

BME 3301A: Neural Systems Engineering

Course Outline 2023-24

Course Overview:

Neural Systems Engineering is an interdisciplinary field combining neuroscience, engineering, and computational approaches to understand, model, and manipulate neural systems. This course will provide students with a comprehensive understanding of neural engineering principles, technologies, and applications. Students will explore the intricate workings of the nervous system and learn how to design, use and analyze neural interfaces.

Course Objectives:

1. To grasp the fundamental principles of neural engineering and the nervous system's structure.
2. To explore various neural interface technologies and their applications in medical, robotic, and cognitive domains.
3. To understand signal processing techniques for decoding and analyzing neural data.
4. To develop hands-on skills in designing neural engineering experiments and interpreting results.

Course Outline:

Module 1: Introduction to Neural Systems Engineering

1. Course introduction/overview
2. Understanding the interdisciplinary nature of neural engineering
3. Historical perspective and key milestones in neural systems engineering

Module 2: Neuroscience Foundations

4. Structure and function of the nervous system
5. Structure and function of the brain
6. Structure and function of neurons and neural circuits part I
7. Structure and function of neurons and neural circuits part II
8. Hodgkin–Huxley model
9. Neuroplasticity and its implications in neural engineering
10. Brain rhythms and their significance in neural data analysis

Module 3: BCI and Neural Interface Technologies

11. Electroencephalography (EEG)/Magnetoencephalography (MEG)
12. Functional MRI (fMRI)

13. Functional Near-infrared spectroscopy (fNIRS)
14. Cochlear implants
15. Retinal implants
16. Deep Brain Stimulation (DBS) and its role in treating neurological disorders
17. Nerve cuff and vagal nerve stimulation
18. Robotic Prosthesis & Bionics
19. Neurofeedback

Module 4: Signal Processing in Neural Engineering

20. Neural signals pre-processing techniques (EEG)
 21. Time-domain vs. frequency-domain analysis
 22. General Linear Model
 23. Biostatistical concepts
 24. Introduction to machine learning
25. Review/reflection of the material for the mid-term exam (2 hours)

Module 5: AI in Robotics and Neural Engineering

26. Artificial intelligence applications in medicine part I
27. Artificial intelligence applications in medicine part II
28. Neural networks part I
29. Neural networks part II
30. Deep learning
31. Support vector machines

Module 6: Cognitive Enhancement, Neural Augmentation and Future Directions

32. Ethical considerations in cognitive enhancement technologies
 33. Brain-to-brain communication and its implications
 34. Exploring cutting-edge research and innovations in neural systems engineering
 35. Neuroinformatics and its role in advancing the field
 36. Predictions for the future of neural engineering and its potential impact on society
37. Review/reflection of the material for the final exam (2 hours block, last two hours of the course)

Assessments:

- Assignments to evaluate theoretical knowledge and neural engineering problems.
- Laboratory sessions to develop practical skills in working with neural/biological data.

Course Instructor info:

Dr. Daniel Milej

Email: dmilej@uwo.ca

Office hours: Available via Zoom/Teams online meeting or in person

By the end of the course, students will be able to:

1. Explain the structure and functions of the nervous system
2. Designing study focused on monitoring the activity/response of specific area of the human brain
3. Biosensing cardiovascular, respiratory, and neuromuscular physiology;
4. Create experiments and study the design of add-on circuits using the breadboards
5. Compare a raw biosignal and conditioned signal

Course Grading Scheme:

The final course grade will be determined as listed below:

- Deadline dates for assignments, projects, presentations, and examinations are determined according to the **tentative** schedule as follows:
- The final grade is computed as follows:
- **Class Participation:** 5%
- **Assignments:** 15% (3 assignments) (Sep 23, Oct 28, Nov 18)
- **Laboratories:** 20% (4 lab exercises) (TBD)
- **Midterm:** 20% (MCQ Test + open questions, written, TBD)
- **Final Exam:** 40% (MCQ Test+ open questions, written, TBD)

Course Textbook

If you would like to study the reference material used for the course, you might wish to obtain a copy of the following optional textbook

He B, editor. Neural engineering. Springer Science & Business Media; 2007 Dec 31. ([Link to website](#))

In addition, students are encouraged to look for more comprehensive descriptions of the course's topics online.

Office Hours

By appointment (using Zoom/Teams)

Appointment Availability

Video Appointments can be arranged via Zoom/Teams

Email Response Time:

I endeavour to reply to messages within 24 hours between Monday and Friday and within 48 hours on Saturday and Sunday. If your question is course-related, post it to our discussion forums

STATEMENT ON GENDER-BASED AND SEXUAL VIOLENCE

Western [is committed to reducing incidents of gender-based and sexual violence](#) and providing compassionate support to anyone who has gone through these traumatic events. If you have experienced gender-based or sexual violence (either recently or in the past), you will find information about support services for survivors, including emergency contacts, [here](#). To connect with a case manager or set up an appointment, please contact support@uwo.ca.

**INSTRUCTIONS FOR STUDENTS UNABLE TO WRITE TESTS OR EXAMINATIONS
OR SUBMIT ASSIGNMENTS AS SCHEDULED**

If, on medical or compassionate grounds, you are unable to write term tests or final examinations or complete course work by the due date, you should follow the instructions listed below. You should understand that academic relief will not be granted automatically on request. You must demonstrate to your department (or the Undergraduate Services Office) that there are compelling medical or compassionate grounds that can be documented before academic relief will be considered. Different regulations apply to term tests, final examinations and late assignments. Please read the instructions carefully.

A. GENERAL REGULATIONS & PROCEDURES

1. All first-year students will report to the Undergraduate Services Office by submitting the [Academic Consideration Request Form](#), for all instances.
2. If you are an upper year student and you are missing a test/assignment/lab or examination you will report the absence by submitting [Academic Consideration Request Form](#). Absences worth LESS THAN 10% of your mark, will be processed by your department office. If your course work is worth 10% OR MORE of your final grade, your request will be processed by the Undergraduate Services Office.
3. Check the course outline to see if the instructor has a policy for missed tests, examinations, late assignments or attendance.
4. Documentation must be provided as soon as possible. If no one is available in your department office or the Undergraduate Services Office, leave a message clearly stating your name & student number and reason for your call. The department telephone numbers are given at the end of these instructions.
5. If you decide to write a test or an examination you should be prepared to accept the mark you earn. Rewriting tests or examinations or having the value of a test or examination

reweighted on a retroactive basis is not permitted.

B. TERM/MIDTERM TESTS

1. If you are in first year and you are unable to write a midterm/term test, contact the Undergraduate Services Office, SEB 2097 PRIOR to the scheduled date of the test.
2. If you are an upper year student and you are unable to write a midterm/term test, inform your instructor PRIOR to the scheduled date of the test and request relief through the [Academic Consideration Request Form](#). If the instructor is not available, leave a message for him/her at the department office. If the test is worth LESS THAN 10% of your mark, your request for relief will be processed by your department office. If the test is worth MORE THAN 10% of your final grade your request for relief will be processed by the Undergraduate Services Office.
3. Be prepared to attach supporting documentation to the Department Chair and/or the Undergraduate Services Office through the online form (see next page for information on documentation).
4. Discuss with the instructor if and when the test can be rescheduled. The approval of the Chair or the Undergraduate Services Office is required when rescheduling midterm/term tests.

C. FINAL EXAMINATIONS

1. If you are unable to write a final examination, contact the Undergraduate Services Office PRIOR TO THE SCHEDULED EXAMINATION TIME to report your absence using the [Academic Consideration Request Form](#) and request permission to write a Special Final Examination. If no one is available in the Undergraduate Services Office, leave a message clearly stating your name & student number.
2. Be prepared to provide the Undergraduate Services Office with supporting documentation (see next page for information on documentation) the next day, or as soon as possible (in cases where students are hospitalized). The following circumstances are not considered grounds for missing a final examination or requesting special examinations: common cold, headache, sleeping in, misreading timetable and travel arrangements.
3. In order to receive permission to write a Special Examination, you must obtain the approval of the Chair of the Department **and** the Associate Dean and in order to apply you must submit an "[Application for a Special Exam](#)" form. The Undergraduate Services Office will then notify the course instructor(s) and reschedule the examination on your behalf.

PLEASE NOTE: It is the student's responsibility to check the date, time and location of the Special Examination.

D. LATE ASSIGNMENTS

1. Advise the instructor if you are having problems completing the assignment on time (**prior** to the due date of the assignment).
2. Be prepared to submit the [Academic Consideration Request Form](#) and provide documentation if requested by the instructor (see reverse side for information on documentation).
3. If you are granted an extension, establish a due date. The approval of the Chair of your Department (or the Assistant Dean, First Year Studies, if you are in first year) is not required if assignments will be completed prior to the last day of classes.
4.
 - i) Extensions beyond the end of classes must have the consent of the instructor, the department Chair and the Associate Dean, Undergraduate Studies. Documentation is mandatory.
 - ii) A Recommendation of Incomplete Form must be filled out indicating the work to be completed and the date by which it is due. This form must be signed by the student, the instructor, the department Chair and the Associate Dean, Undergraduate Studies.

E. SHORT ABSENCES

If you miss a class due to a minor illness or other problem, check your course outlines for information regarding attendance requirements and make sure you are not missing a test, laboratory or assignment. Cover any readings and arrange to borrow notes from a classmate.

F. EXTENDED ABSENCES

If you are absent more than one week or if you get too far behind to catch up, you should consider reducing your workload by dropping one or more courses. (Note drop deadlines listed below). You are strongly encouraged to seek advice from your Academic Counsellor in the Undergraduate Services Office.

G. DOCUMENTATION

If you consulted an off-campus doctor or Student Health Services regarding your illness or personal problem, **you must provide the doctor with a Student Medical Certificate** to complete at the time of your visit and then bring it to the Department (or the Undergraduate Services Office). **This note must contain the following information: severity of illness, effect on academic studies and duration of absence. Regular doctor's notes will not be accepted; only the Student Medical Certificate will be accepted.**

In Case of Serious Illness of a Family Member: Provide a Student Medical Certificate to your family member's physician to complete and bring it to the Department (or the Undergraduate Services Office if you are in first year).

In Case of a Death: Obtain a copy of the death certificate or the notice provided by the

funeral director's office. You must include your relationship to the deceased and bring it to the Department (or the Undergraduate Services Office if you are in first year).

For Other Extenuating Circumstances: If you are not sure what documentation to provide, ask the Departmental Office (or the Undergraduate Services Office if you are in first year) for direction.

Note: Forged notes and certificates will be dealt with severely. To submit a forged document is a scholastic offence (see below).

H. ACADEMIC CONCERNS

1. You need to know if your instructors have a policy on late penalties, missed tests, etc. This information may be included in the course outlines. If not, ask your instructor(s).
2. **You should also be aware of attendance requirements in some courses. You can be debarred from writing the final examination if your attendance is not satisfactory.**
3. If you are in academic difficulty, check out the minimum requirements for progression in the calendar. If in doubt, see your Academic Counsellor.

Calendar References: Check these regulations in your 2023 Western Academic Calendar available at www.westerncalendar.uwo.ca.

Absences Due to Illness:

https://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=1&SelectedCalendar=Live&ArchiveID=#Page_135

Academic Accommodations for Students with Disabilities:

http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=1&SelectedCalendar=Live&ArchiveID=#Page_10

Academic Accommodations for Religious or Holy Days:

http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=1&SelectedCalendar=Live&ArchiveID=#Page_16

Course Withdrawals:

http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=6&SelectedCalendar=Live&ArchiveID=#Page_75

Examinations:

<http://www.westerncalendar.uwo.ca/PolicyPages.cfm?PolicyCategoryID=5&command=showCategory&SelectedCalendar=Live&ArchiveID=>

Scheduling of Term Assignments:

http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=5&SelectedCalendar=Live&ArchiveID=#SubHeading_78

Scholastic Offences:

http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=1&SelectedCalendar=Live&ArchiveID=#Page_20

Student Medical Certificate:

<https://www.eng.uwo.ca/files/undergraduate/student-medical-certificate.pdf>

Engineering Academic Regulations:

http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=4&SelectedCalendar=Live&ArchiveID=#Page_86

Note: These instructions apply to all students registered in the Faculty of Engineering regardless of whether the courses are offered by the Faculty of Engineering or other faculties in the University.

Add Deadlines:

First term half course (i.e. “A” or “F”)

September 15, 2023

Full courses and full-year half course (i.e. “E”, “Y” or no suffix)

September 15, 2023

Second term half course (i.e. “B” or “G”)

January 16, 2023

Drop Deadlines:

First term half course without penalty (i.e. “A” or “F”)

November 13, 2023

Full courses and full-year half courses without penalty (i.e. “E”, “Y” or no suffix)

November 30, 2023

Second term half or second term full course without penalty (i.e. “B” or “G”)

March 7, 2023

Contact Information:

Undergraduate Services Office:

SEB 2097 Phone: 519-661-2130

E-mail:

engugrad@uwo.ca

Chemical & Green Process Engineering:

TEB 477 Phone: 519-661-2131

E-mail:

cbeugrad@uwo.ca

Civil Engineering:

SEB 3005 Phone: 519-661-2139

E-mail:

civil@uwo.ca

Computer, Electrical, Mechatronic Systems & Software Engineering

TEB 279 Phone: 519-661-3758

E-mail:

cceugrad@uwo.ca

Integrated Engineering

ACEB 2410 Phone: 519-661-6725

E-mail:

engceli@uwo.ca

Mechanical Engineering:

SEB 3002 Phone: 519-661-4122

E-mail:

mmeundergraduate@uwo.ca

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