manufacturing processes (Electrolysis of brine), reactions involved, major equipment, applications, safety and environmental considerations.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                            |           |                 |                |
| <b>Module 4:</b> | <p><b>Inorganic Chemical Industries - Part II</b></p> <p><b>Fertilizers:</b></p> <p>Nitrogenous fertilizers (Urea, Ammonium Nitrate): Manufacturing processes, reactions, applications.</p> <p>Phosphatic fertilizers (Superphosphate, Triple Superphosphate): Manufacturing processes, reactions, applications.</p> <p>Potassic fertilizers (Potassium Chloride, Potassium Sulfate): Sources, processing, applications.</p> <p>Mixed fertilizers: Production and importance, strategies for enhanced nutrient use efficiency and reduced environmental runoff</p> <p><b>Pesticides:</b> Insecticides, Fungicides, Herbicides, Germicides</p> <p><b>Cement:</b> Types of cement, Comparative study of wet/dry manufacturing processes; energy efficiency, CO<sub>2</sub> emissions reduction, and alternative raw materials.</p> <p><b>Glass:</b> Analysis of raw materials impact, manufacturing process, melting process optimization, types of glass, applications.</p> <p><b>Metals and alloys:</b> Metallurgy, Ferrous and non-ferrous alloys</p> | <b>10</b> | CO <sub>2</sub> | K1, K2, K3, K4 |
| <b>Module 5:</b> | <p><b>Organic Chemical Industries - Part I</b></p> <p><b>Petroleum Refining and Petrochemicals:</b></p> <p>Crude oil composition and processing (fractional distillation, cracking, reforming). Production of basic petrochemicals from petroleum and natural Gas (ethylene,</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | <b>11</b> | CO <sub>2</sub> | K1, K2, K3, K4 |

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|------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|-----|------------|
|                  | <p>propylene, benzene, toluene, xylene), product optimisation, Applications of basic petrochemicals.</p> <p><b>Polymer Industries:</b><br/>Classification of polymers (thermoplastics, thermosets, elastomers). Manufacturing processes of major polymers:<br/>Polyethylene (LDPE, HDPE, LLDPE), Polypropylene, Polyvinyl Chloride (PVC), Polystyrene, Polymerization mechanisms and types of reactors. Applications of polymers,</p> <p><b>Pharmaceuticals Industries</b><br/>Classification based on their activity. Synthesis and formulations of Pharmaceutical Products. Quality control of Pharmaceutical Products.</p>                                                                                                                                                                                        |           |     |            |
| <b>Module 6:</b> | <p><b>Organic Chemical Industries - Part II</b></p> <p><b>Sugar Industry:</b><br/>Raw materials (sugarcane, sugar beet). Manufacturing process of sugar from sugarcane. By-products of the sugar industry (molasses, bagasse) and their utilization. Ethanol production from molasses.</p> <p><b>Pulp and Paper Industry:</b><br/>Raw materials (wood, non-wood fibres). Pulping processes (chemical, mechanical). Paper manufacturing process. Environmental considerations in the pulp and paper industry.</p> <p><b>Coal and Coke Industry:</b> Classification of Coal, analysis of coal, Metallurgical coke and its manufacture.</p> <p><b>Dyes and Pigments Industry:</b><br/>Classification of dyes and pigments. Basic principles of dye synthesis. Applications of different types of dyes and pigments.</p> | <b>09</b> | CO2 | K1, K2, K3 |
| <b>Module 7:</b> | <p><b>Selected Materials for Industry Applications</b><br/>Magnetic materials e.g. Ferrites. Ceramics for insulation and super conducting ceramics. Composite materials for high temperature applications.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | <b>04</b> | CO2 | K1, K2, K3 |

|                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |           |     |                |
|------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|-----|----------------|
| <b>Module 8:</b>             | <p><b>Water Treatment in Chemical Industries</b></p> <p>(a) Sources of industrial water and quality requirements, Common impurities in industrial water, Hardness of water, Scale and sludge formation in industrial water, Caustic Embrittlement, Boiler corrosion, Methods of water conditioning: Zeolite softening, Demineralization, Lime soda process, Sedimentation, filtration, coagulation, sterilization; Advanced water treatment methods: Ion exchange, reverse osmosis, desalination</p> <p>(b) Industrial waste water treatment processes: Wastewater treatment in chemical industries: Primary, secondary, and tertiary treatment methods.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | <b>06</b> | CO3 | K1, K2, K3, K4 |
| <b>Pedagogy:</b>             | Mostly lectures and tutorials, seminars/term papers/assignments/presentations/self-study or combination of some of these can also be used. ICT mode to be preferred.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |           |     |                |
| <b>Texts:</b>                | <ol style="list-style-type: none"> <li>1. R. Norris Shreve, Chemical Process Industries, 1<sup>st</sup> Ed, McGraw Hill Book Company New York-London, 1945.</li> <li>2. Jain &amp; Jain, Engineering Chemistry, 16<sup>th</sup> Ed, Dhanpat Rai Publishing Company, New Delhi, 2017.</li> <li>3. B. K. Sharma, Industrial Chemistry; Goel Publishing House, Meerut, 2016.</li> </ol>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |           |     |                |
| <b>References/ Readings:</b> | <ol style="list-style-type: none"> <li>1. Ali, El Ali, and Speight, Handbook of Industrial Chemistry, McGraw-Hill Education - Access Engineering, New York 2005.</li> <li>2. James A Kent, Riegels Handbook of Industrial Chemistry, 8<sup>th</sup> Ed, Van Nostrand Reinhold Comp, New York USA, 1983</li> <li>3. Eugene W. Rice, Laura Bridgewater, Standard Methods for the Examination of Water and Wastewater" American Public Health Association (APHA), American Water Works Association (AWWA), and Water Environment Federation (WEF) 23<sup>rd</sup> Ed, 2017</li> <li>4. S. M. Khopkar, Environmental Pollution Analysis, 2<sup>nd</sup> Ed, New age International Pvt Ltd Publishers, New Delhi, 1995.</li> <li>5. J. D. Lee, Concise Inorganic Chemistry, 5<sup>th</sup> Ed, Chapman and Hall, London, UK 1996.</li> <li>6. James G. Speight, Handbook of Petrochemical processes, CRC Press, Florida, USA, 2019.</li> <li>7. Nazrul Islam, Nanotechnology: Recent Trends, Emerging Issues and Future Directions, Latest Ed, Nova Science Publishers, Hauppauge, New York, USA_2017.</li> <li>8. Futuristic Trends in Chemical Material Sciences &amp; Nano Technology Volume 3 Book 12, IIP Series, Iterative International Publishers (IIP), Karnataka.</li> </ol> |           |     |                |

9. A. K. Dey, Environmental Chemistry, 8<sup>th</sup> Ed, New Age International Publishers, New Delhi, 2016.

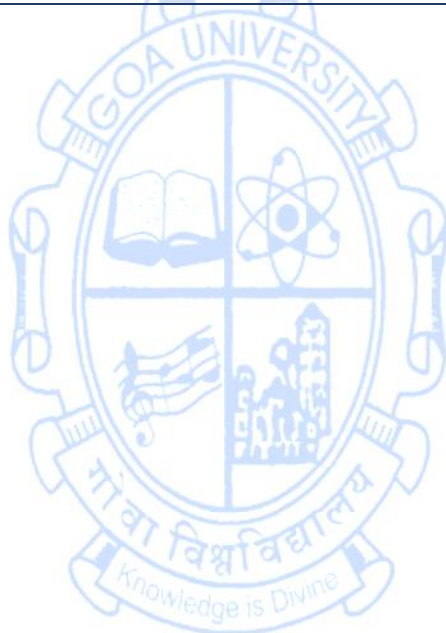


|                                              |                                                                                                                                                                                                                                                                                        |                      |
|----------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|
| <b>Title of the Course</b>                   | Calibration & Validation (QA/QC Compliances)                                                                                                                                                                                                                                           |                      |
| <b>Course Code</b>                           | CIT-5001                                                                                                                                                                                                                                                                               |                      |
| <b>Number of Credits</b>                     | 04                                                                                                                                                                                                                                                                                     |                      |
| <b>Theory/Practical</b>                      | Theory                                                                                                                                                                                                                                                                                 |                      |
| <b>Level</b>                                 | 400                                                                                                                                                                                                                                                                                    |                      |
| <b>Effective from AY</b>                     | 2025-2026                                                                                                                                                                                                                                                                              |                      |
| <b>New Course</b>                            | Yes                                                                                                                                                                                                                                                                                    |                      |
| <b>Bridge Course/<br/>Value added Course</b> | No                                                                                                                                                                                                                                                                                     |                      |
| <b>Course for advanced learners</b>          | No                                                                                                                                                                                                                                                                                     |                      |
| <b>Pre-requisites for the Course:</b>        | Nil                                                                                                                                                                                                                                                                                    |                      |
| <b>Course Objectives:</b>                    | 1. To study the principles of calibration and validation.<br>2. To learn how to write, implement, and manage SOPs.<br>3. To understand instrument calibration procedures and gain hands-on experience.<br>4. To apprise regulatory and quality requirements (e.g., ISO, GLP, GMP, FDA) |                      |
| <b>Course Outcomes:</b>                      | Students will be able to                                                                                                                                                                                                                                                               | <b>Mapped to PSO</b> |
|                                              | CO 1. perform calibration on common laboratory and industrial instruments (e.g., balances, pH meters, spectrophotometers).                                                                                                                                                             | <b>PSO1, PSO2</b>    |
|                                              | CO 2. interpret and maintain calibration records, certificates, and logs according to regulatory standards.                                                                                                                                                                            | <b>PSO2, PSO3</b>    |
|                                              | CO 3. develop and implement validation protocols for equipment, methods, and systems.                                                                                                                                                                                                  | <b>PSO3, PSO4</b>    |

|                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                    |                     |                        |
|------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|---------------------|------------------------|
|                  | CO 4. write, implement and maintain concise and compliant SOPs aligned with industry best practices and quality management system (QMS).                                                                                                                                                                                                                                                                                                                                              |                    | <b>PSO1, PSO3</b>   |                        |
| <b>Content:</b>  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | <b>No of hours</b> | <b>Mapped to CO</b> | <b>Cognitive Level</b> |
| <b>Module 1:</b> | <b>Basics of Calibration and Validation</b><br>Definitions and importance, differences between calibration and validation, role in quality assurance and compliance, calibration terminology (accuracy, precision, uncertainty, traceability), types of calibration (mechanical, electrical, thermal, etc.), frequency and intervals for calibration.                                                                                                                                 | <b>14</b>          | CO1, CO2            | K1, K2                 |
| <b>Module 2:</b> | <b>Instrument Calibration Procedures</b><br>Calibration of Analytical Instruments: Principles and Procedures, calibration methods for pH meter, balance, thermometer, spectrophotometer, etc, use of calibration certificates and logs, maintenance schedules and Performance Qualification (PQ). documentation and Record-Keeping for calibration.                                                                                                                                   | <b>06</b>          | CO3, CO4, CO5       | K1, K2, K3, K4, K5, K6 |
| <b>Module 3:</b> | <b>Method Validation</b><br>Types of validation: Installation Qualification (IQ), Operational Qualification (OQ), Performance Qualification (PQ). validation parameters: accuracy, precision, linearity, specificity, robustness, analytical Method Transfer and Verification, risk assessment and control in method validation, validation vs. verification, Validation Master Plan (VMP), Case Studies: Method Development and Validation in Pharmaceutical and Chemical processes. | <b>15</b>          | CO3, CO4, CO5       | K1, K2, K3, K4, K5, K6 |
| <b>Module 4:</b> | <b>Writing and Implementing SOPs</b><br>Role of SOPs in Quality and Compliance, structure and format of SOPs, writing clear and compliant SOPs Writing, Reviewing, and Approving, SOP training, implementation, and change control, Case Studies: SOP design and calibration in Regulated process.                                                                                                                                                                                    | <b>12</b>          | CO3, CO4, CO5       | K1, K2, K3, K4, K5, K6 |
| <b>Module 5:</b> | <b>Regulatory Framework</b><br>Overview of regulatory standards (ISO, WHO FDA GMP, GLP, BMR, CFR master                                                                                                                                                                                                                                                                                                                                                                               | <b>08</b>          | CO2, CO3,           | K1, K2, K4, K3         |

|                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |           |                             |                              |
|----------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|-----------------------------|------------------------------|
|                                  | documents compliances), regulatory guidelines for method validation (ICH Q2, USP, EP). role of documentation and audits importance of traceability and certification, validation of analytical procedures.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |           | CO4                         |                              |
| <b>Module 6:</b>                 | <b>Equipment Qualification and Maintenance</b><br>Qualification protocols, preventive maintenance and re-qualification, managing deviations and out-of-spec (OOS) results.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>05</b> | CO1,<br>CO4,<br>CO5         | K1, K2,<br>K3, K4,<br>K5,    |
| <b>Module 7:</b>                 | <b>Case Studies and Troubleshooting</b><br>Real-life scenarios for calibration/validation/SOP compliance, root cause analysis and corrective actions, audit preparation and response. validation and calibration of various instruments used for drug analysis such as UV-Visible spectrophotometer, IR spectrophotometer, spectrofluorometer, HPLC, HPTLC GC Etc.                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | <b>06</b> | CO1,<br>CO2,<br>CO4,<br>CO5 | K1, K2,<br>K3, K4,<br>K5, K6 |
| <b>Pedagogy:</b>                 | Mostly lectures and tutorials, seminars/term papers/assignments/presentations/self-study or combination of some of these can also be used. ICT mode to be preferred.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |           |                             |                              |
| <b>Texts:</b>                    | <ol style="list-style-type: none"> <li>1. D.A. Skoog, F.J. Holler, and S.R. Crouch, Principal of Instrumental Analysis. 7<sup>th</sup> Ed, Sunder College Publisher, New York, 2017.</li> <li>2. B. Viswanathan, Catalysis: Principles and Applications, 1<sup>st</sup> Ed.; Narosa Publishing House, New Delhi, 2002.</li> <li>3. G. D. Christian, Analytical Chemistry, 7<sup>th</sup> Ed.; John Wiley &amp; Sons Inc., New Delhi, 2013.</li> <li>4. D. C. Harris, Quantitative Chemical Analysis, 7<sup>th</sup> Ed.; Palgrave Macmillan U.K., 2006.</li> </ol>                                                                                                                                                                                                                                                                        |           |                             |                              |
| <b>References/<br/>Readings:</b> | <ol style="list-style-type: none"> <li>1. Swartz, M.E., &amp; Krull, I.S., Analytical Method Development and Validation. CRC Press, Boca Raton, USA, 2012.</li> <li>2. Joachim Ermer and John H. McB. Miller, Validation of Analytical Procedures: A Textbook. 1<sup>st</sup> Ed.; Wiley, VCH Verlag GmbH &amp; Co., Weinheim, Germany 2005.</li> <li>3. Hoffman, J.A., Pharmaceutical Analysis: A Textbook for Pharmacy Students and Pharmaceutical Chemists., Elsevier Health Sciences, Edinburgh, 2010.</li> <li>4. Konieczka, Piotr, and Jacek Namiesnik. Quality Assurance and Quality Control in the Analytical Chemical Laboratory. CRC Press, , Boca Raton, 2016.</li> <li>5. Miller, J.N., &amp; Miller, J.C., Statistics and Chemometrics for Analytical Chemistry, 7<sup>th</sup> Ed.; Pearson, Harlow, U. K. 2018.</li> </ol> |           |                             |                              |

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|--|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  | <ol style="list-style-type: none"><li>6. ICH Q2(R1): Validation of Analytical Procedures: Text and Methodology – Crucial for pharmaceutical method validation, Geneva, Switzerland, 2005.</li><li>7. USP Chapter &lt;1225&gt;: Validation of Compendial Procedures Maryland, USA 2017</li><li>8. ISO/IEC 17025: Requirements for the competence of testing and calibration laboratories, Geneva, Switzerland, 2017.</li><li>9. FDA Guidance for Industry, Analytical Procedures and Methods Validation for Drugs and Biologics. U.S. Department of Health and Human Services, Food and Drug Administration, 2015.</li></ol> |
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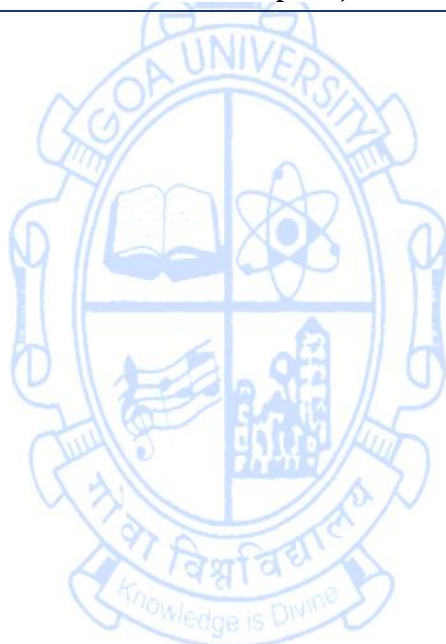


|                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                               |
|----------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|
| <b>Title of the Course</b>                   | Chemical Safety and Ethics of Research                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                               |
| <b>Course Code</b>                           | CIT-5002                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                               |
| <b>Number of Credits</b>                     | 04                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                               |
| <b>Theory/Practical</b>                      | Theory                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                               |
| <b>Level</b>                                 | 400                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                               |
| <b>Effective from AY</b>                     | 2025-2026                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                               |
| <b>New Course</b>                            | Yes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                               |
| <b>Bridge Course/<br/>Value added Course</b> | No                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                               |
| <b>Course for<br/>advanced learners</b>      | No                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                               |
| <b>Pre-requisites<br/>for the Course:</b>    | Nil                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                               |
| <b>Course<br/>Objectives:</b>                | <ol style="list-style-type: none"> <li>1. To understand the core principles of chemical safety in industrial and academic settings.</li> <li>2. To study national regulatory guidelines (e.g., Factories Act, CPCB, GHS) to lab and industrial environments.</li> <li>3. To develop competencies in hazard identification, risk assessment, and mitigation.</li> <li>4. To examine ethical responsibilities in scientific research and industrial practices.</li> <li>5. To foster a culture of safety, integrity, and sustainability in chemical industries.</li> </ol> |                               |
| <b>Course Outcomes:</b>                      | Students will be able to:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>Mapped to PSO</b>          |
|                                              | CO 1. identify chemical hazards, routes of exposure, and classify substances based on safety standards like GHS and MSDS.                                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>PSO1, PSO2, PSO3, PSO5</b> |
|                                              | CO 2. apply appropriate safety procedures, use of PPE, emergency protocols, and standard operating procedures (SOPs) in chemical laboratories and industrial settings.                                                                                                                                                                                                                                                                                                                                                                                                   | <b>PSO2, PSO3, PSO4, PSO5</b> |

|                  |                                                                                                                                                                                                                                                                                                                                                                                                                                     |                    |                                     |                        |
|------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|-------------------------------------|------------------------|
|                  | CO 3. interpret key Indian safety and environmental regulations (e.g., Factories Act, EPA, CPCB guidelines) and relate them to real-life industry practices.                                                                                                                                                                                                                                                                        |                    | <b>PSO2, PSO3, PSO4, PSO5</b>       |                        |
|                  | CO 4. evaluate ethical issues in research and industrial scenarios involving data integrity, intellectual property, plagiarism, and environmental accountability.                                                                                                                                                                                                                                                                   |                    | <b>PSO3, PSO4, PSO5</b>             |                        |
|                  | CO 5. review basic safety audits, emergency response plans, and ethical frameworks applicable to small-scale chemical setups or research labs.                                                                                                                                                                                                                                                                                      |                    | <b>PSO1, PSO2, PSO3, PSO4, PSO5</b> |                        |
| <b>Content:</b>  |                                                                                                                                                                                                                                                                                                                                                                                                                                     | <b>No of hours</b> | <b>Mapped to CO</b>                 | <b>Cognitive Level</b> |
| <b>Module 1:</b> | <b>Introduction to Industrial Chemical Safety</b><br>Importance of chemical safety in industry vs. academia. Chemical hazard identification and classification (GHS), SDS, Routes of exposure and toxicity levels. Safety culture in chemical industries. Case study: Bhopal Gas Tragedy, Seveso Disaster, Chernobyl disaster, Thiokol-Woodbine explosion, Phillips Disaster, Jilin Chemical explosion – causes and lessons learned | <b>13</b>          | CO1, CO2                            | K1, K2, K3             |
| <b>Module 2:</b> | <b>Laboratory and Industrial Safety Practices</b><br>Personal protective equipment (PPE) and safe work practices. Storage, handling, and segregation of chemicals. Use of engineering controls: ventilation, containment systems. Industrial safety audits and SOPs. Waste management: hazardous waste handling and disposal (CPCB guidelines)                                                                                      | <b>12</b>          | CO1, CO2                            | K1, K2, K3             |
| <b>Module 3:</b> | <b>Legal and Regulatory Framework in India</b><br>Factories Act, Environment Protection Act, Hazardous Waste Rules, Central Pollution Control Board (CPCB) and State Pollution Control Boards (SPCBs). Disaster management and Emergency Response Plans (ERPs). Compliance documentation, licenses, and inspections. Introduction to ISO standards (e.g., ISO 45001, ISO 14001)                                                     | <b>10</b>          | CO3, CO5                            | K1, K2, K3, K4         |
| <b>Module 4:</b> | <b>Ethics and Integrity in Industrial and Research Settings</b><br>Definition and importance of ethics in chemical industries. Responsible conduct of research: data management, intellectual honesty. Ethical issues in product development and environmental impact. Plagiarism, patent ethics, and corporate responsibility.                                                                                                     | <b>15</b>          | CO4, CO5                            | K1, K2, K3, K4, K5     |

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|----------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|---------------------|------------------------------|
|                                  | Whistle-blower protection and reporting channels.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |           |                     |                              |
| <b>Module 5:</b>                 | <b>Ethical Issues and Applied Case Studies</b><br>1. <b>Technological, Environmental and other ethical issues.</b><br>a. Artificial Intelligence in Chemical Processes: Automation, algorithmic bias, ethical concerns in decision-making systems, and data privacy.<br>b. Circular Economy and Chemical Industry: Resource efficiency, waste minimization, and sustainable product design.<br>c. Industry-academia conflicts and collaborative research ethics: Intellectual property rights, authorship disputes, and confidentiality agreements.<br>2. <b>Applied learning activities.</b><br>a. Analyse a major chemical accident or ethical breach. Focus on technical cause, human factors, and ethical failings. Propose alternative actions and preventive strategies.<br>b. Mock Safety Audit and Inspection: Role-play exercise simulating an industrial or academic lab audit. Use of checklists for hazard identification, risk assessment, and ethical compliance review. Emphasis on documentation, communication, and corrective action planning. | <b>10</b> | CO3,<br>CO4,<br>CO5 | K1, K2,<br>K3, K4,<br>K5, K6 |
| <b>Pedagogy:</b>                 | Mostly lectures and tutorials, seminars/term papers/assignments/presentations/self-study or combination of some of these can also be used. ICT mode to be preferred. Peer group presentations on case studies of Real-world disasters may be given for to promote critical analysis. Industry expert talk to be organized. Flipped Classroom Activities may be conducted.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |           |                     |                              |
| <b>Texts:</b>                    | 1. National Research Council (U.S.), Prudent Practices in the Laboratory: Handling and Management of Chemical Hazards, National Academies Press, Washington, D.C., 2011.<br>2. Adil E. Shamoo & David B. Resnik, Responsible Conduct of Research, 3 <sup>rd</sup> Ed, Oxford University Press, New York, 2003                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |           |                     |                              |
| <b>References/<br/>Readings:</b> | 1. Roy E. Sanders, Chemical Process Safety: Learning from Case Histories, 4 <sup>th</sup> Ed, Elsevier, USA, 2015<br>2. Norman V. Steere, Safety in the Chemical Laboratory, Wiley-Interscience, 1996<br>3. Gary Comstock, Research Ethics: A Philosophical Guide to the Responsible Conduct of Research, Latest Ed, Cambridge University Press, Cambridge, 2005.<br>4. Chemical Safety Manual for Small Businesses, International Labour Organization (ILO), 3 <sup>rd</sup> Ed, American Chemical Society, Washington, D. C, 2006.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |           |                     |                              |

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|-----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                       | <p>5. Environment (Protection) Act, 1986 &amp; Hazardous Wastes (Management) Rules, 2016 (India), Commercial Law Publishers (India) Pvt. Ltd., 2016</p> <p>6. C.R. Kothari &amp; Gaurav Garg, Research Methodology: Methods and Techniques, 2<sup>nd</sup> Ed, New Age International, New Delhi, 2019</p> <p>7. P. T. Anastas and J. C. Warner, Green Chemistry, Theory and Practice, Oxford University Press, New York, 1998</p> |
| <b>Web Resources:</b> | <p>Ethics in Research - Miller - Major Reference Works - Wiley Online Library<br/> <a href="https://doi.org/10.1002/9781118445112.stat06666.pub2">https://doi.org/10.1002/9781118445112.stat06666.pub2</a></p>                                                                                                                                                                                                                    |



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|----------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|
| <b>Title of the Course</b>                   | Laboratory Course in Chemical Techniques – I                                                                                                                                                                                            |                         |
| <b>Course Code</b>                           | CIT-5003                                                                                                                                                                                                                                |                         |
| <b>Number of Credits</b>                     | 02                                                                                                                                                                                                                                      |                         |
| <b>Theory/Practical</b>                      | Practical                                                                                                                                                                                                                               |                         |
| <b>Level</b>                                 | 400                                                                                                                                                                                                                                     |                         |
| <b>Effective from AY</b>                     | 2025-2026                                                                                                                                                                                                                               |                         |
| <b>New Course</b>                            | Yes                                                                                                                                                                                                                                     |                         |
| <b>Bridge Course/<br/>Value added Course</b> | No                                                                                                                                                                                                                                      |                         |
| <b>Course for advanced learners</b>          | No                                                                                                                                                                                                                                      |                         |
| <b>Pre-requisites for the Course:</b>        | Nil                                                                                                                                                                                                                                     |                         |
| <b>Course Objectives:</b>                    | 1. To develop experimental skills on industrial laboratory techniques<br>2. To acquire skills for analysing results and data interpretation<br>3. To develop research skills<br>4. To have hands on experience on laboratory techniques |                         |
| <b>Course Outcomes:</b>                      | Students will be able to:                                                                                                                                                                                                               | <b>Mapped to PSO</b>    |
|                                              | CO 1. explain various laboratory techniques.                                                                                                                                                                                            | <b>PSO1, PSO2</b>       |
|                                              | CO 2. select the appropriate analysis techniques in industry.                                                                                                                                                                           | <b>PSO2, PSO3, PSO4</b> |
|                                              | CO 3. examine results and interpret data obtained                                                                                                                                                                                       | <b>PSO3, PSO5</b>       |
|                                              | CO 4. apply chemical techniques for research work.                                                                                                                                                                                      | <b>PSO4, PSO5</b>       |

| Content:         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | No of hours | Mapped to CO                | Cognitive Level   |
|------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|-----------------------------|-------------------|
| <b>Module 1:</b> | <p>Minimum 15 experiments to be performed</p> <p>A) General</p> <ol style="list-style-type: none"> <li>1. Evaluation of weight uniformity, hardness, and thickness of dosing units for the purpose of industrial use.</li> <li>2. Optimization of gel formulation using ternary plot: effect of polymer, plasticizer, and drug ratio.</li> <li>3. To determine the surface tension of aqueous solutions of a surfactant (e.g., sodium dodecyl sulfate, sodium decyl sulfate, hexa decyl pyridinium bromide, carbethopendecinium bromide) at different concentrations and to determine the critical micelle concentration (CMC).</li> <li>4. To study dissolution rate of paracetamol (0.100g, 0.250g, 0.500g, 0.650g Tablets) in water and acids at different temperature.</li> <li>5. To study the kinetics of the acid-catalysed hydrolysis of ethyl acetate by monitoring the change in absorbance of bromophenol blue indicator over time using UV-Vis spectrophotometry at different acid concentration and temperature.</li> <li>6. To analyse Lead in an Industrial sample by using conductometry.</li> <li>7. To evaluate flocculants effectiveness in industrial wastewater treatment (Turbidity and pH measurement).</li> <li>8. To determine the corrosion rate of different metals/alloys (e.g., carbon steel, zinc, copper, iron) of industrial importance in various corrosive media (e.g., acidic solution, salt solution) by measuring the change in mass over a specific period.</li> </ol> <p>B) Organic:</p> <ol style="list-style-type: none"> <li>9. To estimate the amount of Ascorbic Acid present in given pharmaceutical sample. (Redox (Iodometry) Titrimetric Method)</li> <li>10. To estimate the amount of API (e.g. Ibuprofen) present in given pharmaceutical sample. (Neutralization Titrimetric method)</li> </ol> | 60          | CO1,<br>CO2,<br>CO3,<br>CO4 | K1, K2,<br>K3, K4 |

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|                                  | <p>11. Analysis of Analgesics Using High-Performance Liquid Chromatography.</p> <p>12. To extract paracetamol using solvent extraction and analyze it spectrophotometrically.</p> <p>13. To determine Aspirin, Phenacetin and Caffeine in APC Tablets using Solvent Extraction and UV spectroscopy</p> <p>(C) Inorganic</p> <p>14. To analyse Phosphate in soft drinks using Molybdenum Blue Method.</p> <p>15. To estimate the amount of Calcium from calcite (Gravimetrically method)</p> <p>16. To estimate the amount of <math>\text{Al}^{3+}</math> and <math>\text{Mg}^{2+}</math> in antacid tablet by complexometric titration.</p> <p>17. To estimate the amount of iron present in given pharmaceutical sample (Colorimetry).</p>                                                                                                                                                                                                              |  |  |  |
| <b>Pedagogy:</b>                 | Mainly pre-laboratory exercises Seminars/ lab hand-out/self-study/assignments or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |  |  |  |
| <b>Texts:</b>                    | <p>1. J. Mendham, R.C. Jenny, J.D. Barnes, M. J. K. Thomas, Vogel's textbook of Quantitative Chemical Analysis 6<sup>th</sup> Ed.: Pearson Education, New Delhi, 2008.</p> <p>2. G. D. Christian, Analytical Chemistry, 6<sup>th</sup> Ed.; Wiley, USA, 2004.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |  |  |  |
| <b>References/<br/>Readings:</b> | <p>1. G. W. Ewing, Instrumental Methods of Chemical Analysis, 5<sup>th</sup> Ed.; McGraw-Hill Int., New York, 1985.</p> <p>2. D. A. Skoog, D. M. West, F. J. Holler, S. R. Crouch, Fundamentals of Analytical Chemistry, 9<sup>th</sup> Ed.; Cengage learning, USA, 2014.</p> <p>3. F. J. Holler, D. A. Skoog, S. R. Crouch, Principles of Instrumental Analysis, 6<sup>th</sup> Ed.; Thomson Books, USA, 2007.</p> <p>4. G. D. Christian, Analytical Chemistry, 5<sup>th</sup> Ed.; Wiley, USA, 1994.</p> <p>5. S. W. Rajbhoj, T. K. Chondhekar, Systematic Experimental Physical Chemistry, 3<sup>rd</sup> Ed, Anjali Publications, Aurangabad, 2013.</p> <p>6. J. B. Yadav, Advanced Practical Physical Chemistry, 36<sup>th</sup> Ed, Krishna Prakashan Media, Meerut, 2016.</p> <p>7. H. Beckett and J. B. Stenlake, Practical Pharmaceutical Chemistry - Part One and Two, 4<sup>th</sup> Ed. CBS Publishers and Distributors, New Delhi, 1998</p> |  |  |  |

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|----------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|
| <b>Title of the Course</b>                   | Laboratory Course in Chemical Techniques - II                                                                                                                                                                                  |                               |
| <b>Course Code</b>                           | CIT-5004                                                                                                                                                                                                                       |                               |
| <b>Number of Credits</b>                     | 02                                                                                                                                                                                                                             |                               |
| <b>Theory/Practical</b>                      | Practical                                                                                                                                                                                                                      |                               |
| <b>Level</b>                                 | 400                                                                                                                                                                                                                            |                               |
| <b>Effective from AY</b>                     | 2025-2026                                                                                                                                                                                                                      |                               |
| <b>New Course</b>                            | Yes                                                                                                                                                                                                                            |                               |
| <b>Bridge Course/<br/>Value added Course</b> | No                                                                                                                                                                                                                             |                               |
| <b>Course for advanced learners</b>          | No                                                                                                                                                                                                                             |                               |
| <b>Pre-requisites for the Course:</b>        | Nil                                                                                                                                                                                                                            |                               |
| <b>Course Objectives:</b>                    | 1. To develop experimental skills on industrial laboratory techniques<br>2. To acquire skills for analysing results and data interpretation<br>3. To develop research skills<br>4. To apply statistical treatment for the data |                               |
| <b>Course Outcomes:</b>                      | Students will be able to                                                                                                                                                                                                       | <b>Mapped to PSO</b>          |
|                                              | CO 1. explain various laboratory techniques.                                                                                                                                                                                   | <b>PSO1, PSO2, PSO3</b>       |
|                                              | CO 2. apply their knowledge for appropriate analysis in industry.                                                                                                                                                              | <b>PSO1, PSO2, PSO3, PSO4</b> |
|                                              | CO 3. examine results and interpret data obtained                                                                                                                                                                              | <b>PSO1, PSO2, PSO3, PSO4</b> |
|                                              | CO 4. apply their learnings for research work or dissertation.                                                                                                                                                                 | <b>PSO1, PSO2, PSO3, PSO4</b> |

| Content:         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | No of hours | Mapped to CO                | Cognitive Level                       |
|------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|-----------------------------|---------------------------------------|
| <b>Module 1:</b> | <p>Minimum 15 experiments to be performed</p> <p>(I) Analysis and Data interpretation based on UV-Visible spectroscopy:</p> <ol style="list-style-type: none"> <li>1. Determination of absorption curve and concentration of a substance (For colorless and colored samples e.g. nitrate, dichromate, complex, dye. etc.)</li> <li>2. The effect of substituents on the absorption spectrum of benzoic acid.</li> <li>3. Determination of active constituents in a medicinal preparation by derivative spectroscopy.</li> <li>4. Determination of Fe(III) with EDTA.</li> <li>5. Determination of Cu(II) with EDTA</li> </ol> <p>Statistical treatment. Calibration curve, best fitting equation, least square method, correlation, and regression.</p> <p>(II) Data interpretation based on Vibrational spectroscopy: (FTIR and Raman)</p> <ol style="list-style-type: none"> <li>1. Acid, (Benzoic acid, Succinic acid)</li> <li>2. phenol, (2-naphthol, resorcinol)</li> <li>3. ketone, (benzophenone)</li> <li>4. aldehyde, (benzaldehyde )</li> <li>5. amide (e.g. acetamide, urea)</li> </ol> <p>(III) Data interpretation based on NMR studies</p> <ol style="list-style-type: none"> <li>1. organic compounds, H1-NMR, C13-NMR. (e.g. Benzoic acid, p-nitroaniline, Benzil, Ethanol))</li> </ol> <p>(IV) Data interpretation based on Mass spectrometry</p> <ol style="list-style-type: none"> <li>1. organic compounds (e.g. Pentane, Butanal, 3-chloro-2-methyl pentane, 2-Pentanone)</li> </ol> <p>(V) Thermal analysis data of Samples</p> <ol style="list-style-type: none"> <li>1. Oxalates of Mg, Ca, Sr and Ba. hydrated Copper sulfate.</li> </ol> | 60          | CO1,<br>CO2,<br>CO3,<br>CO4 | <b>K1, K2,<br/>K3, K4,<br/>K5, K6</b> |

|                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |  |  |  |
|----------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|--|
|                                  | <p>(VI) XRD interpretation:</p> <p>1. Cubic (Primitive, FCC, and BCC) e.g. Polonium, Aluminium, Chromium; spinel's (<math>\text{ZnFe}_2\text{O}_4</math>) &amp; Tetragonal <math>\text{TiO}_2</math></p> <p>(VII) SEM Analysis:</p> <p>Determination of grain size using SEM image in Histogram</p>                                                                                                                                                                                                                                                                                                                                                                                                                                        |  |  |  |
| <b>Pedagogy:</b>                 | Mainly pre-laboratory exercises Seminars/ lab hand-out/self-study/assignments or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |  |  |  |
| <b>Texts:</b>                    | <p>1. J. Bassett, R.C. Denny, G. H. Jeffery and J. Mendham, "Vogel's Text Book of Quantitative Inorganic Analysis" 5<sup>th</sup> Ed. ELBS, England, 1985.</p> <p>2. R. M. Silverstein and F. X. Webster, Spectrometric Identification of Organic Compounds, 6<sup>th</sup> Ed, Wiley, India, 1997</p>                                                                                                                                                                                                                                                                                                                                                                                                                                     |  |  |  |
| <b>References/<br/>Readings:</b> | <p>1. C. Suryanarayana and M. Grant, X-ray diffraction: A practical Approach, Norton Plenum Press, New York, 1998.</p> <p>2. A. R. West, Solid state chemistry and its applications, John-Wiley and Sons, Chichester 1984.</p> <p>3. G. D. Christian, Analytical Chemistry, 6<sup>th</sup> Ed.; Wiley, India, 2004</p> <p>4. G. W. Ewing, Instrumental Methods of Chemical Analysis, 5<sup>th</sup> Ed.; McGraw-Hill Int., New York, 1985.</p> <p>5. D. A. Skoog, D. M. West, F. J. Holler, S. R. Crouch, Fundamentals of Analytical Chemistry, 9<sup>th</sup> Ed.; Cengage learning, USA, 2014.</p> <p>6. F. J. Holler, D. A. Skoog, S. R. Crouch, Principles of Instrumental Analysis, 6<sup>th</sup> Ed.; Thomson Books, USA, 2007.</p> |  |  |  |

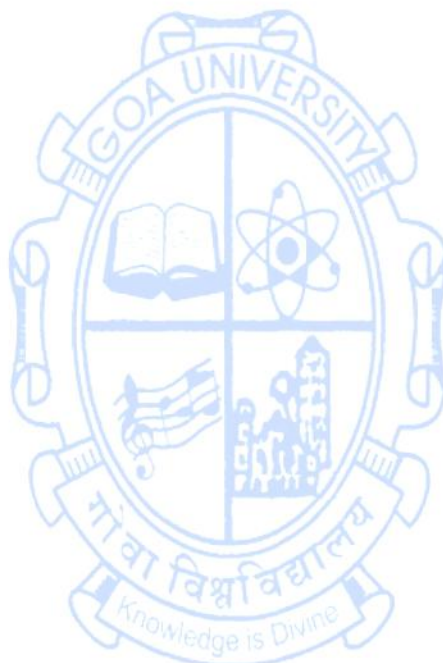
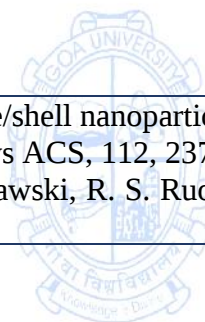
### Discipline Specific Elective Courses

|                                              |                                                                                                                                                                                                                                                                                                                        |                        |
|----------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|
| <b>Title of the Course</b>                   | Concepts in Nanotechnology                                                                                                                                                                                                                                                                                             |                        |
| <b>Course Code</b>                           | CIT-5201                                                                                                                                                                                                                                                                                                               |                        |
| <b>Number of Credits</b>                     | 04                                                                                                                                                                                                                                                                                                                     |                        |
| <b>Theory/Practical</b>                      | Theory                                                                                                                                                                                                                                                                                                                 |                        |
| <b>Level</b>                                 | 400                                                                                                                                                                                                                                                                                                                    |                        |
| <b>Effective from AY</b>                     | 2025-2026                                                                                                                                                                                                                                                                                                              |                        |
| <b>New Course</b>                            | Yes                                                                                                                                                                                                                                                                                                                    |                        |
| <b>Bridge Course/<br/>Value added Course</b> | No                                                                                                                                                                                                                                                                                                                     |                        |
| <b>Course for advanced learners</b>          | No                                                                                                                                                                                                                                                                                                                     |                        |
| <b>Pre-requisites for the Course:</b>        | Nil                                                                                                                                                                                                                                                                                                                    |                        |
| <b>Course Objectives:</b>                    | <ol style="list-style-type: none"> <li>1. To introduce the fundamental concepts of nanotechnology.</li> <li>2. To understand types, synthesis and characterization of nanomaterials.</li> <li>3. To understand the properties of nanomaterials.</li> <li>4. To highlight the applications of nanomaterials.</li> </ol> |                        |
| <b>Course Outcomes:</b>                      | Students will be able to:                                                                                                                                                                                                                                                                                              | <b>Mapped to PSO</b>   |
|                                              | CO1: explain the basic principles of nanotechnology and types of nanomaterials.                                                                                                                                                                                                                                        | PSO1, PSO2, PSO3, PSO4 |
|                                              | CO2: compare common synthesis and characterization techniques of nanomaterials.                                                                                                                                                                                                                                        | PSO1, PSO2, PSO3, PSO4 |
|                                              | CO3: correlate the properties of nanomaterials.                                                                                                                                                                                                                                                                        | PSO1, PSO2, PSO3, PSO4 |

|                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                    |                              |                           |
|------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|------------------------------|---------------------------|
|                  | CO4: recognize practical applications of nanomaterials in industries.                                                                                                                                                                                                                                                                                                                                                                                            |                    | PSO1, PSO2, PSO3, PSO4, PSO5 |                           |
| <b>Content:</b>  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>No of hours</b> | <b>Mapped to CO</b>          | <b>Cognitive Level</b>    |
| <b>Module 1:</b> | <b>Introduction to Nanomaterials</b><br>Definition, scope, and importance of nanotechnology, Nanoscale effects and size-dependent properties, Historical development and global progress in nanotechnology, Industrial relevance and market overview.                                                                                                                                                                                                            | <b>6</b>           | CO1                          | <b>K1, K2, K3, K4, K5</b> |
| <b>Module 2:</b> | <b>Classification of Nanomaterials</b><br>Types of Nanomaterials: OD, 1D, 2D nanomaterials with their examples, Delocalization axis, Confinement axis.<br>Carbon-based nanomaterials: Fullerenes, carbon nanotubes, graphene, Metal and metal oxide-based nanoparticles: Silver, Gold, ZnO, TiO <sub>2</sub> , Fe <sub>3</sub> O <sub>4</sub> , Quantum dots.                                                                                                    | <b>12</b>          | CO1                          | <b>K1, K2, K3, K4, K5</b> |
| <b>Module 3:</b> | <b>Synthesis Techniques of Nanomaterials</b><br>Top-down approaches: mechanical milling, lithography (overview), Bottom-up approaches: sol-gel, co-precipitation, hydrothermal methods, green synthesis: plant-based and sustainable methods, Factors influencing synthesis: temperature, pH, surfactants, capping agents, Industrial-scale synthesis: batch vs. continuous flow methods, Case studies: synthesis of ZnO, Ag, and TiO <sub>2</sub> nanoparticles | <b>14</b>          | CO2                          | <b>K1, K2, K3, K4, K5</b> |
| <b>Module 4:</b> | <b>Characterization Techniques of Nanomaterials</b><br>Electron microscopy: TEM – principle, sample preparation, Spectroscopy: UV-DRS, UV-Vis. Interpretation of Spectra.<br>PXRD – interpretation of Diffractogram, crystallinity, Crystallite size, Particle size analysis, BET surface area measurement, Practical interpretation of data with example of cubic system.                                                                                       | <b>12</b>          | CO2                          | <b>K1, K2, K3, K4, K5</b> |
| <b>Module 5:</b> | <b>Applications of Nanomaterials in Industry</b><br>Use in catalysis: nano-gold in epoxidation reaction, Pt catalysts in CO-NO redox reaction, Paints and coatings: Nano Al <sub>2</sub> O <sub>3</sub> in anti-corrosion, Carbon nanoparticles                                                                                                                                                                                                                  | <b>12</b>          | CO3, CO4                     | <b>K1, K2, K3, K4, K5</b> |

|                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |          |                    |                            |
|------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|--------------------|----------------------------|
|                              | in UV Protection, Nano zeolites in water treatment, Metal Nanoparticles (Ag, Cu, Au NPs) in conductive inks and printable electronics.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |          |                    |                            |
| <b>Module 6:</b>             | <b>Case Studies of Nanomaterials:</b> i) Graphene oxide: Structure, preparation strategies and applications.<br>ii) Fe <sub>3</sub> O <sub>4</sub> -Silica core-shell nanomaterials: Structure, preparation strategies and applications.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>4</b> | CO1, CO2, CO3, CO4 | <b>K1, K2, K3, K4, K5,</b> |
| <b>Pedagogy:</b>             | Mostly lectures and tutorials, seminars/term papers/assignments/presentations/self-study or combination of some of these can also be used. ICT mode to be preferred.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |          |                    |                            |
| <b>Texts:</b>                | <ol style="list-style-type: none"> <li>1. S.K. Kulkarni, Nanotechnology: Principles and Practices, 3<sup>rd</sup> Ed., Springer, New Delhi, India, 2015.</li> <li>2. C. N. R. Rao, A. Müller, A.K. Cheetham, The Chemistry of Nanomaterials: Synthesis, Properties and Applications (Vols. 1 &amp; 2), 1<sup>st</sup> Ed., Wiley, VCH, Weinheim, Germany, 2004</li> <li>3. U. Schubert, N. Husing, Synthesis of Inorganic Materials, 4<sup>th</sup> Ed., Wiley, VCH, Weinheim, Germany, 2019.</li> <li>4. G.D. Christian, Analytical Chemistry, 6<sup>th</sup> Ed., John Wiley &amp; Sons, Hoboken, New Jersey/New York, USA, 2003.</li> <li>5. L. Cademartiri, G.A. Ozin, Nanochemistry: A chemical approach to nanomaterials, 2<sup>nd</sup> Ed., Royal Society of Chemistry, Cambridge, UK, 2008.</li> </ol>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |          |                    |                            |
| <b>References/ Readings:</b> | <ol style="list-style-type: none"> <li>1. D. Vollath, Nanomaterials: An introduction to Synthesis, Properties and Applications, 2<sup>nd</sup> Ed., Wiley, VCH, Weinheim, Germany, 2013.</li> <li>2. D. Astruc (Ed.). Nanoparticles and Catalysis, 1<sup>st</sup> Ed., Wiley, VCH, Weinheim, Germany, 2008.</li> <li>3. M.D. Doganci and H. Sevinc, Investigation of Superhydrophobic and Anticorrosive Epoxy Films with Al<sub>2</sub>O<sub>3</sub> Nanoparticles on Different Surfaces, ACS Omega, 8, 24, 21559-2157, 2023.</li> <li>4. M. R. F. Silva, M.F.R.P Alves, M.H. Fernandes, P.M. Vilarinho, P. Ferreira, Carbon Quantum Dot-Based UV-Protective Coatings, Materials Proceedings, 8(1), 106, 2022.</li> <li>5. C. Casiraghi, O. D. Jurchescu, S. Magdassi and W. Su, Introduction to nanomaterials for printed electronics, Nanoscale, 15, 10480-10483, 2023.</li> <li>6. Rehab O. Abdel Rahman, A. M. El-Kamash and Yung-Tse Hung, Applications of Nano-Zeolite in Wastewater Treatment: An Overview, Water, 14(2), 137, 2022.</li> <li>7. R.B. Gupta, &amp; U.B. Kompella, Nanoparticle Technology for Drug Delivery, 1<sup>st</sup> Ed., Taylor &amp; Francis, New York, 2006.</li> <li>8. C. Brechignac P. Houdy and M. Lahmani, Nanomaterials and Nanochemistry, 1<sup>st</sup> Ed., Springer, Berlin and Heidelberg, Germany, 2006.</li> </ol> |          |                    |                            |

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|  | <p>9. R.G. Chaudhuri and S. Paria. Core/shell nanoparticles: classes, properties, synthesis mechanisms, characterization, and applications, Chemical reviews ACS, 112, 2373-2433, 2012.</p> <p>10. D. R. Dreyer, S. Park, C. W. Bielawski, R. S. Ruoff, The chemistry of graphene oxide, Chem. Soc. Rev. 39, 228-240, 2010.</p> |
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|------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|
| <b>Title of the Course</b>               | Materials in Chemical Industries                                                                                                                                                                                                                                                       |                         |
| <b>Course Code</b>                       | CIT-5202                                                                                                                                                                                                                                                                               |                         |
| <b>Number of Credits</b>                 | 04                                                                                                                                                                                                                                                                                     |                         |
| <b>Theory/Practical</b>                  | Theory                                                                                                                                                                                                                                                                                 |                         |
| <b>Level</b>                             | 400                                                                                                                                                                                                                                                                                    |                         |
| <b>Effective from AY</b>                 | 2025-2026                                                                                                                                                                                                                                                                              |                         |
| <b>New Course</b>                        | Yes                                                                                                                                                                                                                                                                                    |                         |
| <b>Bridge Course/ Value added Course</b> | No                                                                                                                                                                                                                                                                                     |                         |
| <b>Course for advanced learners</b>      | No                                                                                                                                                                                                                                                                                     |                         |
| <b>Pre-requisites for the Course:</b>    | Nil                                                                                                                                                                                                                                                                                    |                         |
| <b>Course Objectives:</b>                | 1. To introduce the fundamentals of materials and their classification.<br>2. To understand the various methods of material preparation<br>3. To understand the properties and applications of materials.<br>4. To explain the sustainability of materials in industrial environments. |                         |
| <b>Course Outcomes:</b>                  | Students will be able to:                                                                                                                                                                                                                                                              | <b>Mapped to PSO</b>    |
|                                          | CO 1. classify materials and explain their core properties.                                                                                                                                                                                                                            | <b>PSO1, PSO2</b>       |
|                                          | CO 2. describe preparation methods of materials used in industries.                                                                                                                                                                                                                    | <b>PSO3, PSO4</b>       |
|                                          | CO 3. explain the basic properties of various materials and their applications.                                                                                                                                                                                                        | <b>PSO1, PSO4</b>       |
|                                          | CO 4. plan a strategy to prevent material degradations and preventive measures.                                                                                                                                                                                                        | <b>PSO3, PSO4, PSO5</b> |

| Content:         |                                                                                                                                                                                                                                                                                                                                                                                                                                   | No of hours | Mapped to CO  | Cognitive Level    |
|------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|---------------|--------------------|
| <b>Module 1:</b> | <b>Fundamentals of Materials Chemistry</b><br>Classification of materials: metals, ceramics, polymers, composites, semiconductors, Covalent solids, Ionic solids, Metallic solids and structural types: amorphous vs crystalline materials, Structure-property relationship                                                                                                                                                       | 8           | CO1           | K1, K2, K3, K4, K5 |
| <b>Module 2:</b> | <b>Inorganic and Metallic Materials</b><br>Metals and alloys: classification, industrial properties (iron, steel, aluminium alloys), Heat treatment and strengthening mechanisms, Refractory materials: classification, synthesis, uses in chemical furnaces, Glass and ceramics: structure, fabrication, industrial uses (borosilicate, alumina ceramics), Industrial case studies: steel industries, foundries, cement industry | 12          | CO2, CO3, CO4 | K1, K2, K3, K4, K5 |
| <b>Module 3:</b> | <b>Organic and Polymeric Materials</b><br>Thermoplastics vs thermosets, Industrial polymers: polyethylene, polypropylene, PVC, PTFE, epoxy resins, Rubber and elastomers: natural and synthetic (SBR, NBR), Industrial applications: coatings, insulation, adhesives, packaging materials.                                                                                                                                        | 10          | CO2, CO3, CO4 | K1, K2, K3, K4, K5 |
| <b>Module 4:</b> | <b>Composite and Hybrid Materials</b><br>Concept of composites, Matrix and reinforcement types, Polymer matrix composites (PMCs), Metal matrix composites (MMCs), Ceramic matrix composites (CMCs), Applications in automotive, aerospace, chemical tanks, piping Nanocomposites (basic introduction)                                                                                                                             | 8           | CO2, CO3, CO4 | K1, K2, K3, K4, K5 |
| <b>Module 5:</b> | <b>Electronic and Functional Materials</b><br>Conductors, semiconductors, insulators – band theory overview, Materials for electronics: Silicon, GaAs, graphite, graphene, Organic conducting polymers- Polyaniline (PANI), Polypyrrole (PPy). Introductory concepts of Piezoelectric, magnetic, and thermoelectric materials & their applications.                                                                               | 8           | CO2, CO3, CO4 | K1, K2, K3, K4, K5 |
| <b>Module 6:</b> | <b>Materials Degradation, Corrosion and Protection</b>                                                                                                                                                                                                                                                                                                                                                                            | 8           | CO2, CO3,     | K1, K2, K3, K4,    |

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|                                  | Types of corrosion: uniform, galvanic, pitting, intergranular, Factors affecting corrosion, Corrosion control methods: coatings, cathodic protection, inhibitors, Industrial examples: pipelines, reactors, marine environments                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |   | CO4                 | K5                        |
| <b>Module 7:</b>                 | <b>Sustainable Materials and Green Chemistry in Material Design</b><br>Introduction to green materials and eco-friendly polymers, Waste minimization, Bio-based and biodegradable materials, Sustainable practices in the chemical and materials industries                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 6 | CO2,<br>CO3,<br>CO4 | K1, K2,<br>K3, K4,<br>K5, |
| <b>Pedagogy:</b>                 | Mostly lectures and tutorials, seminars/term papers/assignments/presentations/self-study or combination of some of these can also be used. ICT mode to be preferred.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |   |                     |                           |
| <b>Texts:</b>                    | <ol style="list-style-type: none"> <li>1. U. Schubert, N. Husing, Synthesis of Inorganic Materials, 4<sup>th</sup> Ed., Wiley, VCH, Weinheim, Germany, 2019.</li> <li>2. A.R. West, Solid-State Chemistry and Its Applications, 1<sup>st</sup> Ed., (Reprinted 2007) John Wiley &amp; Sons, West Sussex, England, 1984.</li> <li>3. L.E. Smart, E. Moore, Solid State Chemistry: An Introduction, 4<sup>th</sup> Ed., CRC Press-Taylor &amp; Francis Group, Boca Raton, Florida, USA, 2012.</li> </ol>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |   |                     |                           |
| <b>References/<br/>Readings:</b> | <ol style="list-style-type: none"> <li>1. B.S. Bahl &amp; A. Bahl, Advanced Organic Chemistry, Revised Ed, S. Chand &amp; Co., New Delhi, India, 2012.</li> <li>2. S.L. Kakani &amp; A. Kakani, Material Science, 2<sup>nd</sup> Revised Ed., New Age International Publishers, New Delhi, India, 2011.</li> <li>3. V. Raghavan, Materials Science and Engineering, 6<sup>th</sup> Ed., PHI Learning Pvt. Ltd., New Delhi, India, 2015.</li> <li>4. W.D. Callister &amp; D.G. Rethwisch, Materials Science and Engineering: An Introduction, 9<sup>th</sup> Ed., Wiley India Pvt. Ltd., New Delhi, India, 2018.</li> <li>5. S.K. Sharma, Green Chemistry for Environmental Sustainability, 1<sup>st</sup> Ed., CRC Press, Taylor &amp; Francis Group, Boca Raton, Florida, USA, 2011.</li> <li>6. K.M. Gupta, Engineering Materials: Research, Applications and Advances, 1<sup>st</sup> Ed., CRC Press, Boca Raton, Florida, USA, 2020.</li> <li>7. C.N.R Rao, &amp; Gopalkrishnan, New directions in solid state chemistry, 2<sup>nd</sup> Ed., Cambridge University Press, Cambridge, 1997.</li> </ol> |   |                     |                           |

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| <b>Title of the Course</b>                   | Modern Characterization Techniques                                                                                                                                                                                                                                                 |                               |
| <b>Course Code</b>                           | CIT-5203                                                                                                                                                                                                                                                                           |                               |
| <b>Number of Credits</b>                     | 04                                                                                                                                                                                                                                                                                 |                               |
| <b>Theory/Practical</b>                      | Theory                                                                                                                                                                                                                                                                             |                               |
| <b>Level</b>                                 | 400                                                                                                                                                                                                                                                                                |                               |
| <b>Effective from AY</b>                     | 2025-2026                                                                                                                                                                                                                                                                          |                               |
| <b>New Course</b>                            | Yes                                                                                                                                                                                                                                                                                |                               |
| <b>Bridge Course/<br/>Value added Course</b> | No                                                                                                                                                                                                                                                                                 |                               |
| <b>Course for advanced learners</b>          | No                                                                                                                                                                                                                                                                                 |                               |
| <b>Pre-requisites for the Course:</b>        | Nil                                                                                                                                                                                                                                                                                |                               |
| <b>Course Objectives:</b>                    | 1. To Understand the principles underlying each analytical technique<br>2. To Impart fundamental and advanced knowledge of modern instrumental methods.<br>3. To Enhance skills in characterizing and data interpretation for the analysis.<br>4. To study interpretation of data. |                               |
| <b>Course Outcomes:</b>                      | Students will be able to:                                                                                                                                                                                                                                                          | <b>Mapped to PSO</b>          |
|                                              | CO 1. explain different analytical techniques                                                                                                                                                                                                                                      | <b>PSO1, PSO2, PSO3, PSO4</b> |
|                                              | CO 2. select the type of techniques used for characterization                                                                                                                                                                                                                      | <b>PSO1, PSO2, PSO3, PSO4</b> |
|                                              | CO 3. investigate and solve the structure based on the analytical data                                                                                                                                                                                                             | <b>PSO1, PSO2, PSO3, PSO4</b> |
|                                              | CO 4. evaluate the data based on the techniques employed.                                                                                                                                                                                                                          | <b>PSO1, PSO2, PSO3, PSO4</b> |

| Content:         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | No of hours | Mapped to CO       | Cognitive Level     |
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| <b>Module 1:</b> | <b>Ultraviolet and visible Spectroscopy</b><br>Woodward-Fieser Rules (Calculation of UV absorption wavelength)<br>Applications of Electronic Spectroscopy- Conjugated Dienes, Trienes, polyenes, $\alpha$ , $\beta$ - unsaturated carbonyl compounds, aromatic hydrocarbons.<br>Presentation of spectral data; spectrophotometric titrations; applications-                                                                                                                                                                                                                                                        | 5           | CO1, CO2, CO3, CO4 | K1, K2, K3, K4, K5  |
| <b>Module 2:</b> | <b>Vibrational Spectroscopy:</b> IR and Raman<br>Characteristic vibrational frequencies of various functional groups and frequency shifts associate with structural changes                                                                                                                                                                                                                                                                                                                                                                                                                                        | 10          | CO1, CO2, CO3, CO4 | K1, K2, K3, K4, K5  |
| <b>Module 3:</b> | <b>Polarimetry and Chiroptical Spectroscopy:</b> Introduction; plane polarized light; optical activity; theory of optical activity; applications of optical activity; polarimeter- principle; instrumentation; optical rotatory dispersion (ORD), plan curves; cotton effect curves; application of optical rotation method in rate constant determination; acid- catalyzed muta rotation of glucose; inversion of cane sugar; relative strengths of acids; circular dichroism and its applications; selection rules; deduction of absolute configuration of molecules; octant rule for ketones and cotton effect; | 10          | CO1, CO2, CO3, CO4 | K1, K2, K3, K4, K5  |
| <b>Module 4:</b> | <b>Diffraction techniques:</b> Bragg's law, Single crystal diffraction, Determining lattice parameters accurately, Relationship between crystalline structure and X-ray data, Powder diffraction, Phase identification, Oriented (or textured) samples.<br>Types of unit cells and their characteristics. Lattice parameter determination: cubic structure, tetragonal structure, hexagonal structure.                                                                                                                                                                                                             | 10          | CO1, CO2, CO3, CO4 | K1, K2, K3, K4, K5  |
| <b>Module 5:</b> | <b>Thermal Analysis:</b> TG-DTA and TG-DSC, inorganic compounds and pharmaceuticals: polymorph and pseudo polymorphs                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 7           | CO1, CO2, CO3, CO4 | K1, K2, K3, K4, K5, |

|                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |           |                    |                     |
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| <b>Module 6:</b>             | <b>Mass spectrometry:</b> Ionisation of a Molecule on Electron Impact (EI)- Presentation of the Molecular Ion , Molecular Weights of Organic Compounds The Molecular Ion and Its Intensity, The Base Peak -The Mass Spectrum- Ratio of Mass to Charge (m/z)- Breakage of Molecular Ion , Detection of the Isotopes of the Elements and the Recognition of Molecular Ion Peak - Use of Heavier Isotope Peaks , Instrumentation-The Mass Spectrometer , Fragmentation -A General View , Recognition of the Molecular Ion and the Index of Hydrogen Deficiency , Molecular Weight-Molecular Formula- High Resolution Mass Spectrometry, General Appearance of Mass Spectrum, Nature of the Compound and Metastable Ions , Fragmentation and Mass Spectra of Classes of Organic Compounds , Gas Chromatography-Mass Spectrometry (GC/MS). | <b>10</b> | CO1, CO2, CO3, CO4 | K1, K2, K3, K4, K5, |
| <b>Module 7:</b>             | <b>Surface and Particle size measurement:</b> BET, SEM-EDX.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <b>8</b>  | CO1, CO2, CO3, CO4 | K1, K2, K3, K4, K5  |
| <b>Pedagogy:</b>             | Mostly lectures and tutorials, seminars/term papers/assignments/presentations/self-study or combination of some of these can also be used. ICT mode to be preferred.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |           |                    |                     |
| <b>Texts:</b>                | <ol style="list-style-type: none"> <li>1. R. M. Silverstein and F. X. Webster, Spectrometric Identification of Organic Compounds, 6<sup>th</sup> Ed, Wiley, India, 1997</li> <li>2. G. W. Ewing, Instrumental Methods of Chemical Analysis, 5<sup>th</sup> Ed.; McGraw-Hill Int., New York, 1985.</li> <li>3. P.S. Kalsi, Spectroscopy of Organic Compounds, 7<sup>th</sup> Ed, New Age International, New Delhi, 2016</li> <li>4. A. R. West, Solid state chemistry and its applications, John-Wiley and Sons, Chichester 1984.</li> <li>5. J. Bassett, R.C. Denny, G. H. Jeffery and J. Mendham, “Vogel’s Text Book of Quantitative Inorganic Analysis” 5<sup>th</sup> Ed. ELBS, England, 1985</li> </ol>                                                                                                                           |           |                    |                     |
| <b>References/ Readings:</b> | <ol style="list-style-type: none"> <li>1. N. Banwell and E. M. McCash, Fundamentals of Molecular Spectroscopy, 4<sup>th</sup> Ed., Tata McGraw Hill, New Delhi 1994</li> <li>2. William Kemp, Organic Spectroscopy, 3<sup>rd</sup> Ed, Palgrave, London, 1991</li> </ol>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |           |                    |                     |

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|----------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|
| <b>Title of the Course</b>                   | Fundamentals of Industrial Catalysis                                                                                                                                                                                                                                                                 |                               |
| <b>Course Code</b>                           | CIT-5204                                                                                                                                                                                                                                                                                             |                               |
| <b>Number of Credits</b>                     | 04                                                                                                                                                                                                                                                                                                   |                               |
| <b>Theory/Practical</b>                      | Theory                                                                                                                                                                                                                                                                                               |                               |
| <b>Level</b>                                 | 400                                                                                                                                                                                                                                                                                                  |                               |
| <b>Effective from AY</b>                     | 2025-2026                                                                                                                                                                                                                                                                                            |                               |
| <b>New Course</b>                            | Yes                                                                                                                                                                                                                                                                                                  |                               |
| <b>Bridge Course/<br/>Value added Course</b> | No                                                                                                                                                                                                                                                                                                   |                               |
| <b>Course for advanced learners</b>          | No                                                                                                                                                                                                                                                                                                   |                               |
| <b>Pre-requisites for the Course:</b>        | Nil                                                                                                                                                                                                                                                                                                  |                               |
| <b>Course Objectives:</b>                    | 1. To understand the importance of catalysis in industrial processes.<br>2. To learn about homogeneous and heterogeneous catalysis.<br>3. To study the applications of catalysis in various industrial processes.<br>4. To understand the role of catalysis in energy and environmental remediation. |                               |
| <b>Course Outcomes:</b>                      | Students will be able to:                                                                                                                                                                                                                                                                            | <b>Mapped to PSO</b>          |
|                                              | CO 1. explain the utility of catalysis in sustainable industrial processes.                                                                                                                                                                                                                          | <b>PSO1, PSO2, PSO3, PSO4</b> |
|                                              | CO 2. identify different types of catalysts and their applications.                                                                                                                                                                                                                                  | <b>PSO1, PSO2, PSO3, PSO4</b> |
|                                              | CO 3. describe the role of catalysts in various industrial processes.                                                                                                                                                                                                                                | <b>PSO1, PSO3, PSO4, PSO5</b> |
|                                              | CO 4. plan the role of catalysis in energy and environmental remediation.                                                                                                                                                                                                                            | <b>PSO2, PSO3, PSO4</b>       |

| Content:         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | No of hours | Mapped to CO       | Cognitive Level    |
|------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|--------------------|--------------------|
| <b>Module 1:</b> | <p><b>Introduction to Industrial Catalysis</b><br/>           Definition, types and industrial significance of catalysis,<br/>           Importance of catalysis, Role of catalysts in lowering activation energy of reactions, Contribution to energy efficiency and sustainability<br/>           Types and characteristics of catalysis: homogeneous, heterogeneous, and enzymatic with basic examples.<br/>           Overview and catalysts used in Haber–Bosch Process, Catalytic Cracking, and biodiesel production.<br/>           Catalyst performance metrics:<br/>           Activity, selectivity, stability, Turnover Number (TON), Turnover Frequency (TOF), Concepts of deactivation and regeneration<br/>           Catalyst characterization techniques:<br/>           Importance of catalysts characterizations, Broad overview of applications and outcomes of characterization techniques such as: BET method for surface area, vibrational spectroscopy, Temperature programmed desorption.</p> | 25          | CO1, CO2, CO3, CO4 | K1, K2, K3, K4, K5 |
| <b>Module 2:</b> | <p><b>Homogeneous Catalysis in industries</b><br/>           Types of homogeneous catalysts: Organometallic, coordination compounds.<br/>           Overview of catalysts used and processes of: Hydroformylation, Monsanto acetic acid process, Wacker process, Alkene metathesis, Wilkinson’s catalysis, Important challenges in industrial homogeneous catalysis such as Catalyst Separation, Recovery, Deactivation.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 10          | CO1, CO2, CO3, CO4 | K1, K2, K3, K4, K5 |
| <b>Module 3:</b> | <p><b>Heterogeneous Catalysis in industries</b><br/>           Types of heterogeneous catalysts: Metals, Metal oxides, Zeolites, General mechanisms of heterogeneous catalysis such as Langmuir-Hinshelwood, Eley-Rideal, Mars Van Krevlen.<br/>           Overview of catalysts used and processes of: Contact Process, Three-Way</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 15          | CO1, CO2, CO3, CO4 | K1, K2, K3, K4, K5 |

|                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |   |                    |                    |
|------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|--------------------|--------------------|
|                              | Catalytic Converters, Fischer–Tropsch Synthesis, Styrene production, Hydrogenation of vegetable oils. Challenges in industrial heterogeneous catalysis: poisoning, sintering, leaching, catalyst selectivity, catalyst preparation and reproducibility.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |   |                    |                    |
| <b>Module 4:</b>             | <b>Polymerization, Phase transfer Catalysis (PTC) and Photo catalysis</b><br>Homogeneous and Heterogeneous Catalysis in polymerization, Ziegler-Natta catalysis, Photosensitized reactions, Semiconductor photo catalysis, Photo degradation of dyes and drugs.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 5 | CO1, CO2, CO3, CO4 | K1, K2, K3, K4, K5 |
| <b>Module 5:</b>             | <b>Catalyst for Energy and Environment</b><br>Fuel cells for energy production (DMFC, DMCFC, SOFC), Catalysis in sustainable energy and environmental remediation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 5 | CO1, CO2, CO3, CO4 | K1, K2, K3, K4, K5 |
| <b>Pedagogy:</b>             | Mostly lectures and tutorials, seminars/term papers/assignments/presentations/self-study or combination of some of these can also be used. ICT mode to be preferred.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |   |                    |                    |
| <b>Texts:</b>                | <ol style="list-style-type: none"> <li>1. B. Viswanathan, Catalysis: Principles and Applications, 1<sup>st</sup> Ed., Narosa Publishing House, New Delhi, India, 2002.</li> <li>2. A.V. Salker, Catalysis: Principles and Basic Concepts, 1<sup>st</sup> Ed., Scientific International, New Delhi, India, 2019.</li> <li>3. D. K. Chakraborty, Adsorption and Catalysis by Solids, 1<sup>st</sup> Ed., New Age International (P) Ltd., Publishers, New Delhi, India, 2008.</li> <li>4. D. K. Chakraborty, B. Viswanathan B, Heterogeneous catalysis, 1<sup>st</sup> ed., New Age International (P) Ltd., New Delhi-India, 1997.</li> <li>5. J. E. Huheey, E. A. Keiter, R. L. Keiter, Inorganic Chemistry: Principles of Structure and Reactivity, 5<sup>th</sup> Ed, Pearson Education (Addison Wesley Publishing), New Delhi, India, 2006.</li> </ol> |   |                    |                    |
| <b>References/ Readings:</b> | <ol style="list-style-type: none"> <li>1. S.S. Dara and S.S. Umare, Textbook of Engineering Chemistry, 12<sup>th</sup> Revised Ed., S. Chand Publishing, New Delhi, India, 2022.</li> <li>2. P.C. Jain and M. Jain, Engineering Chemistry, 16<sup>th</sup> Ed., Dhanpat Rai Publishing Company, New Delhi, India, 2015.</li> <li>3. J.E Speight, Handbook of Petrochemical Processes, 2<sup>nd</sup> Ed., Taylor and Francis group, Boca Raton, Florida, USA, 2019.</li> </ol>                                                                                                                                                                                                                                                                                                                                                                          |   |                    |                    |

## SEMESTER II

### Discipline Specific Core Courses

|                                              |                                               |
|----------------------------------------------|-----------------------------------------------|
| <b>Title of the Course</b>                   | Data analysis & Analytical Method Development |
| <b>Course Code</b>                           | CIT-5005                                      |
| <b>Number of Credits</b>                     | 04                                            |
| <b>Theory/Practical</b>                      | Theory                                        |
| <b>Level</b>                                 | 500                                           |
| <b>Effective from AY</b>                     | 2025-2026                                     |
| <b>New Course</b>                            | Yes                                           |
| <b>Bridge Course/<br/>Value added Course</b> | No                                            |
| <b>Course for advanced learners</b>          | No                                            |

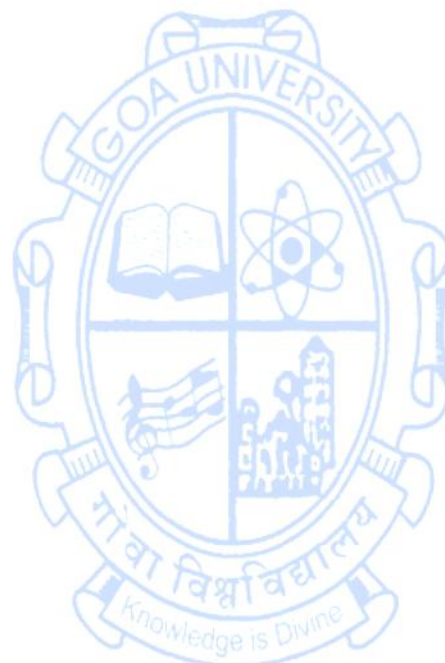
|                                       |                                                                                                                                                                                                                                                                                                                                                                                                       |                         |
|---------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|
| <b>Pre-requisites for the Course:</b> | Nil                                                                                                                                                                                                                                                                                                                                                                                                   |                         |
| <b>Course Objectives:</b>             | <ol style="list-style-type: none"> <li>1. To understand the principles of data analysis and method development in the chemical industry.</li> <li>2. To learn to design and develop analytical methods for chemical analysis.</li> <li>3. To understand method validation and quality control in the chemical industry.</li> <li>4. To analyse and interpret data using statistical tools.</li> </ol> |                         |
| <b>Course Outcomes:</b>               | Students will be able to                                                                                                                                                                                                                                                                                                                                                                              | <b>Mapped to PSO</b>    |
|                                       | CO 1. explain the data analysis and method development in the chemical industry.                                                                                                                                                                                                                                                                                                                      | <b>PSO1, PSO2, PSO3</b> |
|                                       | CO 2. compare Quality Systems in different industries                                                                                                                                                                                                                                                                                                                                                 | <b>PSO2</b>             |

|                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                    |                     |                        |
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|                  | CO 3. make use of the knowledge in report writing and presentation of results.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                    | PSO4                |                        |
|                  | CO 4. analyze real world examples of data analysis and method development in the chemical industry                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                    | PSO1                |                        |
|                  | CO 5. use experimental design for robust and optimized method development.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                    | PSO4, PSO5          |                        |
|                  | CO 6. validate analytical methods using ICH and pharmacopeial guidelines.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                    | PSO3, PSO4          |                        |
| <b>Content:</b>  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | <b>No of hours</b> | <b>Mapped to CO</b> | <b>Cognitive Level</b> |
| <b>Module 1:</b> | <b>Introduction to Data Analysis and Method Development</b><br>Overview of data analysis and method development in the chemical industry. Importance of data quality and method validation. Introduction to GLP and GMP: History, Scope, and Importance. Regulatory Framework: FDA, WHO, ICH, OECD Guidelines. Principles of GLP: Study Planning, Conduct, Reporting, and Archiving. GMP Essentials: Production Processes, Quality Control, and Risk Management. Documentation and Record-Keeping in GLP and GMP. Compliance Audits and Inspections: Preparation and Response. Case Studies: GLP/GMP Implementation in Pharma, Agrochemical, and Fine Chemical Industries.                                                                                                                                                                                                                                                                                 | 15                 | CO1                 | K1, K2                 |
| <b>Module 2:</b> | <b>Analytical Method Development</b><br>Importance and objectives of analytical method development, role in drug discovery, formulation, and quality control, regulatory requirements (ICH, USP, FDA, EMA guidelines), Principles of method development. Method optimization.<br>Method Validation (As per ICH Q2 Guidelines): Definition and need for validation, parameters: specificity & selectivity, linearity & range, accuracy, precision (repeatability, intermediate precision and reproducibility). Limit of Detection (LOD) & Limit of Quantitation (LOQ). Robustness & ruggedness. System Suitability Testing. Method development report preparation, Regulatory submissions (NDA, ANDA), Compliance with pharmacopoeias (USP, IP, BP, EP), Method development for Assay of bulk drugs and formulations, Impurity profiling and Residual solvents analysis.<br>Case studies: Assay and impurity profiling of Active Pharmaceutical Ingredients | 15                 | CO1                 | K1, K2, K3             |

|                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |           |          |                           |
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|                              | (APIs) in Pharmaceutical / Fine Chemicals, Detection of additives, preservatives, and contaminants in Food & Beverage Industry (Overlapping with Chemicals).                                                                                                                                                                                                                                                                                                                                                                                                                               |           |          |                           |
| <b>Module 3:</b>             | <b>Quality Control and Assurance</b><br>Fundamentals of Quality Systems: Definitions and Scope. Quality Control Processes: Sampling, Testing, and Reporting. Quality Assurance Practices: Internal Audits, CAPA, and Documentation. Statistical Quality Control (SQC) and Data Analysis. Out-of-Specification (OOS) and Out-of-Trend (OOT) Investigations. Stability Studies and Shelf-Life Determination. ICH Guidelines on Quality (Q-Series). Case Studies: QC and QA Challenges in Different Industries.                                                                               | <b>20</b> | CO2, CO4 | <b>K1, K2, K3, K4</b>     |
| <b>Module 4:</b>             | <b>Data Interpretation and Reporting</b><br>Types of data in chemistry (spectral, chromatographic, kinetic, thermodynamic, computational). Characteristics of effective visual representation. Choosing the right type of graph (scatter, bar, line, histogram, box plot, heat map). Visualization of experimental data: absorbance versus wavelength, NMR spectra, IR fingerprints, Chromatograms, retention time plots, peak integration and XRD patterns. Plotting and interpreting UV-Vis, IR, NMR spectra and chromatographic data plotting. Report writing. Presentation of results. | <b>10</b> | CO3      | <b>K1, K2, K3, K4, K5</b> |
| <b>Pedagogy:</b>             | Mostly lectures and tutorials, seminars/term papers/assignments/presentations/self-study or combination of some of these can also be used. ICT mode to be preferred.                                                                                                                                                                                                                                                                                                                                                                                                                       |           |          |                           |
| <b>Texts:</b>                | 1. D. Brynn Hibbert and J. Justin Gooding, Data Analysis for Chemistry, OUP USA, 2005,<br>2. Michael E. Swartz and Ira S. Krull, Analytical Method Development and Validation, Marcel Dekkar 1997<br>3. C. Allen Bennett and N. L. Franklin, Statistical Analysis in Chemistry and the Chemical Industry: Wiley Publications in Statistics, 1954<br>4. R. Caulcutt, Data Analysis in the Chemical Industry: Volume 1: Basic Techniques: 001, Ellis Horwood Ltd, 1989.                                                                                                                      |           |          |                           |
| <b>References/ Readings:</b> | 1. D. A. Skoog, F. J. Holler, & S. R. Crouch, Principles of instrumental analysis, 7 <sup>th</sup> edition, Thomson Books, USA, 2018.<br>2. H. H. Willard, L. L. Merritt, J. A. Dean, and F. A. Settle, Instrumental methods of analysis, 7 <sup>th</sup> Ed, Wadsworth Publishing Company, California, 1988.                                                                                                                                                                                                                                                                              |           |          |                           |

**Web Resources:**

1. U.S. Food and Drug Administration. 2015. Analytical Procedures and Methods Validation for Drugs and Biologics: Guidance for Industry. Washington, DC: U.S. Food and Drug Administration, CDER & CBER.
2. International Council for Harmonization of Technical Requirements for Pharmaceuticals for Human Use (ICH). 2005. ICH Harmonized Tripartite Guideline Q2(R1): Validation of Analytical Procedures: Text and Methodology



|                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|----------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Title of the Course</b>                   | Drug development & Pharmacopeial Aspects                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| <b>Course Code</b>                           | CIT-5006                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| <b>Number of Credits</b>                     | 04                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <b>Theory/Practical</b>                      | Theory                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <b>Level</b>                                 | 500                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <b>Effective from AY</b>                     | 2025-26                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>New Course</b>                            | Yes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <b>Bridge Course/<br/>Value added Course</b> | No                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <b>Course for advanced learners</b>          | No                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <b>Pre-requisites for the Course:</b>        | Nil                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <b>Course Objectives:</b>                    | <ol style="list-style-type: none"> <li>1. To study the overall drug development process and the role of chemical industrial techniques.</li> <li>2. To explain Pharmacopeia standards and specifications, including monograph development, validation, and key Pharmacopeia methods.</li> <li>3. To outline the regulatory requirements for drug development, including the roles of agencies like the FDA and EMA, and the processes for IND and NDA submissions.</li> <li>4. To understand quality control measures in drug development, including analytical method validation, impurity profiling, and stability testing.</li> <li>5. To analyse real-world case studies in drug development, identifying challenges and solutions in the development of specific drugs like penicillin, COVID-19 vaccines, and others.</li> </ol> |

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|-------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|---------------------|------------------------|
|                         | 6. To identify current trends and future directions in drug development, and analyze the impact of emerging technologies.                                                             |                               |                     |                        |
| <b>Course Outcomes:</b> | Student will be able to                                                                                                                                                               | <b>Mapped to PSO</b>          |                     |                        |
|                         | CO 1. describe the key stages of the drug development process, including the role of chemical industrial techniques.                                                                  | <b>PSO1, PSO2, PSO3</b>       |                     |                        |
|                         | CO 2. explain the significance of Pharmacopeia standards and regulatory requirements in ensuring drug quality and the processes involved in monograph development and validation.     | <b>PSO1, PSO2, PSO3</b>       |                     |                        |
|                         | CO 3. apply regulatory guidelines from agencies like the FDA and EMA to prepare IND and NDA submissions, and to implement GMP and quality control measures.                           | <b>PSO1, PSO2, PSO3</b>       |                     |                        |
|                         | CO 4. analyze and interpret data from quality control measures, including analytical method validation, impurity profiling, and stability testing, to ensure drug quality and safety. | <b>PSO1, PSO2, PSO4</b>       |                     |                        |
|                         | CO 5. evaluate the challenges and solutions encountered in real-world drug development and assess the impact of these factors on the success or failure of drug development projects. | <b>PSO3, PSO4, PSO5</b>       |                     |                        |
|                         | CO 6. develop strategies to address emerging trends and future directions in drug development, and propose innovative solutions that leverage new technologies.                       | <b>PSO1, PSO3, PSO4, PSO5</b> |                     |                        |
| <b>Content:</b>         |                                                                                                                                                                                       | <b>No of hours</b>            | <b>Mapped to CO</b> | <b>Cognitive Level</b> |
| <b>Module 1:</b>        | <b>Introduction to Drug Development</b><br>Overview of drug development process. Role of chemical industrial techniques in drug development.                                          | <b>6</b>                      | CO1                 | <b>K1</b>              |
| <b>Module 2:</b>        | <b>Pharmacopeia Standards and Specifications</b><br>Overview of pharmacopeia (e.g., USP, EP, IP). Monograph development and validation. Pharmacopeia methods and standards.           | <b>12</b>                     | CO2                 | <b>K1, K2</b>          |
| <b>Module 3:</b>        | <b>Regulatory Requirements for Drug Development</b><br>Overview of regulatory agencies (e.g., FDA, EMA). Regulatory requirements for IND                                              | <b>15</b>                     | CO2, CO3            | <b>K1, K2, K3</b>      |

|                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |           |             |                                       |
|----------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|-------------|---------------------------------------|
|                                  | and NDA submissions. GMP and quality control measures.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |           |             |                                       |
| <b>Module 4:</b>                 | <b>Quality Control Measures in Drug Development</b><br>Analytical method validation. Impurity profiling. Stability testing. Raw Material and Excipient Testing, In-Process and Finished Product Testing                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | <b>09</b> | CO2,<br>CO4 | <b>K1, K2,<br/>K4</b>                 |
| <b>Module 5:</b>                 | <b>Case Studies in Drug Development</b><br>Real-world examples of drug development Penicillin, Covid-19 vaccine (Covishield/Covaxin), Insulin, Thalidomide, Acyclovir, Azidothymidine, Warfarin. Challenges and solutions in drug development.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | <b>12</b> | CO5         | <b>K1, K2,<br/>K3, K4,<br/>K5</b>     |
| <b>Module 6:</b>                 | <b>Current Trends and Future Directions</b><br>Emerging trends in drug development: Artificial intelligence in drug discovery and development, Advanced therapies (CRISPR-Cas9, nanomedicine). Impact of new technologies on drug development: Modernized production                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <b>06</b> | CO6         | <b>K1, K2,<br/>K3, K4,<br/>K5, K6</b> |
| <b>Pedagogy:</b>                 | Mostly lectures and tutorials, seminars/term papers/assignments/presentations/self-study or combination of some of these can also be used. ICT mode to be preferred.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |           |             |                                       |
| <b>References/<br/>Readings:</b> | <ol style="list-style-type: none"> <li>1. Watson, D. G. Pharmaceutical Analysis: A Textbook for Pharmacy Students and Pharmaceutical Chemists. 5<sup>th</sup> Ed, Elsevier Health Sciences, Edinburgh. 2020.</li> <li>2. Indian Pharmacopoeia. Controller of Publication. Delhi, 1996.</li> <li>3. British Pharmacopoeia. British Pharmacopoeia Commission Office, London, 2008.</li> <li>4. United States Pharmacopoeia. United States Pharmacopoeial Convention, Inc, USA, 2003.</li> <li>5. Guarino, R. A. Drug Development and Approval Process. Informa Healthcare, New York, 2010</li> <li>6. Rang, H. P., Dale, M. M., Flower, R. J., &amp; Henderson, G. Rang &amp; Dale's pharmacology, 9<sup>th</sup> Ed. Elsevier, USA, 2020</li> <li>7. Huang, X., &amp; Aslanian, R. G. Case studies in modern drug discovery and development. Wiley, India, 2012</li> <li>8. Lotfy, P., &amp; Hsu, P. D. 11 Genome Editing with CRISPR-Cas Systems. CRISPR: Biology and Applications, 165. 2022</li> <li>9. Chawla, P., Kumar, A., Nayyar, A., &amp; Naved, M. Blockchain, IoT, and AI technologies for supply chain management. CRC Press, USA, 2023</li> </ol> |           |             |                                       |
| <b>Web Resources:</b>            | <a href="https://www.sciencedirect.com/science/article/pii/S1359644620304256?via%3Dihub">https://www.sciencedirect.com/science/article/pii/S1359644620304256?via%3Dihub</a>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |           |             |                                       |

<https://database.ich.org/sites/default/files/Q2%28R1%29%20Guideline.pdf>  
<https://database.ich.org/sites/default/files/Q6A%20Guideline.pdf>  
<https://www.ecfr.gov/current/title-21/chapter-I/subchapter-C/part-210>  
<https://www.ecfr.gov/current/title-21/chapter-I/subchapter-C/part-211>  
<https://www.ema.europa.eu/en/human-regulatory-overview/research-development/compliance-research-development/good-manufacturing-practice>

Guideline documents & Research Articles:

1. International Council for Harmonisation of Technical Requirements for Pharmaceuticals for Human Use. Validation of Analytical Procedures: Text and Methodology Q2(R1). 2005
2. International Council for Harmonisation of Technical Requirements for Pharmaceuticals for Human Use. Specifications: Test Procedures and Acceptance Criteria for New Drug Substances and New Drug Products: Chemical Substances Q6A. Pharmacopeial Forum. United States Pharmacopeial Convention, Bi-Monthly. 1999
3. United States Food and Drug Administration. Code of Federal Regulations Title 21, Part 210: Current Good Manufacturing Practice in Manufacturing, Processing, Packing, or Holding of Drugs; General. 2025
4. United States Food and Drug Administration. Code of Federal Regulations Title 21, Part 211: Current Good Manufacturing Practice for Finished Pharmaceuticals. 2025
5. European Medicines Agency. EU Guidelines to Good Manufacturing Practice for Medicinal Products for Human and Veterinary Use. 2024
6. Lee, S.L., O'Connor, T.F., Yang, X. et al. Modernizing Pharmaceutical Manufacturing: from Batch to Continuous Production. J Pharm. Innov., 2015, **10** 191–199. <https://doi.org/10.1007/s12247-015-9215-8>

|                                              |                                         |
|----------------------------------------------|-----------------------------------------|
| <b>Title of the Course</b>                   | Process Safety and Pollution management |
| <b>Course Code</b>                           | CIT-5007                                |
| <b>Number of Credits</b>                     | 04                                      |
| <b>Theory/Practical</b>                      | Theory                                  |
| <b>Level</b>                                 | 500                                     |
| <b>Effective from AY</b>                     | 2025-2026                               |
| <b>New Course</b>                            | Yes                                     |
| <b>Bridge Course/<br/>Value added Course</b> | No                                      |
| <b>Course for advanced learners</b>          | No                                      |

|                                       |                                                                                                                                                                                                                                                    |                      |
|---------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|
| <b>Pre-requisites for the Course:</b> | Nil                                                                                                                                                                                                                                                |                      |
| <b>Course Objectives:</b>             | 1. To understand the types of pollution, its effects and control methodology.<br>2. To focus on industrial law and acts.<br>3. To educate students to identify and assess hazards in any stage of operation,<br>4. To quantify and manage hazards. |                      |
| <b>Course Outcomes:</b>               | Students will be able to:                                                                                                                                                                                                                          | <b>Mapped to PSO</b> |
|                                       | CO 1. discuss source models, dispersion models, fires and fire prevention, explosions and explosion prevention, pressure relief systems, runaway reactions and risk analysis as they apply to chemical process safety.                             | <b>PSO1, PSO4</b>    |
|                                       | CO 2. explain the factors that can lead to an accident. Learn different methods of hazard analysis and control of hazards.                                                                                                                         | <b>PSO2, PSO4</b>    |
|                                       | CO 3. compare types of pollution, its sources, effects and control methodology and thereby                                                                                                                                                         | <b>PSO3, PSO4</b>    |

|                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                    |                     |                        |
|------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|---------------------|------------------------|
|                  | environmental protection. Know about environmental impact assessment and EIS.<br>Discuss methodology for environmental audit and safety audit.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                    |                     |                        |
|                  | CO 4. apply the Industrial Laws and Act.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                    | PSO1, PSO5          |                        |
| <b>Content:</b>  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <b>No of hours</b> | <b>Mapped to CO</b> | <b>Cognitive Level</b> |
| <b>Module 1:</b> | <p><b>Process Safety</b></p> <p>Development of safety movement, need for safety</p> <p>General introduction historical background and growth of safety science, aims of safety science, safety and the organization, safety audit</p> <p>Basic concepts of safety science. hazard, risk, nature of the accident process, use of engineering fundamentals in safety science.</p> <p>Risk assessment &amp; hazard identification checklist procedure, preliminary hazard analysis, what if analysis, failure mode effect analysis, hazard and operability (hazop) studies, hazard analysis techniques: fault tree analysis, event tree analysis, general outline of dow index, risk estimation and management, major hazard control</p> <p>Fault and event tree analysis for risk prediction</p> <p>Source models of accidental release of toxic/flammable liquids and vapours, models of flow of liquids and vapours through pipes.</p> <p>Dispersion Models: Mathematical models for prediction of dispersion patterns for toxic/flammable materials released into atmosphere, various types of "plume" and "puff" models of dispersion.</p> <p>Nature of fires and explosion calculation of blast damage due to over-pressure, prevention of fires and explosions.</p> <p>Control of major chemical hazards, emergency control and disaster planning, On-site and Off-site emergency preparedness.</p> <p>Introduction to various personal protective equipment's.</p> <p>Instruments for safety: Pressure safety valve, Rupture disc, Interlocks etc.</p> | <b>30</b>          | CO1<br>CO2          | <b>K1, K2, K3</b>      |
| <b>Module 2:</b> | <b>Pollution Management</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | <b>20</b>          | CO3                 | <b>K1, K2</b>          |

|                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |           |     |           |
|------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|-----|-----------|
|                              | <p><b>Environmental Protection:</b></p> <p>Concept of environment and ecology, various natural cycles in environment and ecology, effect of human activities on environment and ecology.</p> <p>Various types of environmental pollution in general and in chemical and allied industry in particular, sources and causes of environmental pollution, effect of pollution on environment, environmental impact assessment and Environment Impact Statement, methodologies for environmental pollution prevention (including process technology up gradation, development, Invention etc.), control, abatement and treatment and waste disposal. Rules, regulations, laws etc. regarding environmental protection, pollution prevention and control, waste disposal etc.</p> <p>Role of government, semi/quasi govt. and voluntary organizations. Current trends and topics</p> |           |     |           |
| <b>Module 3:</b>             | <p><b>Industrial Laws and Act</b></p> <p>Introduction to Industrial laws, Industries Factory act, Energy audit, Environment Audit, Trade union, Labor laws and acts. Industrial Electricity rules, Industrial Dispute Acts. Workmen's compensation Act, ESIC Act, Payment and Wages act, Minimum Wages act, Payment of Bonus act.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | <b>10</b> | CO4 | <b>K1</b> |
| <b>Pedagogy:</b>             | Mostly lectures and tutorials, seminars/term papers/assignments/presentations/self-study or combination of some of these can also be used. ICT mode to be preferred.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |           |     |           |
| <b>Texts:</b>                | <ol style="list-style-type: none"> <li>1. F. P Lees, Loss Prevention in Process Industries Volume 1, 2 &amp; 3, by Elsevier, USA, 2012.</li> <li>2. T.R. Banga &amp; S.C. Sharma, Industrial Organization and Economics, 25<sup>th</sup> Ed, Khanna publishers, New Delhi, 2006.</li> <li>3. N.D. Kapoor, Handbook of Industrial Law by Sultan Chand &amp; Sons, New Delhi, 2011</li> </ol>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |           |     |           |
| <b>References/ Readings:</b> | <ol style="list-style-type: none"> <li>1. F. L. Burton, H. D. Stensel, Environment Engineering by George Tchobanoglous, 5<sup>th</sup> Ed, Metcalf &amp; Eddy Inc, New York, 2019.</li> <li>2. C. S. Rao, Environmental Pollution Control Engineering by New Age International Publishers, New Delhi, 1991.</li> <li>3. A. Singh &amp; H. Kaur, Introduction to labour and industrial law I 4<sup>th</sup> Ed, Lexis Nexis, Haryana, 2017.</li> </ol>                                                                                                                                                                                                                                                                                                                                                                                                                          |           |     |           |

|                                              |                                                                                                                                                                                                                                                                                            |                         |
|----------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|
| <b>Title of the Course</b>                   | Instrumental Techniques                                                                                                                                                                                                                                                                    |                         |
| <b>Course Code</b>                           | CIT-5008                                                                                                                                                                                                                                                                                   |                         |
| <b>Number of Credits</b>                     | 04                                                                                                                                                                                                                                                                                         |                         |
| <b>Theory/Practical</b>                      | Theory                                                                                                                                                                                                                                                                                     |                         |
| <b>Level</b>                                 | 500                                                                                                                                                                                                                                                                                        |                         |
| <b>Effective from AY</b>                     | 2025-2026                                                                                                                                                                                                                                                                                  |                         |
| <b>New Course</b>                            | Yes                                                                                                                                                                                                                                                                                        |                         |
| <b>Bridge Course/<br/>Value added Course</b> | No                                                                                                                                                                                                                                                                                         |                         |
| <b>Course for advanced learners</b>          | No                                                                                                                                                                                                                                                                                         |                         |
| <b>Pre-requisites for the Course:</b>        | Nil                                                                                                                                                                                                                                                                                        |                         |
| <b>Course Objectives:</b>                    | 1. To impart fundamental and advanced knowledge of modern instrumental methods.<br>2. To understand the theoretical principles underlying each analytical technique.<br>3. To enhance skills for critical analysis.<br>4. To interpret data obtained from various instrumentation methods. |                         |
| <b>Course Outcomes:</b>                      | Students will be able to                                                                                                                                                                                                                                                                   | <b>Mapped to PSO</b>    |
|                                              | CO 1. explain the fundamentals of analytical instrumentation, calibration of commonly used analytical instruments.                                                                                                                                                                         | <b>PSO1, PSO2, PSO3</b> |
|                                              | CO 2. demonstrate knowledge of the working principles, maintenance, and calibration of commonly used analytical instruments                                                                                                                                                                | <b>PSO1, PSO2, PSO3</b> |
|                                              | CO 3. apply spectroscopic, chromatographic, electroanalytical, and thermal analysis techniques for qualitative and quantitative analysis of various samples.                                                                                                                               | <b>PSO3, PSO4</b>       |

|                  |                                                                                                                                                                                                                                                                                                                                                                                                                                               |                    |                     |                        |
|------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|---------------------|------------------------|
|                  | CO 4. interpret data obtained from advanced instrumentation methods such as X-ray crystallography, SEM, and LC-MS.                                                                                                                                                                                                                                                                                                                            |                    | <b>PSO3, PSO4</b>   |                        |
| <b>Content:</b>  |                                                                                                                                                                                                                                                                                                                                                                                                                                               | <b>No of hours</b> | <b>Mapped to CO</b> | <b>Cognitive Level</b> |
| <b>Module 1:</b> | <b>Regulatory standards for instrumentation:</b><br>Accuracy, precision and error analysis, calibration techniques and standards, overview of International regulatory bodies (ISO, WHO, USFDA), regulatory standard for analytical methodology.                                                                                                                                                                                              | <b>08</b>          | CO1                 | K1, K2, K3             |
| <b>Module 2:</b> | <b>Validation of Analytical instruments:</b><br>Instrument specific validation parameters for spectroscopic instruments (UV-Vis, IR), HPLC/GC, pH meters, conductometers, balances.                                                                                                                                                                                                                                                           | <b>07</b>          | CO2                 | K1, K2, K3, K4         |
| <b>Module 3:</b> | <b>Spectroscopic Techniques:</b><br>UV-Visible Spectroscopy: Principle, instrumentation and applications in quantitative analysis, IR Spectroscopy: Molecular Vibrations, functional group identification, applications, AAS and AES Spectroscopy: Flame photometry and detection methods, NMR Spectroscopy: Chemical shifts, spin-spin coupling and applications, Mass Spectrometry: Ionization techniques, mass analyzers and applications. | <b>14</b>          | CO2, CO3            | K1, K2, K3, K4         |
| <b>Module 4:</b> | <b>Chromatographic Techniques:</b><br>TLC: Stationary phases, solvent systems and visualization, GC, HPLC: Injection, Mobile phases, Column types, detectors and applications.                                                                                                                                                                                                                                                                | <b>12</b>          | CO2, CO3            | K1, K2, K3, K4         |
| <b>Module 5:</b> | <b>Electroanalytical Methods:</b><br>Potentiometry, Voltammetry (polarography, cyclic voltammetry) & Conductometry: Principle, working and applications.                                                                                                                                                                                                                                                                                      | <b>08</b>          | CO2, CO3            | K1, K2, K3             |
| <b>Module 6:</b> | <b>Thermal Analysis Techniques:</b><br>Principle and applications of TGA, DTA and DSC                                                                                                                                                                                                                                                                                                                                                         | <b>04</b>          | CO3                 | K1, K2, K3             |
| <b>Module 7:</b> | <b>Advanced Instrumentation:</b>                                                                                                                                                                                                                                                                                                                                                                                                              | <b>07</b>          | CO4                 | K1, K2, K3, K4,        |

|                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |  |  |  |
|------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|--|
|                              | Powder X-ray diffraction: Determination of lattice parameters, SEM and EDAX: Surface morphology and elemental analysis, LC-MS: Principle and applications.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |  |  |  |
| <b>Pedagogy:</b>             | Mostly lectures and tutorials, seminars/term papers/assignments/presentations/self-study or combination of some of these can also be used. ICT mode to be preferred.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |  |  |  |
| <b>Texts:</b>                | <ol style="list-style-type: none"> <li>1. G. D. Christian, Analytical Chemistry, 6<sup>th</sup> Ed.; Wiley, Singapore, 2004.</li> <li>2. G. W. Ewing, Instrumental Methods of Chemical Analysis, 5<sup>th</sup> Ed.; McGraw-Hill Int., New York, 1985.</li> <li>3. D. A. Skoog, D. M. West, F. J. Holler, S. R. Crouch, Fundamentals of Analytical Chemistry, 9<sup>th</sup> Ed.; Cengage learning, USA, 2014.</li> <li>4. F. J. Holler, D. A. Skoog, S. R. Crouch, Principles of Instrumental Analysis, 6<sup>th</sup> Ed.; Thomson Books, London, 2007.</li> <li>5. C. N. Banwell, E. M. McCash, Fundamentals of Molecular Spectroscopy, 4<sup>th</sup> Ed.; Tata McGraw- Hill, India, 2006.</li> <li>6. H. Willard, L. L. Merritt, J. A. Dean, F. A. Settle, Instrumental Methods of Analysis, 7<sup>th</sup> Ed.; HCBS Publishing, India, 2004.</li> <li>7. W. Kemp, Organic Spectroscopy, 3<sup>rd</sup> Ed.; Palgrave, New York, 1991.</li> <li>8. R. M. Silverstein, F. X. Webster, Spectrometric Identification of Organic Compounds, 6<sup>th</sup> Ed.; Wiley, USA, 1998.</li> <li>9. P. S. Kalsi, Spectroscopy of Organic Compounds, 2<sup>nd</sup> Ed.; New Age International, New Delhi, 2000.</li> </ol> |  |  |  |
| <b>References/ Readings:</b> | <ol style="list-style-type: none"> <li>1. H. Gunzler, A. Williams, Handbook of Analytical Techniques, 1<sup>st</sup> Ed.; Wiley, Germany, 2001.</li> <li>2. R. A. Day, A. L. Underwood, Quantitative Analysis, 6<sup>th</sup> Ed.; Prentice Hall, USA, 2001.</li> <li>3. P. J. Larkin, Infrared and Raman Spectroscopy: Principles and Spectral Interpretation, 2<sup>nd</sup> Ed.; Elsevier, Netherlands, 2018.</li> <li>4. J. H. Kennedy, Analytical Chemistry: Principles, 2<sup>nd</sup> Ed.; Saunders College Publishing, Pennsylvania, 1990.</li> <li>5. R. D. Braun, Introduction to Instrumental Analysis, 1<sup>st</sup> Ed.; McGraw-Hill, New York, 1987.</li> </ol>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |  |  |  |

### Discipline Specific Elective Courses

|                                              |                                                                                                                                                                                                                                                                                                             |                         |
|----------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|
| <b>Title of the Course</b>                   | Laboratory Course in Chemical Techniques – III                                                                                                                                                                                                                                                              |                         |
| <b>Course Code</b>                           | CIT-5205                                                                                                                                                                                                                                                                                                    |                         |
| <b>Number of Credits</b>                     | 02                                                                                                                                                                                                                                                                                                          |                         |
| <b>Theory/Practical</b>                      | Practical                                                                                                                                                                                                                                                                                                   |                         |
| <b>Level</b>                                 | 500                                                                                                                                                                                                                                                                                                         |                         |
| <b>Effective from AY</b>                     | 2025-2026                                                                                                                                                                                                                                                                                                   |                         |
| <b>New Course</b>                            | Yes                                                                                                                                                                                                                                                                                                         |                         |
| <b>Bridge Course/<br/>Value added Course</b> | No                                                                                                                                                                                                                                                                                                          |                         |
| <b>Course for advanced learners</b>          | No                                                                                                                                                                                                                                                                                                          |                         |
| <b>Pre-requisites for the Course:</b>        | Nil                                                                                                                                                                                                                                                                                                         |                         |
| <b>Course Objectives:</b>                    | <ol style="list-style-type: none"> <li>1. To develop experimental skills on industrial laboratory techniques</li> <li>2. To acquire skills for analysing results and data interpretation</li> <li>3. To develop research skills</li> <li>4. To have hands on experience on laboratory techniques</li> </ol> |                         |
| <b>Course Outcomes:</b>                      | Students will be able to:                                                                                                                                                                                                                                                                                   | <b>Mapped to PSO</b>    |
|                                              | CO 1. explain various laboratory techniques.                                                                                                                                                                                                                                                                | <b>PSO1, PSO2</b>       |
|                                              | CO 2. apply the appropriate analysis techniques in industry.                                                                                                                                                                                                                                                | <b>PSO2, PSO3, PSO4</b> |
|                                              | CO 3. examine results and interpret data obtained                                                                                                                                                                                                                                                           | <b>PSO3, PSO5</b>       |

|                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                    |                     |                        |
|------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|---------------------|------------------------|
|                  | CO 4. select a proper chemical technique for research work.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                    | PSO4, PSO5          |                        |
| <b>Content:</b>  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>No of hours</b> | <b>Mapped to CO</b> | <b>Cognitive Level</b> |
| <b>Module 1:</b> | <p>Minimum 15 experiments to be performed</p> <ol style="list-style-type: none"> <li>1. To determine the amount of Paracetamol in a tablet formulation using UV-Visible spectrophotometry.</li> <li>2. To determine the amount of Paracetamol in a syrup formulation using UV-Visible spectrophotometry.</li> <li>3. To determine the disintegration time of coated and uncoated tablets as per IP/USP.</li> <li>4. To determine the lipophilicity (log P) of a drug (e.g.), indicating its membrane permeability.</li> <li>5. To study the drug release pattern from a tablet using USP Apparatus II.</li> <li>6. Analytical Method Validation: Linearity and Range Determination for an Active Pharmaceutical Ingredient (API)</li> <li>7. To determine the pK<sub>a</sub> or pK<sub>b</sub> of a pharmaceutical excipient (e.g., polyethylene glycol, fatty acid ester) using titration, understanding its relevance to formulation and stability.</li> <li>8. To quantify the API content in a provided raw material or a simple solution using UV-Visible spectrophotometry, following simplified pharmacopeial approach.</li> <li>9. To determine the water content in a pharmaceutical raw material (solid or liquid) using the volumetric Karl Fischer titration method, a critical quality control parameter.</li> <li>10. To determine the ferrous content in the supplied sample of iron ore by titrimetric analysis against standard K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> solution using potassium ferricyanide as external indicator</li> <li>11. Preparation of Methyl Orange-An Azodye</li> <li>12. Preparation of [Ni(NH<sub>3</sub>)<sub>6</sub>]<sup>2+</sup> and its analysis.</li> <li>13. To study the rate constant for mutarotation of chiral pharmaceutical drug using polarimetry.</li> <li>14. To separate Cobalt and Nickel ions using anion exchange chromatography.</li> <li>15. Estimation of calcium in pharmaceutical tablet using EDTA method.</li> </ol> | <b>60</b>          | CO1, CO2, CO3, CO4  | <b>K1, K2, K3, K4</b>  |

|                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |  |  |  |
|----------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|--|
|                                  | 16. Determination of Chemical Oxygen Demand (COD) of water sample.<br>17. Determination of dissolved oxygen content in the given of water sample.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |  |  |  |
| <b>Pedagogy:</b>                 | Mainly pre-laboratory exercises Seminars/ lab hand-out/self-study/assignments or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |  |  |  |
| <b>Texts:</b>                    | 1. J. Mendham, R.C. Jenny, J.D. Barnes, M. J. K. Thomas, Vogel's textbook of Quantitative Chemical Analysis 6 <sup>th</sup> Ed.: Pearson Education, New Delhi, 2008.<br>2. G. D. Christian, Analytical Chemistry, 6 <sup>th</sup> Ed.; Wiley, USA, 2004.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |  |  |  |
| <b>References/<br/>Readings:</b> | 1. Anil J. Elias, A collection of General Chemistry Experiments, Revised Ed, Universities press Pvt Ltd, Hyderabad, 2016,<br>2. Miller, J. C., Miller, J. N. Statistics and Chemometrics for Analytical Chemistry, 7 <sup>th</sup> Ed, Pearson Publications, United Kingdom, 2018<br>3. Sharma, P. P., How to Practice GMPs, 7 <sup>th</sup> Ed, Vandana Publications, New Delhi, 2015<br>4. Indian Pharmacopoeia (IP), 2022.<br>5. British Pharmacopoeia (BP), 2023.<br>6. G. W. Ewing, Instrumental Methods of Chemical Analysis, 5 <sup>th</sup> Ed.; McGraw-Hill Int., New York, 1985.<br>7. D. A. Skoog, D. M. West, F. J. Holler, S. R. Crouch, Fundamentals of Analytical Chemistry, 9th Ed.; Cengage learning, USA, 2014.<br>8. F. J. Holler, D. A. Skoog, S. R. Crouch, Principles of Instrumental Analysis, 6th Ed.; Thomson Books, USA, 2007.<br>9. G. D. Christian, Analytical Chemistry, 5th Ed.; Wiley, USA, 1994.<br>10. S. W. Rajbhoj, T. K. Chondhekar, Systematic Experimental Physical Chemistry, 3 <sup>rd</sup> Ed, Anjali Publications, Aurangabad, 2013.<br>11. J. B. Yadav, Advanced Practical Physical Chemistry, 36 <sup>th</sup> Ed, Krishna Prakashan Media, Meerut, 2016.<br>12. H. Beckett and J. B. Stenlake, Practical Pharmaceutical Chemistry - Part One and Two, 4 <sup>th</sup> Ed. CBS Publishers and Distributors, New Delhi, 1998 |  |  |  |

|                                              |                                                                                                                                                                                                                                         |                         |
|----------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|
| <b>Title of the Course</b>                   | Laboratory Course in Chemical Techniques - IV                                                                                                                                                                                           |                         |
| <b>Course Code</b>                           | CIT-5206                                                                                                                                                                                                                                |                         |
| <b>Number of Credits</b>                     | 02                                                                                                                                                                                                                                      |                         |
| <b>Theory/Practical</b>                      | Practical                                                                                                                                                                                                                               |                         |
| <b>Level</b>                                 | 500                                                                                                                                                                                                                                     |                         |
| <b>Effective from AY</b>                     | 2025-2026                                                                                                                                                                                                                               |                         |
| <b>New Course</b>                            | Yes                                                                                                                                                                                                                                     |                         |
| <b>Bridge Course/<br/>Value added Course</b> | No                                                                                                                                                                                                                                      |                         |
| <b>Course for advanced learners</b>          | No                                                                                                                                                                                                                                      |                         |
| <b>Pre-requisites for the Course:</b>        | Nil                                                                                                                                                                                                                                     |                         |
| <b>Course Objectives:</b>                    | 1. To develop experimental skills on industrial laboratory techniques<br>2. To acquire skills for analysing results and data interpretation<br>3. To develop research skills<br>4. To have hands on experience on laboratory techniques |                         |
| <b>Course Outcomes:</b>                      | Students will be able to:                                                                                                                                                                                                               | <b>Mapped to PSO</b>    |
|                                              | CO 1. explain various laboratory techniques.                                                                                                                                                                                            | <b>PSO1, PSO2</b>       |
|                                              | CO 2. apply appropriate analysis techniques in industry.                                                                                                                                                                                | <b>PSO2, PSO3, PSO4</b> |
|                                              | CO 3. examine results and interpret data obtained                                                                                                                                                                                       | <b>PSO3, PSO5</b>       |
|                                              | CO 4. select a proper chemical technique for research work.                                                                                                                                                                             | <b>PSO4, PSO5</b>       |

| Content:         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | No of hours | Mapped to CO                | Cognitive Level   |
|------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|-----------------------------|-------------------|
| <b>Module 1:</b> | <p>Minimum 15 experiments to be performed</p> <ol style="list-style-type: none"> <li>1. Estimation of Iodine in iodized salt.</li> <li>2. Determination of chloride content of a water sample by Mohr's method.</li> <li>3. Extraction of Caffeine from soft drinks/energy drinks</li> <li>4. Preparation of potash alum from Scrap aluminium</li> <li>5. Photochemical reduction of ferric Oxalate in cyanotype blue printing.</li> <li>6. Synthesis of Aspirin using conventional method</li> <li>7. Synthesis of Aspirin using microwave assisted method.</li> <li>8. Extraction of clove oil from clove buds through distillation and characterization by melting point, TLC and density.</li> <li>9. Application of Statistical Tools for Analytical Data Validation (Linearity, precision (%RSD), accuracy (% recovery), t-test, F-test.)</li> <li>10. Validation of Analytical Balance and Preparation of Calibration Certificate</li> <li>11. Validation of a Titrimetric Method for Assay of NaOH</li> <li>12. Calibration and Validation of a UV-Vis. Spectrophotometer using <math>K_2Cr_2O_7</math> solution</li> <li>13. Preparation of spinel oxides by precursor method.</li> <li>14. Estimation of metals in precursors and oxides.</li> <li>15. Characterization of precursors by thermal analysis.</li> <li>16. Isolation and characterization of p-carotene from carrot using TLC and UV-Vis. Spectrophotometry.</li> <li>17. Determination of total hardness and alkalinity of water sample</li> </ol> | 60          | CO1,<br>CO2,<br>CO3,<br>CO4 | K1, K2,<br>K3, K4 |
| <b>Pedagogy:</b> | Mainly pre-laboratory exercises Seminars/ lab hand-out/self-study/assignments or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |             |                             |                   |
| <b>Texts:</b>    | <ol style="list-style-type: none"> <li>1. J. Mendham, R.C. Jenny, J.D. Barnes, M. J. K. Thomas, Vogel's textbook of Quantitative Chemical Analysis 6<sup>th</sup> Ed.: Pearson Education, New Delhi, 2008.</li> <li>2. G. D. Christian, Analytical Chemistry, 6<sup>th</sup> Ed.; Wiley, USA, 2004.</li> </ol>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |             |                             |                   |

**References/  
Readings:**

1. Anil J. Elias, A collection of General Chemistry Experiments, Revised Ed, Universities press Pvt Ltd, Hyderabad, 2016,
2. Miller, J. C., Miller, J. N. Statistics and Chemometrics for Analytical Chemistry, 7<sup>th</sup> Ed, Pearson Publications, United Kingdom, 2018
3. Sharma, P. P., How to Practice GMPs, 7<sup>th</sup> Ed, Vandana Publications, New Delhi, 2015
4. Indian Pharmacopoeia (IP), 2022.
5. British Pharmacopoeia (BP), 2023.
6. G. W. Ewing, Instrumental Methods of Chemical Analysis, 5<sup>th</sup> Ed.; McGraw-Hill Int., New York, 1985.
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8. F. J. Holler, D. A. Skoog, S. R. Crouch, Principles of Instrumental Analysis, 6th Ed.; Thomson Books, USA, 2007.
9. G. D. Christian, Analytical Chemistry, 5th Ed.; Wiley, USA, 1994.
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12. H. Beckett and J. B. Stenlake, Practical Pharmaceutical Chemistry - Part One and Two, 4<sup>th</sup> Ed. CBS Publishers and Distributors, New Delhi, 1998

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|----------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|
| <b>Title of the Course</b>                   | Laboratory Course in Chemical Techniques - V                                                                                                                                                                                            |                         |
| <b>Course Code</b>                           | CIT-5207                                                                                                                                                                                                                                |                         |
| <b>Number of Credits</b>                     | 02                                                                                                                                                                                                                                      |                         |
| <b>Theory/Practical</b>                      | Practical                                                                                                                                                                                                                               |                         |
| <b>Level</b>                                 | 500                                                                                                                                                                                                                                     |                         |
| <b>Effective from AY</b>                     | 2025-2026                                                                                                                                                                                                                               |                         |
| <b>New Course</b>                            | Yes                                                                                                                                                                                                                                     |                         |
| <b>Bridge Course/<br/>Value added Course</b> | No                                                                                                                                                                                                                                      |                         |
| <b>Course for advanced learners</b>          | No                                                                                                                                                                                                                                      |                         |
| <b>Pre-requisites for the Course:</b>        | Nil                                                                                                                                                                                                                                     |                         |
| <b>Course Objectives:</b>                    | 1. To develop experimental skills on industrial laboratory techniques<br>2. To acquire skills for analysing results and data interpretation<br>3. To develop research skills<br>4. To have hands on experience on laboratory techniques |                         |
| <b>Course Outcomes:</b>                      | Students will be able to:                                                                                                                                                                                                               | <b>Mapped to PSO</b>    |
|                                              | CO 1. explain various laboratory techniques.                                                                                                                                                                                            | <b>PSO1, PSO2</b>       |
|                                              | CO 2. apply appropriate analysis techniques in industry.                                                                                                                                                                                | <b>PSO2, PSO3, PSO4</b> |
|                                              | CO 3. examine results and interpret data obtained                                                                                                                                                                                       | <b>PSO3, PSO5</b>       |
|                                              | CO 4. select a proper chemical technique for research work.                                                                                                                                                                             | <b>PSO4, PSO5</b>       |

| Content:  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | No of hours | Mapped to CO                | Cognitive Level   |
|-----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|-----------------------------|-------------------|
| Module 1: | Minimum 15 experiments to be performed<br><b>Simple identification tests as described in pharmacopeias for common inorganic salts or organic compounds used in pharmaceuticals</b><br><b>A. Identification Reactions of Ions &amp; Functional Groups:</b> <ol style="list-style-type: none"> <li>1. Identification of Barbiturates</li> <li>2. Identification of Related Substances in Barbiturates</li> <li>3. Identification of Phenothiazines</li> <li>4. Identification of Related Substances in Phenothiazines</li> <li>5. Identification of Related Foreign Steroids</li> <li>6. Identification of Related Substances in Sulphonamides</li> </ol> | 4           | CO1,<br>CO2,<br>CO3,<br>CO4 | K1, K2,<br>K3, K4 |
|           | <b>B. Quantitative Analysis of chemical substances:</b> <ol style="list-style-type: none"> <li>1. Acetyl Value</li> <li>2. Acid Value</li> <li>3. Cineole</li> <li>4. Ester Value</li> <li>5. Hydroxyl Value</li> <li>6. Iodine value</li> <li>7. Nitrite Titration</li> <li>8. Peroxide Value</li> <li>9. Phenol in Vaccines and Antisera</li> <li>10. Saponification Value</li> <li>11. Analysis of Steroids</li> <li>12. Analysis of Vitamin A</li> <li>13. Analysis of Vitamin D</li> <li>14. Analysis of Zinc</li> <li>15. Analysis of Ethanol</li> </ol>                                                                                          | 36          |                             |                   |
|           | <b>C. Isolation/Estimation of chemical substances</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 20          |                             |                   |

|                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |  |  |  |
|----------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|--|
|                                  | <ol style="list-style-type: none"> <li>1. Isolation of Casein from skim milk</li> <li>2. Estimation of Calcium in skim milk</li> <li>3. Determination of residual chlorine in a portable water sample</li> <li>4. Determine the percentage of available chlorine in a given sample of bleaching powder.</li> <li>5. Determination the composition of copper(II) and iron (III) solution by photometric titration with EDTA</li> <li>6. Estimation of phenol/aniline by brominating mixture</li> </ol>                                                                                             |  |  |  |
| <b>Pedagogy:</b>                 | Mainly pre-laboratory exercises Seminars/ lab hand-out/self-study/assignments or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.                                                                                                                                                                                                                                                                                                                                                           |  |  |  |
| <b>Texts:</b>                    | <ol style="list-style-type: none"> <li>1. Indian Pharmacopoeia (IP), 2010.</li> <li>2. Indian Pharmacopoeia (IP), 2014.</li> <li>3. Indian Pharmacopoeia (IP), 2018.</li> <li>4. J. B. Yadav, Advanced Practical Physical Chemistry, 36<sup>th</sup> Ed, Krishna Prakashan Media, Meerut, 2016.</li> <li>5. S. W. Rajbhoj, T. K. Chondhekar, Systematic Experimental Physical Chemistry, 3<sup>rd</sup> Ed, Anjali Publications, Aurangabad, 2013</li> <li>6. N. K. Vishnoi, Advanced Practical Organic Chemistry, 3<sup>rd</sup> Ed, Vikas Publishing House Pvt Ltd, New Delhi, 2009.</li> </ol> |  |  |  |
| <b>References/<br/>Readings:</b> | British Pharmacopoeia (BP), 2023.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |  |  |  |