# AAVARTAN’23-24

**VIGYAAN**
**DEPARTMENT OF CHEMICAL ENGINEERING**

**PROBLEM STATEMENTS**

## *Industrial*

CHEM01. <u>Design a system for real-time monitoring and control of chemical processes to optimize production of plug flow reactor</u>

The real-time monitoring and control system for chemical processes aims to enhance production efficiency and product quality by continuously collecting data and adjusting process parameters like Sensors and Data Acquisition, Data Processing and Analysis, Control Algorithms, Actuators and Control Devices, Human-MachineInterface, Historical Data Storage & Alarm System. The proposed system should offer a comprehensive solution for optimizing plug flow reactor production through real-time monitoring and control of chemical processes. By integrating a network of sensors to collect critical data, establishing a central control system with advanced analytics, and deploying adaptive control strategies, the system enables dynamic adjustments to process parameters, ultimately leading to improved productivity and resource utilization. The implementation of this real-time monitoring and control system yields several substantial benefits. Cost savings should be achieved through reduced raw material waste, lowered energy consumption, and efficient resource allocation. The system's precision in maintaining optimal conditions ensures higher product quality by minimizing variations. Furthermore, the immediate detection and response to deviations enhance operational safety, mitigating potential hazards. While past efforts focused on static adjustments, the system effectively addresses the challenge of Residence Time Distribution (RTD) variability by employing dynamic control strategies.

CHEM02. <u>Reduction of the emissions of volatile organic compounds (VOCs)in industrial processes</u>

The pressing need to mitigate volatile organic compound (VOC) emissions in industrial sectors like Chemical Manufacturing, Petroleum Refining, and Paint Coating has led to a critical challenge in ensuring environmental preservation and human health. This challenge requires a comprehensive approach involving regulatory compliance, technological innovations, and cost-effectiveness analysis. Despite historical efforts in emission control and process optimization, the variability of costs based on industry characteristics, regulations, and technology choices necessitates a systematic assessment of cost-benefit considerations.Recent advancements in emission control technologies, membrane separation methods, bioremediation techniques, and sustainable solvent development offer promising avenues for VOC reduction. An integrated implementation of these strategies is paramount for industries to efficiently reduce VOC emissions, leading to a healthier and sustainable environment. Therefore, a comprehensive investigation into effective VOC reduction strategies is crucial to address this multifaceted challenge.

CHEM03. <u>Reducing Carbon Emissions in Cement Production: Developing Sustainable Practices and Technologies to Minimize the Environmental Impact of Fossil Fuel Combustion and Limestone Heating Processes</u>

The production of cement, a vital material in construction, is inherently associated with substantial carbon emissions due to the combustion of fossil fuels and the chemical reactions involved in heating limestone. This emission-intensive process contributes to 40% of lifecycle $CO_2$ emissions from fuel burning, while the remaining 60% results from limestone heating. The challenge at hand is to devise effective strategies that can significantly reduce carbon emissions in cement production. This challenge involves finding innovative and sustainable approaches to mitigate the environmental impact of both fuel combustion and limestone heating processes. Prior efforts have explored energy efficiency improvements, alternative raw materials utilization, carbon capture and utilization (CCU), and the exploration of low-carbon clinker alternatives. Although the implementation of emission reduction measures involves initial costs, it promises long-term benefits such as capital investments, operational savings, regulatory compliance, and access to emerging markets. Recent advancements in emission reduction techniques encompass carbon capture and storage (CCS), carbon utilization, electrification, and the integration of artificial intelligence for digitalization. Achieving a balance between environmental gains and economic viability remains a pivotal challenge, underscoring the importance of innovation, policy support, and collaboration among stakeholders within the cement industry. The journey towards substantial carbon emission reduction in cement production necessitates comprehensive efforts and holistic solutions.

***Environmental***

CHEM04. The Synthesis of Biodegradable Detergents with High Performance: Developing an Efficient and Scalable Manufacturing Process to Meet Consumer Demand and Regulatory Requirements

Developing a process for the synthesis of biodegradable detergents with high performance involves selecting environmentally friendly raw materials and optimizing the reaction conditions with parameters Emulsification or Micellization, pH Adjustment & Toxicity and Biodegradability. In the pursuit of synthesizing high-performance biodegradable detergents, the focus should lie on developing an efficient and scalable manufacturing process that adheres to consumer demand and regulatory standards. This endeavor entails the careful selection of environmentally friendly raw materials and the meticulous optimization of reaction conditions, considering factors such as emulsification or micellization techniques, and biodegradability considerations. Previous research efforts have explored the production of biodegradable detergents from Azadirachta Indica (neem) seed oil and low-temperature lignite tar, paving the way for innovative approaches. While cost economics present challenges, manufacturers must navigate the initial higher costs of biodegradable detergents by weighing them against long-term benefits, including reduced environmental impact and growing consumer preference for eco-friendly products. Advancements in enzyme engineering, nanotechnology, and smart formulations hold promise for enhancing detergent performance. Addressing current issues such as regulatory compliance, performance expectations and raw material sourcing .

CHEM05. Utilizing Agricultural By-Products in Biodegradable Plastics Production: Developing an Efficient and Sustainable Process to Optimize Resource Utilization and Reduce Environmental Impact

Developing a process for utilizing agricultural by-products in biodegradable plastics production involves By product selection, Pre Treatment , Chemical Treatment, Mixing , Plastic Processing , scalability & Environmental Assessment. In the pursuit of sustainable plastic production, harnessing agricultural by-products as resources involves the meticulous development of an efficient process that encompasses by-product selection, pre-treatment, chemical treatment, mixing, plastic processing, scalability considerations, and environmental assessment. Building upon previous endeavors like the preparation of cellulose acetate from flax fiber and cotton linters, and the introduction of polylactic acid, this approach aims to optimize resource utilization and minimize environmental impact. Despite potential cost advantages over traditional plastics, challenges arise from refining by-products into usable plastic precursors, demanding specialized equipment and additional processing steps. Advancements in advanced conversion technologies, biotechnological approaches, and supply chain integration further fuel progress. However, issues related to raw material variability, processing complexities, resource competition, and regulatory compliance must be navigated.

In conclusion, the integration of agricultural by-products in biodegradable plastics production holds the promise of fostering sustainability and offering environmentally conscious plastic alternatives.

CHEM06. The Degradation of Plastic Materials in Marine Environments: Assessing Microplastics, Degradation Factors, and Implementing Source Reduction and Biodegradable Alternatives to Mitigate Environmental Impact

The degradation of plastic materials in marine environments is essential to understanding the environmental impact of plastic pollution through Microplastics, Degradation Factor, Environmental Impact Assessment by Source Reduction & Biodegradable Alternatives. Understanding the degradation of plastic materials in marine environments is pivotal for comprehending the impact of plastic pollution, encompassing microplastics and degradation factors. This entails a holistic approach involving environmental impact assessment through source reduction and the integration of biodegradable alternatives. Building upon previous research on the degradation of plastic waste, the endeavor considers the intricate aspects of plastic deterioration, microplastics formation, and their far-reaching consequences. In terms of cost economics, the endeavor should involve upfront investments for sustainable solutions that yield both immediate benefits and long-term savings. Recent strides include biodegradable polymers, microplastic cleanup technologies, advanced recycling methods, and innovative systems like blockchain for tracking plastic waste. Yet, challenges persist, including the need for regulatory frameworks, global collaboration, overcoming technological barriers, and strengthening waste management infrastructure. Ultimately, addressing plastic degradation in marine environments necessitates a comprehensive approach that combines scientific research, technological innovation, policy development, and global cooperation to safeguard our oceans and marine life.

***Mixed***

CHEM07. <u>Minimizing Environmental Impact and Improving Recycling Practices in the Paper Industry: Developing Efficient Recycling Technologies And Collaborating with Stakeholders to Enhance Sustainability and Quality of Recycled Products</u>

The paper industry confronts environmental issues such as deforestation and pollution. While reusing solid waste helps curb pollution, recycling contaminated paper proves complex and compromises recycled product quality. To rectify this, embracing sustainable practices, investing in advanced recycling technologies, and partnering with stakeholders are essential. These efforts aim to boost recycling rates, decrease contamination, and cultivate a greener, more sustainable paper industry.

In this challenge, you are tasked with minimizing the environmental impact and improving recycling practices within the paper industry. Your objective is to develop efficient recycling technologies while fostering collaboration with stakeholders. By Enhancing sustainability and the quality of recycled products, you aim to create a more environmentally friendly and economically viable paper recycling ecosystem. Tackling these issues mandates the embrace of sustainable practices, investment in improved recycling technologies, and fostering partnerships to bolster recycling rates and curtail contamination. The cost economics of these endeavors entail initial investments alongside potential long-term savings and market-driven demand. Recent advancements encompass advanced sorting technologies, chemical recovery and pulping innovations, and digital watermarking solutions. However, ongoing challenges include contamination management, infrastructural enhancements, ensuring consistent product quality, and responding to market dynamics and pricing.

In summary, your overarching aim in this challenge is to transform the paper industry's recycling practices by developing efficient technologies, promoting collaboration among stakeholders, and improving the overall sustainability and economic feasibility of paper recycling. By achieving these goals, you will contribute to the creation of an eco-friendly and economically sustainable paper recycling ecosystem.

CHEM08 Improving the Quality and Eco-Friendliness of Faux Leather: Developing Sustainable Alternatives to PVC Leather to Mitigate Environmental Harm and Enhance Animal Welfare

The faux leather industry faces environmental issues with PVC leather due to dioxin emissions and breathability concerns. To enhance their quality and eco friendliness, the industry aims to develop sustainable alternatives that are biodegradable and free from harmful emissions. This will reduce the environmental impact and improve animal welfare while providing a more environmentally friendly and breathable option for consumers. In this challenge, your task is to enhance the quality and ecological sustainability of faux leather. Your objective involves the development of viable alternatives to PVC leather, focusing on mitigating the adverse environmental impacts associated with its production and use, all while elevating the standards of animal welfare. By adopting innovative solutions, you aim to create faux leather materials that rival the quality of traditional options, offering not only superior aesthetics and functionality but also reduced ecological harm and increased consideration for animal rights. Your efforts in this endeavor will contribute to a future where fashion and material choices align harmoniously with environmental preservation and ethical treatment of animals.

While the shift involves initial costs such as research and development and raw material expenses, the potential for long-term economic benefits, driven by market demand for eco-friendly products, underscores the importance of these advancements.

Embracing bio-based and recycled materials, water-based coatings, and even 3D printing, the industry strives for progress. However, prime focus should include addressing environmental concerns, ensuring quality and aesthetics, extending product durability, and securing animal welfare. In pursuit of this holistic transformation, the faux leather sector aims to redefine its landscape, crafting a future that is both environmentally conscious and animal-friendly.

CHEM09. Design and develop an AI-based system that can effectively assess the quality of various vegetables and predict their chemical content. The system should take input in the form of images of the vegetables and provide output indicating the quality rating and estimated chemical composition

Design and implement an AI-powered solution to accurately evaluate the quality of diverse vegetables by analyzing images and predicting their chemical composition. The system must process input images of vegetables and deliver an output that includes a quality rating as well as an estimated breakdown of chemical constituents. The solution should contribute to enhancing the efficiency and reliability of vegetable quality assessment, benefiting both consumers and the agricultural industry.

The AI model development process involves collecting a diverse dataset of vegetable images, quality assessments, and chemical content measurements. After Preprocessing the data, relevant features are extracted for input. The model is trained using a CNN for image analysis and regression/classification models for chemical content prediction.

The trained model is then integrated into a user-friendly interface, enabling real-time quality assessment. The associated costs encompass data collection and preparation, development and infrastructure, and deployment and maintenance.

Recent advancements in AI, such as transfer learning, explainable AI, and edge computing, could further enhance the project's outcomes. Addressing challenges related to data quality and quantity, model robustness, and user acceptance is critical for the system's success. This AI-based solution holds promise for revolutionizing the assessment of vegetable quality and chemical content, with far-reaching implications for agriculture and nutrition industries.

## CRUCIAL GUIDELINES FOR PARTICIPANTS

Ensure your Powerpoint presentation includes the following content in a structured sequence:

1. Commence with an introduction to the topic. Offer an initial overview of the subject matter.

2. Elaborate on prior work accomplished within the project. The prior efforts and accomplishments dedicated to the project before the current phase commenced.

3. Highlight prevailing challenges encountered. Provide an overview of the current challenges and issues that the project is currently encountering.

4. Showcase recent advancements made in the project. Write about the recent groundbreaking developments that have taken place within the project.

5. Introduce your unique model. Provide an introductory overview of your model, detailing its key features, functions, and purposes.

6. Conclude your presentation with a comprehensive summary, summarizing the key findings, outcomes, and implications that have emerged from your research and efforts.