ICE-T Modules 2023-2024

Fall 2023

10.492A Topic: To Be Determined

MWF10-11 66-168, Prof. Hadley Sikes, first half of term

10.492A is a half-semester-long Integrated Chemical Engineering course, where students are exposed to a particular topic within the broad realm of chemical engineering.

Prof. Sikes' Research Overview:
Our efforts focus on engineering biomolecular systems to detect and treat disease in new ways. We use the principles of engineering design to support and extend the practice of evidence-based diagnosis and selection of therapy.
Engineering design starts with interviewing intended users to formulate a quantitative problem statement and to understand the context and constraints for a new medical test. In the area of infectious disease, proteins in bodily fluids can indicate malaria or tuberculosis. The protein identity, quantity, and bodily fluid varies with the disease. In cancer, particular epigenetic and post-translational protein modifications can predict which therapies are likely to be effective against an individual tumor. We use an understanding of thermodynamics, kinetics, and transport phenomena to design medical tests that simultaneously meet design criteria for analytical performance, assay time, cost, robustness, and infrastructural requirements. We iteratively test prototypes with clinical collaborators to assess and improve real-world utility.

10.492B *Process Intensification*

MWF10-11 66-168, Prof. Klavs Jensen, second half of term

Process intensification invokes new reaction techniques and equipment to improve chemical processes by miniaturizing, combining, controlling, and/or enhancing the underlying chemical and physical transport processes. The ultimate goal of process intensification is achieving higher efficiency, reduced energy consumption, less waste, safer operation, and long-term sustainability. This class explores the principles of process intensification through lectures, demonstrations, homework, and projects based on concepts introduced in transport phenomena (10.301/2), thermodynamics (10.213), kinetics, and reaction engineering (10.37). The current transition in pharmaceutical manufacturing from batch to continuous flow serves one of several examples of process intensification. Microwave, electrochemical, and photochemical reaction processes illustrate alternative, intensified approaches to drive chemical reactions instead of by conventional heating. Membrane reactors exemplify combined reaction and separation unit operations. 3D printing and other modern fabrication techniques serve to realize new, efficient processing equipment. Integration, automation, control and optimization form important elements in achieving further process intensification.

10.01 *Ethics for Engineers* (full term)

M3-5, 56-169, Prof. Bernhardt Trout, Peter Hansen
T3-5, 66-148, Prof. Doug Lauffenburger, Kathryn Hansen (BE focus)
T3-5, 66-144, Peter Hansen (CS focus)
W7-9(EVE), 66-148 Peter Hansen

Explores the ethical principles by which an engineer ought to be guided. Integrates foundational texts in ethics with case studies illustrating ethical problems arising in the practice of engineering. Readings from classic sources including Aristotle, Kant, Locke, Bacon, Franklin, Tocqueville, Arendt and King. Case studies include articles and films that address engineering disasters, safety, biotechnology, the internet and AI, and the ultimate scope and aims of engineering. Different sections may focus on themes, such as AI or biotechnology. Students taking independent inquiry version 6.9041 will expand the scope of their term project. Students taking 20.005 focus their term project on a problem in biological engineering in which there are intertwined ethical and technical issues. In person not required. Limited to 18 per section.

IAP 2023

10.493 *Electrochemical Energy,* Schedule TBD, Javit Drake, IAP

Energy technology plays a critical role on an individual and societal scale. Electrochemical energy conversion systems, such as batteries and fuel cells, find applications in personal power--e.g., handheld electronic devices; stationary home power; vehicles; and large-scale power plants. Design, sizing, and choice of operation point are important considerations for appropriately engineering these potentially efficient electrochemical systems. Lectures and assignments address the ways that thermodynamics, electrochemical reaction, and transport factor into power, durability, and efficiency trade-offs. For the project, each group undertakes a detailed analysis of a single or hybrid combination of power sources, leading to design choices targeting a particular device and consumer use.

10.496/1.096 *Design of Sustainable Polymer Systems*

Brazil, Jan. 8-Jan. 26, Prof. Brad Olsen, IAP

This ICE Module 10.496/1.096, “Design of Sustainable Polymer Systems,” teaches students about sustainable design in the global context of conservation of the Amazon Rain Forest. Combining Chemical and Environmental Engineering with MISTI Global Classroom components, students will explore the sustainable design and use of polymers, focusing on their properties and historical applications. The course delves into the end-of-life scenarios, regulations, waste management, recycling, and re-use of both natural and synthetic polymers in the US and South America. Life cycle assessment, carbon impact, human behavior, cost estimation, and scalability of production are also discussed, particularly regarding resource extraction and sensitive ecosystems. In collaboration with Brazilian student colleagues, MIT students engage in a real-life design challenge, developing new, more sustainable polymer materials. Pedagogical materials will be combined with an experiential learning approach, immersing students in the Amazon region to confront, with the local community, the sociocultural, technological, and economic impacts of their designs. Daily pedagogical lectures based on active learning methodologies provide instruction in the mornings, while afternoons offer hands-on technological and cultural enrichment for the first two weeks. The final week culminates in a design competition, where joint teams of MIT and local Amazonian students will gain practical skills and collaborate to address local materials sustainability challenges, such as packaging, textiles, or construction. Through engagement of local partners as part of the teaching team, as design consultants and judges, and as students in the course, MIT students will have a unique opportunity to learn from local experts and to appreciate the full potential for sustainable development, climate solutions, and social impact that they can have in this special place.

SPRING 2024

10.494A Design of new processes for reducing GHG emissions in the energy sector, MWF10-11, 66-168, Prof. William H. Green, first half of term

Currently the transportation fuel sector is a major source of greenhouse gas emissions, both in the fuel production process (and ancillary processes handling or valorizing byproducts) as well as in direct fuel use by consumers, and the relative importance of this sector to global GHG emissions is expected to increase over the next 20 years. There is therefore great interest in reducing the greenhouse gas emissions associated with fuel production. This half-semester subject will give the students experience designing a new chemical engineering process to reduce GHG emissions from this sector, considering a wide range of technical, practical, economic, ethical, environmental, and societal-impact factors. While most of this subject will be focused on a design project done by a student team, there will also be some lectures and homework focused on specific issues, to help prepare the students to tackle this challenging design problem. Prior experience with ASPEN is helpful for quantitatively evaluating proposed designs.

10.494B Therapeutic Nanoparticle Manufacturing, MWF10-11, 66-168, Prof. Daniel G. Anderson, second half of term

Lipid nanoparticles are poised to revolutionize the treatment of genetic disease by enabling the therapeutic delivery of nucleic acids that can turn your genes off, turn them on, or even permanently and specifically edit your genome. This class will provide an over view of lipid nanoparticles and drug delivery including what nanoparticles are made of, how they will be used, and in particular how they are made and analyzed. Projects will focus on the application of chemical engineering principles to design a continuous nanoparticle formulation process for pharmaceutical scale production. This will include examination of small-scale nanoparticle production procedures based on microfluidics, hands-on construction of nanoparticle formulation chips, and a study of how these devices might be adjusted to meet the needs of commercial-scale production.