SYSC 5307 / BIOM 5101
Biological Signals

Calendar description
Modeling of neuromuscular biological signals, including subthreshold phenomena, active behaviour of cell membranes, and innervation processes. Measurement of biological signals, including electrode effects. Time domain, frequency domain, and adaptive filtering techniques for noise reduction.

Precludes additional credit for BIOM 5101 (BMG 5104).

https://calendar.carleton.ca/grad/courses/SYSC/

Prerequisites
None.
Course will build on experience from undergraduate work including biology, physics, mathematics, statistics and signal processing.

Prior knowledge
Students should be able to:
- Analyze simple RLC circuits (e.g., Kirchhoff's circuit laws, Kirchhoff's voltage laws)
- Understand multivariate calculus
- Understand frequency domain analysis (e.g., Fourier series, Fourier transforms)

Course objectives and Learning outcomes
By the end of this course, students should be able to:

At the end of course, a student will be able to:
- describe how bioelectric signals manifest physiologically
- appraise methods of acquiring bioelectric signals
- apply models for bioelectric signals
- choose appropriate preprocessing methods for biomedical signals

https://carleton.ca/edc/teachingresources/course-design/learning-outcomes
Special Information for Pandemic Measures

It is important to remember that COVID is still present in Ottawa. The situation can change at any time and the risks of new variants and outbreaks are very real. There are a number of actions you can take to lower your risk and the risk you pose to those around you including being vaccinated, wearing a mask, staying home when you’re sick, washing your hands and maintaining proper respiratory and cough etiquette.

Feeling sick? Remaining vigilant and not attending work or school when sick or with symptoms is critically important. If you feel ill or exhibit COVID-19 symptoms do not come to class or campus. If you feel ill or exhibit symptoms while on campus or in class, please leave campus immediately. In all situations, you must follow Carleton’s symptom reporting protocols.

Masks: Carleton has paused the COVID-19 Mask Policy, but continues to strongly recommend masking when indoors, particularly if physical distancing cannot be maintained. It may become necessary to quickly reinstate the mask requirement if pandemic circumstances were to change.

Vaccines: Further, while proof of vaccination is no longer required as of May 1 to attend campus or in-person activity, it may become necessary for the University to bring back proof of vaccination requirements on short notice if the situation and public health advice changes. Students are strongly encouraged to get a full course of vaccination, including booster doses as soon as they are eligible, and submit their booster dose information in cuScreen as soon as possible. Please note that Carleton cannot guarantee that it will be able to offer virtual or hybrid learning options for those who are unable to attend the campus.

All members of the Carleton community are required to follow requirements and guidelines regarding health and safety which may change from time to time. For the most recent information about Carleton’s COVID-19 response and health and safety requirements please see the University’s COVID-19 website and review the Frequently Asked Questions (FAQs). Should you have additional questions after reviewing, please contact covidinfo@carleton.ca.

Self-Declaration Process in Effect for Fall 2022 Term

Since the beginning of the COVID-19 pandemic, Carleton has temporarily suspended the need for doctor’s notes or medical certificates for academic accommodation requests related to COVID-19. This decision was made in recognition of the fact that alternate course delivery and assessment methods present unique challenges and that it continues to be more difficult than usual for students to see a doctor and obtain documentation.

As we all continue to navigate ongoing disruptions caused by the public health crisis, we are extending this process for the Fall 2022 Term.

In place of a doctor’s note or medical certificate, students will be advised to complete the self-declaration form available on the Registrar’s Office website to request academic accommodation for missed course work including exams and assignments. Students

Carleton University acknowledges the location of its campus on the traditional, unceded territories of the Algonquin nation.
will also be encouraged to connect directly with their instructors to discuss required accommodations arising from the COVID-19 situation.

**Instructor and TA contact**

**Instructor Information and Office hours**

Dr. Adrian D. C. Chan  
Pronouns: he/him/his  
Email: adrian.chan@carleton.ca  
Office: Canal Building 6201

Office Hours: There are no fixed office hours.

Note that emails should be written from your Carleton (or uOttawa) email account and that you should check (or forward) email on your Carleton email account. Email from accounts other than your Carleton email account may not receive any response.

**Textbook (or other resources)**

There are no mandatory textbooks for this course. Some recommended textbooks include:


**Evaluation and grading scheme**

<table>
<thead>
<tr>
<th>Deliverable</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assignments</td>
<td>40%</td>
</tr>
<tr>
<td>Project</td>
<td>30%</td>
</tr>
</tbody>
</table>

Carleton University acknowledges the location of its campus on the traditional, unceded territories of the Algonquin nation.
Tentative week-by-week breakdown

Week 0 (Sept 5)
Course Introduction

Week 1 (Sept 12)
Introduction (Basic terminology, Excitable cells, Resting membrane, and Action potentials)
  - Chapter 4
  - Chapter 1 and 2
  - Chapter 1
  - Chapter 1

Week 2 (Sept 19)
Laboratory demo
Resting Membrane Potential (Nernst equation and GHK equation)
  - Chapter 3.6 - 3.7
  - Chapter 4 and 5

Week 3 (Sept 26)
Cable Equation (Cable equation, Sub-threshold phenomena, Strength-duration relationship)
  - Chapter 3.6 - 3.7

Carleton University acknowledges the location of its campus on the traditional, unceded territories of the Algonquin nation.
Fall 2022

Action Potentials (Space clamp, Voltage clamp, TTX/TEA blocking of ion channels, Parallel conductance model, Hodgkin-Huxley model, Patch clamp)

  - Chapter 4
  - Chapter 6 and 7

**Week 4 (Oct 3)**

Action Potentials (Conduction velocity, Myelination)

  - Chapter 4
  - Chapter 6 and 7

**Week 5 (Oct 10)**

Double Dipole Model, Transmission Line Model, Volume Conductor

  - Chapter 7
- Effect of Electrode Configuration (monopolar, bipolar, and double differential electrode configurations)

*Carleton University acknowledges the location of its campus on the traditional, unceded territories of the Algonquin nation.*
  o Chapter 5 - 5.4

**Week 6 (Oct 17)**

**Effect of Electrode Size**

  o Chapter 5 - 5.4

**Fall Break (Oct 24-28)**

**Week 7 (Oct 31)**

**Biopotential Electrodes** (half-cell potentials, overpotentials, polarizable/nonpolarizable electrodes, Warburg model, motion artifact)

  o Chapter 5 - 5.5

**Week 8 (Nov 7)**

**Biopotential Amplifiers**

  o Chapter 6 - 6.7
  o Chapter 5.5

*Carleton University acknowledges the location of its campus on the traditional, unceded territories of the Algonquin nation.*
Chapter 2 - 2.4

**Week 9 (Nov 14)**
Stochastic Processes (random variable, random processing, cumulative distribution function, probability density function, stationarity, ergodicity)


**Week 10 (Nov 21)**
Modeling of Innervations (renewal process, power spectrum of renewal process, power spectrum of action potential train)


Dispersion Effects (effect of innervation zone dispersion, power spectrum of motor unit action potential train)

- Zhang YT, Paker PA, Scott RN, "Modifications of the ME Signal power density spectrum", Proceedings of the IEEE EMBS, pp. 2198-2199, 1990. (equation 3a is perhaps wrong)

Neural communication channels (integral pulse frequency modulator, power spectrum, signal-to-noise ratio)

Fall 2022


**Week 11 (Nov 28)**

Random noise, structured noise, physiological interference

  - Chapter 3

**Week 12 (Dec 5)**

Project Presentations

**Parental/Caretaking Accommodations**

Based on my commitment to students who are parents or the primary caretaker for a young child, the following is my own classroom policy:

- Nursing or bottle-fed babies are welcome in class anytime, and you are welcome to feed your baby during class. If class lasts for more than 1.5 hours, you are welcome to take a break to pump.
- For older children, I understand that illnesses and unforeseen disruptions in childcare happen. It is acceptable to bring a child to class during emergencies like these as long as the child does not distract other students and it does not become a regular occurrence.
- When babies and children come to class, I recommend that you sit close to the door so that if your little one needs special attention and is disrupting learning for other students, you may step outside until their need has been met.
- You do not need to request prior permission for any of the points above. Please communicate with me if we need to discuss other accommodations related to parenting/caregiving.

**General regulations**

**Attendance:** Students are expected to attend all lectures and lab periods. The University requires students to have a conflict-free timetable. For more information, visit [https://calendar.carleton.ca/grad/gradregulations/administrationoftheregulations/#19](https://calendar.carleton.ca/grad/gradregulations/administrationoftheregulations/#19) for Graduate Regulations

Carleton University acknowledges the location of its campus on the traditional, unceded territories of the Algonquin nation.
**Health and Safety:** Every student should have a copy of our Health and Safety Manual. A PDF copy of this manual is available online: [http://sce.carleton.ca/courses/health-and-safety.pdf](http://sce.carleton.ca/courses/health-and-safety.pdf)

**Deferred Term Work:** Students who claim illness, injury or other extraordinary circumstances beyond their control as a reason for missed term work are held responsible for immediately informing the instructor concerned and for making alternate arrangements with the instructor and in all cases, this must occur no later than three (3.0) working days after the term work was due. The alternate arrangement must be made before the last day of classes in the term as published in the academic schedule.

Instructors may, at their discretion, require students to provide medical documentation to support requests for accommodation for missed course work including exams and assignments. As per the Provost’s message of August 27, 2021, for the Fall 2021 term, students have been instructed to complete the [Medical Self-Declaration](http://sce.carleton.ca/courses/health-and-safety.pdf) form available on the Registrar’s Office website rather than seeking to obtain a doctor’s note or medical certificate. Instructions for the Winter 2022 term will be communicated by the Provost’s office.

For more information, visit [https://calendar.carleton.ca/grad/gradregulations/administrationoftheregulations/#19](https://calendar.carleton.ca/grad/gradregulations/administrationoftheregulations/#19) for Graduate Regulations

**Appeal of Grades:** Within one month of the release of grades or the announcement of examination by committee (comprehensive examination, research essay or thesis) results, a graduate student may request, through the Faculty of Graduate and Postdoctoral Affairs, that one or more of their grades or results be reviewed. The results of examination by committee (including comprehensive, research essay or thesis examinations) will only be reviewed on procedural grounds. Grades for other courses will be reviewed through the submission of all or part of the written coursework to two re-readers. The average grade of the re-readers will replace the original of the reviewed work. Parts of grades based on non-written work (e.g., participation) will not be reviewed. The process for the conduct of reviews can be found at [http://gradstudents.carleton.ca/wp-content/uploads/Grade-Appeal-Procedures.pdf](http://gradstudents.carleton.ca/wp-content/uploads/Grade-Appeal-Procedures.pdf)

**Academic Integrity:** Students should be aware of their obligations with regards to academic integrity. Please review the information about academic integrity at: [https://carleton.ca/registrar/academic-integrity/](https://carleton.ca/registrar/academic-integrity/). This site also contains a link to the complete Academic Integrity Policy that was approved by the University’s Senate.

**Plagiarism:** The University Academic Integrity Policy defines plagiarism as “presenting, whether intentionally or not, the ideas, expression of ideas or work of others as one’s own.” This includes reproducing or paraphrasing portions of someone else’s published or unpublished material, regardless of the source, and presenting these as one’s own without proper citation or reference to the original source. Examples of sources from which the ideas, expressions of ideas or works of others may be drawn from include but are not limited to: books, articles, papers, literary compositions and phrases, Carleton University acknowledges the location of its campus on the traditional, unceded territories of the Algonquin nation.
performance compositions, chemical compounds, artworks, laboratory reports, research results, calculations and the results of calculations, diagrams, constructions, computer reports, computer code/software, material on the internet and/or conversations.

Examples of plagiarism include, but are not limited to:

- any submission prepared in whole or in part, by someone else;
- using ideas or direct, verbatim quotations, paraphrased material, algorithms, formulae, scientific or mathematical concepts, or ideas without appropriate acknowledgment in any academic assignment;
- using another’s data or research findings without appropriate acknowledgement;
- submitting a computer program developed in whole or in part by someone else, with or without modifications, as one’s own; and
- failing to acknowledge sources through the use of proper citations when using another’s work and/or failing to use quotations marks.

**Academic Accommodations**

Carleton University is committed to providing access to the educational experience in order to promote academic accessibility for all individuals.

Academic accommodation refers to educational practices, systems and support mechanisms designed to accommodate diversity and difference. The purpose of accommodation is to enable students to perform the essential requirements of their academic programs. At no time does academic accommodation undermine or compromise the learning objectives that are established by the academic authorities of the University.

**Requests for Academic Accommodation**

You may need special arrangements to meet your academic obligations during the term. For an accommodation request, the processes are as follows:

- **Addressing Human Rights Concerns**: The University and all members of the University community share responsibility for ensuring that the University’s educational, work and living environments are free from discrimination and harassment. Should you have concerns about harassment or discrimination relating to your age, ancestry, citizenship, colour, creed (religion), disability, ethnic origin, family status, gender expression, gender identity, marital status, place of origin, race, sex (including pregnancy), or sexual orientation, please contact the [Department of Equity and Inclusive Communities](mailto:equity@carleton.ca).

- **Pregnancy Obligation**: Please contact your instructor with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details, please review the [Student Guide to Academic Accommodation (PDF, 2.1 MB)](mailto:equity@carleton.ca).

- **Religious Obligation**: Please contact your instructor with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist.

Carleton University acknowledges the location of its campus on the traditional, unceded territories of the Algonquin nation.
possible after the need for accommodation is known to exist. For more details, please review the [Student Guide to Academic Accommodation (PDF, 2.1 MB)](https://example.com/student-guide).

- **Academic Accommodations for Students with Disabilities**: If you have a documented disability requiring academic accommodations in this course, please contact the Paul Menton Centre for Students with Disabilities (PMC) at 613-520-6608 or pmc@carleton.ca for a formal evaluation or contact your PMC coordinator to send your instructor your Letter of Accommodation at the beginning of the term. You must also contact the PMC no later than two weeks before the first in-class scheduled test or exam requiring accommodation (if applicable). **Requests made within two weeks will be reviewed on a case-by-case basis.** After requesting accommodation from PMC, meet with your instructor as soon as possible to ensure accommodation arrangements are made. For more details, visit the [Paul Menton Centre website](https://example.com/PMC).

- **Survivors of Sexual Violence**: As a community, Carleton University is committed to maintaining a positive learning, working and living environment where sexual violence will not be tolerated, and where survivors are supported through academic accommodations as per Carleton’s Sexual Violence Policy. For more information about the services available at the university and to obtain information about sexual violence and/or support, visit the [Equity and Inclusive Communities website](https://example.com/Equity).

- **Accommodation for Student Activities**: Carleton University recognizes the substantial benefits, both to the individual student and for the university, that result from a student participating in activities beyond the classroom experience. Reasonable accommodation must be provided to students who compete or perform at the national or international level. Please contact your instructor with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details, see the [Senate Policy on Accommodation for Student Activities (PDF, 25KB)](https://example.com/senate-policy).

**Copyright on Course Materials**: The materials created for this course (including the course outline and any slides, posted notes, labs, project, assignments, quizzes, exams and solutions) are intended for personal use and may not be reproduced or redistributed or posted on any web site without prior written permission from the author(s).