

ECE 6501 Reinforcement Learning and Its Application to Large Language Models

Fall 2025

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Prerequisites

- Proficiency in Python. All coding assignments will be in Python.
- Probability, Linear Algebra and Calculus.
- Basic understanding of machine learning and convex optimization is preferred.

References

A collection of notes, relevant papers and materials will be prepared and distributed. Textbooks recommended for further reading are:

- *Reinforcement Learning: An Introduction*, Sutton and Barto, 2nd Edition, The MIT Press, 2018.
<http://incompleteideas.net/book/the-book.html>
- *Reinforcement Learning: An Overview*, Kevin Murphy, <https://arxiv.org/abs/2412.05265>
- *Bandit Algorithms*, Tor Lattimore and Csaba Szepesvari, Cambridge University Press, 2020.
<https://tor-lattimore.com/downloads/book/book.pdf>

Course Outline

1. Basics of Markov Decision Processes (MDPs)
2. Dynamic Programming
3. Monte Carlo Methods
4. Temporal Difference Learning
5. Value Function Approximation
6. Policy Gradient Methods
7. Actor-Critic Methods
8. Reinforcement Learning from Human Feedback (RLHF)
9. Reinforcement Learning for Reasoning

Course Project

The final project is a focused, reproducible study that answers a clear RL question. You may choose one of the two tracks: (1) Core RL track: algorithms/analysis on classic RL tasks. (2) LLM post-training track: RLHF or preference optimization on small open models. You will complete it *in groups of two*.

Tentative timeline:

- **Week 8: Proposal:** State the topics that you plan to work on. Describe why they are important or interesting, and provide some appropriate references. (≤ 2 pages)
- **Week 10: Progress report:** Refers back to your project proposal: what has been accomplished, what goals should be revised, etc.
- **Weeks 14-15: Presentation:** Deliver a 25-minute Presentation + Q&A in class. Peer-evaluated.
- **12/9: Final project report.**

Grading

- Homework assignments (45%), In-class mid-term exam (20%), Final project (35%).
- Homework assignment may contain written and programming problems. All programming assignments will be in Python. You must submit source code with every programming assignment.
- All homework will be submitted to Canvas before the deadline. Late homework will not be accepted.
- Final project grade consists of three parts: Proposal (5%), Progress report (2%), Oral Presentation (14%), Final Report (14%).
- The final grade will be assigned according to the table below:

Grade	A+	A	A-	B+	B	B-	C+	C	C-	D+	D	D-	F
Score	100	95	90	87	83	80	77	73	70	67	63	60	Below 60

AI Use & Academic Integrity Policy

Use of generative AI tools (e.g., ChatGPT/Claude, GitHub Copilot) is permitted for conceptual explanations, debugging hints, light writing polish. You must author and understand all core algorithms and analyses yourself; submitting AI-generated code or solutions as your own, or using AI to implement substantial assignment solutions, is prohibited. Submissions must remain reproducible and you may be asked to complete an oral walkthrough to verify authorship. Prohibited AI use may result in grade penalties or an academic integrity referral under the university policy.

Students with disabilities or learning needs

It is my goal to create a learning experience that is as accessible as possible. If you anticipate any issues related to the format, materials, or requirements of this course, please meet with me outside of class so we can explore potential options. Students with disabilities may also wish to work with the Student Disability Access Center (SDAC) to discuss a range of options to removing barriers in this course, including official accommodations. We are fortunate to have an SDAC advisor, Courtney MacMasters, physically located in Engineering. You may email her at cmacmasters@virginia.edu to schedule an appointment. For general questions please visit the SDAC website: sdac.studenthealth.virginia.edu. If you have already been approved for accommodations through SDAC, please send me your accommodation letter and meet with me so we can develop an implementation plan together.

Religious accommodations

It is the University's long-standing policy and practice to reasonably accommodate students so that they do not experience an adverse academic consequence when sincerely held religious beliefs or observances conflict with academic requirements.

Students who wish to request academic accommodation for a religious observance should submit their request to me by email as far in advance as possible. Students who have questions or concerns about academic accommodations for religious observance or religious beliefs may contact the University's Office for Equal Opportunity and Civil Rights (EOCR) at UVAEOCR@virginia.edu or 434-924-3200.

Harassment, Discrimination, and Interpersonal Violence

The University of Virginia is dedicated to providing a safe and equitable learning environment for all students. If you or someone you know has been affected by power-based personal violence, more information can be found on the UVA Sexual Violence website that describes reporting options and resources available - www.virginia.edu/sexualviolence.

The same resources and options for individuals who experience sexual misconduct are available for discrimination, harassment, and retaliation. UVA prohibits discrimination and harassment based on age, color, disability, family medical or genetic information, gender identity or expression, marital status, military status, national or ethnic origin, political affiliation, pregnancy (including childbirth and related conditions), race, religion, sex, sexual orientation, or veteran status. UVA policy also prohibits retaliation for reporting such behavior.

If you witness or are aware of someone who has experienced prohibited conduct, you are encouraged to submit a report to Just Report It (justreportit.virginia.edu) or contact EOCR, the office of Equal Opportunity and Civil Rights.

If you would prefer to disclose such conduct to a confidential resource where what you share is not reported to the University, you can turn to Counseling & Psychological Services (“CAPS”) and Women’s Center Counseling Staff and Confidential Advocates (for students of all genders).

As your professor and as a person, know that I care about you and your well-being and stand ready to provide support and resources as I can. As a faculty member, I am a responsible employee, which means that I am required by University policy and by federal law to report certain kinds of conduct that you report to me to the University’s Title IX Coordinator. The Title IX Coordinator’s job is to ensure that the reporting student receives the resources and support that they need, while also determining whether further action is necessary to ensure survivor safety and the safety of the University community.

Support for your career development

Engaging in your career development is an important part of your student experience. For example, presenting at a research conference, attending an interview for a job or internship, or participating in an extern/shadowing experience are not only necessary steps on your path but are also invaluable lessons in and of themselves. I wish to encourage and support you in activities related to your career development. To that end, please notify me by email as far in advance as possible to arrange for appropriate accommodations.

Student support team

You have many resources available to you when you experience academic or personal stresses. In addition to your professor, the School of Engineering and Applied Science has staff members located in Thornton Hall who you can contact to help manage academic or personal challenges. Please do not wait until the end of the semester to ask for help!

- Learning
 - Lisa Lampe, Assistant Dean for Undergraduate Affairs
 - Georgina Nembhard, Director of Student Success
 - Courtney MacMasters, Accessibility Specialist
 - Free tutoring is available for most classes.
- Health and Wellbeing
 - Kelly Garrett, Assistant Dean of Students, Student Safety and Support
 - Elizabeth Ramirez-Weaver, CAPS counselor*
 - Katie Fowler, CAPS counselor*

*You may schedule time with the CAPS counselors through Student Health (<https://www.studenthealth.virginia.edu/getting-started-caps>). When scheduling, be sure to specify that you are an Engineering student. You are also urged to use TimelyCare for either scheduled or on-demand 24/7 mental health care.

Community and Identity

The Center for Connection (The Connect) is a dedicated student space within UVA Engineering that fosters academic success and personal growth. Through its programs and initiatives, The Connect helps students strengthen their engineering identity while providing resources to help them thrive during their studies and beyond. Our work centers on three key areas: student belonging and development, academic support, and community programming grounded in intentional, data-driven strategies.

The Connect features an open study area, a flexible event space, and on-site staff who provide direct support and advising to students. It is part of the Office of Community, Opportunity, and Engagement.