Faculty of Applied Science and Engineering - Edward S. Rogers Sr. Dept. of Electrical & Computer Engin.

ECE368H1 S

Probabilistic Reasoning

Winter 2025 Syllabus

Course Meetings

ECE421H1 S

Section	Day & Time	Delivery Mode & Location
LEC0101	Tuesday, 10:00 AM - 12:00 PM Friday, 11:00 AM - 12:00 PM	In Person: GB 244 In Person: GB 248
LEC0102	Monday, 1:00 PM - 3:00 PM Tuesday, 5:00 PM - 6:00 PM	In Person: GB 244 In Person: GB 244
TUT0101	Thursday, 11:00 AM - 12:00 PM	In Person: GB 303
TUT0102	Friday, 9:00 AM - 10:00 AM	In Person: WB 219
TUT0103	Monday, 11:00 AM - 12:00 PM	In Person: GB 303
TUT0104	Friday, 2:00 PM - 3:00 PM	In Person: BA 1230

Refer to ACORN for the most up-to-date information about the location of the course meetings.

Course Contacts

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Course Overview

Calendar Description

This course will focus on different classes of probabilistic models and how, based on those models, one deduces actionable information from data. The course will start by reviewing basic concepts of probability including random variables and first and second-order statistics. Building from this foundation the course will then cover probabilistic models including vectors (e.g., multivariate Gaussian), temporal (e.g., stationarity and hidden Markov models), and graphical (e.g., factor graphs). On the inference side topics such as hypothesis testing, marginalization,

estimation, and message passing will be covered. Applications of these tools cover a vast range of data processing domains including machine learning, communications, search, recommendation systems, finance, robotics and navigation.

Course Learning Outcomes

- Understand joint distributions, marginal distributions, conditionals, and Bayes' rule.
- Understand vector-based probabilistic models, e.g., jointly Gaussian vectors and linear inference.
- Understand graphical models, message-passing inference, and MAP rule.
- Understand hidden Markov models (HMMs), the forward-backward algorithm and the Viterbi algorithm.
- Be able to model decision problems in engineering as probabilistic reasoning.
- Be able to identify which type of probabilistic model (vector, graphical, temporal) to use for different engineering applications.

Prerequisite: ECE286H1/ECE302H1
Corequisite: None
Exclusion: CSC412H
Recommended Preparation: None
Credit Value: 0.5

Course Materials

Textbooks:

- Alberto Leon-Garcia, *Introduction to Probability and Probabilistic Reasoning*, draft 2024
- Kevin P. Murphy, *Probabilistic Machine Learning: An Introduction*, MIT Press, 2022
- Christopher Bishop, *Machine Learning and Pattern Recognition*, Springer, 2006
- Alberto Leon-Garcia, *Probability, Statistics, and Random Processes for Electrical Engineers*, 3rd Edition, Pearson, 2008

Marking Scheme

Assessment	Percent	Details	Due Date
Homework	10%		Weekly
Computer Labs	15%		TBD
Midterm Exam	35%		2025-03-06
Final Exam	40%		Final Exam Period

- Homework problem sets will be assigned each week. They should be submitted on Quercus, and they will be marked for effort instead of correctness.
- There are three take-home computer labs. They can be done in teams of two.

Late Assessment Submissions Policy

- 5% per day of lateness.

Course Schedule

Week of Jan 6	Probability Review		
Jan 13	Sample Mean & Convergence, Maximum Likelihood (ML) Estimation, Frequentist vs. Bayesian Views	Tut 1	
Jan 20	Maximum a Posteriori (MAP) Estimation, Least Mean Square (LMS) Estimation, Conjugate Priors	Tut 2	
Jan 27	Binary Hypothesis Testing, Bayesian Hypothesis Testing	Tut 3	
Feb 3	Gaussian Random Vectors, Linear and Quadratic Discriminant Analysis	Tut 4	
Feb 10	Bayesian Inference in Gaussian Systems	Tut 5	
Feb 17	**Reading Week**		
Feb 24	Linear Regression, Bayesian Linear Regression	Tut 6	
Mar 3	Markov Chain, Transient State Probabilities, Stationary Distribution		**Midterm Exam** 6 - 8 pm, Mar 6
Mar 10	Bayesian Network, Markov Random Field	Tut 7	
Mar 17	Inference on Markov Models, Message-Passing Algorithm	Tut 8	
Mar 24	Hidden Markov Model, Viterbi Algorithm	Tut 9	
Mar 31	Factor Graph, Inference on Tree Graph Models, Expectation-Maximization Algorithm	Tut 10	
Apr 7	Last day of class: Apr 7		

Policies & Statements

University Land Acknowledgement

I wish to acknowledge this land on which the University of Toronto operates. For thousands of years, it has been the traditional land of the Huron-Wendat, the Seneca, and the Mississaugas of the Credit. Today, this meeting place is still the home to many Indigenous people from across Turtle Island and we are grateful to have the opportunity to work on this land.

Learn more about Canada's relationship with Indigenous Peoples here.

Indigenous Students' Supports

If you are an Indigenous engineering student, you are invited to join a private Discord channel to meet other Indigenous students, professors, and staff, chat about scholarships, awards, work opportunities, Indigenous-related events, and receive mentorship. Email Professor Bazylak or Darlee Gerrard if you are interested.

Indigenous students at U of T are also invited to visit First Nations House's (FNH) Indigenous Student Services for culturally relevant programs and services. If you want more information on how to apply for Indigenous specific funding opportunities, cultural programs, traditional medicines, academic support, monthly social events or receive the weekly newsletter, go to the FNH website, email or follow FNH on social media: Facebook, Instagram, or TikTok. A full event calendar is on the CLNX platform. Check CLNX often to see what new events are added!

Wellness and Mental Health Support

As a university student, you may experience a range of health and/or mental health challenges that could result in significant barriers to achieving your personal and academic goals. The University of Toronto and the Faculty of Applied Science & Engineering offer a wide range of free and confidential services that could assist you during these times.

As a U of T Engineering student, you have a Departmental Undergraduate Advisor or a Departmental Graduate Administrator who can support you by advising on personal matters that impact your academics. Other resources that you may find helpful are listed on the U of T Engineering Mental Health & Wellness webpage, and a small selection are also included here:

- U of T Engineering's Mental Health Programs Officer
- Accessibility Services & the On-Location Advisor
- Health & Wellness and the On-Location Health & Wellness Engineering Counsellor
- Graduate Engineering Council of Students' Mental Wellness Commission
- SKULE Mental Wellness
- U of T Engineering's Learning Strategist and Academic Success
- Registrar's Office and Scholarships & Financial Aid Office & Advisor

We encourage you to access these resources as soon as you feel you need support; no issue is too small.

If you find yourself feeling distressed and in need of more immediate support, consider reaching out to the counsellors at U of T Telus Health Student Support or visiting U of T Engineering's Urgent Support – Talk to Someone Right Now.

Accommodations

The University of Toronto supports accommodations for students with diverse learning needs, which may be associated with mental health conditions, learning disabilities, autism spectrum,

ADHD, mobility impairments, functional/fine motor impairments, concussion or head injury, visual impairments, chronic health conditions, addictions, D/deaf, deafened or hard of hearing, communication disorders and/or temporary disabilities, such as fractures and severe sprains, or recovery from an operation.

If you have a learning need requiring an accommodation the University of Toronto recommends that students register with Accessibility Services as soon as possible.

We know that many students may be hesitant to reach out to Accessibility Services for accommodations. The purpose of academic accommodations is to support students in accessing their academics by helping to remove unfair disadvantages. We can assess your situation, develop an accommodation plan with you, and support you in requesting accommodation for your course work. The process of accommodation is private; we will not share details of your needs or condition with any instructor.

If you feel hesitant to register with us, we encourage you to reach out for further information and resources on how we can support. It may feel difficult to ask for help, but it can make all the difference during your time here.

Phone: 416-978-8060
Email: accessibility.services@utoronto.ca

Equity, Diversity and Inclusion

Looking for community? Feeling isolated? Not being understood or heard?

You are not alone. You can talk to anyone in the Faculty that you feel comfortable approaching, anytime – professors, instructors, teaching assistants, first-year or upper years academic advisors, student leaders or the Assistant Dean of Diversity, Inclusion and Professionalism.

You belong here. In this class, the participation and perspectives of everyone is invited and encouraged. The broad range of identities and the intersections of those identities are valued and create an inclusive team environment that will help you achieve academic success. You can read the evidence for this approach here.

You have rights. The University Code of Student Conduct and the Ontario Human Rights Code protect you against all forms of harassment or discrimination, including but not limited to acts of racism, sexism, Islamophobia, antisemitism, homophobia, transphobia, ableism, classism and ageism. Engineering denounces unprofessionalism or intolerance in language, actions or interactions, in person or online, on- or off-campus. Engineering takes these concerns extremely seriously and you can confidentially disclose directly to the Assistant Dean for help here.

Resource List:

- Engineering Equity, Diversity & Inclusion Groups, Initiatives & Student Resources
- Engineering Positive Space Resources

- Request a religious-based accommodation [here](#)
- Email Marisa Sterling, P.Eng, the Assistant Dean, Diversity, Inclusion & Professionalism [here](#)
- Make a confidential disclosure of harassment, discrimination or unprofessionalism [here](#) or email engineering@utoronto.ca or call 416.946.3986
- Email the Engineering Society Equity & Inclusivity Director [here](#)
- [U of T Equity Offices & First Nations House Resources](#)

Plagiarism Detection Tool

Normally, students will be required to submit their course essays to the University's plagiarism detection tool for a review of textual similarity and detection of possible plagiarism. In doing so, students will allow their essays to be included as source documents in the tool's reference database, where they will be used solely for the purpose of detecting plagiarism. The terms that apply to the University's use of this tool are described on the Centre for Teaching Support & Innovation web site (https://uoft.me/pdt-faq).

Academic Integrity

All students, faculty and staff are expected to follow the University's guidelines and policies on academic integrity. For students, this means following the standards of academic honesty when writing assignments, collaborating with fellow students, and writing tests and exams. Ensure that the work you submit for grading represents your own honest efforts. Plagiarism—representing someone else's work as your own or submitting work that you have previously submitted for marks in another class or program—is a serious offence that can result in sanctions. Speak to me or your TA for advice on anything that you find unclear. To learn more about how to cite and use source material appropriately and for other writing support, see the [U of T writing support website](#). Consult the [Code of Behaviour on Academic Matters](#) for a complete outline of the University's policy and expectations. For more information, please see the [U of T Academic Integrity website](#).