

Psychology 503
Computational Neuroscience
Winter 2023

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Course Description

Advanced computational techniques are ever-present in modern neuroscience, ranging from aspects of software development, data science, modeling, and machine learning (to name only a few). Students of psychology and neuroscience are increasingly required to develop proficiency in one or more of these areas as part of their scientific training. This course is intended to introduce students of neuroscience and psychology to computational approaches in modern neuroscience, including - but not limited to - scientific programming, simulation, modeling, and software development. This is intended to be a practical course and practical skills can only be honed through...*practice*. As such, the course features many hands on programming assignments using both real and simulated data to reinforce neuroscience concepts that are covered in class. In some respects, this is a methods course masquerading as a special topics course. However, we will also survey important literature from across systems neuroscience that illustrate how neuronal populations implement specific computations that are used to guide behaviour.

Course Learning Outcomes

The Department of Psychology is committed to student knowledge and skill development. The table below lists the key learning outcomes for this course, the program-learning outcomes they facilitate (see <https://live-arts.ucalgary.ca/psychology/about#program-learning-outcomes>), and the expected level of achievement.

Course Learning Outcomes	Assessment Methods	PLO(s)	Level(s)
Develop computational problem solving skills	Quizzes Coding Assignments	2,5	C
Explain relationships between brain signals and behaviour	Quizzes Coding Assignment Paper Discussions	1,2,4,5	A
Refine critical thinking and scientific communication skills	Coding Assignments Paper Discussions	1,2,4,5	A
Use MATLAB for data analysis in neuroscience research	Quizzes Coding Assignments	1,2,4,5	C
Explain how neurobiological and behavioural phenomena can be modeled using simple mathematics	Quizzes Coding Assignments	1,2,4,5	C

Notes. PLOs = Program-Learning Outcomes: 1 = demonstrate knowledge of psychological sciences, 2 = think critically and solve problems, 3 = conduct research and analyze data, 4 = communicate effectively, 5 = demonstrate information literacy, 6 = understand and implement ethical principles in a diverse world, 7 = apply psychological knowledge and skills, 8 = Demonstrate multicultural competence and awareness of issues related to equity, diversity,* and inclusion. Level of PLO achievement facilitated by this course: I = introductory, C = competency, A = advanced.

Course Format

This is an in-person class held on campus

Acknowledgments and Respect for Diversity

Our classrooms view diversity of identity as a strength and resource. Your experiences and different perspectives are encouraged and add to a rich learning environment that fosters critical thought through respectful discussion and inclusion. The Department of Psychology would also like to acknowledge the traditional territories of the people of the Treaty 7 region in southern Alberta. The City of Calgary is also home to Métis Nation of Alberta, Region III.

Prerequisites

Psyc 300, 301 and admission to the Psychology major or Honours program

Required Text

This is an advanced-level, special topics course. There is no textbook. All required readings will be provided by the instructor and will draw from books, journal articles, and web pages.

Assessment Methods

Your grade in this course will be based on 3 factors

- 1) Coding Assignments (60% of total grade, 10% each)
 - a. Get started early. The problem sets will cover material specific to each module (see schedule) and will require significant time, especially if you are new to MATLAB.
 - b. There are 6 assignments and they are due approximately every two weeks.
 - c. Coding assignments are open book. For this course, open book means that the use of class notes, readings, and consulting the web are all permitted. The use of online resources and calculators is permitted. You may discuss the problem sets with other students and search the web for related materials. You will almost certainly need to do this, so study groups are encouraged. However, don't plagiarize math or code as your work will be submitted to plagiarism-detection software.
 - d. There are many ways to solve computational problems and you can learn a lot by seeing what other people do. Thus, coding assignments will be anonymously peer-graded. A rubric will be provided. If you fail to submit peer-reviews, your grade for that assignment will be scaled down by 50% (e.g., 90% becomes 45%).
 - e. Without instructor approval, late assignments will be penalized 10% per day, including weekends.
 - f. Coding Assignments will be submitted digitally (email, D2L)
- 2) Participation in Paper Discussions (20% of total grade)
 - a. We will discuss some of the assigned readings in class. Students are expected to have read the papers prior to the class discussions and be prepared to present the figures.
 - b. To encourage lively discussions, I will use a random number generator to call on students to present figures during class.
 - c. I will provide you with a rubric of how to read and critically think about scientific research papers and what you would be expected to cover when called on.
- 3) In Class Quiz (20% of total grade, 4% each)
 - a. Quizzes will include short answer, multiple choice, and thought questions related to the material covered in each module (one quiz per module, see schedule).

- b. Quizzes take place In Class on Mondays. To avoid overloading you, the quizzes occur on weeks that the problem sets are *NOT* due. Thus approximately each week you are either taking a quiz or submitting a coding assignment.
- c. In class quizzes are closed book and communicating with others, either verbally or electronically, during quizzes is strictly forbidden.

University of Calgary Academic Integrity Policy

Academic integrity is the foundation of the development and acquisition of knowledge and is based on values of honesty, trust, responsibility, and respect. We expect members of our community to act with integrity.

Research integrity, ethics, and principles of conduct are key to academic integrity. Members of our campus community are required to abide by our institutional code of conduct and promote academic integrity in upholding the University of Calgary’s reputation of excellence. It is your responsibility to ensure that you have read and are familiar with the student academic misconduct policy:

<https://www.ucalgary.ca/legal-services/sites/default/files/teams/1/Policies-Student-Academic-Misconduct-Policy.pdf>

Department of Psychology Criteria for Letter Grades

Psychology course instructors use the following criteria when assigning letter grades:

A+ grade: *Exceptional Performance.* An A+ grade indicates near perfect performance on multiple choice and short answer exams. For research papers/essays/course projects/presentations, an A+ grade is awarded for exceptional work deserving of special recognition and is therefore not a common grade.

A, A- Range: *Excellent Performance.* Superior understanding of course material. Written work is very strong in terms of critical and original thinking, content, organization, and the expression of ideas, and demonstrates student’s thorough knowledge of subject matter.

B Range: *Good Performance.* Above average understanding of course material. Written work shows evidence of critical thinking and attention to organization and editing but could be improved in form and/or content.

C Range: *Satisfactory Performance.* Adequate understanding of course material. Knowledge of basic concepts and terminology is demonstrated. Written work is satisfactory and meets essential requirements but could be improved significantly in form and content. Note: All prerequisites for courses offered by the Faculty of Arts must be met with a minimum grade of C-.

D range: *Marginally meets standards.* Minimal understanding of subject matter. Written work is marginally acceptable and meets basic requirements but requires substantial improvements in form and content. Student has not mastered course material at a level sufficient for advancement into more senior courses in the same or related subjects.

F grade: *Course standards not met.* Inadequate understanding of subject matter. Written work does not meet basic requirements. Student has not demonstrated knowledge of course material at a level sufficient for course credit.

Grading Scale

A+	96-100%	B+	80-84%	C+	67-71%	D+	54-58%
A	90-95%	B	76-79%	C	63-66%	D	50-53%
A-	85-89%	B-	72-75%	C-	59-62%	F	0-49%

It is at the instructor’s discretion to round off either upward or downward to determine a final grade when the average of term work and final examinations is between two letter grades. To determine final

letter grades, final percentage grades will be rounded up or down to the nearest whole percentage (e.g., 89.5% will be rounded up to 90% = A but 89.4% will be rounded down to 89% = A-).

Lecture Schedule

Date	Topic/Activity/Readings/Due Date
M Jan 9	What is Computational Neuroscience?
W Jan 11	<p>Module I: Coding, Data Analysis, and Simulation Bootcamp</p> <ul style="list-style-type: none"> • Introduction to MATLAB • Computational Problem Solving • Data Preprocessing • Probability • Simulations • Visualizations <p><i>Module Readings:</i> <i>Vision by David Marr Chapter 1</i> <i>MATLAB Help Menu</i> <i>Wang et al. 2020</i></p>
F Jan 13	Module I: Coding, Data Analysis, and Simulation Bootcamp
M Jan 16	Module I: Coding, Data Analysis, and Simulation Bootcamp Quiz 1 (In Class)
W Jan 18	Module I: Coding, Data Analysis, and Simulation Bootcamp
Jan 19	<i>Last day to drop a class without a penalty</i>
F Jan 20	Module I: Coding, Data Analysis, and Simulation Bootcamp <i>Last day to add or swap a course</i>
M Jan 23	<p>Module II: Sensory Processing</p> <ul style="list-style-type: none"> • Encoding Models • Color Vision • Priors • Reverse Correlation/Spike Triggered Average • Object Recognition <p><i>Module Readings:</i> <i>Yamins, et al. 2014</i> <i>Hansen et al. 2005</i> <i>Wallisch 2015</i> Coding Assignment #1 Due</p>
W Jan 25	Module II: Sensory Processing
F Jan 27	Module II: Sensory Processing <i>Fee payment deadline for Fall Term full and half courses.</i>
M Jan 30	Module II: Sensory Processing Quiz 2 (In Class)
W Feb 1	Module II: Sensory Processing
F Feb 3	Module II: Sensory Processing
M Feb 6	<p>Module III: Perception</p> <ul style="list-style-type: none"> • Signal Detection Theory and ROC Analysis • Brain Stimulation • Choice Probability • Correlations • Visual Attention • Drift Diffusion Models <p><i>Module Readings:</i> <i>Luo and Maunsell 2015</i> <i>Salzman, Britten, and Newsome 1990</i></p>

	<i>Cohen and Newsome 2008</i> Coding Assignment #2 Due
W Feb 8	Module III: Perception
F Feb 10	Module III: Perception
M Feb 13	Module III: Perception Quiz 3 (In Class)
W Feb 15	Module III: Perception
F Feb 17	Module III: Perception
M Feb 20	UNIVERSITY CLOSED Alberta Family Day
Feb 19-25	Term Break
M Feb 27	Module IV: Motor Control <ul style="list-style-type: none"> • Eye Movements • Dimensionality Reduction • Brain Computer Interface • Corollary Discharge <i>Module Readings:</i> <i>Churchland et al. 2012</i> <i>Lee, Rohrer, and Sparks 1988</i> <i>Sadtler et al. 2014</i> <i>Sommer and Wurtz 2002</i> Coding Assignment #3 Due
W Mar 1	Module IV: Motor Control
F Mar 3	Module IV: Motor Control
M Mar 6	Module IV: Motor Control Quiz 4 (In Class)
W Mar 8	Module IV: Motor Control
F Mar 10	JJC @ CoSyNe meeting <ul style="list-style-type: none"> • Video Lecture TBD
M Mar 13	Module V: Reward and Reinforcement <ul style="list-style-type: none"> • Temporal Difference Learning • Phasic Dopamine Signaling and Reward Prediction Errors • Reinforcement Learning • Alpha Go • Foraging Models • Economic Decision Making <i>Module Readings:</i> <i>Fiorillo, Tobler and Schultz, 2003</i> <i>Wikenheiser et al. 2013</i> <i>Ballesta et al. 2020</i> Coding Assignment #4 Due
W Mar 15	Module V: Reward and Reinforcement
F Mar 17	Module V: Reward and Reinforcement
M Mar 20	Module V: Reward and Reinforcement Quiz 5 (In Class)
W Mar 22	Module V: Reward and Reinforcement
F Mar 24	Module V: Reward and Reinforcement
M Mar 27	Module VI: Analytical Tools <ul style="list-style-type: none"> • Regression, GLMs, and Regularization • Graph Theory • Machine Learning • Cross Validation • Bootstrapping

	<i>Coding Assignment #5 Due</i>
W Mar 29	Module VI: Analytical Tools
F Mar 31	Module VI: Analytical Tools
M Apr 3	Module VI: Analytical Tools <i>Quiz 6 (In Class)</i>
W Apr 5	Module VI: Analytical Tools
F Apr 7	UNIVERSITY CLOSED
M Apr 10	UNIVERSITY CLOSED Easter Monday
W Apr 12	Course Wrap Up Discussion <i>Coding Assignment #6 Due</i> <i>Last day to withdraw with permission from Winter Term half courses</i>
Apr 15-26	Fall Final Exam Period

Extra Research Participation Course Credit is Not Offered for this Course

Absence From Test/Exam

There are no exams in this course. Quizzes are conducted in class and we drop the lowest quiz grade so you can miss one without penalty.

Travel During Exams

Consistent with University regulations, students are expected to be available to write scheduled exams at any time during the official December and April examination periods. Requests to write a make-up exam because of conflicting travel plans (e.g., flight bookings) will NOT be considered by the department. Students are advised to wait until the final examination schedule is posted before making any travel arrangements. Students with an exceptional extenuating circumstance (e.g., a family emergency) should contact the Department of Psychology psyugrd@ucalgary.ca

Reappraisal of Graded Term Work <http://www.ucalgary.ca/pubs/calendar/current/i-2.html>

Reappraisal of Final Grade <http://www.ucalgary.ca/pubs/calendar/current/i-3.html>

Academic Accommodations

Students seeking an accommodation based on disability or medical concerns should contact Student Accessibility Services; SAS will process the request and issue letters of accommodation to instructors. For additional information on support services and accommodations for students with disabilities, visit www.ucalgary.ca/access/. Students who require an accommodation in relation to their coursework based on a protected ground other than disability should communicate this need in writing to their Instructor. The full policy on Student Accommodations is available at [University of Calgary : B.6.1 Accommodation of Students with Disabilities or Medical Conditions \(ucalgary.ca\)](#)

Academic Misconduct

For information on academic misconduct and its consequences, please see the University of Calgary Calendar at <http://www.ucalgary.ca/pubs/calendar/current/k.html>

Instructor Intellectual Property

Course materials created by professor(s) (including course outlines, presentations and posted notes, labs, case studies, assignments, and exams) remain the intellectual property of the professor(s). These materials may NOT be reproduced, redistributed, or copied without the explicit consent of the

professor. The posting of course materials to third party websites such as note-sharing or code-sharing sites without permission is prohibited. Sharing of extracts of these course materials with other students enrolled in the course at the same time may be allowed under fair dealing.

Copyright Legislation

All students are required to read the University of Calgary policy on Acceptable Use of Material Protected by Copyright (<https://www.ucalgary.ca/legal-services/university-policies-procedures/acceptable-use-material-protected-copyright-policy>) and requirements of the copyright act (<https://laws-lois.justice.gc.ca/eng/acts/C-42/index.html>) to ensure they are aware of the consequences of unauthorized sharing of course materials (including instructor notes, electronic versions of textbooks etc.). Students who use material protected by copyright in violation of this policy may be disciplined under the Non-Academic Misconduct Policy.

Freedom of Information and Protection of Privacy

Student information will be collected in accordance with typical (or usual) classroom practice. Students' assignments will be accessible only by the authorized course faculty. Private information related to the individual student is treated with the utmost regard by the faculty at the University of Calgary

Student Support and Resources

<https://www.ucalgary.ca/registrar/registration/course-outlines>

Important Dates

The last day to drop this course with no "W" notation and **still receive a tuition fee refund** is **Thursday, January 19, 2023**. Last day add/swap a course is **Friday, January 20, 2023**. The last day to withdraw from this course is **Wednesday, April 12, 2023** [University of Calgary : Academic Schedule \(ucalgary.ca\)](https://www.ucalgary.ca/academic-schedule)