155:428 Chemical Engineering Design Spring 2025

Course Outline:

Energy underpins industrial, domestic and transport activities. However, our activities and the associated release of more CO_2 than the earth can absorb by natural processes have increased CO2 concentrations in the atmosphere, resulting in global warming, which is driving climate change. Global leaders are exploring ways of working together to plan a transition to a low-carbon economy.

As a result, we are living through a technologically driven revolution where chemical processes are transitioning from fossil fuel-based, high-carbon feeds to renewable, low-carbon feedstocks. This revolution will result in political and social stressors, globally and locally. The transition is also technically, economically, and socially challenging, and we are learning how to design and implement new low-carbon processes as we go.

This course will introduce methodologies for synthesising processes, focusing on the design of integrated systems encompassing mass, heat, and work. The objective is to develop processes that minimise waste, optimise resource utilisation, and reduce energy consumption. Processes designed with inherent sustainability and safety considerations often align with the triple bottom line (people, planet, and prosperity). Consequently, such processes exhibit resilience and success across various dimensions, including economic viability.

The course will consider the fundamental principles of chemical engineering, including mass, energy and entropy balances, to synthesise a process flow diagram. The environmental, social, and economic implications will be considered during the synthesis. Participants will simulate the process flow diagram on Aspen and will optimise the flowsheet. Additionally, the course will provide hands-on experience in equipment sizing and costing, enhancing a holistic understanding of process design.

Course objectives:

This capstone course utilises the fundamentals of chemical and biochemical engineering (material balances, energy balances, entropy analysis, transport phenomena, thermodynamics, kinetics, separations, unit operations, control, and safety) in designing and operating chemical/biochemical plants. The course introduces the concepts and methods of process synthesis, plant design and environmental and economic evaluation. Students will use state-of-the-art computational tools to simulate the process flow design and for economic evaluation.

Through a series of assignments and design exercises, students will explore and develop their skills in the chemical engineering design space, learning to synthesise processes based on the best available data using fundamental chemical engineering concepts. The emphasis will be on reducing CO_2 emissions and energy consumption. This will be achieved by, for example, applying mass, heat and work integration to the process.

The Final Design Report will put together the thinking for developing the flowsheet and present a **working simulation** of a section of the process based on the results of the flowsheet synthesis. The Aspen process flowsheet will model the unit operations necessary to convert raw materials into finished products. To the greatest extent possible, the models for the unit operations must be physics- and chemistry-based, and all models must operate within the limitations of what is feasible in the real world. This requires understanding how the real-world processes work, how Aspen works, and fitting the available Aspen models to the real-world processes in the simulation.

The design project results will be presented in a poster displayed at an event where industry, family and friends will be invited to attend. One team will be invited to present at the event, describing their results and process insights.

Prerequisites:
14:155:304 Transport Phenomena in Chemical Engineering II
14:155:324 Separation Processes
14:155:341 Chemical Engineering Kinetics
01:160:308 Organic Chemistry or 01:160:316 Honors Organic Chemistry