

CGSC 5103-F Formal Methods

Prerequisites: Permission of the department. Precludes additional credit for CGSC 5102.

Lectures: 8:35 a.m. to 9:55 a.m. on Tuesdays and Thursdays (**in person and online**)

- **Location:** Nideyinàn 279 (formerly the University Centre)
- **Zoom Meeting ID:** 981 8551 2856 **Passcode:** 5103
- **Zoom URL:** <https://carleton-ca.zoom.us/j/98185512856?pwd=cGZKW9hNE5nREhGUzN6MHhjaER5Zz09>

Instructor: Mary Kelly, Ph.D. (she/her; mary.kelly4@carleton.ca)

- **Office:** 2213 Dunton Tower; <https://carleton-ca.zoom.us/my/animus.lab>
- **Office Hours:** By appointment (**in person or online**)

- I. **Course description:** The class introduces students to various formal methods relevant to cognitive science, including formal logic, theory of computation, probability theory, decision theory, information theory, linear algebra, and hyperdimensional computing.

By the end, you will be able to:

- Construct formal languages
- Create logical expressions
- Explain probability theory
- Describe choices using decision theory
- Analyze behaviour with information theory
- Explain cognition in terms of vector spaces
- Apply formal methods to cognitive science

- II. **Brightspace:** All materials, including readings, slides, recordings, quizzes, rubrics, and commentaries, are posted here: <https://brightspace.carleton.ca/d2l/home/207747>
- III. **Textbook:** No textbook is required for the course. Readings, slides, and recorded lectures will be provided through the course website.
- IV. **Software:** All students taking are required to either own or have daily access to a computer which can access Brightspace and Zoom and a word processor.
- V. **Seminars:** In the interest of accommodating disabled, sick, immunocompromised, or COVID-cautious students, all seminars may be attended either online or in person.
- VI. **Email:** I try to respond to e-mails within 48 hours (excluding weekends and holidays).

VII. **Evaluation:** The coursework consists of attendance and participation, exercises based on readings, commentaries on readings, a term paper and a presentation on the term paper. All course materials will be available through Brightspace.

<i>Evaluation</i>	<i>Value</i>	<i>Due Date</i>
Participation	10%	Every seminar, in person or online
Exercises	15% (1% each)	For some readings, due by end of day
Commentaries	30% (5% each)	Six commentaries, due by end of class (10am)
Presentation	15%	Nov. 23, 28, 30, Dec. 5, or 7
Term Paper	30%	Dec. 22nd

VIII. **Participation:** To earn full marks for participation, you need to

- (a) Attend all classes, either in person or online, except when unable to do so due to life circumstances communicated to me;
- (b) Be prepared for class (as evidenced by having done the readings);
- (c) Participate in class discussions: ask thoughtful questions, find ways to link issues from one topic to another, and/or come up with new ways to examine issues;

IX. **Exercises:** Some readings will have exercises or quizzes to practice your understanding of the material. These quizzes or exercises will be due by **end of day** on the day of the seminar of the assigned reading.

X. **Commentaries:** You are required to write six short (450~550 word) commentaries on weekly readings. These commentaries are due by the end of the class of the reading that you are commenting on. Commentaries should reflect both understanding and insight into the readings and should include a discussion question, or “thought” question as a launch point for class discussion. Guidelines for the commentaries can be found on Brightspace. You **cannot** do a commentary on the textbooks *All The Math You Missed* or *Introduction to Logic* or the *Introduction to Fuzzy Logic*. **Late commentaries will not be accepted.**

XI. **Term Paper:** A research proposal that applies some of the formal methods discussed in this course (or another formal method with my permission) to a topic in cognitive science of your choice. Guidelines for the term paper will be available on Brightspace. The paper is due on the last day exams can be submitted for grading, as such, **no extensions will be given.**

XII. Term Paper Presentation: You are required to do a presentation on the topic of your term paper. The presentation will be **20 minutes**, with **10 minutes** for questions.

XIII. Course Schedule: *This schedule is to be regarded as tentative.*

Date	Topic	Readings
Sept. 7	Introduction	course syllabus
Sept. 12	Mind as Computation	Newell (1980) Physical Symbol Systems
Sept. 14	Formal Language	Jäger & Rogers (2012) Formal language theory
Sept. 19	Functionalism	Lycan (1991) Homuncular Functionalism Meets PDP
Sept. 21	Logic	Genesereth & Kao (2016) <i>Introduction to Logic</i> , ch. 1 http://intrologic.stanford.edu/public/chapters.php
Sept. 26	Propositional Logic	Genesereth & Kao (2016) <i>Introduction to Logic</i> , ch. 2 Evans, Barston, Pollard (1989) On the conflict between logic and belief in syllogistic reasoning
Sept. 28	Predicate Logic	Genesereth & Kao (2016) <i>Introduction to Logic</i> , ch. 7
Oct. 3	Fuzzy Logic	Dernoncourt (2013) Introduction to Fuzzy Logic
Oct. 5	Linear Algebra	Garrity (2001) <i>All the Math You Missed</i> , ch. 1
Oct. 10	Neural Engineering	Eliasmith (2015) <i>How to build a brain</i>
Oct. 12	Vector Symbolic	Gayler (2003) Vector Symbolic Architectures answer Jackendoff's challenges for cognitive neuroscience
Oct. 17	Memory	Jamieson & Mewhort (2009) Applying an Exemplar Model to the Artificial-Grammar Task
Oct. 19	Vector Logic	Widdows & Cohen (2015) Reasoning with vectors
Oct. 23-27	Fall break	No classes
Oct. 31	Halloween	Class cancelled
Nov. 2	Probability	Tversky & Kahneman (1983) Extensional versus intuitive reasoning: The Conjunction Fallacy in Probability Judgement
Nov. 7	Information Theory	Sayood (2018) Information theory and cognition
Nov. 9	Decision Theory	Gigerenzer (2006) Bounded and Rational
Nov. 14	Decision Theory	Matheson (2006) Bounded Rationality and the Enlightenment Picture of Cognitive Virtue
Nov. 15		Last day for academic withdrawal

Nov. 16	Learning	Sutton & Barto (2018) <i>Reinforcement Learning</i>
Nov. 21	Learning	Sutton & Barto (2018) <i>Reinforcement Learning</i>
Nov. 23	T.B.A.	
Nov. 28	Presentations	
Nov. 30	Presentations	
Dec. 5	Presentations	
Dec. 7	Presentations	
Dec. 10-22	Exam Period	Term paper due on Dec. 22nd

XIV. Copyright: Classroom teaching and learning activities, including lectures, discussions, presentations, etc., by both instructors and students, are copyright protected and remain the intellectual property of their respective author(s). All course materials, including presentations, outlines, and other materials, are also protected by copyright and remain the intellectual property of their respective author(s).

Students registered in the course may take notes and make copies of course materials for their own educational use only. Students are not permitted to reproduce or distribute lecture notes and course materials publicly for commercial or non-commercial purposes without express written consent from the copyright holder(s).

XV. 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 at equity@carleton.ca.

In accordance with the Carleton University Undergraduate Calendar (p 34), the letter grades assigned in this course will have the following percentage equivalents:

A+ = 90-100	B+ = 77-79	C+ = 67-69	D+ = 57-59
A = 85-89	B = 73-76	C = 63-66	D = 53-56
A - = 80-84	B - = 70-72	C - = 60-62	D - = 50-52
F = Below 50			

Grades entered by Registrar:

WDN = Withdrawn from the course

DEF = Deferred

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, 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, including the unauthorized use of generative AI tools (e.g., ChatGPT);
- 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.

Plagiarism is a serious offence that cannot be resolved directly by the course’s instructor. The Associate Dean of the Faculty conducts a rigorous investigation, including an interview with the student, when an instructor suspects a piece of work has been plagiarized. Penalties are not trivial. They can include a final grade of “F” for the course.

Statement on Student Mental Health

As a University student you may experience a range of mental health challenges that significantly impact your academic success and overall well-being. If you need help, please speak to someone. There are numerous resources available both on- and off-campus to support you. Here is a list that may be helpful:

Emergency Resources (on and off campus): <https://carleton.ca/health/emergencies-and-crisis/emergency-numbers/>

Carleton Resources:

- Mental Health and Wellbeing: <https://carleton.ca/wellness/>
- Health & Counselling Services: <https://carleton.ca/health/>
- Paul Menton Centre: <https://carleton.ca/pmc/>
- Academic Advising Centre (AAC): <https://carleton.ca/academicadvising/>
- Centre for Student Academic Support (CSAS): <https://carleton.ca/csas/>
- Equity & Inclusivity Communities: <https://carleton.ca/equity/>

Off Campus Resources:

- Distress Centre of Ottawa and Region: (613) 238-3311 or TEXT: 343-306-5550, <https://www.dcottawa.on.ca/>
- Mental Health Crisis Service: (613) 722-6914, 1-866-996-0991, <http://www.crisisline.ca/>
- Empower Me: 1-844-741-6389, <https://students.carleton.ca/services/empower-me-counselling-services/>
- Good2Talk: 1-866-925-5454, <https://good2talk.ca/>
- The Walk-In Counselling Clinic: <https://walkincounselling.com>

Requests for Academic Accommodations

ACADEMIC ACCOMMODATION

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

Pregnancy obligation: write to me 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 accommodation regarding a formally-scheduled final exam, you must complete the Pregnancy Accommodation Form ([click here](#)).

Religious obligation: write to me 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 [click here](#).

Academic Accommodations for Students with Disabilities: The Paul Menton Centre for Students with Disabilities (PMC) provides services to students with Learning Disabilities (LD), psychiatric/mental health disabilities, Attention Deficit Hyperactivity Disorder (ADHD), Autism Spectrum Disorders (ASD), chronic medical conditions, and impairments in mobility, hearing, and vision. If you have a disability requiring academic accommodations in this course, please contact PMC at 613-520-6608 or pmc@carleton.ca for a formal evaluation. If you are already registered with the PMC, please request your accommodations for this course through

the [Ventus Student Portal](#) at the beginning of the term, and 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. For final exams, the deadlines to request accommodations are published in the [University Academic Calendars](#). After requesting accommodation from PMC, meet with me to ensure accommodation arrangements are made. Please consult the PMC website for the deadline to request accommodations for the formally-scheduled exam (if applicable).

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: <https://carleton.ca/equity/sexual-assault-support-services>

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 will be provided to students who compete or perform at the national or international level. Write to me 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. <https://carleton.ca/senate/wp-content/uploads/Accommodation-for-Student-Activities-1.pdf>

Important Information

- Students must always retain a hard copy of all work that is submitted.
- Standing in a course is determined by the course instructor subject to the approval of the Faculty Dean. This means that grades submitted by the instructor may be subject to revision. No grades are final until they have been approved by the Dean
- For us to respond to your emails, we need to see your full name, CU ID, and the email must be written from your valid CARLETON address. Therefore, in order to respond to your inquiries, please send all email from your Carleton CMail account. If you do not have or have yet to activate this account, you may wish to do so by visiting <http://carleton.ca/ccs/students/>
- November 23, 2023: Last day for academic withdrawal from full fall and late fall classes
- March 15, 2024: Last day for academic withdrawal from full winter, late winter and fall/winter courses.

For a list of dates and deadlines, including holidays and exam dates, please visit:

<https://calendar.carleton.ca/academicyear/>