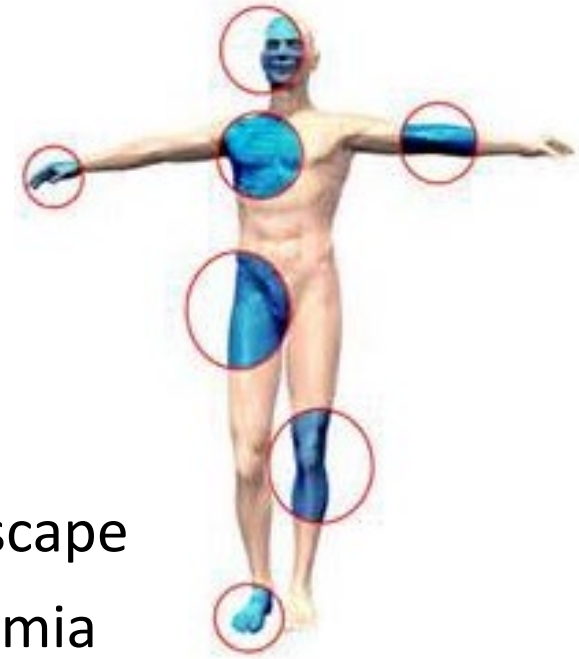
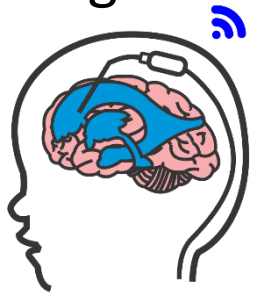
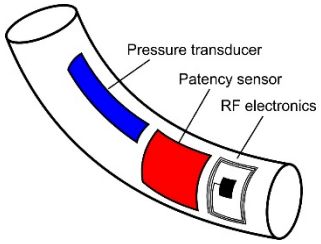
BME 452: Biomimetic Neural Engineering

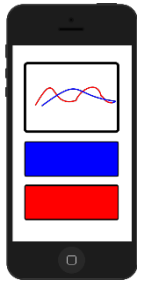
Tuan Hoang, Director, USC Coulter Translational Research Program
BME Technical Elective (2 units)
Fridays: 10:00am to 11:50am; GFS 204



- Investigate the Nervous System and its functions
- Identify neuroanatomical targets for intervention
- Explore neuromodulation paradigms
- Assess biomedical technologies & solutions
- Navigate ethical, regulatory & reimbursement landscape
- Interact with BME innovators in Industry and Academia
- Innovate to restore or augment neurofunction







BME-452: Introduction to Biomimetic Neural Engineering (2 units)

Instructor: Tuan Hoang
Lecturer, Biomedical Engineering
Director, USC Coulter Translational Research Partnership Program
Disclosure: Managing Partner, NineSquare Global Fund, NineSquare Ventures
Co-founder, Fluid Synchrony LLC, Senseer LLC, and Senseer Health Inc.

Email: tuan.q.hoang@usc.edu
Office Hours: By appointment in DRB 159

Meeting Time & Location: Fridays, 10am – 11:50am, GFS 204

Course Description
Engineering principles, biology, technological challenges and state-of-the-art developments in the design of implantable biomimetic microelectronic devices that interface with the nervous system will be presented. A structured 10-week lab internship will be with faculty in this field.

Prerequisite EE-202L; basic knowledge of biology recommended.

Reading Materials

(1) Chapter 2.1-2.4 (Neuroprosthetics: Theory and Practice. Eds. Horch and Dhillon)
(2) Chapter 1-3 (Biomedical Microsystems. E. Meng, CRC Press, 2010)
(3) Journal papers will be given for selected topics.

Grading

Attendance and participation is mandatory for lectures and class projects.
Project goals and time schedules will be determined between the student and the faculty.

Final Grade will be based on:
(a) Midterm Exam (30%)
(b) Final Exam (30%)
(c) Term Paper (20%)
(d) Oral Presentation (10%)
(e) Homework (10%)

Course Objectives

This course (BME 452) provides an overview of the scientific principles, basic biology and technical difficulties involved in the design of biomimetic microelectronic devices that are to be implanted into the human body for the restoration of neural function. Specific case studies will also be presented that focuses on engineering devices applicable for a variety of disorders that include deafness, blindness, paralysis, and memory loss. Guest lectures will be given largely by faculty and industry experts who conduct research in this area of work.

BME 452 Course Outcomes:

Outcome 1: Integrate knowledge of neuroanatomy and physiology learned in previous courses to create implementable solutions to neuroengineering problems at the interface of engineering, medicine, and biology. Integrate theories and models related to electrical stimulation and recording learned in previous courses to create implementable solutions to neuroengineering problems at the interface of engineering, medicine, and biology.

Outcome 2: Select appropriate materials for the construction of biomedical devices and understand its effects on tissue.

Outcome 3: Describe techniques and design considerations of PNS (neuromuscular) stimulation and recordings. Describe techniques and design considerations of CNS (cortical) stimulation. Describe existing FES systems in clinical use and its limitations.

Outcome 4: Function effectively as a part of a group of student engineers working on a multi-week project.

Outcome 5: Document in writing and orally exercises and projects performed individually and as part of a team of student engineers.

Outcome 6: Independently acquire through reading, practice exercises, and self-initiated research technical knowledge related to the course content and projects, including the emerging applications of biomedical devices.

BME Student Outcomes:

(a) an ability to apply knowledge of mathematics, science, and engineering
(b) an ability to design and conduct experiments, as well as to analyze and interpret data
(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
(d) an ability to function on multi-disciplinary teams
(e) an ability to identify, formulate, and solve engineering problems
(f) an understanding of professional and ethical responsibility
(g) an ability to communicate effectively
(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
(i) a recognition of the need for, and an ability to engage in life-long learning
(j) a knowledge of contemporary issues
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

Relation between course outcomes and Student Outcomes:

Course outcomes↓ Student Outcomes →	a	b	c	d	e	f	g	h	i	j	k
Outcome 1:	x										
Outcome 2:			x								
Outcome 3:						x					x
Outcome 4:				x							
Outcome 5:				x			x				
Outcome 6:									x	x	
All course outcomes	x		x	x		x	x		x	x	x

Lecture schedule:

Wk#1: Overview of the Biomimetic Microelectronic Systems.

Wk#2: Basic engineering design issues in biomedical devices.

Wk#3: Neuroanatomical targets in the CNS/PNS.

Wk#4: Ethics and Regulatory Issues in Neuroprosthetics R & D.

Wk#5: Implantable neural engineering for stimulation and recording.

Wk#6: Deep Brain Stimulations.

Wk#7: Visual Electrophysiology & Retinal Implants.

Wk#8: Cochlear Implants: Normal and abnormal auditory physiology; Psychophysics of hearing.

Wk#9: ***MIDTERM WRITTEN EXAM***

Wk#10: Device-based drug therapies targeting the CNS/PNS.

Wk#11: Hippocampal memory & prostheses. **[Draft *Final Term Paper Due*]**

Wk#12: Bioelectric pain neuromodulations approaches.

Wk#13: Functional electrical stimulation of muscles: state of the art.

Wk#14: No Class, Thanksgiving Break

Wk#15: ***FINAL ORAL EXAM*** **[*Final Term Paper Due*]**

Wk#16: 2-4pm ***FINAL WRITTEN EXAM***

Statement for Students with Disabilities:

Any student requesting academic accommodations based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP. Please be sure the letter is delivered to your course instructor (or TA) as early in the semester as possible. DSP is located in STU 301 and is open from 8:30am to 5:00pm, Monday through Friday. Website and contact information for DSP http://sait.usc.edu/academicsupport/centerprograms/dsp/home_index.html (213) 740-0776 (Phone), (213) 740-6948 (TDD only), (213) 740-8216 (FAX) ability@usc.edu

Statement on Academic Integrity:

USC seeks to maintain an optimal learning environment. General Principles of academic honesty include the concept of respect for the intellectual property of others, the expectation that individual work will be submitted unless otherwise allowed by an instructor, and the obligations both to protect one's own academic work from misuse by others as well as to avoid using another's work as one's own. All students are expected to understand and abide by these principles. Scampus, The Student Guidebook, contains the Student Conduct Code in Section

11.00, while the recommended sanctions are located in Appendix A: http://usc.edu/dept/publications/SCAMPUS/gov/

Students will be referred to the Office of Student Judicial Affairs and Community Standards for further review should there be any suspicion of academic dishonesty. The Review process can be found at: http://usc.edu/student-affaris/SJACS/ Information on intellectual property at USC is available at: http://usc.edu/academe/acsen/issues/ipr/index.html

Potential Lectures:

Physiology & pathophysiology of the Eye; Retinal Surgery. ***(Mark Humayun, Ophthal & BME)***
Visual Electrophysiology & Retinal Implants. (***Jack Whalen, Ophthal***)
Intraocular Camera for retinal prosthetics. (***Armand Tanguay, EE-EP***)
Biomedical MEMS applications in CNS/PNS (***Ellis Meng, BME***)
Modeling of hippocampal neural networks; nonlinear signal processing.
(***Ted Berger, Dong Song, BME***)
Deep-brain stimulation. (***Deborah Won, CSULA, Tuan Hoang, BME***)
Function and modeling of the Hand and its prosthetic.
(***Francisco Valero-Cuevas, BME, Biokinesiology, and Physical Therapy***)
Functional electrical stimulation of muscles: state of the art. (***Lucinda Baker, Biokinesiology***)
Model-based development of neural prostheses for movement (***Gerald Loeb, BME***)
Cochlear Implants: Normal and abnormal auditory physiology; Psychophysics of hearing.
(***Robert Shannon, USC, Tuan Hoang, BME***)
Cochlear Implants: State of the art developments. (***Leonid Litvak, Advanced Bionics***)
Mixed-signal systems on chip & sources of implant power.
(***John Granacki, EE & Information Sciences Institute***)
Surface Modification for biotic-abiotic interfaces; Cell Adhesion.
(***Mark Thompson, Chemistry; Anupam Madhukar, Materials Science***)
Modeling Neonatal Hemodynamics during PDA closure. (***Michael Khoo, BME***)
Ultrasound imaging for biomedical applications (***Qifa Zhou, Ophthal & BME***)
Phased array ultrasound imaging for biomedical applications (**Jesse Yen, BME**)
Ethics and Regulatory Issues in Neuroprosthetics R & D. (***Frances Richmond, Tuan Hoang, BME***)