ICE-T Modules 2024-2025

Fall 2024

10.492A *Electrochemical Systems*

MWF10-11 66-168, Prof. Fikile Brushett, 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. This course provides an introduction to electrochemical engineering with a focus on highlighting the connection to the chemical engineering discipline and exploring the unique aspects of electrochemical processes. Electrochemical technologies are an integral part of modern life. Methods based on electrochemical phenomena underlie sensors, energy storage and conversion, and microfabrication processes. Moreover, electricity can be used to drive the clean production of chemical and remediation of environmental pollutants. Though chemical engineers have an important role to play in the field, undergraduates are not typically exposed to electrochemistry. Thus, our aim is to provide an introduction to the fundamental principles, to demystify existing electrochemical systems, and, hopefully, to inspire ideas for future products and processes.

10.492B *Biomolecular Systems*

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

10.492B 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.

10.01 *Ethics for Engineers* (full term)

M3-5, E17-517, Prof. Bernhardt Trout, Peter Hansen
T3-5, 66-148, Prof. Doug Lauffenburger, Kathryn Hansen (BE focus)
W3-5, 66-148, Kathryn Hansen
W7-9(EVE), 66-148 Peter Hansen

Explores how to be an ethical engineer. Students examine engineering case studies alongside key readings by foundational ethical thinkers from Aristotle to Martin Luther King, Jr., and investigate which ethical approaches are best and how to apply them. Topics include justice, rights, cost-benefit analysis, safety, bias, genetic engineering, climate change, and the promise and peril of AI. Discussion-based, with the aim of introducing students to new ways of thinking. All sections cover the same core ethical frameworks, but some sections have a particular focus for case studies, such as bioengineering, or have an in-depth emphasis on particular thinkers. The subject is taught in separate sections. Students are eligible to take any section regardless of their registered subject number. For 20.005, students additionally undertake an ethical-technical analysis of a BE-related topic of their choosing. 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 Therapeutic Nanoparticle Manufacturing,
Prof. Daniel G. Anderson, first 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.