FLORIDA ATLANTIC UNIVERSITY

NEW COURSE PROPOSAL
Graduate Programs

Department Computer and Electrical Eng. and Comp. Science

College Engineering and Computer Science

(*To obtain a course number, contact* ***erudolph@fau.edu***)

UGPC Approval _____
UFS Approval _____
SCNS Submittal _____
Confirmed _____
Banner _____
Catalog _____

Prefix BME **Number** 6390	*(L = Lab Course; C = Combined Lecture/Lab; add if appropriate)* **Lab Code**	**Type of Course** Lecture	**Course Title** Neural Engineering

Credits *(Review Provost Memorandum)*
3

Effective Date *(TERM & YEAR)*
Fall 2021

Grading *(Select One Option)*
Regular X
Sat/UnSat

Course Description *(Syllabus must be attached; see Guidelines)*

Neural engineering concentrate on development of technologies for rehabilitation, treatment, or compensation of damages in the central and peripheral nervous system. Modern techniques and signal processing algorithms used in brain machine interface applications, including different brain recording and stimulation methods and closed-loop brain control applications, are discussed.

Prerequisites

None

Prerequisites, Corequisites and Registration Controls are enforced for all sections of course.

Academic Service Learning (ASL) course

Academic Service Learning statement must be indicated in syllabus and approval attached to this form.

Corequisites
NA

Registration Controls *(For example, Major, College, Level)*

Minimum qualifications needed to teach course:
Member of the FAU graduate faculty and has a terminal degree in the subject area (or a closely related field.)

List textbook information in syllabus or here
Please see the syllabus.

Faculty Contact/Email/Phone
Hanqi Zhuang, zhuang@fau.edu; 5612973413

List/Attach comments from departments affected by new course
College of Science, College of Medicine, Brain Institute

Approved by		***Date***
Department Chair	Hanqi Zhuang — Digitally signed by Hanqi Zhuang Date: 2020.12.09 14:03:23 -05'00'	
College Curriculum Chair	Francisco Presuel-Moreno — Digitally signed by Francisco Presuel-Moreno DN: cn=Francisco Presuel-Moreno, o=Florida Atlantic University, ou=Ocean and Mechanical Engineering, email=fpresuel@fau.edu, c=US Date: 2020.12.09 18:25:27 -05'00'	
College Dean	MCardei — Digitally signed by Mihaela Cardei DN: cn=Mihaela Cardei, o=Florida Atlantic University, ou, email=mcardei@fau.edu, c=US Date: 2020.12.10 07:48:46 -05'00'	12/10/2020
UGPC Chair		
UGC Chair		
Graduate College Dean		
UFS President		
Provost		

Email this form and syllabus to UGPC@fau.edu 10 days before the UGPC meeting.

Department of Computer & Electrical Engineering and Computer Science
Florida Atlantic University
Course Syllabus

1. Course title/number, number of credit hours	
BME 6390 Neural Engineering	# of credit hour 3
2. Course prerequisites, corequisites, and where the course fits in the program of study	
Prerequisites: None	
3. Course logistics	
Term: TBD *Class location and time: TBD*	
4. Instructor contact information	
Instructor's name *Office address* *Office Hours* *Contact telephone number* *Email address*	Ramin Pashaie EE 317 TBD 561-297-1041 rpashaie@fau.edu
5. TA contact information	
TA's name *Office address* *Office Hours* *Contact telephone number* *Email address*	NA
6. Course description	
Neural engineering concentrate on development of technologies for rehabilitation, treatment, or compensation of damages in the central and peripheral nervous system. Modern techniques and signal processing algorithms used in brain machine interface applications, including different brain recording and stimulation methods and closed-loop brain control applications, are discussed.	
7. Course objectives/student learning outcomes/program outcomes	
Course objectives	The main objective of the course is to provide a training opportunity for students and help them see how the engineering skills that they have acquired in other courses, including signal processing, control theory, machine learning, embedded systems etc, can be used to understand, repair, replace, enhance, or treat diseases of nervous system. The topic is highly interdisciplinary be nature and the main task for the instructor is to facilitate the learning process for students and help them overcome the gaps and see the opportunities in the field.
Student learning outcomes & relationship to ABET 1-7 outcomes	
8. Course evaluation method	

• We will have 8 mini-projects in the form of computer programming. The task for each project will be assigned by the instructor and students will have one week to finish the project and return reports. • We will have one final project in which students will choose the topic from recently published literature, they will get the confirmation from the instructor, and they will have up to one-month time frame to return their reports. Based on the load of the project, students can work individually or as a member of a team.	• Mini projects are the best way for the students to learn the topics covered in lectures. These projects are based on research publications. Students will receive one or two papers for each project. They need to carefully study assigned papers, understand the material of the paper and implement a computer model to test the theory or hypothesis in a biological neural assembly. • The main idea for the final project is to give students the opportunity to review the literature and learn more about the applications of what they have learned in the lectures.

9. Course grading scale

80% of the final score comes from 8 mini projects (10% for each project) and 20% from a research based final project.

For each project, student will ask to return a report. In the report, they will summarize their approach, analysis of the network or process they have studied, computer codes generated for modeling, and results obtained.

90 and above: "A", 87-89: "A-", 83-86: "B+", 80-82: "B", 77-79 : "B-", 73-76: "C+", 70-72: "C", 67-69: "C-", 63-66: "D+", 60-62: "D", 51-59: "D-", 50 and below: "F."

10. Policy on makeup tests, late work, and incompletes

No project report can be delivered after the assigned deadline unless the student provides justifications which are acceptable based on the university code of conduct including sickness with valid approval from doctor's office or proven family emergency etc.

11. Special course requirements

NA

12. Classroom etiquette policy

NA

13. Attendance policy statement

Students are expected to attend all of their scheduled University classes and to satisfy all academic objectives as outlined by the instructor. The effect of absences upon grades is determined by the instructor, and the University reserves the right to deal at any time with individual cases of non-attendance.
Students are responsible for arranging to make up work missed because of legitimate class absence, such as illness, family emergencies, military obligation, court-imposed legal obligations or participation in University-approved activities. Examples of University-approved reasons for absences include participating on an athletic or scholastic team, musical and theatrical performances and debate activities. It is the student's responsibility to give the instructor notice prior to any anticipated absences and within a

reasonable amount of time after an unanticipated absence, ordinarily by the next scheduled class meeting. Instructors must allow each student who is absent for a University-approved reason the opportunity to make up work missed without any reduction in the student's final course grade as a direct result of such absence.

14. Disability policy statement

In compliance with the Americans with Disabilities Act Amendments Act (ADAAA), students who require reasonable accommodations due to a disability to properly execute coursework must register with Student Accessibility Services (SAS) and follow all SAS procedures. SAS has offices across three of FAU's campuses – Boca Raton, Davie and Jupiter – however disability services are available for students on all campuses. For more information, please visit the SAS website at www.fau.edu/sas/.

15. Counseling and Psychological Services (CAPS) Center

Life as a university student can be challenging physically, mentally and emotionally. Students who find stress negatively affecting their ability to achieve academic or personal goals may wish to consider utilizing FAU's Counseling and Psychological Services (CAPS) Center. CAPS provides FAU students a range of services – individual counseling, support meetings, and psychiatric services, to name a few – offered to help improve and maintain emotional well-being. For more information, go to http://www.fau.edu/counseling/

16. Code of Academic Integrity policy statement

Students at Florida Atlantic University are expected to maintain the highest ethical standards. Academic dishonesty is considered a serious breach of these ethical standards, because it interferes with the university mission to provide a high quality education in which no student enjoys an unfair advantage over any other. Academic dishonesty is also destructive of the university community, which is grounded in a system of mutual trust and places high value on personal integrity and individual responsibility. Harsh penalties are associated with academic dishonesty. For more information, see University Regulation 4.001. If your college has particular policies relating to cheating and plagiarism, state so here or provide a link to the full policy—but be sure the college policy does not conflict with the University Regulation.

17. Required texts/reading

Neural Engineering, Bin He (Editor), 3rd Edition, Springer, ISBN 978-3-030-43395-6

18. Supplementary/recommended readings

- Neuroengineering, by Evelyn Page (Editor), Publisher: Hayel Medical, Sep 8 2020.
- Research papers will be uploaded on the course webpage for students to get updated information about the state-of-the-art applications of the techniques we study in during lectures. This is a research oriented course and it is essential that students read multiple papers for each topic we cover.

19. Course topical outline, including dates for exams/quizzes, papers, completion of reading

Week - 1 Introduction to Neurophysiology,

	The main objective of week 1 is to review fundamentals of neurophysiology and basics of theoretical neuroscience. Main concepts including the process of generation of action potential and mathematical frame work of the process will be reviewed.
Week - 2	Bio-potential Measurements and physics of Extracellular Recoding, Cells of the nervous system generate electrical signals which are known as neural bio-potentials. Recording these signals, from single cells or aggregated signals from cell populations, yields information about basic functions of the nervous system and these techniques are frequently used in clinics and research. Many different recoding modalities are invented which differ in spatial scale, temporal resolution, and purpose. To engineering the appropriate recording device or to choose the right technology for an application, we need to understand the nature of each signal and the type of recording technology that can be used for any specific application, including the form, shape, material, or circuitry required for each recording application.
Week - 3	Electrophysiological Mapping and Source Localization, From the recorded electrophysiology signals, we usually try to recover two separate classes of information which are *source identification* and *source localization*. Source identification is about which type of cells are contributing to the recorded signals and source localization is about which area in the brain is producing the recorded signals. Since, electrophysiology recording provides just a partial observation from a much higher dimensional system, both system identification and source localization problems are highly ill-posed. Nonetheless, over years many useful techniques are developed to process the acquired information and generate valuable statistical inference.
Week - 4	Brain-Computer Interfaces, Brain-computer interface (BCI) is the technology that is used to directly connect the brain to prosthetic or remote advanced integrated systems to directly interpret brain signals and deliver input to devices without going through the neuromuscular pathways. Many BCI technologies are developed to be bidirectional so that the developed systems can also pass sensory information directly to the brain. We will review building blocked of BCI systems including signal acquisition, signal processing, feature extraction, feature translation, and device control.
Week - 5	Deep Brain Stimulation, Deep Brain Stimulation (DBS) techniques are a set of technologies developed to continuously deliver electrical pulses through chronically implanted electrodes that are connected to neurostimulators. DBS is proven to be a promising technology for the treatment of severe and drug-resistant movement disorders.

	We will review basics of the technology, approaches currently taken to improve its efficiency, computational models involved, and closed-loop DBS algorithms.
Week - 6	Intracortical Brain-Machine Interface, We expand the DBS discussion to intracortical neural recording, intracortical neural decoding techniques, design of output device and delivery of sensory inputs.
Week - 7	Transcranial Magnetic Stimulation, Transcranial Magnetic Stimulation (TMS) is a non-invasive method used for focal brain stimulation. TMS can help establish a causal link brain a circuit and behavior. In these lectures we will cover the physics of TMS technology and the algorithm used to study brain circuits both in clinics and research.
Week - 8	Transcranial Electrical Stimulation, Transcranial Electrical Stimulation (TES) is the technology in which brain functions are modulated via imposing brain cells to electric fields that are generated by electrode arrays which are implanted over the head. Physics of TES technology and data analysis algorithms will be covered.
Week - 10	Optical Brain Stimulation, Optical brain stimulation techniques were recently developed as alternatives to traditional methods of stimulation via electric or magnetic fields. Nonetheless, by combining optics with molecular genetics, a new class of brain stimulation method is introduced in recent years which provide a unique opportunity to deliver stimulating pulses only to specific cell population of interest. The targeting benefit of these methods can help reduce side effects of other brain stimulation methods such as DBS techniques. Basics of optical stimulation and specifically optogenetic neuro-modulation will be the main line of discussion in these lectures.
Week - 11	Chronic Recording in Peripheral Nervous Systems, Detection and decoding of neural signals in peripheral nervous system has many benefits including detection of motor signals in patients with amputation and replacing lost organs with robotic platforms. We will discuss recording technologies that are developed to collect data from peripheral nervous system and algorithms used to decipher the collected data to generate commands to compensating electronic systems.
Week - 12	Functional and Causal Connectivity in the Brain, Functional and causal connectivity is a main topic in neuroscience. We will review fundamentals theories of causal connectivity and the theory of Granger causality and its applications.

Week - 13	Neural Coding, Population codes are neural representations at the level of groups of cells. From single cell coding theory, we expand to population coding and we study how neurons response to complex stimulations or sensory inputs.
Week - 14	Information theory and Neural Codes, Information theory quantifies how much information a neural response carries about the stimulus. We study neural codes from the information theory point of view to quantitatively measure how much information is embedded in a collection of given firing patterns.
Week - 15	Control of Brain Networks We will study the applications of linear control theory and linear dynamical systems, and well as the nonlinear control theory and will show how these techniques are used to develop brain interface platforms.

From: William Kalies <WKALIES@fau.edu>
Sent: Tuesday, February 2, 2021 1:07 AM
To: Mihaela Cardei <mcardei@fau.edu>
Subject: Re: Neuroengineering concentrations and related courses

Hello Mihaela

The Neuroengineering concentration and new course proposals were sent to the departments of Biological Sciences, Psychology, and Physics, as well as the Center for Complex Systems and Brain Sciences, as the those in the College of Science that would potentially be affected by the proposals. After the withdrawal of EEE 6266, these departments support the proposal for the new concentration and the new courses BME 6390 and BME 6718.

Bill

—
Bill Kalies
Associate Dean for Graduate Studies
Charles E. Schmidt College of Science
Professor of Mathematical Sciences

Florida Atlantic University
777 Glades Rd, SE-43, Room 242
Boca Raton, FL 33431
tel: 561-297-1107
—

On Jan 8, 2021, at 9:49 AM, Mihaela Cardei <mcardei@fau.edu> wrote:

Hello Bill,

Happy New Year!

Our College has prepared proposals for adding the Neuroengineering concentration to the PhD in Electrical Engineering and to the PhD in Mechanical Engineering programs, as well as three new course proposals:
EEE 6266 Medical Imaging
BME 6390 Neural Engineering
BME 6718 Computational Modeling of Biological Neural Networks

Please find attached all these proposals. Please let us know whether the College of Science has any objections for the proposed curriculum items.

Thank you,
Mihaela

From: Marc Kantorow <MKANTORO@health.fau.edu>
Sent: Tuesday, January 19, 2021 4:09 PM
To: Mihaela Cardei <mcardei@fau.edu>
Cc: Janet Robishaw <jrobishaw@health.fau.edu>; Massimo Caputi <MCAPUTI@health.fau.edu>; Bridget Smith <BSTATLER@health.fau.edu>
Subject:FW: Neuroengineering concentrations and related courses

Hi Mihaela,
Hope all is well. Our committee raised no objectives to the proposal and new courses.
Let us know if we can be of further assistance.
All the best,
Marc

Marc Kantorow PhD, FARVO
Associate Dean for Graduate Programs
Professor of Biomedical Science
Charles E. Schmidt College of Medicine
Florida Atlantic University
Boca Raton, FL USA 33431
mkantoro@health.fau.edu
561-297-2910

From: Mihaela Cardei <mcardei@fau.edu>
Date: Friday, January 8, 2021 at 9:51 AM
To: Marc Kantorow <MKANTORO@health.fau.edu>
Cc: Hanqi Zhuang <zhuang@fau.edu>, Manhar Dhanak <dhanak@fau.edu>
Subject: Neuroengineering concentrations and related courses

Hello Marc,

Happy New Year!

Our College has prepared proposals for adding the Neuroengineering concentration to the PhD in Electrical Engineering and to the PhD in Mechanical Engineering programs, as well as three new course proposals:
EEE 6266 Medical Imaging
BME 6390 Neural Engineering
BME 6718 Computational Modeling of Biological Neural Networks

Please find attached all these proposals. Please let us know whether the College of Medicine has any objections for the proposed curriculum items.

Thank you,
Mihaela

From: Mihaela Cardei <mcardei@fau.edu>
Sent: Wednesday, January 13, 2021 8:15 AM
To: Randy Blakely <rblakely@health.fau.edu>
Cc: William Kalies <WKALIES@fau.edu>; Hanqi Zhuang <zhuang@fau.edu>; Manhar Dhanak <dhanak@fau.edu>
Subject: Re: COECS – Neuroengineering concentrations

Great, thank you for your feedback Randy.

Best regards,
Mihaela

From: Randy Blakely <rblakely@health.fau.edu>
Sent: Tuesday, January 12, 2021 8:26 PM
To: Mihaela Cardei <mcardei@fau.edu>
Cc: William Kalies <WKALIES@fau.edu>; Hanqi Zhuang <zhuang@fau.edu>; Manhar Dhanak <dhanak@fau.edu>
Subject: Re: COECS – Neuroengineering concentrations

Hi Mihaela
Thanks for the follow up. Yes, those course title change requests went in some time ago, surprised it hasn't been accomplished yet. My suspicion for the two courses being different was just as Ramin explained. I am not sure a student would get the difference from reading the text which as I noted was significantly duplicated. I like what he wrote in his email and would suggest that he work that into his text. Regardless, it's great to see them going on the books
Randy

Randy D. Blakely, Ph.D.
Executive Director, FAU Brain Institute
Professor of Biomedical Science
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5353 Parkside Dr.
Jupiter, FL 33458
Tel: 561-799-8100
email: rblakely@health.fau.edu
http://www.blakelylab.org


From: Mihaela Cardei <mcardei@fau.edu>
Date: Monday, January 11, 2021 at 10:10 AM
To: Randy Blakely <rblakely@health.fau.edu>
Cc: William Kalies <WKALIES@fau.edu>, Hanqi Zhuang <zhuang@fau.edu>, Manhar

Dhanak <dhanak@fau.edu>
Subject: Re: COECS – Neuroengineering concentrations

Hello Randy,

Thank you for your reply and for taking time to review the items. We have approved them in the college and are ready to submit for approvals to the university level.

Thank you for letting me know about the upcoming course title changes. "Cellular and Molecular Neuroscience" and "Systems and Integrative Neuroscience" are not in the catalog as of now. Therefore, we will have to keep Neuroscience 1 & 2 in the proposal and change them as soon as the catalog is updated.

The Neuroengineering Concentration for the ME Major document doesn't list the extent of elective courses as with the one in EE. It has a note "Additional courses may be approved by the dissertation advisor" that gives flexibility to the advisor and student to derive a plan of study including courses from other departments and colleges as electives.

BME 6390 and BME 6718 are being proposed by Dr. Ramin Pashaie. He changed the title of the special topics course "Brain Modeling" to "Computational Modeling of Biological Neural Networks". He confirmed that the two courses are different, please see below his explanation email*.

Regarding the PhD in Neuroscience program, master's "along the way" (MALW) is a great idea (https://fau.edu/graduate/docs/Masters_Along_the_Way_Instructions.pdf). MS in Bioengineering is the closest, and we could also consider MS ME and MS EE. We will have to check and confirm with the Graduate College since the document indicates that "The MALW must be in the same field as the doctoral program". The master programs in our college are 30 credits. Non-thesis (10 courses) may be an easier path. For thesis, we cannot use the same research for the MS and PhD. Even if the area is the same, the research problem that they address must be different.

Thank you,
Mihaela
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* Here is the email from Dr. Pashaie:

Hi Mihaela and Hanqi,

Neural engineering and Computational Modeling for Biological Neural Networks are completely different topics.

Neural engineering concentrated on development of devices (such as electrodes or prosthetic platforms) that can record from brain or stimulate brain circuits. For example, we see people who have lost an arm and the arm is replaced by a robotic system which reads signals from neurons and transform those to commands for the artificial limb. This is about implementation of brain machine interface (BMI) platforms.
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Computational modeling concentrates on building mathematical and computational models for the dynamics of a cell or network of cells. for example, a mathematical model for how an ion channel functions under different membrane voltages or how an electric signal propagates along the body of a nerve cell. We study with mathematical tool how neurons get connected to each other and how learning takes place in biology again by using engineering and mathematics.

These two courses can be offered with minimum or zero overlap. The syllabus that I provided for neural engineering has a little overlap with computational modeling. The reason is that I first prepared the syllabus for computational modeling and at the time I didn't know that we will go for neural engineering any time soon. Therefore, I included just some minimum neural engineering related topics that I thought are very beneficial for students who don't have a chance to take a neural engineering course. It is possible to modify the syllabus of computational modeling and remove any form of overlap with neural engineering.

Hope this is helpful. Please let me know if you need more information.

Sincerely Yours,
Ramin

From: Randy Blakely <rblakely@health.fau.edu>
Sent: Sunday, January 10, 2021 2:50 PM
To: Mihaela Cardei <mcardei@fau.edu>
Cc: William Kalies <WKALIES@fau.edu>; Hanqi Zhuang <zhuang@fau.edu>; Manhar Dhanak <dhanak@fau.edu>
Subject: Re: COECS – Neuroengineering concentrations

Hi Mihaela
Thanks for sending these items along. Nice to see the effort progressing. Just a few notes

• Neuroscience 1 is being renamed Cellular and Molecular Neuroscience, with the same course code.
• Neuroscience 2 is being renamed Systems and Integrative Neuroscience, with the same course code.
• The Neuroengineering Concentration for the ME Major document doesn’t list the extent of elective courses as with the one in EE (many would be the same). Is this is due to heavier core coursework?
• 6390 and 6718 look identical and have duplicated text for Course Evaluation Method. At least on paper, the two courses don’t appear well enough differentiated. Are these courses listed as distinct courses due to having different kinds of students? Have both already been approved?

I wonder if you have considered the pathway by which Neuroscience PhD students, training with Engineering faculty, could obtain a Masters degree in Engineering? After they do their Core courses, it is conceivable that the three electives they take prior to being examined for their PhD thesis proposal could be ones acceptable for a Masters, with a couple courses taken after qualification leading to the

Masters? Can you see a curricular path that might work for this? Could a defense of their PhD thesis proposal, written as a thesis document, satisfy the thesis requirement for the Engineering Masters?

Randy

Randy D. Blakely, Ph.D.
Executive Director, FAU Brain Institute
Professor of Biomedical Science
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Room 109, MC-17
5353 Parkside Dr.
Jupiter, FL 33458
Tel: 561-799-8100
email: rblakely@health.fau.edu
http://www.blakelylab.org


From: Mihaela Cardei <mcardei@fau.edu>
Date: Friday, January 8, 2021 at 9:48 AM
To: Randy Blakely <rblakely@health.fau.edu>
Cc: William Kalies <WKALIES@fau.edu>, Hanqi Zhuang <zhuang@fau.edu>, Manhar Dhanak <dhanak@fau.edu>
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Thank you,
Mihaela