

ICTQual AB

Qualification Specification



Level 5 Diploma in Chemical Engineering 240 Credits – Two Years



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Qualification Specifications about

ICTQual Level 5 Diploma in Chemical Engineering 240 Credits – Two Years

About ICTQual AB

ICTQual AB UK Ltd. is a distinguished awarding body based in the United Kingdom, dedicated to fostering excellence in education, training, and skills development. Committed to global standards, ICTQual AB provides internationally recognized qualifications that empower individuals and organizations to thrive in an increasingly competitive world. Their offerings span diverse industries, including technical fields, health and safety, management, and more, ensuring relevance and adaptability to modern workforce needs.

The organization prides itself on delivering high-quality educational solutions through a network of Approved Training Centres worldwide. Their robust curriculum and innovative teaching methodologies are designed to equip learners with practical knowledge and skills for personal and professional growth. With a mission to inspire lifelong learning and drive positive change, ICTQual AB continuously evolves its programs to stay ahead of industry trends and technological advancements.

ICTQual AB's vision is to set benchmarks for educational excellence while promoting inclusivity and integrity. Their unwavering focus on quality and accessibility makes them a trusted partner in shaping future-ready professionals and advancing societal progress globally.

Course Overview

The ICTQual Level 5 Diploma in Chemical Engineering is a two-year program designed to provide students with a deep understanding of core chemical engineering concepts. The course covers a wide range of topics, including thermodynamics, fluid mechanics, process control, and materials science, all of which are essential for aspiring engineers in various industries such as manufacturing, energy, and pharmaceuticals.

Throughout the program, students will gain both theoretical knowledge and practical skills that are directly applicable to real-world engineering challenges. The diploma ensures that graduates are well-equipped to contribute to process optimization, sustainability efforts, and efficient design in chemical engineering roles.

With flexible learning options, the course is suitable for both full-time students and professionals looking to enhance their expertise while continuing their careers. This qualification offers a strong foundation for those seeking career advancement or a solid entry into the chemical engineering field.

Certification Framework

Qualification title	ICTQual Level 5 Diploma in Chemical Engineering 240 Credits – Two Years
Course ID	CHE0002
Qualification Credits	240 Credits
Course Duration	Two Years
Grading Type	Pass / Fail
Competency Evaluation	Coursework / Assignments / Verifiable Experience
Assessment	The assessment and verification process for ICTQual qualifications involves two key stages: Internal Assessment and Verification: <ul style="list-style-type: none">✓ Conducted by the staff at the Approved Training Centre (ATC). Ensures learners meet the required standards through continuous assessments.✓ Internal quality assurance (IQA) is carried out by the centre's IQA staff to validate the assessment processes. External Quality Assurance: <ul style="list-style-type: none">✓ Managed by ICTQual AB verifiers, who periodically review the centre's assessment and IQA processes.✓ Verifies that assessments are conducted to the required standards and ensures consistency across centres

Entry Requirements

To enroll in the ICTQual Level 5 Diploma in Chemical Engineering 240 Credits – Two Years, candidates must meet the following entry requirements:

- ✓ Applicants must hold a Level 4 qualification, such as a diploma, certificate, or equivalent, in a related field. A background in subjects like chemistry, physics, mathematics, or engineering is highly recommended, as the course builds on foundational concepts in chemical engineering.
- ✓ Candidates must be at least 16 years old to enroll in the program, ensuring they possess the maturity to manage the academic and practical aspects of the course.
- ✓ Proficiency in English is essential, as students must navigate technical terminology, submit written assignments, and communicate effectively within the chemical engineering domain.
- ✓ Basic computer skills are required, as the program involves assignments, simulations, and the use of engineering software for process design and analysis.
- ✓ While not mandatory, prior exposure to chemical engineering concepts, laboratory practices, or industrial processes can provide an added advantage, enhancing understanding and overall performance in the program.

Qualification Structure

This qualification comprises 24 mandatory units, totaling 240 credits. Candidates must successfully complete all mandatory units to achieve the qualification.

Mandatory Units		
Unit Ref#	Unit Title	Credits
Year 1 (120 Credits)		
Semester 1		
CHE0002 - 1	Introduction to Chemical Engineering Principles	10
CHE0002 - 2	Engineering Mathematics and Statistics	10
CHE0002 - 3	Material and Energy Balances	10
CHE0002 - 4	Thermodynamics	10
CHE0002 - 5	Chemistry for Engineers	10
CHE0002 - 6	Fluid Mechanics	10
CHE0002 - 7	Heat Transfer Processes	10
CHE0002 - 8	Chemical Process Industries	10
CHE0002 - 9	Mechanical Properties of Materials	10
CHE0002 - 10	Laboratory Skills and Safety	10
CHE0002 - 11	Environmental Science and Sustainability	10
CHE0002 - 12	Technical Communication and Report Writing	10
Year 2 (120 Credits)		
CHE0002 - 13	Advanced Thermodynamics	10
CHE0002 - 14	Advance Fluid Mechanics	10
CHE0002 - 15	Process Control and Instrumentation	10
CHE0002 - 16	Chemical Reaction Engineering	10
CHE0002 - 17	Separation Processes	10
CHE0002 - 18	Industrial Health and Safety Management	10
CHE0002 - 19	Chemical Process Design and Simulation	10
CHE0002 - 20	Advanced Separation Processes	10
CHE0002 - 21	Energy Systems and Renewable Technologies	10
CHE0002 - 22	Advance Chemical Reaction Engineering	10
CHE0002 - 23	Industrial Project Management	10
CHE0002 - 24	Research Project in Chemical Engineering	10

Centre Requirements

Even if a centre is already registered with ICTQual AB, it must meet specific requirements to deliver the ICTQual Level 5 Diploma in Chemical Engineering 240 Credits – Two Years. These standards ensure the quality and consistency of training, assessment, and learner support.

1. Approval to Deliver the Qualification

- ✓ Centres must obtain formal approval from ICTQual AB to deliver this specific qualification, even if they are already registered.
- ✓ The approval process includes a review of resources, staff qualifications, and policies relevant to the program.

2. Qualified Staff

- ✓ **Tutors:** Must have relevant qualifications in Chemical Engineering at Level 6 or higher, alongside teaching/training experience.
- ✓ **Assessors:** Must hold a recognized assessor qualification and demonstrate expertise in Chemical Engineering
- ✓ **Internal Quality Assurers (IQAs):** Must be appropriately qualified and experienced to monitor the quality of assessments.

3. Learning Facilities

Centres must have access to appropriate learning facilities, which include:

- ✓ **Classrooms:** Modern, multimedia-equipped classrooms for delivering engaging theoretical instruction on chemical processes, reaction engineering, and industrial applications.
- ✓ **Practical Areas:** Advanced labs featuring state-of-the-art equipment for chemical analysis, process simulation, distillation, heat transfer, and fluid mechanics to provide hands-on training and experimental experience.
- ✓ **Technology Access:** High-performance computers with specialized software (e.g., Aspen Plus, MATLAB, CHEMCAD) and internet connectivity for process modeling, simulations, and technical project work.

4. Health and Safety Compliance

- ✓ Centres must ensure that practical training environments comply with relevant health and safety regulations.
- ✓ Risk assessments must be conducted regularly to maintain a safe learning environment.

5. Resource Requirements

- ✓ **Learning Materials:** Approved course manuals, textbooks, and study guides aligned with the curriculum.
- ✓ **Assessment Tools:** Templates, guidelines, and resources for conducting and recording assessments.
- ✓ **E-Learning Systems:** If offering online or hybrid learning, centres must provide a robust Learning Management System (LMS) to facilitate remote delivery.

6. Assessment and Quality Assurance

- ✓ Centres must adhere to ICTQual's assessment standards, ensuring that all assessments are fair, valid, and reliable.
- ✓ Internal quality assurance (IQA) processes must be in place to monitor assessments and provide feedback to assessors.
- ✓ External verification visits from ICTQual will ensure compliance with awarding body standards.

7. Learner Support

- ✓ Centres must provide learners with access to guidance and support throughout the program, including:
- ✓ Academic support for coursework.
- ✓ Career guidance for future progression.
- ✓ Additional support for learners with specific needs (e.g., disabilities or language barriers).

8. Policies and Procedures

Centres must maintain and implement the following policies, as required by ICTQual:

- ✓ Equal Opportunities Policy.
- ✓ Health and Safety Policy.
- ✓ Safeguarding Policies and Procedures.
- ✓ Complaints and Appeals Procedure.
- ✓ Data Protection and Confidentiality Policy.

9. Regular Reporting to ICTQual

- ✓ Centres must provide regular updates to ICTQual AB on learner enrollment, progress, and completion rates.
- ✓ Centres are required to maintain records of assessments and learner achievements for external auditing purposes.

Support for Candidates

Centres should ensure that materials developed to support candidates:

- ✓ Facilitate tracking of achievements as candidate's progress through the learning outcomes and assessment criteria.
- ✓ Include information on how and where ICTQual's policies and procedures can be accessed.
- ✓ Provide mechanisms for Internal and External Quality Assurance staff to verify and authenticate evidence effectively.

This approach ensures transparency, supports candidates' learning journeys, and upholds quality assurance standards.

Assessment

This qualification is competence-based, requiring candidates to demonstrate proficiency as defined in the qualification units. The assessment evaluates the candidate's skills, knowledge, and understanding against the set standards. Key details include:

1. Assessment Process:

- ✓ Must be conducted by an experienced and qualified assessor.
- ✓ Candidates compile a portfolio of evidence that satisfies all learning outcomes and assessment criteria for each unit.

2. Types of Evidence:

- ✓ Observation reports by the assessor.
- ✓ Assignments, projects, or reports.
- ✓ Professional discussions.

- ✓ Witness testimonies.
- ✓ Candidate-produced work.
- ✓ Worksheets.
- ✓ Records of oral and written questioning.
- ✓ Recognition of Prior Learning (RPL).

3. Learning Outcomes and Assessment Criteria:

- ✓ **Learning Outcomes:** Define what candidates should know, understand, or accomplish upon completing the unit.
- ✓ **Assessment Criteria:** Detail the standards candidates must meet to demonstrate that the learning outcomes have been achieved.

This framework ensures rigorous and consistent evaluation of candidates' competence in line with the qualification's objectives.

Unit Descriptors

CHE0002 – 1 Introduction to Chemical Engineering Principles

The aim of this study unit is to provide students with a solid foundation in the fundamental concepts of chemical engineering and their application in industrial processes. This unit focuses on the role of chemical engineers in optimizing and managing various chemical processes. Students will gain an understanding of core principles such as mass transfer, fluid flow, and heat exchange, and will learn how to apply these concepts to solve practical chemical engineering problems. By integrating theoretical knowledge with real-world applications, this unit prepares students to approach chemical process challenges with a strong analytical and problem-solving mindset.

Learning Outcome:	Assessment Criteria:
<p>1. Understand the role of chemical engineering in industrial processes.</p>	<p>1.1. Demonstrate a clear understanding of the fundamental principles of chemical engineering and their application in various industrial processes, emphasizing the role of chemical engineers in process design, optimization, and operations.</p> <p>1.2. Explain how chemical engineering integrates core scientific disciplines, such as chemistry, physics, and biology, to develop efficient and sustainable industrial processes.</p> <p>1.3. Identify and describe the various industrial sectors where chemical engineering plays a key role, such as petrochemicals, pharmaceuticals, food processing, and environmental management.</p> <p>1.4. Assess the impact of chemical engineering innovations on industrial efficiency, product quality, and sustainability, recognizing the contributions of chemical engineers to technological advancements.</p> <p>1.5. Understand the importance of process safety, environmental stewardship, and regulatory compliance within industrial processes, highlighting the responsibility of chemical engineers in maintaining safe and ethical operations.</p> <p>1.6. Discuss the key responsibilities of a chemical engineer in ensuring the scalability of laboratory processes to full-scale industrial production, focusing on factors such as cost-effectiveness, safety, and performance.</p> <p>1.7. Analyze the interdisciplinary nature of chemical engineering, recognizing the collaboration with other engineering disciplines, business, and management to drive successful project outcomes.</p> <p>1.8. Demonstrate knowledge of process control and</p>

	<p>optimization techniques, explaining how chemical engineers use these tools to improve process efficiency, reduce waste, and enhance product consistency.</p> <p>1.9. Evaluate the evolving role of chemical engineering in addressing global challenges, such as energy efficiency, waste reduction, and sustainable resource use, with an emphasis on the engineer's role in environmental impact reduction.</p>
<p>2. Analyze basic principles such as mass transfer, fluid flow, and heat exchange.</p>	<p>2.1. Demonstrate a clear understanding of the fundamental principles of mass transfer, fluid flow, and heat exchange, and their significance in chemical engineering processes.</p> <p>2.2. Apply the concepts of mass transfer to analyze the movement of components in various systems, including diffusion, convection, and dispersion, and evaluate their impact on process efficiency.</p> <p>2.3. Analyze fluid flow behavior, distinguishing between laminar and turbulent flow regimes, and apply appropriate mathematical models, such as the Reynolds number, to predict fluid dynamics in pipes and reactors.</p> <p>2.4. Utilize the principles of fluid mechanics to design and optimize equipment such as pumps, valves, and pipelines, ensuring efficient and cost-effective fluid transport in industrial processes.</p> <p>2.5. Understand the role of heat transfer in chemical processes, identifying the mechanisms of conduction, convection, and radiation, and applying these principles to thermal management in reactors, heat exchangers, and distillation columns.</p> <p>2.6. Analyze and solve problems related to heat exchange processes, including calculating heat duty, temperature profiles, and heat exchanger design parameters, to ensure optimal thermal performance in industrial operations.</p> <p>2.7. Use mathematical models and computational tools to predict and optimize mass transfer, fluid flow, and heat exchange in industrial processes, ensuring maximum efficiency and minimal energy consumption.</p> <p>2.8. Assess the influence of operating conditions, such as temperature, pressure, and concentration, on mass transfer, fluid flow, and heat exchange rates,</p>

	<p>and adjust process parameters to achieve desired outcomes.</p> <p>2.9. Integrate knowledge of mass transfer, fluid flow, and heat exchange to design and optimize unit operations like absorption columns, heat exchangers, and evaporators, ensuring both technical and economic feasibility.</p>
<p>3. Apply fundamental engineering concepts to solve chemical process problems.</p>	<p>3.1. Demonstrate the ability to apply fundamental engineering principles, such as material and energy balances, to solve complex chemical process problems, ensuring a systematic approach to problem-solving.</p> <p>3.2. Utilize thermodynamics, reaction kinetics, and fluid mechanics to analyze and resolve issues related to heat, mass, and energy transfer in chemical processes.</p> <p>3.3. Apply concepts of process control and optimization to develop solutions that improve efficiency, reduce waste, and enhance product quality in chemical systems.</p> <p>3.4. Use mathematical modeling and computational tools to simulate chemical processes, predicting outcomes and identifying areas for improvement in process design and operation.</p> <p>3.5. Integrate the principles of heat exchange, mass transfer, and fluid flow to solve problems in equipment design, such as reactors, distillation columns, and heat exchangers, ensuring effective and safe operation.</p> <p>3.6. Analyze process dynamics under varying conditions and apply engineering concepts to adjust the process for optimal performance.</p> <p>3.7. Evaluate the feasibility and sustainability of proposed solutions, considering factors such as energy consumption, environmental impact, and economic viability.</p> <p>3.8. Solve problems using appropriate engineering tools and techniques, demonstrating a practical understanding of chemical engineering concepts in real-world applications.</p> <p>3.9. Communicate the results of problem-solving efforts clearly and effectively, presenting solutions and supporting calculations in a professional manner to stakeholders.</p>

CHE0002 – 2 Engineering Mathematics and Statistics

The aim of this study unit is to equip students with the advanced mathematical and statistical tools necessary for solving complex engineering problems. This unit focuses on applying mathematical techniques to model, analyze, and optimize chemical processes. Students will learn to interpret and analyze statistical data relevant to chemical engineering, improving their ability to make data-driven decisions.

Learning Outcome:	Assessment Criteria:
<p>1. Utilize advanced mathematical techniques for engineering problem-solving.</p>	<ul style="list-style-type: none"> 1.1. Demonstrate proficiency in applying advanced mathematical techniques, such as differential equations, linear algebra, and numerical methods, to solve complex engineering problems in chemical processes. 1.2. Use mathematical models to represent physical systems, ensuring that variables and parameters are correctly defined and appropriate assumptions are made for the given engineering context. 1.3. Apply statistical methods to analyze data, identify trends, and make predictions, ensuring that results are accurate and reliable for process optimization and decision-making. 1.4. Implement optimization techniques, including linear programming, nonlinear optimization, and dynamic programming, to find the best solutions for engineering challenges such as cost minimization and efficiency maximization. 1.5. Use advanced calculus and vector analysis to analyze multi-dimensional systems and complex process interactions, ensuring a deeper understanding of chemical process behavior. 1.6. Employ numerical methods, such as finite difference and finite element methods, to solve complex equations that cannot be solved analytically, ensuring accurate modeling of real-world systems. 1.7. Apply simulation and computational tools to solve engineering problems, interpreting results and refining models to improve the accuracy and efficiency of process designs. 1.8. Integrate advanced mathematical techniques with chemical engineering principles to develop scalable, cost-effective, and

	<p>sustainable solutions to real-world engineering problems.</p> <p>1.9. Communicate the application of advanced mathematical techniques in problem-solving clearly, providing well-supported rationale and interpretations for decisions made in the engineering design process.</p>
<p>2. Interpret statistical data relevant to chemical processes.</p>	<p>2.1. Demonstrate the ability to collect, organize, and analyze statistical data relevant to chemical processes, ensuring accuracy and consistency in data interpretation.</p> <p>2.2. Apply descriptive statistical techniques, such as mean, median, standard deviation, and variance, to summarize and characterize data distributions in chemical processes.</p> <p>2.3. Use inferential statistics, including hypothesis testing and confidence intervals, to make data-driven decisions and assess the reliability of process parameters and performance.</p> <p>2.4. Analyze process variability by applying control charts, process capability analysis, and statistical process control (SPC) to monitor and improve process consistency and quality.</p> <p>2.5. Interpret regression analysis results to identify relationships between process variables, helping to optimize process conditions and predict outcomes based on statistical trends.</p> <p>2.6. Utilize multivariate statistical methods, such as principal component analysis (PCA) or multiple regression, to analyze complex datasets and identify key factors influencing chemical process performance.</p> <p>2.7. Apply probability distributions to model and predict process behavior, ensuring appropriate assumptions are made based on the nature of the data.</p> <p>2.8. Evaluate the significance of statistical findings in the context of process design and optimization, ensuring that statistical methods are aligned with engineering objectives and process requirements.</p>
<p>3. Develop mathematical models for process simulations.</p>	<p>3.1. Demonstrate the ability to develop mathematical models that accurately</p>

	<p>represent the behavior of chemical processes, including mass and energy balances, reaction kinetics, and thermodynamic principles.</p> <ol style="list-style-type: none">3.2. Use fundamental equations, such as conservation of mass, energy, and momentum, to create models that describe process dynamics and system interactions.3.3. Apply process-specific assumptions, such as ideal conditions or simplifications, to develop solvable models that can be used for simulation and optimization purposes.3.4. Implement advanced mathematical techniques, such as differential equations, linear/nonlinear programming, and system of equations, to model complex chemical processes and equipment.3.5. Integrate appropriate boundary conditions, initial conditions, and process parameters into the model to ensure accuracy and relevance to real-world applications.3.6. Use computational tools and software to simulate the behavior of the developed models, predicting system responses under varying conditions and constraints.3.7. Validate mathematical models by comparing simulation results with experimental or operational data, ensuring that the model provides reliable and accurate predictions.3.8. Apply optimization techniques within the simulation model to identify optimal operating conditions, process configurations, and system efficiencies for process improvement.3.9. Communicate the developed models and simulation results effectively, presenting both technical details and actionable insights for process design and decision-making to stakeholders.
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CHE0002 – 3 Material and Energy Balances

The aim of this study unit is to provide students with the essential skills to analyze and optimize chemical processes through accurate mass and energy balance calculations. This unit emphasizes the application of conservation principles to evaluate process efficiency and resource utilization in chemical systems. By integrating theoretical knowledge with practical applications, students will develop the ability to address real-world chemical engineering challenges, ensuring sustainable and efficient process design and operation. This unit serves as a cornerstone for understanding and solving complex engineering problems in advanced chemical engineering studies.

Learning Outcome:	Assessment Criteria:
<p>1. Perform mass and energy balance calculations for chemical systems.</p>	<p>1.1. Demonstrate the ability to set up and solve mass balance equations for chemical systems, ensuring that all inputs, outputs, and accumulation terms are properly accounted for.</p> <p>1.2. Apply the law of conservation of mass to perform material balances on chemical processes, such as reactors, separators, and mixers, ensuring the consistency of the flow rates and compositions.</p> <p>1.3. Conduct energy balance calculations by incorporating all relevant energy inputs, outputs, and losses, such as heat, work, and phase changes, to determine system performance and efficiency.</p> <p>1.4. Use appropriate assumptions, such as steady-state or constant properties, to simplify calculations and make them manageable while still maintaining accuracy and relevance to the process.</p> <p>1.5. Incorporate thermodynamic principles, such as enthalpy and entropy, into energy balance calculations to account for temperature and pressure changes across the system.</p> <p>1.6. Perform both open and closed system mass and energy balances, ensuring that all material and energy flows in and out of the system are accurately accounted for.</p> <p>1.7. Apply mass and energy balances to design and optimize chemical processes, such as distillation, reaction, and heat exchange systems, ensuring that the desired objectives, like energy efficiency or product yield, are achieved.</p> <p>1.8. Use computational tools, such as spreadsheets or process simulation software, to assist in</p>

	<p>performing complex mass and energy balance calculations, improving both speed and accuracy.</p> <p>1.9. Interpret the results of mass and energy balance calculations to provide actionable insights, optimizing process efficiency, minimizing waste, and ensuring sustainability and cost-effectiveness.</p>
<p>2. Evaluate process efficiency and resource utilization.</p>	<p>2.1. Analyze key performance indicators (KPIs) such as yield, conversion rates, and throughput to assess the overall efficiency of chemical processes.</p> <p>2.2. Calculate and evaluate the energy efficiency of processes by comparing energy input to useful output, using metrics like energy intensity and specific energy consumption.</p> <p>2.3. Perform material efficiency assessments by analyzing the input-to-output ratios of raw materials, identifying opportunities to minimize waste and optimize resource utilization.</p> <p>2.4. Assess the environmental impact of the process by evaluating emissions, waste generation, and resource depletion, ensuring that the process adheres to sustainability and regulatory standards.</p> <p>2.5. Use mass and energy balances to identify inefficiencies in the system, such as excess energy consumption, material losses, or suboptimal reaction conditions, and propose improvements.</p> <p>2.6. Apply economic analysis tools, such as cost-benefit analysis and life cycle assessment (LCA), to evaluate the financial and environmental costs of resource utilization and process efficiency.</p> <p>2.7. Perform heat integration and utility optimization to identify opportunities for energy recovery, improving overall thermal efficiency and reducing operational costs.</p> <p>2.8. Assess the utilization of water and other essential resources in the process, proposing techniques for recycling or reducing consumption to enhance sustainability.</p> <p>2.9. Provide recommendations based on the evaluation of resource utilization and process efficiency to improve the sustainability, cost-effectiveness, and competitiveness of the chemical process.</p>

<p>3. Apply conservation principles to real-world chemical engineering scenarios.</p>	<p>3.1. Apply the principles of conservation of mass, energy, and momentum to analyze and solve real-world chemical engineering problems, ensuring accurate representation of process systems.</p> <p>3.2. Use mass conservation to track material flow through processes such as reactors, separation units, and mixers, identifying key inputs, outputs, and accumulation points to ensure system consistency.</p> <p>3.3. Implement energy conservation principles to evaluate the heat and work interactions within chemical processes, optimizing energy use and minimizing losses in systems like heat exchangers and distillation columns.</p> <p>3.4. Apply the conservation of momentum to analyze fluid flow through pipelines, pumps, and reactors, ensuring the design and operation of equipment are optimized for efficiency and stability.</p> <p>3.5. Use conservation laws to identify inefficiencies, such as unaccounted material losses or energy waste, and propose solutions for improvement, ensuring process optimization and sustainability.</p> <p>3.6. Solve real-world engineering problems by incorporating conservation principles into process simulations, optimizing operations for minimal resource consumption and maximum output.</p> <p>3.7. Consider the impact of operational conditions, such as temperature, pressure, and flow rates, on conservation principles to improve process design and performance under varying scenarios.</p> <p>3.8. Utilize conservation principles to evaluate the scalability of laboratory-scale processes to industrial-scale operations, ensuring that processes remain efficient and sustainable when scaled up.</p> <p>3.9. Communicate the application of conservation principles in real-world scenarios clearly, presenting findings and recommendations for process improvement and sustainability to stakeholders.</p>
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CHE0002 – 4 Thermodynamics

The aim of this study unit is to equip students with a comprehensive understanding of the principles governing energy and material transformations in chemical engineering processes. This unit focuses on the application of the first and second laws of thermodynamics to solve practical engineering problems. Students will develop skills in analyzing phase equilibria and evaluating thermodynamic properties of substances, enabling them to design and optimize processes across a range of industrial applications. By mastering these concepts, students will gain a solid foundation for addressing complex challenges in energy management and process efficiency.

Learning Outcome:	Assessment Criteria:
<p>1. Explain thermodynamic principles related to energy and material transformations.</p>	<p>1.1. Demonstrate a thorough understanding of the laws of thermodynamics, including the first and second laws, and how they govern energy and material transformations in chemical processes.</p> <p>1.2. Explain the concept of energy conservation (first law of thermodynamics) and its application to chemical systems, ensuring that energy inputs, outputs, and losses are properly accounted for in processes such as heating, cooling, and work interactions.</p> <p>1.3. Analyze and apply the second law of thermodynamics, focusing on entropy and its implications for the direction of spontaneous processes and the efficiency of energy transformations in chemical engineering systems.</p> <p>1.4. Understand the concept of enthalpy and how it relates to heat energy in constant pressure processes, applying it to calculate heat changes in reactions, phase transitions, and mixing processes.</p> <p>1.5. Apply Gibbs free energy to predict the spontaneity of chemical reactions and phase changes, ensuring that reactions proceed under the desired conditions for optimal process design.</p> <p>1.6. Explain the principles of ideal and real gas behavior, utilizing equations of state, such as the ideal gas law and Van der Waals equation, to predict the behavior of gases in chemical processes.</p> <p>1.7. Evaluate the impact of temperature, pressure, and volume changes on material</p>

	<p>transformations, such as in reaction kinetics, phase equilibria, and distillation processes, using thermodynamic models.</p> <p>1.8. Apply thermodynamic concepts to analyze phase diagrams, chemical equilibria, and reaction equilibria, optimizing conditions to achieve desired product compositions and yields.</p> <p>1.9. Integrate thermodynamic principles into the design and analysis of chemical engineering processes, ensuring energy and material efficiency, minimizing waste, and enhancing sustainability.</p>
<p>2. Solve problems involving the first and second laws of thermodynamics.</p>	<p>2.1. Apply the first law of thermodynamics to solve problems related to energy conservation in chemical systems, ensuring that energy inputs, outputs, and changes in internal energy are accurately accounted for in processes like heating, cooling, and work interactions.</p> <p>2.2. Use the first law to perform calculations on closed and open systems, determining heat, work, and internal energy changes during various thermodynamic processes such as adiabatic, isothermal, and isobaric processes.</p> <p>2.3. Solve problems involving energy balance in chemical reactors, heat exchangers, and compressors by applying the first law to track energy transformations and calculate system efficiency.</p> <p>2.4. Apply the second law of thermodynamics to determine the feasibility of processes, calculating entropy changes and assessing the direction of spontaneous processes, identifying any potential inefficiencies or irreversibilities in the system.</p> <p>2.5. Use the second law to calculate the entropy generation within processes and evaluate the potential for improving the efficiency of chemical systems by reducing energy losses and optimizing heat recovery.</p> <p>2.6. Solve problems involving reversible and irreversible processes, identifying the key factors that impact the efficiency of a process</p>

	<p>and proposing improvements based on the second law's implications for entropy and irreversibility.</p> <p>2.7. Analyze the thermodynamic cycles (e.g., Carnot cycle) to solve problems related to heat engines, refrigeration, and other energy conversion processes, calculating work output, heat input, and efficiency.</p> <p>2.8. Calculate changes in Gibbs free energy to predict the spontaneity and equilibrium position of chemical reactions and phase transitions, applying the second law to determine whether a reaction can proceed under specific conditions.</p> <p>2.9. Solve complex thermodynamic problems by integrating both the first and second laws, using appropriate assumptions and simplifying techniques to provide practical solutions for real-world chemical processes.</p>
<p>3. Analyze phase equilibrium and thermodynamic properties of substances.</p>	<p>3.1. Use phase diagrams to analyze the phase behavior of substances, identifying phase boundaries, critical points, and regions of stability for different phases (solid, liquid, gas) under varying temperature and pressure conditions.</p> <p>3.2. Apply Raoult's Law and Henry's Law to analyze vapor-liquid equilibrium (VLE) in binary mixtures, determining the composition of the vapor and liquid phases at equilibrium.</p> <p>3.3. Analyze the effects of temperature, pressure, and composition on phase equilibria in systems such as binary mixtures, multi-component mixtures, and heterogeneous systems, using thermodynamic principles to predict phase changes.</p> <p>3.4. Apply the Clapeyron equation and Gibbs phase rule to calculate phase transition properties and the number of independent variables for multi-phase systems in equilibrium.</p> <p>3.5. Calculate and interpret the thermodynamic properties of substances, such as enthalpy, entropy, Gibbs free energy, and chemical potential, to predict phase behavior and</p>

	<p>equilibrium conditions.</p> <p>3.6. Analyze the impact of pressure and temperature on phase transitions, such as boiling, melting, sublimation, and condensation, using the Clausius-Clapeyron equation to estimate latent heats and transition enthalpies.</p> <p>3.7. Use the van der Waals equation of state or other real gas models to describe the behavior of substances under non-ideal conditions, correcting for deviations from ideal gas behavior in phase equilibrium calculations.</p> <p>3.8. Perform calculations for critical points and supercritical fluids, evaluating the unique properties and behavior of substances in these phases and their impact on process design.</p> <p>3.9. Integrate phase equilibrium data into process design and optimization, using this information to determine the most efficient conditions for separation processes like distillation, absorption, and crystallization.</p>
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CHE0002 – 5: Chemistry for Engineers

The aim of this study unit is to provide students with a solid foundation in chemical principles essential for understanding and optimizing engineering processes. This unit focuses on the analysis of chemical reactions, stoichiometry, and reaction kinetics, equipping students with the skills to evaluate and predict chemical behavior in various engineering contexts. By examining the interaction of materials in diverse chemical environments, students will gain critical insights into material selection, process efficiency, and the development of innovative solutions to engineering challenges.

Learning Outcome:	Assessment Criteria:
<p>1. Understand the chemical principles underpinning engineering processes.</p>	<p>1.1. Demonstrate a solid understanding of fundamental chemical principles, including stoichiometry, reaction kinetics, thermodynamics, and material properties, as they relate to chemical engineering processes.</p> <p>1.2. Explain the role of chemical reactions in industrial processes, emphasizing the principles of reaction rates, equilibrium, and the factors that influence reaction progress, such as temperature, pressure, and catalysts.</p> <p>1.3. Understand the application of the laws of thermodynamics, including the conservation of mass and energy, to chemical engineering systems, ensuring efficient and sustainable process design.</p> <p>1.4. Analyze how the properties of materials, such as viscosity, density, and thermal conductivity, affect process design, equipment selection, and operation.</p> <p>1.5. Apply principles of chemical bonding and molecular structure to predict the behavior of substances under various conditions, including phase changes, solubility, and reactivity.</p> <p>1.6. Explain the concept of mass and energy balances and how they are used to analyze and design chemical processes, ensuring that all inputs, outputs, and transformations are accounted for.</p> <p>1.7. Understand the principles of fluid mechanics, heat transfer, and mass transfer, and their integration into process systems such as pumps, reactors, heat exchangers, and separation units.</p> <p>1.8. Recognize the importance of catalysts and catalyst design in speeding up chemical reactions and improving process efficiency, particularly in</p>

	<p>complex industrial processes.</p> <p>1.9. Apply chemical principles to optimize process conditions, minimize waste, reduce energy consumption, and enhance product yield and purity in various chemical engineering operations.</p>
<p>2. Analyze chemical reactions, stoichiometry, and kinetics.</p>	<p>2.1. Apply stoichiometric principles to balance chemical reactions, ensuring that mass and atom conservation are maintained across reactants and products in both ideal and real-world scenarios.</p> <p>2.2. Use stoichiometric calculations to determine the quantities of reactants and products in a given chemical reaction, incorporating limiting reactants and excess reactants to optimize process efficiency.</p> <p>2.3. Analyze the rates of chemical reactions by understanding the factors that affect reaction speed, such as temperature, concentration, pressure, and the presence of catalysts.</p> <p>2.4. Apply the principles of chemical kinetics to determine the rate laws for reactions, using experimental data to establish relationships between concentration and reaction rate.</p> <p>2.5. Solve differential rate equations to predict the behavior of reaction systems over time, including reaction order and half-life for first, second, and complex-order reactions.</p> <p>2.6. Interpret the activation energy and Arrhenius equation to analyze the temperature dependence of reaction rates, determining how temperature variations affect the rate of a chemical reaction.</p> <p>2.7. Utilize the concept of reaction mechanisms to break down complex reactions into elementary steps, identifying rate-determining steps and intermediates in the process.</p> <p>2.8. Analyze the effect of catalysts on reaction rates, explaining how catalysts lower activation energy and speed up reactions without being consumed in the process.</p>
<p>3. Evaluate the behavior of materials in various chemical environments.</p>	<p>3.1. Analyze the chemical stability of materials under different temperature, pressure, and chemical environments, predicting potential reactions and</p>

	<p>degradation mechanisms such as corrosion, oxidation, and hydrolysis.</p> <ol style="list-style-type: none">3.2. Assess the effect of acidic, basic, and saline conditions on material integrity, evaluating material selection and resistance to chemical attack in environments like reactors, pipelines, and storage vessels.3.3. Evaluate the mechanical properties of materials, including strength, ductility, and toughness, under various chemical exposures, ensuring the material's performance is suited to the specific chemical environment.3.4. Apply corrosion science to predict the corrosion rates of metals and alloys in chemical environments, using tools such as electrochemical analysis and corrosion rate models to optimize material selection and process design.3.5. Investigate the impact of high-temperature chemical environments on materials, including the risk of thermal degradation, phase changes, and embrittlement, ensuring that materials can withstand the process conditions without failure.3.6. Analyze the compatibility of materials with different solvents, gases, and liquids used in chemical processes, assessing solubility, swelling, and diffusion properties to prevent material failure or inefficiency.3.7. Evaluate the behavior of polymers and composites in chemical environments, considering factors like chemical resistance, permeability, and degradation over time in harsh chemical conditions.3.8. Assess the impact of chemical reactions on material properties, such as changes in phase, morphology, or surface structure, using techniques like spectroscopy, microscopy, and X-ray diffraction.3.9. Use material property databases and standards to identify optimal materials for specific chemical processes, ensuring long-term performance and safety under varying chemical conditions.
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CHE0002 – 6: Fluid Mechanics

The aim of this study unit is to provide students with a comprehensive understanding of fluid properties and their significance in engineering process systems. This unit focuses on the application of fundamental principles, such as Bernoulli’s equation, to the design and analysis of fluid flow systems. Students will develop the skills to solve engineering problems involving key components like pumps, turbines, and pipe networks, enabling them to optimize fluid transport and energy efficiency in industrial applications. Through theoretical and practical learning, this unit lays the foundation for tackling advanced challenges in fluid dynamics and process engineering.

Learning Outcome:	Assessment Criteria:
<p>1. Explain fluid properties and their impact on process systems.</p>	<p>1.1. Describe the fundamental fluid properties, including viscosity, density, surface tension, and compressibility, and explain how these properties affect fluid flow behavior in chemical process systems.</p> <p>1.2. Analyze the effect of viscosity on the pumping, mixing, and flow characteristics of fluids in pipelines, reactors, and other process equipment, and discuss how high or low viscosity impacts energy consumption and equipment selection.</p> <p>1.3. Explain the role of fluid density in process operations, such as fluid dynamics, separation processes, and the design of vessels and columns, and how changes in density influence buoyancy and flow patterns.</p> <p>1.4. Assess the impact of temperature and pressure on fluid properties, including how these factors affect density, viscosity, and phase changes, and discuss their significance in the operation of heat exchangers and reactors.</p> <p>1.5. Understand the relationship between fluid velocity, Reynolds number, and flow regime (laminar or turbulent), and how these influences design considerations in piping, pumps, and reactors for efficient material transport.</p> <p>1.6. Evaluate the effect of surface tension in multiphase flow systems, such as liquid-gas or liquid-solid interactions, and its impact on equipment design in processes like distillation, absorption, and crystallization.</p> <p>1.7. Explain compressibility effects for gases in chemical processes, particularly in gas transport and storage systems, and how changes in pressure and temperature influence gas volume and flow rates.</p>

	<p>1.8. Apply fluid property data to optimize process system design, ensuring that pumps, valves, and other components are appropriately selected for the specific fluid characteristics and operational conditions.</p> <p>1.9. Analyze the impact of non-Newtonian fluid behavior in processes involving slurries, polymers, or food products, and determine how rheological properties influence equipment design and flow control.</p>
<p>2. Design and analyze fluid flow systems using Bernoulli's equation and other principles.</p>	<p>2.1. Apply Bernoulli's equation to analyze fluid flow in process systems, considering factors such as pressure, velocity, and elevation changes, to predict and optimize flow characteristics in pipelines, ducts, and open channels.</p> <p>2.2. Use Bernoulli's equation to determine the relationship between pressure and velocity in incompressible fluids, calculating flow rates and pressure drops in systems like pumps, fans, and reactors.</p> <p>2.3. Design fluid flow systems by applying the principles of energy conservation, using Bernoulli's equation to calculate head losses and determine the required pump or compressor specifications to meet flow rate and pressure requirements.</p> <p>2.4. Incorporate other fluid dynamics principles such as the Darcy-Weisbach equation and the Moody chart to analyze and calculate pressure losses due to friction in pipes, fittings, and valves, ensuring system efficiency and reliability.</p> <p>2.5. Analyze and design open channel flow systems by applying Bernoulli's equation and the concept of flow rate, considering the effects of channel geometry, roughness, and slope on fluid velocity and pressure.</p> <p>2.6. Evaluate the impact of fluid density and viscosity on flow behavior in complex systems, using Bernoulli's equation in conjunction with correction factors for real-world conditions like temperature and pressure variations.</p> <p>2.7. Use flow rate calculations from Bernoulli's equation to size and select piping, pumps, and valves in process systems, ensuring that system</p>

	<p>components are appropriately sized to handle expected flow rates and pressures.</p> <p>2.8. Analyze the impact of changes in pipe diameter, flow velocity, and elevation on the overall pressure distribution in a system, using Bernoulli's equation to optimize design and minimize energy consumption.</p> <p>2.9. Apply Bernoulli's principle in combination with continuity equations to design and analyze multi-phase flow systems, ensuring that phase behavior is accurately accounted for in system analysis.</p>
<p>3. Solve engineering problems involving pumps, turbines, and pipe networks.</p>	<p>3.1. Demonstrates the ability to identify and analyze engineering problems related to pumps, turbines, and pipe networks, using appropriate methodologies and techniques.</p> <p>3.2. Applies relevant mathematical models and principles to solve problems associated with the design, operation, and maintenance of pumps, turbines, and pipe networks.</p> <p>3.3. Selects and utilizes suitable equipment, tools, and software for solving engineering problems in fluid dynamics and mechanical systems.</p> <p>3.4. Demonstrates a clear understanding of the interrelationship between pumps, turbines, and pipe networks in complex systems.</p> <p>3.5. Accurately calculates performance parameters, including flow rates, pressures, and power outputs, for pumps and turbines under various operational conditions.</p> <p>3.6. Analyzes system behavior under different load conditions, recognizing potential issues such as cavitation, efficiency losses, and pressure fluctuations.</p> <p>3.7. Designs solutions that meet functional requirements, taking into account factors such as energy efficiency, system reliability, and cost-effectiveness.</p> <p>3.8. Evaluates the impact of system modifications on overall performance, providing recommendations for optimization or improvement.</p> <p>3.9. Communicates technical solutions and problem-solving approaches effectively, using appropriate engineering terminology and documentation standards.</p>

CHE0002 – 7 Heat Transfer Processes

The aim of this study unit is to equip students with a detailed understanding of the mechanisms of heat transfer, including conduction, convection, and radiation, and their applications in engineering systems. This unit focuses on the design and analysis of heat exchangers for industrial processes, emphasizing techniques to evaluate and enhance thermal efficiency. By mastering these principles, students will develop the ability to optimize heat transfer systems, contributing to the sustainability and efficiency of industrial operations. This unit serves as a critical foundation for addressing thermal management challenges in chemical and process engineering.

Learning Outcome:	Assessment Criteria:
<p>1. Understand conduction, convection, and radiation heat transfer mechanisms.</p>	<p>1.1. Demonstrates a clear understanding of the fundamental principles of heat transfer, including conduction, convection, and radiation, and their applications in engineering systems.</p> <p>1.2. Analyzes heat transfer in solid materials using Fourier's law for conduction, and explains the factors influencing thermal conductivity.</p> <p>1.3. Applies the principles of convection to analyze heat transfer in fluids, considering both natural and forced convection processes.</p> <p>1.4. Evaluates the role of fluid properties, such as viscosity and thermal conductivity, in convection heat transfer.</p> <p>1.5. Understands and calculates radiation heat transfer using Stefan-Boltzmann law and considers the effects of emissivity and temperature differences.</p> <p>1.6. Explains the significance of the heat transfer modes in different engineering applications, such as heat exchangers, thermal insulation, and electronic cooling systems.</p> <p>1.7. Integrates the three modes of heat transfer (conduction, convection, and radiation) in real-world engineering scenarios to solve thermal management problems.</p> <p>1.8. Demonstrates proficiency in using relevant equations and methods to calculate heat transfer rates for various materials and systems.</p> <p>1.9. Communicates technical findings and solutions related to heat transfer clearly and</p>

	accurately, using appropriate scientific and engineering terminology.
<p>2. Design and analyze heat exchangers for industrial applications.</p>	<p>2.1. Demonstrates a comprehensive understanding of the types, functions, and applications of heat exchangers in industrial settings.</p> <p>2.2. Applies fundamental principles of heat transfer, fluid mechanics, and thermodynamics to design efficient heat exchangers that meet the thermal performance requirements.</p> <p>2.3. Selects appropriate heat exchanger configurations (e.g., shell-and-tube, plate, air-cooled) based on process conditions, fluid properties, and system requirements.</p> <p>2.4. Utilizes relevant design equations, such as the effectiveness-NTU method and Log Mean Temperature Difference (LMTD) to optimize heat exchanger design for specific applications.</p> <p>2.5. Analyzes the heat transfer rate, pressure drop, and flow distribution in the heat exchanger, ensuring compliance with operational and safety standards.</p> <p>2.6. Identifies potential issues in heat exchanger performance, including fouling, scaling, and thermal stress, and proposes solutions to mitigate them.</p> <p>2.7. Conducts thermal and hydraulic simulations to assess heat exchanger performance under varying operational conditions and adjusts design parameters for optimization.</p> <p>2.8. Considers economic factors, such as material selection, maintenance costs, and energy efficiency, in the heat exchanger design process.</p> <p>2.9. Communicates the design, analysis, and performance evaluation of heat exchangers clearly through technical documentation, including drawings, calculations, and system specifications.</p>
<p>3. Evaluate thermal efficiency and optimize heat transfer systems.</p>	<p>3.1. Demonstrates a solid understanding of thermal efficiency concepts and their</p>

	<p>application in heat transfer systems, including both steady-state and transient conditions.</p> <ol style="list-style-type: none">3.2. Applies thermodynamic principles to evaluate the performance of heat transfer systems, calculating heat transfer rates, temperature gradients, and efficiency.3.3. Identifies key factors influencing thermal efficiency, such as material properties, heat transfer coefficients, and system design, and uses this information to assess system performance.3.4. Utilizes energy balance equations and performance metrics to quantify the thermal efficiency of heat exchangers, pumps, turbines, and other components within a system.3.5. Analyzes and identifies areas of energy loss in heat transfer systems, such as heat leakage, thermal bridging, and inefficient heat exchange, proposing corrective measures.3.6. Employs optimization techniques, such as multi-variable analysis and computational simulations, to improve heat transfer efficiency and reduce energy consumption in industrial systems.3.7. Considers the impact of system modifications, including material changes, fluid flow adjustments, and temperature control, on overall thermal efficiency.3.8. Evaluates the effectiveness of different heat transfer enhancement methods, including the use of fins, extended surfaces, and phase-change materials, to maximize efficiency.3.9. Communicates findings, optimization strategies, and system improvements effectively through technical reports, graphs, and simulations, using appropriate engineering terminology and standards.
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CHE0002 – 8 Chemical Process Industries

The aim of this study unit is to provide students with an in-depth understanding of the structure and operation of major chemical industries, including petrochemical, pharmaceutical, and food processing sectors. This unit focuses on analyzing industrial processes, tracing the transformation of raw materials into finished products, and evaluating their efficiency and sustainability. Students will also gain insights into the economic and environmental factors that influence chemical production, preparing them to assess and improve industrial operations in a global context. This unit builds the knowledge necessary for advancing innovation and sustainability in chemical manufacturing.

Learning Outcome:	Assessment Criteria:
<p>1. Analyze key chemical industries, including petrochemical, pharmaceutical, and food processing.</p>	<p>1.1. Demonstrates a thorough understanding of the structure, operations, and key processes within the petrochemical, pharmaceutical, and food processing industries.</p> <p>1.2. Analyzes the chemical processes involved in each industry, identifying key reactions, raw materials, and product outputs.</p> <p>1.3. Evaluates the operational challenges and risks specific to each sector, including environmental, health, and safety concerns.</p> <p>1.4. Understands the regulatory frameworks governing the petrochemical, pharmaceutical, and food processing industries, and applies them in the analysis of industry practices.</p> <p>1.5. Assesses the economic, environmental, and technological factors influencing the sustainability and competitiveness of these industries.</p> <p>1.6. Identifies the role of innovation and process optimization in improving productivity, reducing costs, and enhancing product quality in each industry.</p> <p>1.7. Analyzes the integration of advanced technologies, such as automation, digitalization, and green chemistry, to improve efficiency and reduce the environmental footprint of chemical processes.</p> <p>1.8. Examines supply chain dynamics, from raw material sourcing to product distribution, highlighting industry-specific logistical and operational strategies.</p> <p>1.9. Communicates insights into the chemical</p>

	<p>industries effectively through reports and presentations, addressing both technical and non-technical stakeholders.</p>
<p>2. Evaluate industrial processes from raw material to final product.</p>	<p>2.1. Demonstrates a clear understanding of the entire industrial process flow, from raw material sourcing to final product manufacturing and distribution.</p> <p>2.2. Analyzes each step of the production process, identifying key stages such as raw material preparation, processing, refining, and packaging, and their impact on product quality.</p> <p>2.3. Evaluates the selection of raw materials based on factors such as cost, availability, environmental impact, and compatibility with the desired product.</p> <p>2.4. Assesses the efficiency and effectiveness of processing techniques used at each stage of production, considering energy consumption, waste generation, and process optimization.</p> <p>2.5. Identifies critical quality control points throughout the process to ensure the final product meets the required standards and specifications.</p> <p>2.6. Examines the role of automation, control systems, and technology integration in improving process efficiency and consistency across different production phases.</p> <p>2.7. Analyzes potential risks, including equipment failures, supply chain disruptions, and regulatory challenges, and proposes solutions to mitigate these issues.</p> <p>2.8. Considers the environmental impact of the entire process, from raw material extraction to final product disposal, and recommends sustainable practices and waste management strategies.</p> <p>2.9. Communicates the evaluation of industrial processes clearly and effectively, highlighting process improvements, cost-benefit analyses, and sustainability efforts.</p>
<p>3. Understand economic and environmental factors in chemical production.</p>	<p>3.1. Demonstrates a comprehensive understanding of the economic principles</p>

	<p>influencing chemical production, including cost analysis, market demand, and pricing strategies.</p> <ol style="list-style-type: none">3.2. Evaluates the financial implications of raw material selection, production processes, and energy consumption, considering their impact on overall profitability.3.3. Assesses the capital investment requirements for setting up and maintaining chemical production facilities, including plant design, equipment costs, and labor expenses.3.4. Identifies and analyzes the environmental factors associated with chemical production, such as emissions, waste management, resource depletion, and ecosystem impact.3.5. Understands and applies sustainability concepts, including green chemistry, energy efficiency, and waste reduction, to minimize the environmental footprint of chemical production.3.6. Evaluates the regulatory frameworks governing chemical production, including environmental laws, safety standards, and sustainability certifications, and their impact on operational practices.3.7. Assesses the trade-offs between economic benefits and environmental impact, recommending strategies for achieving a balance between cost-efficiency and sustainability.3.8. Analyzes the lifecycle cost and environmental impact of chemical products, considering the entire supply chain from raw material extraction to product disposal or recycling.3.9. Communicates economic and environmental assessments effectively, providing actionable insights to stakeholders, including management, regulatory bodies, and the public.
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CHE0002 – 9 Mechanical Properties of Materials

The aim of this study unit is to provide students with a comprehensive understanding of how materials respond to stress, strain, and temperature variations. This unit focuses on evaluating materials for their suitability in chemical engineering applications, with an emphasis on understanding mechanical behavior and failure modes. Students will develop the ability to analyze material performance and select appropriate materials for specific processes, ensuring reliability and safety in engineering designs. This unit prepares students to address challenges in material selection and performance optimization in industrial environments.

Learning Outcome:	Assessment Criteria:
<p>1. Understand material behavior under stress, strain, and temperature variations.</p>	<ul style="list-style-type: none"> 1.1. Demonstrates a fundamental understanding of the concepts of stress, strain, and their relationship in material behavior under different loading conditions. 1.2. Analyzes the effects of external forces on materials, including tensile, compressive, and shear stresses, and calculates corresponding strain values. 1.3. Evaluates the behavior of materials under different types of deformation, considering both elastic and plastic regions of the stress-strain curve. 1.4. Understands the role of temperature variations on material properties, such as thermal expansion, changes in strength, and impact on material integrity. 1.5. Applies material models, including Hooke’s law and constitutive equations, to predict material response to stress, strain, and temperature changes. 1.6. Assesses the effects of cyclic loading and environmental factors (e.g., thermal gradients) on material fatigue, creep, and failure. 1.7. Identifies the impact of temperature-induced changes in material properties, such as thermal conductivity, yield strength, and hardness, under different operational conditions. 1.8. Understands and predicts material behavior in real-world engineering applications, considering factors such as temperature fluctuations, mechanical stress, and long-term performance.

	<p>1.9. Communicates findings on material behavior clearly through technical analysis, ensuring accurate representation of stress-strain data and temperature effects in design and engineering solutions.</p>
<p>2. Evaluate materials for use in chemical engineering applications.</p>	<p>2.1. Demonstrates a thorough understanding of the properties of materials commonly used in chemical engineering applications, including metals, polymers, ceramics, and composites.</p> <p>2.2. Assesses material selection criteria based on factors such as chemical resistance, thermal stability, mechanical strength, and corrosion resistance, relevant to specific chemical processes.</p> <p>2.3. Evaluates the performance of materials in harsh environments, considering factors like exposure to high temperatures, aggressive chemicals, pressure conditions, and fatigue.</p> <p>2.4. Analyzes the compatibility of materials with process fluids, taking into account chemical reactivity, solubility, and potential for degradation or contamination.</p> <p>2.5. Considers material sustainability, including availability, recyclability, and lifecycle costs, when evaluating materials for long-term use in chemical engineering applications.</p> <p>2.6. Applies material science principles, such as phase diagrams, crystallography, and microstructure, to predict material behavior in chemical processes.</p> <p>2.7. Uses industry standards and codes, such as ASME, ASTM, and ISO, to ensure the selected materials meet the required specifications for safety and reliability.</p> <p>2.8. Evaluates the impact of material selection on process efficiency, maintenance costs, and system durability in chemical plants and production facilities.</p> <p>2.9. Communicates material evaluation results effectively through detailed technical reports, considering both performance metrics and economic factors in the decision-making process.</p>

<p>3. Analyze failure modes and select appropriate materials for specific processes.</p>	<ul style="list-style-type: none">3.1. Demonstrates a clear understanding of various failure modes, including mechanical failure (e.g., fatigue, fracture, creep), chemical degradation (e.g., corrosion, oxidation), and thermal failure (e.g., thermal shock, expansion).3.2. Analyzes the causes and consequences of material failure in specific chemical engineering applications, considering operating conditions such as temperature, pressure, and chemical exposure.3.3. Identifies failure mechanisms relevant to different industrial processes, including stress corrosion cracking, erosion, and pitting, and correlates these to process conditions and material properties.3.4. Evaluates material performance under both static and dynamic loading conditions, using principles of strength of materials and failure theories (e.g., von Mises, Tresca).3.5. Selects appropriate materials based on their resistance to identified failure modes, ensuring the material choice enhances process reliability, safety, and longevity.3.6. Considers economic factors, such as material cost, availability, and life cycle cost, in the selection process while ensuring material performance meets operational requirements.3.7. Utilizes industry standards and testing methods, such as ASTM and ISO, to assess material performance in simulated or real-life process conditions.3.8. Analyzes the impact of material selection on system maintenance, considering factors such as wear, fatigue, and the potential need for frequent replacements or repairs.3.9. Communicates the rationale behind material selection and failure mode analysis effectively, providing clear recommendations to stakeholders based on technical, operational, and economic considerations.
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CHE0002 – 10 Laboratory Skills and Safety

The aim of this study unit is to equip students with essential practical skills for conducting chemical analysis and engineering experiments in a safe and professional manner. This unit emphasizes the importance of adhering to safety protocols and performing comprehensive risk assessments in laboratory environments. Students will also develop the ability to accurately record, analyze, and interpret experimental data, fostering a meticulous and scientific approach to problem-solving. Through hands-on experience, this unit prepares students to confidently and safely conduct experiments and contribute to research and industrial processes.

Learning Outcome:	Assessment Criteria:
<p>1. Develop practical laboratory skills for chemical analysis and engineering experiments.</p>	<p>1.1. Demonstrates proficiency in operating laboratory equipment and instruments used in chemical analysis and engineering experiments, ensuring proper handling and safety procedures are followed.</p> <p>1.2. Accurately performs quantitative and qualitative chemical analyses, applying appropriate techniques such as titration, chromatography, spectrometry, and gas analysis.</p> <p>1.3. Develops the ability to prepare chemical solutions, reagents, and samples with precision, adhering to prescribed concentrations and experimental protocols.</p> <p>1.4. Applies principles of experimental design, including control of variables, reproducibility, and calibration, to ensure reliable and valid experimental results.</p> <p>1.5. Evaluates experimental data critically, identifying sources of error, performing necessary calculations, and applying statistical methods to interpret results.</p> <p>1.6. Conducts experiments under controlled conditions, following standard operating procedures (SOPs) and maintaining proper documentation of all steps and observations.</p> <p>1.7. Demonstrates the ability to troubleshoot and resolve common technical issues encountered during chemical experiments, ensuring minimal disruption to experimental outcomes.</p> <p>1.8. Understands and applies the principles of safety, waste disposal, and environmental protection in laboratory settings, ensuring</p>

	<p>compliance with regulatory standards.</p> <p>1.9. Communicates experimental findings effectively, preparing clear and accurate reports, presentations, and analyses of laboratory results, with appropriate interpretation and recommendations.</p>
<p>2. Follow safety protocols and risk assessments in laboratory environments.</p>	<p>2.1. Demonstrates a clear understanding of safety protocols and risk assessment procedures specific to laboratory environments, ensuring compliance with relevant standards and regulations.</p> <p>2.2. Identifies potential hazards in laboratory settings, including chemical, physical, biological, and environmental risks, and takes appropriate preventive measures.</p> <p>2.3. Conducts comprehensive risk assessments for laboratory experiments, considering factors such as material toxicity, flammability, reactivity, and potential for accidents.</p> <p>2.4. Ensures proper use of personal protective equipment (PPE), including gloves, lab coats, safety goggles, and respirators, in line with the nature of the experiment and identified risks.</p> <p>2.5. Applies safe handling, storage, and disposal procedures for chemicals, reagents, and waste materials, adhering to safety data sheets (SDS) and local regulations.</p> <p>2.6. Follows emergency response protocols for accidents such as chemical spills, fires, or exposure to hazardous materials, including first aid, evacuation, and alerting relevant authorities.</p> <p>2.7. Demonstrates the ability to operate laboratory equipment safely, following operational manuals, calibration procedures, and ensuring that all devices are functioning correctly before use.</p> <p>2.8. Conducts regular safety checks and inspections of laboratory equipment, tools, and workspaces to identify potential hazards and ensure proper maintenance.</p> <p>2.9. Communicates laboratory safety procedures clearly to colleagues and students, promoting</p>

	<p>a culture of safety and ensuring everyone is aware of emergency protocols and risk mitigation strategies.</p>
<p>3. Accurately record, analyze, and interpret experimental data.</p>	<ul style="list-style-type: none"> 3.1. Demonstrates the ability to accurately record experimental data, ensuring all measurements, observations, and conditions are documented clearly and systematically. 3.2. Uses appropriate units of measurement and maintains consistency in data recording to ensure reliability and ease of analysis. 3.3. Analyzes experimental data by applying suitable mathematical and statistical methods, identifying trends, patterns, and outliers to draw meaningful conclusions. 3.4. Utilizes software tools or manual calculations to process data, perform error analysis, and calculate key results, ensuring accuracy and precision in all analyses. 3.5. Interprets experimental data in the context of the experiment's objectives, making informed conclusions and identifying potential sources of error or uncertainty. 3.6. Organizes data into tables, charts, and graphs, presenting the results clearly for easy understanding and comparison, ensuring that visual representations are accurate and appropriately labeled. 3.7. Cross-checks experimental data with theoretical predictions or literature values to assess the validity and consistency of the results. 3.8. Identifies and explains deviations from expected results, providing hypotheses for potential causes and suggesting improvements or further investigations. 3.9. Communicates the results of data analysis effectively in written reports or presentations, ensuring that the interpretations are clear, justified, and supported by the recorded data.

CHE0002 – 11 Environmental Science and Sustainability

The aim of this study unit is to provide students with a comprehensive understanding of the environmental impacts associated with chemical engineering processes and the importance of sustainability in modern industry. This unit emphasizes the development of sustainable engineering solutions for waste management, resource optimization, and energy efficiency. Students will also gain the knowledge to analyze and comply with regulatory requirements for environmental protection, equipping them to implement strategies that balance industrial productivity with ecological responsibility. This unit prepares students to lead in creating sustainable and environmentally compliant engineering practices.

Learning Outcome:	Assessment Criteria:
<p>1. Understand environmental impacts of chemical engineering processes.</p>	<p>1.1. Demonstrates a comprehensive understanding of the environmental impacts associated with chemical engineering processes, including air, water, and soil pollution.</p> <p>1.2. Analyzes the life cycle of chemical products, from raw material extraction through production to disposal, and evaluates the associated environmental effects.</p> <p>1.3. Identifies and assesses the key environmental risks in chemical processes, such as emissions, waste generation, resource depletion, and energy consumption.</p> <p>1.4. Understands the principles of sustainability and applies them to chemical processes, recommending strategies for reducing environmental harm and promoting resource efficiency.</p> <p>1.5. Evaluates the effectiveness of pollution control technologies, waste treatment systems, and emission reduction methods used in chemical engineering applications.</p> <p>1.6. Considers the environmental regulations, standards, and best practices that govern chemical engineering processes, ensuring compliance and promoting environmental stewardship.</p> <p>1.7. Assesses the impact of raw material selection and process design on environmental outcomes, including the use of renewable resources and eco-friendly chemicals.</p> <p>1.8. Evaluates the potential for energy conservation and carbon footprint reduction within chemical processes, recommending energy-efficient</p>

	<p>technologies and practices.</p> <p>1.9. Communicates the environmental impact of chemical engineering processes clearly, providing actionable recommendations to minimize adverse effects and enhance sustainability.</p>
<p>2. Develop sustainable engineering solutions for waste management and energy efficiency.</p>	<p>2.1. Demonstrates an in-depth understanding of the principles of sustainable engineering, including the integration of resource conservation, waste reduction, and energy efficiency into engineering solutions.</p> <p>2.2. Identifies and evaluates the environmental and economic impacts of different waste management strategies, including recycling, waste-to-energy processes, and material recovery.</p> <p>2.3. Develops innovative and cost-effective solutions for waste management, considering the entire life cycle of materials, from production and use to disposal and recycling.</p> <p>2.4. Applies energy-efficient design principles to optimize processes, reducing energy consumption and enhancing the sustainability of engineering systems.</p> <p>2.5. Assesses and implements renewable energy options, such as solar, wind, and bioenergy, in waste management and chemical engineering processes to reduce reliance on non-renewable resources.</p> <p>2.6. Utilizes advanced technologies, such as waste segregation, treatment, and conversion methods (e.g., anaerobic digestion, pyrolysis, and gasification), to improve waste management efficiency and sustainability.</p> <p>2.7. Develops strategies to minimize the environmental footprint of energy-intensive processes, including process optimization, heat recovery, and waste heat utilization.</p> <p>2.8. Incorporates life cycle assessment (LCA) techniques to evaluate the long-term environmental impacts of waste management and energy solutions, ensuring sustainability.</p> <p>2.9. Communicates sustainable solutions effectively, providing clear, actionable recommendations to stakeholders, including industry leaders, regulatory bodies, and the public, to promote</p>

	eco-friendly engineering practices.
<p>3. Analyze regulatory requirements for environmental protection.</p>	<p>3.1. Demonstrates a comprehensive understanding of the regulatory frameworks and standards governing environmental protection, including local, national, and international regulations.</p> <p>3.2. Analyzes and interprets key environmental regulations such as emissions standards, waste management protocols, water quality regulations, and air pollution control requirements.</p> <p>3.3. Evaluates the compliance requirements of chemical engineering processes with environmental protection laws, including understanding permits, reporting obligations, and penalties for non-compliance.</p> <p>3.4. Identifies and assesses the potential environmental risks associated with chemical processes and develops strategies to ensure adherence to relevant regulatory standards.</p> <p>3.5. Applies knowledge of environmental impact assessments (EIAs) and environmental audits to assess the potential effects of industrial activities on ecosystems and public health.</p> <p>3.6. Understands and integrates the principles of sustainable development and environmental justice within the regulatory framework, ensuring that engineering practices minimize harm to vulnerable communities and ecosystems.</p> <p>3.7. Tracks and analyzes updates in environmental legislation, industry best practices, and technological innovations to ensure ongoing regulatory compliance and continuous improvement.</p> <p>3.8. Prepares and presents compliance reports, environmental assessments, and impact studies in line with regulatory requirements, ensuring transparency and accountability.</p> <p>3.9. Communicates regulatory implications to stakeholders, providing clear guidance on the legal responsibilities and potential environmental impacts associated with engineering projects and operations.</p>

CHE0002 – 12 Technical Communications and Report Writing

The aim of this study unit is to equip students with the skills necessary to communicate technical information clearly and effectively in professional settings. This unit focuses on developing the ability to prepare comprehensive engineering reports and documentation, adhering to industry standards. Students will also learn to present technical findings in a manner appropriate for diverse audiences, ensuring clarity, accuracy, and engagement. By mastering these skills, students will be prepared to convey complex engineering concepts and results effectively, both in written and oral forms, within academic, industrial, and professional contexts.

Learning Outcome:	Assessment Criteria:
<p>1. Develop technical writing skills for clear and concise communication.</p>	<ul style="list-style-type: none"> 1.1. Demonstrates the ability to write clear, concise, and well-structured technical documents that effectively communicate complex information to the intended audience. 1.2. Utilizes appropriate technical terminology and language suited to the subject matter, ensuring accessibility and comprehension for both technical and non-technical readers. 1.3. Ensures proper organization of ideas and concepts, with logical flow and coherent structure throughout the document. 1.4. Adheres to grammatical, spelling, and punctuation standards, ensuring the document is error-free and professionally presented. 1.5. Effectively uses visuals (charts, graphs, diagrams) where appropriate to support and enhance the written content, aiding reader understanding. 1.6. Demonstrates proficiency in adapting writing style and tone to suit different document types, such as manuals, reports, proposals, and instructions. 1.7. Incorporates feedback from peers, instructors, or subject matter experts to improve clarity, accuracy, and overall quality of the technical writing. 1.8. Exhibits an understanding of the target audience’s needs and tailors the content to meet those needs while maintaining clarity and precision. 1.9. Demonstrates the ability to revise and refine drafts through multiple iterations to ensure

<p>2. Prepare comprehensive engineering reports and documentation.</p>	<p>clarity, conciseness, and technical accuracy.</p> <ol style="list-style-type: none"> 2.1. Demonstrates the ability to compile and present engineering data, research, and analysis in a structured and organized report format. 2.2. Includes clear and precise technical details, ensuring all relevant information is presented accurately to support conclusions and recommendations. 2.3. Utilizes appropriate engineering terminology and conventions, ensuring that the document is both accessible to professionals in the field and understandable to non-experts when necessary. 2.4. Effectively structures the report with appropriate sections, such as introduction, methodology, results, discussion, and conclusions, following industry-standard formats. 2.5. Presents complex engineering concepts, calculations, and analyses in a clear and concise manner, using visual aids (e.g., graphs, charts, tables) where necessary to enhance comprehension. 2.6. Demonstrates proficiency in referencing sources and citing relevant literature in accordance with industry standards or specific citation styles. 2.7. Adheres to all relevant industry standards, guidelines, and regulatory requirements in the preparation of reports and documentation. 2.8. Clearly defines objectives, scope, and outcomes of engineering projects or analyses, ensuring stakeholders can understand the context and implications. 2.9. Effectively integrates feedback from colleagues, supervisors, or industry experts to enhance the technical accuracy and clarity of the report.
<p>3. Present technical findings effectively to varied audiences.</p>	<ol style="list-style-type: none"> 3.1. Demonstrates the ability to clearly articulate technical findings in both written and verbal formats, tailoring the level of detail to suit the knowledge and interests of the audience.

	<ul style="list-style-type: none">3.2. Utilizes appropriate visual aids (e.g., slides, diagrams, charts) to enhance the clarity and impact of the presentation, ensuring that key points are emphasized.3.3. Adjusts communication style and tone to effectively engage and inform different audiences, ranging from technical experts to non-specialists.3.4. Presents technical information in a logical, organized sequence, ensuring that the audience can follow the progression of ideas and findings easily.3.5. Responds confidently and accurately to audience questions or feedback, demonstrating thorough understanding of the subject matter and the ability to explain complex concepts in simpler terms when needed.3.6. Engages the audience through interactive elements, such as discussions or Q&A sessions, fostering understanding and encouraging dialogue.3.7. Demonstrates effective use of timing, ensuring that the presentation is well-paced and respects the audience's attention span.3.8. Utilizes professional presentation techniques, including clear articulation, appropriate body language, and effective use of visual media, to enhance audience engagement and comprehension.3.9. Tailors the depth and focus of technical findings according to the specific needs and expectations of different stakeholders (e.g., clients, colleagues, management).
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CHE0002 – 13 Advanced Thermodynamics

The aim of this study unit is to deepen students' understanding of thermodynamic principles and their application to complex systems and cycles. This unit focuses on the analysis of advanced thermodynamic cycles and systems, including multi-phase and non-ideal systems, equipping students with the skills to solve intricate thermodynamic problems. Students will learn to apply these advanced concepts to optimize industrial processes, improving efficiency and sustainability in various chemical engineering applications. Through theoretical and practical learning, this unit prepares students to address sophisticated thermodynamic challenges in real-world industrial settings.

Learning Outcome:	Assessment Criteria:
<p>1. Analyze advanced thermodynamic cycles and systems.</p>	<p>1.1. Demonstrates the ability to apply advanced thermodynamic principles to analyze complex cycles and systems, identifying key variables and their relationships.</p> <p>1.2. Effectively uses thermodynamic models and simulations to predict system behavior under various operating conditions, ensuring accuracy and reliability of results.</p> <p>1.3. Analyzes the performance of advanced thermodynamic cycles, such as Rankine, Brayton, and combined cycles, evaluating their efficiency and effectiveness in real-world applications.</p> <p>1.4. Applies principles of energy conservation, entropy, and enthalpy in the analysis of thermodynamic systems, demonstrating a clear understanding of system dynamics.</p> <p>1.5. Evaluates the impact of different working fluids and cycle configurations on system performance, considering factors such as energy efficiency, environmental impact, and cost-effectiveness.</p> <p>1.6. Demonstrates the ability to conduct energy and exergy analyses to assess the sustainability and optimization potential of thermodynamic systems.</p> <p>1.7. Identifies and evaluates potential system losses, inefficiencies, and areas for improvement in advanced thermodynamic cycles, offering practical solutions for optimization.</p> <p>1.8. Applies fundamental thermodynamic laws and principles to complex system integration, ensuring that all subsystems work cohesively and efficiently.</p> <p>1.9. Demonstrates proficiency in using computational</p>

	<p>tools and software to model, simulate, and analyze advanced thermodynamic systems, presenting findings with clarity and technical accuracy.</p>
<p>2. Solve complex problems involving multi-phase and non-ideal systems.</p>	<p>2.1. Demonstrates the ability to identify and define complex problems involving multi-phase and non-ideal systems, breaking them down into manageable components for analysis.</p> <p>2.2. Applies advanced thermodynamic principles and models to analyze multi-phase systems, considering phase transitions, equilibrium states, and the effects of non-ideality on system behavior.</p> <p>2.3. Utilizes appropriate equations of state and thermodynamic relationships to model non-ideal fluids and multi-phase mixtures, ensuring accuracy in predictions and calculations.</p> <p>2.4. Effectively uses computational tools and simulation software to solve complex problems involving non-ideal and multi-phase systems, interpreting results with technical precision.</p> <p>2.5. Incorporates real fluid behavior, including deviations from ideal gas laws, into problem-solving strategies, accurately accounting for interactions and non-idealities in system modeling.</p> <p>2.6. Analyzes the impact of temperature, pressure, and composition changes on multi-phase equilibrium, using phase diagrams and other tools to visualize and solve related problems.</p> <p>2.7. Demonstrates a deep understanding of thermodynamic cycles and processes involving non-ideal and multi-phase fluids, offering innovative solutions to improve system performance or efficiency.</p> <p>2.8. Evaluates the influence of external factors, such as temperature fluctuations and pressure variations, on multi-phase and non-ideal systems, applying appropriate models to predict system behavior under varying conditions.</p> <p>2.9. Solves problems involving non-ideal mixtures by applying concepts such as fugacity, activity coefficients, and non-ideal phase equilibria, ensuring comprehensive solutions.</p>

<p>3. Apply thermodynamic principles to optimize industrial processes.</p>	<ul style="list-style-type: none">3.1. Demonstrates the ability to identify key thermodynamic principles and apply them to optimize the efficiency and performance of industrial processes, considering both energy and resource utilization.3.2. Analyzes and models industrial processes using thermodynamic cycles and systems, optimizing variables such as pressure, temperature, and fluid flow to maximize energy efficiency and minimize waste.3.3. Utilizes advanced thermodynamic techniques, such as exergy analysis and energy audits, to identify inefficiencies in industrial systems and propose actionable solutions for improvement.3.4. Applies principles of heat transfer, fluid dynamics, and thermodynamic cycles to design and optimize systems like heat exchangers, compressors, and turbines in industrial settings.3.5. Demonstrates the ability to assess the impact of process modifications on overall system performance, ensuring that changes lead to cost reduction, energy savings, and enhanced sustainability.3.6. Uses computational tools and simulation software to model industrial processes, performing sensitivity analysis to identify key factors affecting system performance and optimize operation parameters.3.7. Evaluates environmental and economic considerations in process optimization, applying thermodynamic principles to achieve a balance between performance, cost-effectiveness, and sustainability.3.8. Develops and implements thermodynamic strategies for waste heat recovery, improving the overall energy efficiency and reducing environmental impact in industrial operations.3.9. Works within safety, regulatory, and operational constraints to optimize processes, ensuring that thermodynamic solutions adhere to industry standards and best practices
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CHE0002 – 14 Advanced Fluid Mechanics

The aim of this study unit is to provide students with an in-depth understanding of complex fluid dynamics concepts, including turbulence, compressible flow, and other advanced topics. This unit equips students with the skills to design and optimize fluid transport systems, ensuring efficiency and reliability in engineering applications.

Learning Outcome:	Assessment Criteria:
<p>1. Understand advanced concepts in fluid dynamics, including turbulence and compressible flow.</p>	<ul style="list-style-type: none"> 1.1. Demonstrates a deep understanding of advanced fluid dynamics concepts, including the governing equations and principles for both incompressible and compressible flow. 1.2. Accurately applies the Navier-Stokes equations to analyze and solve complex fluid flow problems, considering both laminar and turbulent flow regimes. 1.3. Demonstrates proficiency in characterizing and analyzing turbulence, including the use of turbulence models (e.g., k-ϵ, LES) to predict turbulent behavior in various fluid systems. 1.4. Understands and applies the principles of compressible flow, including shock waves, expansion fans, and the concept of Mach number, to solve problems in high-speed flow scenarios. 1.5. Analyzes the behavior of fluid systems under varying thermodynamic conditions, including the effects of pressure, temperature, and velocity on compressible flow properties. 1.6. Demonstrates the ability to model and simulate fluid flow in complex systems, using computational fluid dynamics (CFD) tools to solve real-world engineering problems involving turbulence and compressible fluids. 1.7. Explores the impact of boundary layers, separation, and pressure gradients on fluid flow behavior, and understands how these factors influence design and performance in engineering applications. 1.8. Applies advanced concepts such as Reynolds number, Prandtl number, and Mach number to analyze and predict the transition between different flow regimes in industrial systems. 1.9. Understands the role of turbulence in heat and mass transfer processes and is able to predict and optimize these effects in

	<p>engineering applications like heat exchangers and aerodynamic systems.</p>
<p>2. Design and optimize fluid transport systems.</p>	<ul style="list-style-type: none"> 2.1. Demonstrates the ability to design fluid transport systems, considering factors such as fluid properties, flow rate, pressure drop, and system layout to ensure efficiency and functionality. 2.2. Applies principles of fluid dynamics, including Bernoulli’s equation and the Darcy-Weisbach equation, to analyze and design pipelines, pumps, and valves for optimal performance. 2.3. Utilizes computational tools and simulation software to model and optimize fluid transport systems, ensuring accurate predictions of system behavior under different operating conditions. 2.4. Analyzes and selects appropriate materials and components for fluid transport systems, ensuring compatibility with the fluid properties and long-term reliability of the system. 2.5. Considers both steady-state and transient flow conditions in the design process, optimizing for factors like pressure fluctuations, flow stability, and system resilience. 2.6. Applies principles of energy conservation and efficiency to reduce energy consumption, minimize losses, and optimize the power requirements of pumps and compressors in the transport system. 2.7. Evaluates and designs for factors such as pipe diameter, roughness, and flow velocity to minimize friction losses and optimize the overall energy efficiency of the fluid transport network. 2.8. Identifies potential hazards, such as cavitation, erosion, or system overpressure, and incorporates design strategies to mitigate these risks, ensuring system safety and longevity. 2.9. Optimizes the system for cost-effectiveness, balancing initial design costs with operational and maintenance expenses over the lifecycle

	of the fluid transport system.
<p>3. Use computational tools to model fluid behavior in engineering systems.</p>	<p>3.1. Demonstrates proficiency in using computational tools, such as Computational Fluid Dynamics (CFD) software, to model and simulate fluid behavior in complex engineering systems.</p> <p>3.2. Accurately sets up simulation parameters, including boundary conditions, initial conditions, and material properties, to ensure the validity of the model in representing real-world fluid behavior.</p> <p>3.3. Applies advanced numerical methods to solve fluid dynamics equations and accurately predict flow characteristics in engineering applications.</p> <p>3.4. Analyzes simulation results to evaluate key fluid behavior parameters, such as velocity, pressure distribution, turbulence, and heat transfer, and interprets these results to inform system design and optimization.</p> <p>3.5. Utilizes appropriate turbulence models to simulate turbulent flow regimes and assess their effects on system performance, ensuring accurate representation of real-world fluid behavior.</p> <p>3.6. Incorporates multiphase flow and compressible flow models into simulations to address complex fluid dynamics scenarios, such as cavitation, flow separation, and shock waves, as they occur in engineering systems.</p> <p>3.7. Performs sensitivity analyses to understand the impact of varying input parameters on system performance and optimize design decisions.</p> <p>3.8. Demonstrates the ability to integrate CFD results with other engineering tools to solve multidisciplinary problems involving fluid flow, heat transfer, and structural behavior.</p> <p>3.9. Validates simulation results through comparison with experimental data or analytical solutions to ensure the accuracy and reliability of the models.</p>

CHE0002 – 15 Process Control and Instrumentation

The aim of this unit is to provide students with a thorough understanding of the principles and applications of process control in chemical engineering. This unit focuses on key concepts such as feedback and feed forward control systems, enabling students to design effective control strategies for industrial chemical processes. Students will also gain practical knowledge in using modern instrumentation and sensors for process monitoring and control, ensuring process efficiency, stability, and safety. Through this unit, students will be equipped to implement and optimize control systems in real-world industrial settings.

Learning Outcome:	Assessment Criteria:
<p>1. Understand process control principles, including feedback and feed forward systems.</p>	<p>1.1. Demonstrates a clear understanding of process control principles, including the role of feedback and feed forward systems in regulating and optimizing process behavior.</p> <p>1.2. Explains the differences between feedback and feed forward control systems, and their applications in industrial processes, recognizing when each type is most appropriate.</p> <p>1.3. Applies control theory concepts, such as stability, dynamic response, and time constants, to design and analyze feedback and feed forward systems in real-world engineering processes.</p> <p>1.4. Utilizes mathematical models and transfer functions to analyze the behavior of feedback and feed forward systems, ensuring accurate prediction and control of process variables.</p> <p>1.5. Identifies the key components of a control system, including sensors, controllers, and actuators, and understands their interaction in maintaining desired process outputs.</p> <p>1.6. Designs and tunes controllers (e.g., PID controllers) to optimize the performance of feedback systems, minimizing error, overshoot, and response time in dynamic processes.</p> <p>1.7. Integrates feed forward control strategies to anticipate disturbances and improve process control, particularly in systems with measurable disturbances or predictable changes in input variables.</p> <p>1.8. Analyzes and addresses common challenges in process control, such as noise, dead time, and nonlinearities, ensuring robust and reliable system performance under varying conditions.</p> <p>1.9. Evaluates the performance of feedback and feed</p>

	<p>forward systems using standard criteria, including stability, accuracy, and disturbance rejection, making adjustments to improve overall process efficiency.</p>
<p>2. Design control strategies for industrial chemical processes.</p>	<p>2.1. Demonstrates the ability to design effective control strategies for industrial chemical processes, incorporating fundamental control principles to ensure optimal system performance.</p> <p>2.2. Applies process dynamics and system modeling techniques to identify key process variables and determine the most appropriate control approach for maintaining desired outputs.</p> <p>2.3. Designs and tunes controllers (e.g., PID, model predictive control) for chemical processes, ensuring accurate regulation of temperature, pressure, flow, and concentration within desired operational ranges.</p> <p>2.4. Utilizes advanced control strategies, such as cascade control, ratio control, and feed forward control, to address disturbances, improve process stability, and optimize performance.</p> <p>2.5. Incorporates safety and reliability considerations into control system design, ensuring the chemical process operates within safe limits and responds effectively to potential hazards or system failures.</p> <p>2.6. Uses process simulation tools and software to model and simulate chemical processes, testing control strategies under various operating conditions and identifying potential performance improvements.</p> <p>2.7. Implements process control strategies that account for nonlinearities, time delays, and multivariable interactions inherent in complex chemical systems.</p> <p>2.8. Analyzes and optimizes control loops, adjusting controller parameters and tuning strategies to improve response time, reduce oscillations, and minimize energy consumption and material waste.</p> <p>2.9. Incorporates advanced techniques, such as real-time optimization, data-driven control, and adaptive control, to improve the efficiency and</p>

	flexibility of chemical processes under varying operating conditions.
<p>3. Use modern instrumentation and sensors for process monitoring.</p>	<p>3.1. Demonstrates proficiency in selecting and using modern instrumentation and sensors to monitor critical parameters in industrial processes, ensuring accurate data collection for process optimization.</p> <p>3.2. Understands the principles of operation for various types of sensors, such as temperature, pressure, flow, level, and composition sensors, and applies them appropriately to monitor and control chemical processes.</p> <p>3.3. Configures and calibrates instruments and sensors to ensure accurate and reliable measurements, minimizing errors and improving the quality of process data.</p> <p>3.4. Integrates instrumentation and sensors into control systems, enabling real-time monitoring and feedback for process control, and enhancing system responsiveness to changes in process variables.</p> <p>3.5. Uses advanced sensor technologies, such as smart sensors, wireless sensors, and distributed control systems (DCS), to improve data acquisition and enable remote monitoring and diagnostics.</p> <p>3.6. Analyzes sensor data to identify trends, anomalies, and potential issues, using this information to make informed decisions about process adjustments and troubleshooting.</p> <p>3.7. Implements signal conditioning techniques to ensure the proper transmission and interpretation of sensor data, minimizing noise and improving measurement accuracy.</p> <p>3.8. Demonstrates knowledge of process control loops and how to integrate instrumentation and sensor feedback into feedback and feed forward control strategies for optimal system performance.</p> <p>3.9. Utilizes modern data analytics and diagnostic tools to assess sensor performance, identify maintenance needs, and ensure sensors are functioning within desired specifications.</p>

CHE0002 – 16 Chemical Reaction Engineering

The aim of this study unit is to provide students with a comprehensive understanding of reaction kinetics and reactor design principles. It focuses on equipping students with the analytical skills required to optimize chemical reactors for enhanced efficiency, safety, and sustainability. The unit also emphasizes the application of advanced modeling techniques to facilitate the scale-up of chemical reactions from laboratory settings to industrial processes, ensuring both practical and theoretical knowledge are integrated for real-world problem-solving.

Learning Outcome:	Assessment Criteria:
<p>1. Analyze reaction kinetics and reactor design.</p>	<ol style="list-style-type: none"> 1.1. Demonstrates the ability to apply fundamental principles of reaction kinetics to analyze various types of chemical reactions, accurately determining rate laws, reaction orders, and activation energies. 1.2. Utilizes experimental data to derive kinetic parameters, applying statistical methods and curve fitting techniques to ensure accurate analysis and interpretation of reaction rates. 1.3. Effectively applies differential equations and mathematical models to describe reaction rates and predict the behavior of reactions under varying conditions, including temperature, concentration, and pressure. 1.4. Analyzes complex reaction mechanisms, identifying key steps and intermediate species, and accurately determines their impact on overall reaction kinetics. 1.5. Evaluates the effect of different operating conditions (e.g., temperature, pressure, and catalyst presence) on reaction rates, optimizing conditions for desired reaction outcomes. 1.6. Demonstrates the ability to design chemical reactors, including batch, continuous, and semi-batch systems, using appropriate models to ensure effective mixing, heat transfer, and mass transfer in the reactor. 1.7. Integrates reactor design considerations, such as residence time, flow patterns, and scale-up factors, to ensure optimal performance, efficiency, and safety in industrial applications. 1.8. Demonstrates the use of simulation tools and software to model and predict reactor

	<p>performance, analyzing variables such as temperature gradients, pressure drops, and reaction conversions for both small-scale and large-scale reactors.</p> <p>1.9. Effectively communicates the analysis of reaction kinetics and reactor design, presenting findings clearly to stakeholders while providing recommendations for process improvements, safety considerations, and efficiency optimization.</p>
<p>2. Optimize chemical reactors for efficiency and safety.</p>	<p>2.1. Demonstrates the ability to assess and optimize chemical reactor performance by analyzing key parameters such as reaction rates, temperature control, residence time, and mixing efficiency to improve overall process efficiency.</p> <p>2.2. Applies advanced techniques in heat and mass transfer to optimize reactor designs, ensuring that thermal management, reactant distribution, and catalyst effectiveness are maximized for improved yields and reduced energy consumption.</p> <p>2.3. Identifies and evaluates potential bottlenecks, inefficiencies, and safety risks in reactor systems, offering actionable solutions to enhance performance and minimize operational disruptions.</p> <p>2.4. Utilizes computational tools and simulation software to model reactor behavior, conducting sensitivity analyses to optimize variables such as flow rate, temperature, and pressure for improved reaction efficiency and reduced downtime.</p> <p>2.5. Designs and implements process control strategies to ensure stable reactor operation, including temperature, pressure, and flow control systems, to maintain optimal reaction conditions and avoid unsafe operating scenarios.</p> <p>2.6. Applies principles of safety engineering to evaluate and mitigate potential hazards in reactor design, including runaway reactions, overpressure, and thermal instability, ensuring the system operates within safe</p>

	<p>limits.</p> <p>2.7. Integrates real-time monitoring and feedback mechanisms, using sensors and instrumentation, to continuously optimize reactor performance and immediately respond to deviations from desired conditions.</p> <p>2.8. Demonstrates a thorough understanding of materials handling, corrosion resistance, and equipment longevity, ensuring that reactor systems are designed and operated to maintain safety and reliability over time.</p> <p>2.9. Effectively communicates optimization strategies and safety considerations to both technical and non-technical stakeholders, ensuring alignment with industry standards, regulatory requirements, and safety protocols.</p>
<p>3. Apply modeling techniques to scale up chemical reactions from lab to industry.</p>	<p>3.1. Demonstrates the ability to apply scaling laws and principles to transition chemical reactions from laboratory-scale experiments to industrial-scale systems, ensuring that reaction behavior and kinetics are accurately preserved during scale-up.</p> <p>3.2. Utilizes advanced process modeling techniques, such as computational fluid dynamics (CFD), reaction kinetics models, and mass and energy balance equations, to predict the behavior of chemical reactions in larger reactors and optimize scale-up parameters.</p> <p>3.3. Identifies and addresses key challenges in scale-up, such as heat and mass transfer limitations, mixing efficiency, and pressure drop, ensuring that the scaled-up system performs efficiently and consistently with lab-scale results.</p> <p>3.4. Applies principles of hydrodynamics, thermodynamics, and reactor design to scale-up chemical reactors, ensuring that both small- and large-scale systems maintain optimal performance in terms of yield, energy efficiency, and safety.</p> <p>3.5. Conducts sensitivity analysis to identify critical</p>

	<p>variables that affect scale-up performance, such as residence time, flow patterns, and temperature gradients, ensuring that the scale-up design accounts for these factors.</p> <p>3.6. Incorporates industrial constraints such as cost, equipment limitations, and material handling during the scale-up process, balancing performance optimization with practical considerations.</p> <p>3.7. Uses dynamic modeling and simulation tools to predict reactor performance under industrial operating conditions, comparing results from lab-scale experiments with simulated data to ensure scalability and system reliability.</p> <p>3.8. Evaluates the impact of different reactor configurations (e.g., batch, continuous, plug flow) on the scalability of chemical reactions, optimizing for mass transfer, temperature control, and product quality.</p> <p>3.9. Communicates the modeling, scale-up process, and potential risks to both technical teams and non-technical stakeholders, ensuring clarity and alignment with operational goals, safety standards, and regulatory requirements.</p>
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CHE0002 – 17 Separation Processes

The aim of this study unit is to provide students with a thorough understanding of the fundamental principles and applications of various separation techniques, including distillation, filtration, and chromatography. The unit focuses on developing the ability to design, evaluate, and optimize industrial separation systems, ensuring the ability to meet process requirements while maximizing cost-effectiveness and energy efficiency. Students will be equipped with the skills necessary to apply separation processes in a wide range of industrial contexts, emphasizing practical solutions for real-world challenges.

Learning Outcome:	Assessment Criteria:
<p>1. Understand principles of separation techniques such as distillation, filtration, and chromatography.</p>	<p>1.1. Demonstrates a comprehensive understanding of the fundamental principles behind separation techniques such as distillation, filtration, and chromatography, including their underlying scientific principles and applications in various industries.</p> <p>1.2. Applies knowledge of phase equilibria, mass transfer, and thermodynamics to analyze and optimize distillation processes, including factors such as reflux ratio, column design, and feed composition.</p> <p>1.3. Understands the principles of filtration, including the mechanics of particle separation, filter media selection, and pressure drop calculations, and applies this knowledge to design effective filtration systems for solid-liquid separation.</p> <p>1.4. Applies the principles of chromatography, including partitioning, adsorption, and diffusion, to separate mixtures based on differences in the distribution of components between phases, utilizing techniques like gas, liquid, and ion-exchange chromatography.</p> <p>1.5. Evaluates the advantages and limitations of each separation technique, selecting the most appropriate method based on factors such as the properties of the mixture, desired purity, and operating conditions.</p> <p>1.6. Demonstrates proficiency in analyzing separation system performance, using principles such as mass balance, equilibrium stages, and separation factor, to ensure optimal operation and efficiency.</p> <p>1.7. Incorporates modern advancements in</p>

	<p>separation technology, such as membrane filtration and supercritical fluid chromatography, into the understanding and design of efficient separation processes.</p> <p>1.8. Understands and applies the impact of operational parameters, such as temperature, pressure, flow rates, and solvent selection, on the efficiency and effectiveness of separation techniques.</p> <p>1.9. Effectively communicates the principles, applications, and optimization strategies of separation techniques to technical and non-technical stakeholders, ensuring alignment with project goals and operational requirements.</p>
<p>2. Design and evaluate industrial separation systems.</p>	<p>2.1. Demonstrates the ability to design industrial separation systems, selecting appropriate techniques such as distillation, filtration, membrane processes, or chromatography based on the properties of the mixture, throughput requirements, and product specifications.</p> <p>2.2. Utilizes principles of mass transfer, phase equilibria, and thermodynamics to design separation units, ensuring optimal efficiency, throughput, and energy consumption for industrial applications.</p> <p>2.3. Applies process modeling tools and simulations to evaluate the performance of separation systems, optimizing parameters like flow rates, temperature, pressure, and feed composition to maximize separation efficiency.</p> <p>2.4. Designs separation systems that are scalable from laboratory to industrial scale, ensuring that design assumptions and operational parameters maintain their effectiveness in larger, more complex systems.</p> <p>2.5. Evaluates the economic and environmental impact of different separation techniques, considering factors such as operating costs, energy consumption, waste generation, and sustainability, to design cost-effective and eco-friendly solutions.</p>

	<p>2.6. Conducts detailed performance analysis of separation units by applying mass and energy balances, evaluating the separation factor, recovery rate, and purity of components to ensure that the system meets design specifications.</p> <p>2.7. Identifies potential challenges in the operation of separation systems, such as fouling, scaling, or equipment wear, and designs strategies to mitigate these issues and ensure system reliability and longevity.</p> <p>2.8. Integrates safety and regulatory considerations into the design of separation systems, ensuring compliance with industry standards, safety protocols, and environmental regulations.</p> <p>2.9. Communicates the design, evaluation, and optimization of industrial separation systems effectively to stakeholders, providing clear reports on system performance, potential improvements, and areas for cost or energy savings.</p>
<p>3. Optimize separation processes for cost and energy efficiency.</p>	<p>3.1. Demonstrates the ability to analyze and optimize separation processes by identifying key variables such as energy consumption, throughput, and separation efficiency, and adjusting them to achieve the most cost-effective operation.</p> <p>3.2. Applies principles of process optimization, including energy and mass balance calculations, to minimize energy usage while maintaining or improving the separation performance in industrial systems.</p> <p>3.3. Utilizes advanced modeling and simulation tools to evaluate the impact of different operating conditions (e.g., temperature, pressure, flow rates) on both energy consumption and separation efficiency, identifying opportunities for optimization.</p> <p>3.4. Applies cost-benefit analysis to evaluate and select the most economical separation technologies, considering factors such as equipment costs, maintenance, energy consumption, and operational efficiency.</p>

	<ul style="list-style-type: none">3.5. Implements energy recovery strategies, such as heat integration or the use of waste heat, to improve the overall energy efficiency of separation processes, reducing operational costs and environmental impact.3.6. Identifies and reduces inefficiencies in separation processes by analyzing bottlenecks, downtime, and suboptimal performance, and recommends improvements to enhance overall system productivity.3.7. Integrates sustainable practices into process optimization by selecting separation techniques that minimize waste, reduce energy usage, and improve resource utilization, supporting long-term cost reduction goals.3.8. Conducts sensitivity analysis to assess how changes in process parameters, such as feed composition or flow rates, impact energy consumption and cost, and uses this information to fine-tune operational conditions.3.9. Communicates optimization strategies effectively to stakeholders, providing clear recommendations on process adjustments, cost reductions, and energy-saving opportunities, ensuring alignment with operational and sustainability goals.
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CHE0002 – 18 Industrial Health and Safety Management

The aim of this study unit is to equip students with the knowledge and skills necessary to analyze and mitigate risks associated with chemical engineering processes. The unit focuses on the development of safety management plans, emergency response protocols, and the implementation of effective strategies to ensure the safety and well-being of workers in industrial environments. Emphasis is placed on ensuring compliance with health and safety regulations, preparing students to address safety challenges in complex industrial settings and promoting a culture of safety within the workplace.

Learning Outcome:	Assessment Criteria:
<p>1. Analyze risks associated with chemical engineering processes.</p>	<p>1.1. Demonstrates the ability to identify and assess potential hazards in chemical engineering processes, considering factors such as chemical reactivity, material properties, and operating conditions.</p> <p>1.2. Applies hazard analysis methodologies, including hazard and operability studies (HAZOP), fault tree analysis (FTA), and failure mode effects analysis (FMEA), to systematically evaluate risks in chemical processes.</p> <p>1.3. Understands the principles of process safety management (PSM), identifying critical safety parameters and ensuring that processes operate within safe limits to prevent accidents and minimize potential harm to personnel and the environment.</p> <p>1.4. Analyzes the impact of equipment failures, human errors, and external factors on process safety, and develops strategies to mitigate these risks, ensuring continuous safe operation.</p> <p>1.5. Evaluates chemical process risks related to toxic exposure, flammability, explosiveness, and environmental contamination, proposing risk reduction strategies such as containment, ventilation, and safe chemical handling practices.</p> <p>1.6. Assesses the potential for runaway reactions, overpressure situations, and thermal instability, recommending appropriate design features, safety devices, and operational procedures to prevent accidents.</p> <p>1.7. Uses risk analysis tools to quantify the</p>

	<p>likelihood and severity of potential process hazards, providing risk-based prioritization to guide safety measures and resource allocation.</p> <p>1.8. Integrates safety protocols, emergency response plans, and regulatory compliance requirements into the design and operation of chemical processes, ensuring that all safety standards and industry regulations are met.</p> <p>1.9. Communicates risk assessments and mitigation strategies effectively to technical and non-technical stakeholders, ensuring proper understanding and implementation of safety measures across the organization.</p>
<p>2. Develop safety management plans and emergency protocols.</p>	<p>2.1. Demonstrates the ability to develop comprehensive safety management plans that identify potential hazards, assess risks, and define preventive measures to ensure safe operation in chemical engineering processes.</p> <p>2.2. Applies principles of process safety management (PSM) to design safety programs that include hazard identification, risk assessment, safety training, and continuous monitoring to prevent accidents and maintain a safe working environment.</p> <p>2.3. Develops emergency response protocols tailored to specific hazards, including chemical spills, fires, explosions, and toxic releases, ensuring that clear actions are outlined for each potential emergency scenario.</p> <p>2.4. Ensures that safety management plans comply with industry regulations, standards, and best practices, such as OSHA, EPA, and ISO standards, while incorporating site-specific safety needs.</p> <p>2.5. Collaborates with cross-functional teams to integrate safety management and emergency protocols into daily operations, ensuring that safety measures are aligned with organizational goals and effectively communicated to all personnel.</p> <p>2.6. Implements procedures for the maintenance, testing, and calibration of safety equipment,</p>

	<p>such as fire suppression systems, gas detection systems, and personal protective equipment (PPE), to ensure readiness in case of an emergency.</p> <p>2.7. Develops and conducts regular safety drills and simulations to test the effectiveness of emergency protocols, ensuring that all personnel are trained and prepared to respond effectively during emergencies.</p> <p>2.8. Establishes a clear chain of command and communication strategy for emergency situations, ensuring that roles, responsibilities, and reporting mechanisms are well-defined and understood by all personnel.</p> <p>2.9. Continuously monitors and reviews the safety management plan and emergency protocols, using feedback from incidents, audits, and drills to make improvements and enhance the overall safety culture within the organization.</p>
<p>3. Ensure compliance with health and safety regulations in industrial environments.</p>	<p>3.1. Demonstrates a thorough understanding of local, national, and international health and safety regulations, ensuring that all processes, procedures, and operations adhere to legal and industry standards.</p> <p>3.2. Identifies regulatory requirements relevant to chemical engineering processes, including OSHA, EPA, ISO standards, and specific industry guidelines, and ensures that all safety practices are compliant with these regulations.</p> <p>3.3. Develops and implements compliance programs that monitor and enforce adherence to health and safety regulations, including regular audits, inspections, and documentation of compliance activities.</p> <p>3.4. Integrates risk assessment and hazard identification into compliance activities, ensuring that all potential health and safety risks are addressed in line with regulatory requirements and industry best practices.</p> <p>3.5. Collaborates with regulatory bodies, internal teams, and stakeholders to ensure all operational activities, including equipment</p>

	<p>design, process controls, and waste management, meet the required health and safety standards.</p> <p>3.6. Trains personnel on relevant health and safety regulations and ensures they are aware of their roles and responsibilities in maintaining a safe and compliant working environment.</p> <p>3.7. Monitors and evaluates health and safety performance regularly, using key performance indicators (KPIs) and metrics to assess compliance levels and identify areas for improvement.</p> <p>3.8. Develops corrective and preventive action plans to address non-compliance issues, ensuring that safety deficiencies are resolved promptly and that the process meets the required regulatory standards.</p> <p>3.9. Communicates compliance efforts effectively to management, employees, and regulatory authorities, ensuring transparency and maintaining a proactive approach to health and safety in the industrial environment.</p>
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CHE0002 – 19 Chemical Process Design and Simulation

The aim of this study unit is to provide students with the expertise to design, simulate, and analyze chemical processes using advanced simulation tools. The unit emphasizes the creation of process flow diagrams and the identification of optimization opportunities to enhance process performance and efficiency. Students will also develop the ability to assess the economic feasibility of chemical process designs, ensuring a comprehensive understanding of both technical and financial considerations in process development and implementation.

Learning Outcome:	Assessment Criteria:
<p>1. Use simulation tools to design and analyze chemical processes.</p>	<p>1.1. Demonstrates proficiency in selecting and using appropriate simulation software tools (e.g., Aspen Plus, HYSYS, ChemCAD) to model and simulate chemical processes, ensuring accurate representation of process dynamics.</p> <p>1.2. Applies process flow diagrams (PFDs) and piping and instrumentation diagrams (P&IDs) in simulation tools to design chemical processes, ensuring all components, such as reactors, distillation columns, and heat exchangers, are properly integrated.</p> <p>1.3. Utilizes thermodynamic models and property estimation methods to predict phase equilibria, reaction kinetics, and transport properties, ensuring that the simulated process conditions are realistic and accurate.</p> <p>1.4. Analyzes simulation results, identifying key process parameters such as temperature, pressure, flow rates, and material balances, to evaluate process performance and optimize design choices.</p> <p>1.5. Conducts sensitivity analysis using simulation tools to assess the impact of varying operating conditions (e.g., feed composition, temperature, pressure) on process efficiency, yield, and energy consumption.</p> <p>1.6. Uses simulation software to optimize process design, improving factors such as energy efficiency, product quality, and throughput, while reducing costs and environmental impact.</p> <p>1.7. Validates simulation models by comparing results with experimental or real-world data, ensuring the accuracy of the model and making necessary adjustments to improve</p>

	<p>reliability.</p> <p>1.8. Simulates process dynamics and controls to evaluate the stability and response of the system under various operating conditions, identifying potential issues such as instability, oscillations, or control failures.</p> <p>1.9. Communicates simulation results and recommendations effectively to technical and non-technical stakeholders, providing clear insights into process design, optimization, and operational improvements.</p>
<p>2. Develop process flow diagrams and identify optimization opportunities.</p>	<p>2.1. Demonstrates the ability to create detailed and accurate process flow diagrams (PFDs) that represent chemical processes, clearly illustrating key equipment, process streams, and system interactions.</p> <p>2.2. Identifies critical process variables and key performance indicators (KPIs) within the PFD, ensuring that all aspects of the chemical process, including material and energy balances, are properly represented.</p> <p>2.3. Utilizes process flow diagrams to evaluate and analyze the flow of materials, heat, and energy throughout the system, identifying areas where inefficiencies may occur.</p> <p>2.4. Applies knowledge of process dynamics, thermodynamics, and equipment design to identify and propose optimization opportunities within the PFD, such as improving heat integration, reducing energy consumption, or enhancing material recovery.</p> <p>2.5. Assesses the impact of different operating conditions on the process flow, using the PFD as a tool to simulate process adjustments and evaluate potential improvements in productivity, safety, and environmental performance.</p> <p>2.6. Incorporates feedback loops, control systems, and safety devices in the PFD to ensure process stability, operational safety, and compliance with regulatory requirements.</p> <p>2.7. Collaborates with cross-functional teams to review the PFD and identify areas for process improvement, proposing modifications to</p>

	<p>enhance system performance and reduce costs.</p> <p>2.8. Identifies opportunities for sustainability improvements in the process, such as waste minimization, recycling, or alternative energy sources, within the context of the PFD.</p> <p>2.9. Communicates the process flow diagram and optimization recommendations clearly to stakeholders, ensuring that all proposed changes align with overall business objectives, safety standards, and regulatory compliance.</p>
<p>3. Evaluate the economic feasibility of chemical process designs.</p>	<p>3.1. Demonstrates the ability to perform cost estimation for chemical process designs, including capital expenditures (CAPEX), operating costs (OPEX), and fixed and variable costs associated with raw materials, labor, and utilities.</p> <p>3.2. Utilizes economic evaluation tools and techniques, such as discounted cash flow (DCF), net present value (NPV), internal rate of return (IRR), and payback period, to assess the financial viability of chemical process designs.</p> <p>3.3. Identifies and quantifies the financial risks and uncertainties associated with chemical processes, including fluctuations in raw material prices, energy costs, and market demand for products.</p> <p>3.4. Analyzes the financial impact of different design alternatives, including changes in process configuration, equipment choices, and energy optimization strategies, to select the most cost-effective solution.</p> <p>3.5. Assesses the potential for cost reduction by evaluating opportunities for energy efficiency improvements, waste minimization, and process intensification, ensuring that economic feasibility aligns with sustainability goals.</p> <p>3.6. Performs sensitivity analysis to evaluate how variations in key parameters, such as production rates, utility costs, and product yield, affect the overall economic feasibility of the process.</p>

	<p>3.7. Collaborates with engineering, operations, and finance teams to integrate technical and financial considerations in the decision-making process, ensuring that economic feasibility aligns with technical capabilities and business objectives.</p> <p>3.8. Compares the economic feasibility of different process designs or process modifications, presenting recommendations based on cost, return on investment (ROI), and long-term financial sustainability.</p> <p>3.9. Communicates economic feasibility findings to stakeholders through clear reports and presentations, ensuring that the financial implications of the chemical process design are understood and considered in strategic decision-making.</p>
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CHE0002 – 20 Advanced Separation Processes

The aim of this study unit is to provide students with an in-depth understanding of complex separation techniques, including membrane processes and crystallization, and their applications in chemical engineering. The unit focuses on the design of advanced separation systems tailored to meet high-purity product requirements while optimizing process efficiency. Students will also learn to evaluate the environmental impacts of various separation technologies, equipping them with the knowledge to integrate sustainable practices and ensure minimal ecological footprint in industrial separation processes.

Learning Outcome:	Assessment Criteria:
<p>1. Understand complex separation techniques, including membrane processes and crystallization.</p>	<p>1.1. Demonstrates a comprehensive understanding of the principles behind advanced separation techniques, including membrane processes and crystallization, and their application in chemical engineering processes.</p> <p>1.2. Applies knowledge of mass transfer, thermodynamics, and fluid mechanics to analyze and design membrane separation processes, optimizing parameters such as pressure, flow rate, and selectivity to achieve efficient separation.</p> <p>1.3. Understands the different types of membranes (e.g., polymeric, ceramic, composite) and their properties, selecting the most appropriate material based on the specific application and operating conditions.</p> <p>1.4. Analyzes the factors that affect membrane performance, such as fouling, scaling, and degradation, and develops strategies for maintaining membrane integrity and prolonging service life.</p> <p>1.5. Applies crystallization principles, including nucleation, crystal growth, and supersaturation, to design and optimize crystallization processes for separating solid phases from liquid mixtures with high purity and yield.</p> <p>1.6. Evaluates and optimizes operating conditions for crystallization, such as temperature, concentration, and solvent choice, to control crystal size distribution and minimize energy consumption.</p> <p>1.7. Integrates advanced separation techniques</p>

	<p>with other unit operations in process design, ensuring compatibility and efficiency in overall chemical processes.</p> <p>1.8. Applies modern innovations in membrane technology, such as membrane distillation, forward osmosis, or hybrid membrane processes, to improve separation performance and address specific industrial challenges.</p> <p>1.9. Communicates the principles, challenges, and optimization strategies of complex separation techniques effectively to stakeholders, ensuring clear understanding and alignment with operational objectives and industry standards.</p>
<p>2. Design advanced systems for high-purity product requirements.</p>	<p>2.1. Demonstrates the ability to design advanced separation and purification systems tailored to meet high-purity product specifications, incorporating a deep understanding of thermodynamics, kinetics, and material properties.</p> <p>2.2. Utilizes advanced separation techniques such as distillation, membrane processes, chromatography, and crystallization to achieve the desired purity levels while considering factors like efficiency, cost, and scalability.</p> <p>2.3. Applies process simulations and modeling tools to design systems that optimize separation performance, ensuring that all critical parameters (e.g., temperature, pressure, flow rate) are carefully controlled to meet product purity requirements.</p> <p>2.4. Identifies potential impurities and contaminants in feed materials and designs multi-stage separation systems that effectively remove or reduce these components to ensure product quality and regulatory compliance.</p> <p>2.5. Evaluates and integrates cutting-edge technologies, such as solvent extraction, supercritical fluid separation, or reactive distillation, to enhance system efficiency and product purity for complex processes.</p>

	<p>2.6. Designs robust purification systems that can handle fluctuations in feed composition, maintaining consistent product quality and yield while minimizing energy consumption and waste generation.</p> <p>2.7. Incorporates process control strategies to maintain tight specifications on product purity throughout the system, utilizing real-time monitoring and feedback loops for continuous optimization.</p> <p>2.8. Conducts a comprehensive economic and environmental evaluation to balance the trade-offs between system performance, cost-effectiveness, and sustainability in high-purity production.</p> <p>2.9. Communicates the design, challenges, and optimization strategies for high-purity product systems clearly to stakeholders, ensuring that all design choices align with operational, safety, and regulatory requirements.</p>
<p>3. Evaluate environmental impacts of separation technologies.</p>	<p>3.1. Demonstrates the ability to assess the environmental impacts of various separation technologies, considering factors such as energy consumption, waste generation, resource utilization, and potential emissions throughout the life cycle of the process.</p> <p>3.2. Applies environmental impact assessment (EIA) methodologies to quantify the ecological footprint of separation processes, ensuring that the technology chosen minimizes adverse effects on air, water, and soil quality.</p> <p>3.3. Evaluates energy efficiency in separation systems, identifying opportunities for energy savings, heat recovery, and the reduction of greenhouse gas emissions, while maintaining process efficiency and product quality.</p> <p>3.4. Assesses the potential for waste generation in separation processes, including by-products, solvents, and membranes, and designs waste reduction or recycling strategies to minimize environmental harm.</p> <p>3.5. Analyzes the impact of separation technologies on water consumption and</p>

	<p>wastewater discharge, ensuring that processes are designed to reduce water usage and meet regulatory standards for effluent treatment and disposal.</p> <p>3.6. Incorporates sustainability principles into the selection of separation technologies, considering the use of renewable resources, low-impact materials, and non-toxic solvents to reduce environmental risks.</p> <p>3.7. Conducts life cycle analysis (LCA) to evaluate the long-term environmental impacts of separation processes, including manufacturing, operation, and disposal of equipment and materials used in separation technologies.</p> <p>3.8. Identifies and evaluates the potential environmental risks associated with hazardous materials used in separation technologies, recommending safe handling, disposal, and containment practices to mitigate exposure and contamination.</p> <p>3.9. Communicates findings on the environmental impacts of separation technologies effectively to stakeholders, ensuring that design decisions align with sustainability goals, regulatory compliance, and corporate responsibility initiatives.</p>
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CHE0002 – 21 Energy Systems and Renewable Technologies

The aim of this study unit is to equip students with the knowledge and skills to analyze energy systems and their critical role in chemical engineering applications. The unit emphasizes the integration of renewable energy technologies in process industries, focusing on developing innovative solutions to enhance sustainability and reduce environmental impact. Students will also learn to evaluate energy efficiency in industrial processes, ensuring they can design and implement systems that optimize energy use while promoting long-term sustainability in energy management.

Learning Outcome:	Assessment Criteria:
<p>1. Analyze energy systems and their applications in chemical engineering.</p>	<ul style="list-style-type: none"> 1.1. Demonstrates a thorough understanding of energy systems, including the principles of energy conversion, thermodynamics, and heat transfer, as applied to chemical engineering processes. 1.2. Analyzes the different types of energy systems, such as cogeneration, combined heat and power (CHP), and renewable energy systems, to determine their suitability for various chemical engineering applications. 1.3. Utilizes thermodynamic models and tools to evaluate the efficiency of energy systems, identifying potential energy losses and opportunities for improvement in process design and operation. 1.4. Applies mass and energy balance techniques to assess energy flows in chemical processes, ensuring optimal integration of energy systems within the overall process. 1.5. Evaluates the economic feasibility of implementing energy systems, considering capital costs, operational expenses, and energy savings, while aligning with environmental and sustainability goals. 1.6. Identifies and analyzes the role of energy systems in process intensification, aiming to reduce energy consumption, improve system efficiency, and lower environmental impact. 1.7. Assesses the environmental impact of energy systems, considering factors such as greenhouse gas emissions, energy consumption, and the carbon footprint, and recommends strategies to minimize adverse environmental effects.

	<p>1.8. Investigates and applies alternative energy sources, including solar, wind, geothermal, and bioenergy, to chemical engineering systems to enhance energy sustainability and reduce reliance on fossil fuels.</p> <p>1.9. Communicates the analysis and recommendations for energy systems in chemical engineering to stakeholders, providing insights into process optimization, cost reduction, and environmental sustainability.</p>
<p>2. Develop solutions using renewable energy technologies in process industries.</p>	<p>2.1. Demonstrates a comprehensive understanding of renewable energy technologies, such as solar, wind, bioenergy, and geothermal, and their integration into process industries to enhance sustainability and reduce reliance on non-renewable energy sources.</p> <p>2.2. Evaluates the feasibility of incorporating renewable energy sources into chemical and industrial processes, considering factors such as energy requirements, scalability, geographic location, and environmental impact.</p> <p>2.3. Applies energy conversion and storage technologies, such as photovoltaics, wind turbines, and biogas systems, to design integrated renewable energy solutions that meet the energy demands of process industries efficiently.</p> <p>2.4. Conducts life cycle assessments (LCAs) to evaluate the long-term environmental and economic impacts of renewable energy systems, ensuring that renewable energy adoption contributes to the overall sustainability of the process.</p> <p>2.5. Designs hybrid energy systems combining renewable sources with traditional power generation methods (e.g., natural gas or coal) to ensure reliable energy supply while minimizing carbon emissions.</p> <p>2.6. Optimizes renewable energy systems for specific industrial applications, such as heat and power generation, through advanced</p>

	<p>modeling, simulations, and process integration techniques.</p> <p>2.7. Identifies potential challenges in the integration of renewable energy technologies, such as variability in energy production, storage capacity, and grid connection, and develops strategies to overcome these issues.</p> <p>2.8. Analyzes the economic viability of renewable energy solutions, conducting cost-benefit analyses, and considering factors such as capital investment, return on investment (ROI), and energy savings over time.</p> <p>2.9. Communicates the technical, environmental, and economic benefits of renewable energy technologies to stakeholders, ensuring clear understanding and alignment with the goals of process optimization and sustainability in the industry.</p>
<p>3. Evaluate energy efficiency and sustainability in industrial processes.</p>	<p>3.1. Demonstrates the ability to apply energy audits and efficiency assessments to industrial processes, identifying areas for improvement in energy consumption, heat recovery, and overall system performance.</p> <p>3.2. Utilizes energy management tools and techniques, such as energy balance calculations and pinch analysis, to assess and optimize energy flows within industrial processes, minimizing waste and maximizing energy recovery.</p> <p>3.3. Applies principles of process integration and energy optimization, including heat integration and advanced control strategies, to improve energy efficiency and reduce operational costs.</p> <p>3.4. Analyzes the environmental impact of energy use in industrial processes, evaluating factors such as carbon emissions, resource consumption, and waste generation, and develops strategies for reducing the ecological footprint.</p> <p>3.5. Assesses the potential for integrating renewable energy sources into industrial processes, considering factors such as availability, cost, and compatibility with</p>

	<p>existing systems to enhance sustainability.</p> <p>3.6. Evaluates the role of energy-efficient equipment and technologies, such as high-efficiency pumps, compressors, and heat exchangers, in reducing energy consumption and improving process sustainability.</p> <p>3.7. Conducts life cycle assessments (LCA) to evaluate the sustainability of industrial processes, considering the full range of environmental, social, and economic impacts from raw material acquisition to end-of-life disposal.</p> <p>3.8. Identifies opportunities for waste minimization and resource recovery, such as recycling, reuse of by-products, and closed-loop systems, to promote circular economy practices and enhance process sustainability.</p> <p>3.9. Communicates energy efficiency and sustainability findings effectively to stakeholders, presenting actionable recommendations for process improvements, cost reductions, and environmental performance enhancements.</p>
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CHE0002 – 22 Advanced Chemical Reaction Engineering

The aim of this study unit is to provide students with a deep understanding of complex reaction mechanisms and multi-reaction systems commonly encountered in chemical engineering. The unit focuses on optimizing both catalytic and non-catalytic reactions within industrial reactors to improve process efficiency and product yield. Students will also gain practical experience in applying computational tools and modeling techniques to simulate and analyze reaction engineering systems, equipping them with the skills to solve advanced problems in reaction optimization and reactor design.

Learning Outcome:	Assessment Criteria:
<p>1. Explore complex reaction mechanisms and multi-reaction systems.</p>	<p>1.1. Demonstrates a deep understanding of complex reaction mechanisms, including elementary and non-elementary steps, reaction intermediates, and rate-determining steps, and their influence on overall reaction rates and product distribution.</p> <p>1.2. Analyzes multi-reaction systems, considering the interactions between parallel, series, and consecutive reactions, and applies advanced mathematical modeling techniques to describe their kinetics and predict product yields.</p> <p>1.3. Utilizes experimental data and reaction pathway analysis to identify and validate reaction mechanisms in both homogeneous and heterogeneous systems, ensuring accurate representation of the system's behavior.</p> <p>1.4. Applies knowledge of thermodynamics, equilibrium, and kinetics to model and optimize multi-reaction systems, predicting the effects of temperature, pressure, and concentration on reaction rates and conversions.</p> <p>1.5. Develops and uses computational tools and simulations to model complex reaction systems, evaluating factors such as reaction network complexity, competing reactions, and reactor configurations for efficient process design.</p> <p>1.6. Investigates the impact of catalyst selection and reaction conditions on reaction mechanisms and multi-reaction systems, optimizing for factors such as selectivity, yield,</p>

	<p>and energy consumption.</p> <p>1.7. Identifies the role of mass transfer limitations, diffusion, and reactor hydrodynamics in complex reaction systems and integrates these factors into the design of reactors for optimal performance.</p> <p>1.8. Analyzes the stability and robustness of multi-reaction systems under varying operating conditions, identifying potential challenges such as unwanted side reactions, catalyst deactivation, or instability.</p> <p>1.9. Communicates findings related to complex reaction mechanisms and multi-reaction systems effectively, providing insights into optimization strategies and guiding process improvements in industrial applications.</p>
<p>2. Optimize catalytic and non-catalytic reactions in industrial reactors.</p>	<p>2.1. Demonstrates a comprehensive understanding of the principles and mechanisms behind both catalytic and non-catalytic reactions, including the role of catalysts, reaction kinetics, and thermodynamics in industrial reactor design and operation.</p> <p>2.2. Analyzes reaction conditions (e.g., temperature, pressure, concentration) to determine optimal operating parameters for both catalytic and non-catalytic reactions, maximizing conversion rates and minimizing energy consumption.</p> <p>2.3. Applies reactor design and modeling techniques, such as plug flow reactors (PFR), continuous stirred-tank reactors (CSTR), and fixed-bed reactors, to optimize reaction efficiency and selectivity in industrial applications.</p> <p>2.4. Utilizes advanced tools and simulations, including computational fluid dynamics (CFD) and kinetic modeling, to predict the behavior of catalytic and non-catalytic reactions under different operating conditions and reactor configurations.</p> <p>2.5. Evaluates the impact of catalysts on reaction rates and selectivity, optimizing catalyst properties (e.g., surface area, pore structure,</p>

	<p>and active sites) for improved performance and longer catalyst life in industrial settings.</p> <p>2.6. Investigates and addresses issues such as catalyst deactivation, poisoning, sintering, or fouling in catalytic reactions, proposing strategies for catalyst regeneration, replacement, or improved catalyst management.</p> <p>2.7. Identifies the influence of mass transfer, heat transfer, and fluid dynamics on reaction efficiency, optimizing reactor design to minimize resistance to these transfers and ensure uniformity in reactant and temperature distribution.</p> <p>2.8. Integrates process intensification strategies, such as reactive distillation or membrane reactors, into catalytic and non-catalytic processes to enhance productivity, reduce energy requirements, and improve overall process efficiency.</p> <p>2.9. Communicates optimization strategies and results clearly to stakeholders, ensuring that the proposed changes improve operational performance, reduce costs, and comply with safety, environmental, and regulatory standards in industrial reactor operations.</p>
<p>3. Apply computational tools to model reaction engineering systems.</p>	<p>3.1. Demonstrates proficiency in using computational tools such as computational fluid dynamics (CFD), Aspen Plus, MATLAB, and custom reaction kinetics models to simulate and analyze reaction engineering systems.</p> <p>3.2. Develops accurate models for both catalytic and non-catalytic reactions, integrating parameters such as reaction rates, mass and energy balances, and system dynamics to predict performance under varying conditions.</p> <p>3.3. Utilizes reaction mechanism data to input correct kinetic parameters into simulation software, ensuring reliable predictions of reaction behavior in different reactor configurations and operating conditions.</p> <p>3.4. Applies numerical methods to solve complex</p>

	<p>differential equations and reaction rate laws, ensuring that the models developed are both accurate and computationally efficient for industrial-scale applications.</p> <p>3.5. Analyzes the impact of different reactor types (e.g., CSTR, PFR, batch reactors) on reaction performance using computational models, identifying optimal designs and operational parameters to maximize yield and minimize by-products.</p> <p>3.6. Simulates heat and mass transfer effects within reactors, including non-ideal flow patterns, to evaluate their influence on reaction rates, conversion, and selectivity.</p> <p>3.7. Incorporates process optimization tools into modeling, using techniques such as sensitivity analysis, genetic algorithms, or design of experiments (DOE) to identify optimal operating conditions and design parameters for reactors.</p> <p>3.8. Integrates computational models with experimental data to validate and refine simulations, ensuring the accuracy and relevance of the model for real-world applications.</p> <p>3.9. Communicates computational modeling results clearly to stakeholders, providing actionable insights into reactor design, process improvements, and optimization strategies for reaction engineering systems.</p>
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CHE0002 – 23: Industrial Project Management

The aim of this study unit is to equip students with the skills and knowledge required to effectively plan, execute, and monitor industrial engineering projects within the chemical process industry. The unit focuses on applying project management tools and techniques to ensure that projects are managed efficiently, staying within scope, timeline, and budget constraints. Students will develop a comprehensive understanding of project lifecycle management, enabling them to successfully lead and deliver complex industrial projects while addressing challenges in resource allocation, risk management, and stakeholder communication.

Learning Outcome:	Assessment Criteria:
<p>1. Plan, execute, and monitor industrial engineering projects.</p>	<ul style="list-style-type: none"> 1.1. Demonstrates the ability to develop detailed project plans, including defining project objectives, scope, timelines, resources, and deliverables, ensuring alignment with organizational goals and industry standards. 1.2. Utilizes project management methodologies, such as Agile, Waterfall, or Lean Six Sigma, to structure, execute, and monitor industrial engineering projects, ensuring efficient resource utilization and adherence to project timelines. 1.3. Identifies and allocates appropriate resources, including personnel, equipment, and materials, ensuring that all components of the project are available when needed to maintain progress and minimize delays. 1.4. Develops and implements risk management strategies, identifying potential project risks (e.g., budget overruns, delays, resource shortages) and mitigating them through proactive planning and contingency strategies. 1.5. Monitors project progress through key performance indicators (KPIs), such as cost performance, schedule adherence, and quality, adjusting project plans as necessary to stay on track and meet objectives. 1.6. Coordinates cross-functional teams, ensuring effective communication and collaboration between engineers, stakeholders, and suppliers, facilitating smooth project execution and resolution of issues. 1.7. Applies quality control principles to ensure that all aspects of the project meet technical

	<p>specifications, regulatory standards, and customer expectations, using continuous improvement processes to address any deviations.</p> <p>1.8. Prepares and presents regular project status reports to stakeholders, providing updates on progress, challenges, and outcomes, and making recommendations for adjustments or improvements.</p> <p>1.9. Conducts post-project evaluations, gathering feedback and analyzing project outcomes to identify lessons learned and improve future project planning, execution, and monitoring processes.</p>
<p>2. Apply project management tools and techniques to chemical process industries.</p>	<p>2.1. Demonstrates proficiency in using project management tools, such as Gantt charts, critical path method (CPM), and project scheduling software (e.g., Microsoft Project, Primavera), to plan, track, and manage chemical process industry projects.</p> <p>2.2. Applies project management methodologies, such as Agile, Waterfall, or Stage-Gate, to structure and execute chemical process projects, ensuring timely and cost-effective completion while meeting industry-specific regulatory and quality standards.</p> <p>2.3. Utilizes risk management techniques, including risk assessment matrices, failure modes and effects analysis (FMEA), and Monte Carlo simulations, to identify potential risks in chemical process projects and develop mitigation strategies.</p> <p>2.4. Employs cost estimation and budgeting tools to develop accurate project financial plans, track expenditures, and ensure that the project stays within the defined budget while maintaining operational and safety standards.</p> <p>2.5. Integrates resource management techniques, ensuring the efficient allocation of human resources, equipment, and materials throughout the lifecycle of the project, while managing resource constraints and avoiding delays.</p> <p>2.6. Uses process simulation software and</p>

	<p>modeling tools (e.g., Aspen Plus, HYSYS) to optimize process design, evaluate process parameters, and assess the impact of changes on overall project performance.</p> <p>2.7. Monitors and controls project progress through performance metrics, including earned value analysis (EVA), schedule variance (SV), and cost variance (CV), ensuring alignment with project goals and timelines.</p> <p>2.8. Communicates project status and progress to stakeholders using regular reports, meetings, and dashboards, ensuring transparency and effective decision-making.</p> <p>2.9. Conducts post-project evaluations and reviews, identifying successes and areas for improvement, and integrates lessons learned into future project management practices within the chemical process industry.</p>
<p>3. Ensure projects are completed on time, within scope, and on budget.</p>	<p>3.1. Demonstrates the ability to develop comprehensive project plans with clearly defined objectives, deliverables, timelines, and budgets, ensuring alignment with organizational goals and stakeholder expectations.</p> <p>3.2. Utilizes project management tools, such as Gantt charts, milestone tracking, and resource allocation techniques, to monitor project progress and ensure that tasks are completed on schedule and within the allocated scope.</p> <p>3.3. Identifies potential risks early in the project, implementing proactive risk management strategies, such as risk mitigation plans and contingency measures, to avoid delays and budget overruns.</p> <p>3.4. Monitors and controls project expenses, tracking costs against the approved budget, and takes corrective actions when necessary to prevent cost overruns and ensure financial discipline throughout the project lifecycle.</p> <p>3.5. Regularly reviews project scope to ensure it remains aligned with initial goals, effectively managing scope changes through proper change control procedures to avoid scope creep and maintain focus on key deliverables.</p>

	<ul style="list-style-type: none">3.6. Communicates project status consistently with stakeholders, providing transparent updates on progress, challenges, and changes to scope, timeline, or budget, fostering informed decision-making.3.7. Coordinates and optimizes the use of project resources, ensuring personnel, materials, and equipment are available when needed, avoiding delays and ensuring the efficient execution of tasks.3.8. Ensures effective collaboration across project teams and stakeholders, addressing any conflicts or communication issues promptly to maintain momentum and ensure timely delivery of project milestones.3.9. Conducts post-project reviews to assess performance against scope, schedule, and budget, documenting lessons learned to continuously improve project management practices and ensure future projects are more efficient and successful.
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CHE0002 – 24 Research Project in Chemical Engineering

The aim of this study unit is to provide students with the opportunity to conduct independent research on a chemical engineering topic of their choice. The unit emphasizes the application of theoretical knowledge to solve practical problems, either through experimental work or simulations. Students will develop their research skills, critically analyze data, and present their findings through comprehensive reports and formal presentations, fostering the ability to communicate technical results effectively in both academic and professional contexts.

Learning Outcome:	Assessment Criteria:
<p>1. Conduct independent research on a chemical engineering topic.</p>	<p>1.1. Demonstrates the ability to independently identify and select a relevant chemical engineering topic, ensuring it is aligned with current industry trends, research gaps, and scientific advancements.</p> <p>1.2. Conducts a thorough literature review, critically analyzing and synthesizing existing research to gain a deep understanding of the topic and identify key areas for further exploration or innovation.</p> <p>1.3. Develops a clear research question or hypothesis based on the findings from the literature review, ensuring that the research objectives are well-defined, focused, and achievable within the scope of the study.</p> <p>1.4. Applies appropriate research methodologies, such as experimental design, simulations, or computational modeling, to gather relevant data or generate insights that address the research question.</p> <p>1.5. Ensures the use of reliable and valid data sources, adhering to ethical research standards and industry best practices for data collection, analysis, and interpretation.</p> <p>1.6. Analyzes research results using appropriate statistical or computational tools, drawing meaningful conclusions that contribute to the understanding of the chosen chemical engineering topic.</p> <p>1.7. Evaluates the implications of the research findings for both academic and industrial applications, considering how the results can be used to inform practice, enhance processes, or contribute to advancements in the field.</p> <p>1.8. Communicates research findings clearly and</p>

	<p>effectively in written and oral formats, preparing high-quality reports, papers, or presentations that meet academic or professional standards.</p> <p>1.9. Demonstrates the ability to critique and reflect on the research process, identifying areas for improvement, and suggesting potential avenues for further study or exploration based on the outcomes of the research.</p>
<p>2. Apply theoretical knowledge to practical problems through experiments or simulations.</p>	<p>2.1. Demonstrates the ability to translate theoretical concepts from chemical engineering into practical applications by designing and executing experiments or simulations that address real-world problems.</p> <p>2.2. Identifies and formulates clear, measurable objectives for experiments or simulations based on theoretical principles, ensuring alignment with the problem at hand and the goals of the study.</p> <p>2.3. Selects and applies appropriate experimental methods, simulation software, and tools (e.g., Aspen Plus, MATLAB, CFD) to replicate chemical engineering processes, ensuring reliable and accurate data collection.</p> <p>2.4. Utilizes sound engineering judgment to design controlled experiments or simulations, considering variables such as temperature, pressure, and concentration, while ensuring proper safety protocols are followed.</p> <p>2.5. Analyzes experimental or simulation data using appropriate statistical and computational techniques, drawing insightful conclusions that demonstrate a solid understanding of underlying theoretical principles.</p> <p>2.6. Identifies potential sources of error in experiments or simulations, implementing corrective measures to minimize uncertainties and ensure the validity and reliability of results.</p> <p>2.7. Integrates theoretical knowledge with experimental or simulation outcomes to validate models, refine assumptions, and improve understanding of chemical engineering processes.</p> <p>2.8. Applies findings from experiments or simulations to propose practical solutions for industry-specific problems, ensuring that the recommendations are feasible, cost-effective, and sustainable.</p>

<p>3. Present findings through detailed reports and presentations.</p>	<ul style="list-style-type: none">3.1. Demonstrates the ability to organize and structure technical reports and presentations, ensuring clarity, logical flow, and coherence in the presentation of findings, methodologies, and conclusions.3.2. Effectively presents complex chemical engineering concepts, data, and analysis in a clear, concise manner, using appropriate language and visual aids (e.g., charts, graphs, diagrams) tailored to the target audience.3.3. Includes relevant background information, objectives, experimental or simulation methodologies, results, and conclusions in reports and presentations, ensuring that all critical aspects are well-documented and comprehensible.3.4. Applies appropriate technical writing standards to ensure that reports are accurate, precise, and free from ambiguity, using proper referencing and citations to support research and findings.3.5. Demonstrates proficiency in using presentation tools (e.g., PowerPoint, Prezi) to communicate findings effectively, using visual aids, animations, and slides to enhance understanding and engage the audience.3.6. Anticipates potential questions or challenges from the audience and prepares clear, well-supported responses, demonstrating in-depth understanding and critical thinking of the subject matter.3.7. Tailors the level of detail and technical depth in reports and presentations to the audience's background and expertise, ensuring that both technical and non-technical stakeholders can understand and appreciate the findings.3.8. Delivers presentations confidently, using effective verbal communication techniques such as pacing, tone, and body language to enhance audience engagement and comprehension.3.9. Ensures that reports and presentations are well-edited, formatted, and aligned with professional and academic standards, submitting them on time and with a high level of attention to detail.
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