NE - NEURAL ENGINEERING

NE Class Schedule (https://courses.illinois.edu/schedule/DEFAULT/DEFAULT/NE/)

Courses

NE 100 Introduction to Neural Engineering credit: 2 Hours. **(**https://courses.illinois.edu/schedule/terms/NE/100/**)**
A broad introduction to the fundamental principles and ever-advancing technologies at the interface of neuroscience, bioengineering and computer science. We will explore how neural engineering tools are used to measure, modulate and image the nervous system in the context of neurological function, dysfunction and injury. The course is divided into four sections: 1) Neuroanatomy and neurophysiology; 2) Technologies for monitoring neural activity in vivo (whole brain, from human to small animals) and in vitro (from dissociated cells to slices), EEG fMRI, MEAs, patch clamp electrophysiology recordings; 3) Devices for replacing and restoring neuronal function: implantable electrodes, brain computer interface, deep brain stimulation, and prosthetics; 4) Imaging and computational approaches. The course will cover information processing from the level of single cells, neural circuits and networks to systems and, ultimately, behavior. Prerequisite: Restricted to Neural Engineering majors.

NE 330 Neuroscience for Engineers credit: 3 Hours. **(**https://courses.illinois.edu/schedule/terms/NE/330/**)**
Provides an introduction to the fields of Neuroscience and Neural Engineering. Content includes a systems-level overview of the central nervous system, its blood supply, and its structural and functional features, and its connection to the peripheral nervous system. The course focuses on the mechanisms by which cells create, transmit, integrate, and perceive signals to enable memory, speech, language, pain, consciousness, and mood. Neuroscience fundamentals are taught from the perspective of engineering principles that guide the development and implementation of neural technologies and enable a quantitative understanding of function through modeling. Neural engineering applications include robotics, brain and spinal cord stimulation, non-invasive brain machine interfaces, and virtual reality gamification. Neuroimaging techniques and their application for brain science, as well as the novel tools and devices used to diagnose, monitor and improve neurological function will also be discussed. Upon completion of this course, students will have an understanding of technological developments in neural engineering and a foundational understanding of neurobiology and the pathological mechanisms underlying prevalent disorders of the nervous system. Prerequisite: NE 100, MCB 252. Restricted to Neural Engineering majors.

NE 402 Neural Engineering Senior Design credit: 4 Hours. **(**https://courses.illinois.edu/schedule/terms/NE/402/**)**
This capstone course in neural engineering design is the culmination of the NE curriculum. It features market research, the development of a working prototype device or process, along with entrepreneurship in the neural engineering field. The course takes students through the identification of a problem, prototyping solutions, testing, and solution analysis for real world problems focusing on end-user value and benefit. Students will use principles of design, engineering analysis, and customer discovery. This course emphasizes effective teamwork and technical communication, intellectual property, quality, human factors, FDA regulation, professionalism, and ethics. The overall goal of the course is to prepare the students for careers in Neural engineering. 4 undergraduate hours. No graduate credit. Prerequisite: NE 410/ECE 410, NE 420/ECE 421, NE 422. Concurrent enrollment or previous credit in both NE 412 and NE 431 is required.

NE 410 Neural Circuits and Systems credit: 3 or 4 Hours. **(**https://courses.illinois.edu/schedule/terms/NE/410/**)**
Same as ECE 410. See ECE 410.

NE 412 Neural Data Analysis credit: 3 Hours. **(**https://courses.illinois.edu/schedule/terms/NE/412/**)**
Modern technologies for recording brain activity hold the potential to enable a range of applications in neurology, neurobiology, and neuroscience in general. However, those recording technologies generate data at such scale and complexity that rigorous data analysis approaches for automatic information retrieval are required to fully leverage their potential. This course will introduce students to multiple neural data modalities (e.g., EEG and fMRI) and illustrate through examples, how modern data analysis techniques such as machine learning can be used to automatically extract meaningful information from those data. We will cover basics of neural data acquisition, preprocessing methods, data representation, dimensionality reduction, clustering, supervised learning, unsupervised learning, and some select advanced analytic concepts. This course will put equal emphasis on the understanding of analytical methods as well as practical hands-on experience, and equip the students with the essential skills to analyze neural data using advanced data analysis techniques such as machine learning. This course is designed for junior/senior undergraduate students with no or very limited prior experience in data science. Although prior exposure to the Python programming language is preferred, it is not required. 3 undergraduate hours. No graduate credit. Prerequisite: BIOE 210, BIOE 310, or instructor consent.

NE 420 Neural Interface Engineering credit: 3 or 4 Hours. **(**https://courses.illinois.edu/schedule/terms/NE/420/**)**
Same as ECE 421. See ECE 421.

NE 422 Introduction to Neuroimaging credit: 3 or 4 Hours. **(**https://courses.illinois.edu/schedule/terms/NE/422/**)**
Basic physics and physiology associated with imaging approaches that are unlocking the secrets of organization and function in both health and disease in the human brain at both the microscale and the macroscale. From cellular structure to metabolic signals to electrical signaling, this course will cover fundamental neuroimaging techniques and provide access to representative data sets to help the student understand the types of neuroscience questions that can be answered by the technologies. From the microscale, including multiphoton microscopy, neural circuit reconstruction, and brain clearing techniques to macroscale electrophysiology, hemodynamics, and molecular imaging approaches. Students will process data from these modalities using MATLAB or other specialized analysis software. 3 undergraduate hours. 4 graduate hours. Prerequisite: BIOE 210, BIOE 310, NE 330.

NE 430 Neural Cell and Tissue Engineering credit: 3 Hours. **(**https://courses.illinois.edu/schedule/terms/NE/430/**)**
This course will expose students to engineered technologies and strategies currently used to control the behavior of cells in the nervous system, with a special emphasis placed on their applications in regenerative medicine and gene therapy. This course will first introduce students to the pathogenic mechanisms underlying many neurodegenerative and neurodevelopmental diseases, with a focus toward identifying potential opportunities for therapeutic intervention. With this foundation in place, students will then be introduced to contemporary strategies for directing the differentiation of pluripotent stem cells to neural cells and tissues, with an emphasis on the role that biomaterials can play in the process. Applications of neural tissue engineering for disease modeling and drug discovery will also be discussed. The course will then introduce students to the genetic technologies that can be used to modulate and dissect the activity of cells in the nervous system, discussing in-depth the potential for these technologies to treat neurodegenerative and neurodevelopmental disorders by gene therapy. 3 undergraduate hours. No graduate credit. Prerequisite: NE 330 or instructor consent.

NE 431 Neural Cell & Tissue Engineering Lab credit: 4 Hours. **(**https://courses.illinois.edu/schedule/terms/NE/431/**)**
This laboratory course, which serves as a companion to Neural Cell and Tissue Engineering, will provide students with a hands-on understanding of many of the concepts and techniques central to this field. Students will take part in an immersive laboratory experience centered on the biomaterial-guided directed differentiation of neural stem cells from pluripotent stem cells and their transplantation into the nervous system of a rodent model for the goal creating a functional neural graft. Cell culture, nucleic acid extraction, qPCR and immunofluorescent imaging are among the laboratory techniques that students will become proficient in. Data quantitation, methods for statistical analysis and scientific writing are emphasized. 4 undergraduate hours. No graduate credit. Prerequisite: NE 330 or instructor consent. Concurrent enrollment or credit in NE 430 is required.