ECE 425/525: Introduction to Deep Learning: An Engineering Perspective

[DRAFT- Fall 2025] Course Syllabus

Final syllabus will be posted closer to the start of Fall'25 semester

---

Instructor: Dr. Jyotikrishna Dass
Contact Information: jdass@arizona.edu
Phone: xxx
Office: xxx
Office Hours: TBD. Appointments can be made outside of normal office hours by contacting the instructor to schedule a time that is mutually convenient.

Deep Learning is revolutionizing artificial intelligence tasks such as language understanding, speech and image recognition, machine translation, autonomous driving, etc. This transformative impact of deep learning, which tries to model the neural networks in brains, was recognized with Nobel Prizes in 2024 and Turing Award in 2018. This course provides a comprehensive introduction to deep neural networks with a focus on underlying principles and engineering applications. Students will explore the fundamental concepts, optimization techniques, and software tools of deep learning starting from the basics of perceptron and progressing to advanced neural network models with convolutions and attentions. The course emphasizes an engineering perspective, hands-on learning, and integrating theory with practice. The course also introduces latest methods to enhance the efficiency of training and inference in deep learning models and systems. Designed for students from diverse engineering disciplines, this course aims to equip them with the skills and knowledge to effectively apply deep learning in their respective fields.

Learning Outcomes

This course aims to develop a comprehensive understanding of deep learning principles and their applications, enabling students to:

- Define the underlying principles of neural networks and deep learning.
- Analyze the mechanisms, applications, and limitations of techniques commonly used in training and inference of deep neural networks.
- Develop the skills to design, implement, and evaluate deep learning models.
- Gain hands-on programming experience with deep learning frameworks and software tools in PyTorch.
- For graduate students (ECE 525): Apply deep learning techniques to solve engineering problems in computer vision, natural language processing, and broader engineering disciplines like mechanical engineering or biomedical engineering.

Course Objectives

Welcome to the exhilarating world of Deep Learning from an engineering perspective! In this course, we will embark on an exciting journey to uncover the engineering principles behind the design and training of intelligent systems. Engineering is all about applying scientific and mathematical principles to solve real-world problems, and in this course, we'll dive into the fundamentals of neural networks and explore the advanced architectures that drive today's cutting-edge AI applications. Together, we'll learn how to build, optimize, and deploy these systems, ensuring they are efficient, scalable, and impactful.

- **Fundamentals and Implementation:** Students will understand the foundational concepts of deep learning, including neural networks, loss functions, backpropagation, and optimization algorithms, and will implement these using frameworks like PyTorch.
- **Modern Architectures and Efficient Techniques**: Students will explore and apply modern neural network architectures such as CNNs, RNNs, and Transformers, as well as efficient deep learning techniques like pruning, sparsity, quantization, and distributed/federated learning.
- **Applications and Computational Performance:** Students will explore applications of deep learning to real-world problems in various engineering domains, understand computational performance and hardware systems, and engage in hands-on programming assignments and case study/project to demonstrate their skills.
- **Advanced Machine Learning:** Students will get acquainted with advanced machine learning techniques such as Graph Neural Networks, Deep Reinforcement Learning, Contrastive Learning, etc.
- **Ethics and Responsible AI:** Students will examine the ethical considerations and societal impacts of advanced AI technologies, ensuring the models are fair, secure, interpretable, and responsible.

Course Prerequisites

Advanced standing is required. We expect students to have the necessary object-oriented programming experience (preferably Python; we will be using Numpy and PyTorch in this class), and be familiar with linear algebra, basic calculus (differentiation, chain rule), and probability. Understanding of data science, and machine learning concepts is beneficial but not required. Prerequisites: ECE 201, ECE 310, MATH 125 or MATH 122b, or equivalent experiences.

Textbook

Aston Zhang, Zachary C. Lipton, Mu Li, and Alexander J. Smola. *Dive into deep learning*. Cambridge University Press, 2023, https://d2l.ai.

References

1. Christopher M. Bishop and Hugh Bishop, *Deep Learning: Foundations and Concepts*, 2024, ISBN: 978-3-031-45467-7, https://www.bishopbook.com/.
2. Yiran Chen, Hai (Helen) Li, and Huanrui Yang, *Computer Engineering Machine Learning and Neural Networks*, first edition, Springer, 2025. ISBN TBD.
3. Simon J.D. Prince, *Understanding deep learning*, MIT press, 2023, https://udlbook.github.io/udlbook/.
4. Python, Jupyter notebook, and PyTorch documentations at https://docs.python.org/ https://jupyter.org/, and https://pytorch.org/docs/.

Additional supplemental materials will be referenced and made available to students through D2L.

Course Schedule [Subject to Change]

The following table outlines the topics that will be covered in this course. Engineering applications will be integrated throughout all modules, and programming assignments will be introduced to apply theory to practice. Specific dates for each topic will be posted on D2L.
In each module, graduate students will be guided to learn and practice advanced problems, theoretical derivations, and project-oriented programming skills.

Module	Topic	Textbook Chapter
1	Introduction to Deep Learning Preliminaries	Chapters 1-2
2	Linear Neural Networks Loss Functions and Softmax	Chapters 3-4
3	Multilayer Perceptron Backpropagation	Chapter 5
4	Optimization Algorithms	Chapter 12
5	Convolutional Neural Networks	Chapters 7-8
6	Recurrent Neural Networks	Chapters 9-10
7	Attentions and Transformers	Chapter 11

8	Generative AI: Large Language Models and Image Generation	Additional resources https://microsoft.github.io/generative-ai-for-beginners
9	Computational Performance Hardware Systems	Chapter 13
10	Efficient Deep Learning Techniques: Pruning, Sparsity, Quantization, Knowledge Distillation, Transfer Learning, Parameter Efficient Fine Tuning, Distributed Machine Learning	Additional resources
11	Selected Advanced Topics **(optional)**: Graph Neural Networks, Contrastive Learning, Automated Machine Learning, Deep Reinforcement Learning	Additional resources
12	Selected Applied topics in AI + **X**, where **X** = {"*Security and Privacy*", "Fairness, *Interpretability, and Explainability*", "*Hardware Accelerator and Edge Computing*", "*Science*", "*Engineering*"}	Additional resources Guest lectures, survey papers, etc.
13	Applied Deep Learning (Case study/Project)	

Course Assignments, Projects, and Exams [Subject to Change]

Undergraduate section (ECE 425): There will be *five* regular homework assignments comprising both written and programming components related to the topics covered in class, along with *one* written midterm exam and *one* case study (or project) on applications of AI/deep learning in engineering field leading to a final presentation in class.

Graded Activities (ECE 425)	(Tentative) Due Date (11:59PM MST)	Incentive Date: 10% Bonus (11:59PM MST)
Homework Assignment 1 *(Modules 1-2)*	Week 3: Sun, 09/14/2025	Fri, 09/12/2025
Homework Assignment 2 *(Modules 3-4)*	Week 5: Sun, 09/28/2025	Fri, 09/26/2025
Homework Assignment 3 *(Modules 4-5)*	Week 7: Sun, 10/12/2025	Fri, 10/10/2025
Midterm Exam *(Modules 1-7)*	**Week 9: Wed, 10/22/2025**	**Not Applicable**
Homework Assignment 4 *(Modules 6-7)*	Week 10: Sun, 11/02/2025	Fri, 10/31/2025

Homework Assignment 5 *(Modules 7-8)*	Week 12: Sun, 11/16/2025	Fri, 11/14/2025
Final presentation	Week 16: Mon, 12/08/2025	**Not Applicable**
Case Study Deliverables	**(TBD) From (12/12/2025 -12/18/2025)**	**Not Applicable**

Graduate section (ECE 525): Graduate students enrolled in ECE 525 will have *six* regular homework assignments*, i.e., an additional assignment*. They will be required to complete extra problems in the first five homework assignments and in the midterm. Each assignment will include one additional comprehensive question requiring an in-depth analysis of theory and programming skills, and the midterm exam will include an extra question. Furthermore, graduate students will be expected to undertake a structured project (in lieu of case study) applying deep learning principles in practice with programming.

Graded Activities (ECE 525)	(Tentative) Due Date (11:59PM MST)	Incentive Date: 10% Bonus (11:59PM MST)
Homework Assignment 1 *(Modules 1-2)*	Week 3: Sun, 09/14/2025	Fri, 09/12/2025
Homework Assignment 2 *(Modules 3-4)*	Week 5: Sun, 09/28/2025	Fri, 09/26/2025
Homework Assignment 3 *(Modules 4-5)*	Week 7: Sun, 10/12/2025	Fri, 10/10/2025
Midterm Exam *(Modules 1-7)*	**Week 9: Wed, 10/22/2025**	**Not Applicable**
Homework Assignment 4 *(Modules 6-7)*	Week 10: Sun, 11/02/2025	Fri, 10/31/2025
Homework Assignment 5 *(Modules 7-8)*	Week 12: Sun, 11/16/2025	Fri, 11/14/2025
Homework Assignment 6 *(Modules 9-10)*	Week 15: Wed, 12/03/2025	Mon, 12/01/2025
Final presentation	Week 16: Mon, 12/08/2025	**Not Applicable**
Project Deliverables	**(TBD) From (12/12/2025 -12/18/2025)**	**Not Applicable**

The submission dates (mm/dd/yyyy), due and incentive, may be subject to change with advance notice, as deemed appropriate by the instructor.

Grading [Subject to Change]

Undergraduate section (ECE 425): The grading distribution for the undergraduate section will be determined based on the following criteria:

5 Homework Assignments	*60%*
Mid-Term Exam	*20%*
Case study report	*10%*
Case study presentation	*10%*
Total	***100%***

Graduate section (ECE 525): The grading distribution for the graduate section will be determined based on the following criteria. Graduate students in ECE 525 are required to complete an *additional homework assignment* and an *applied deep learning project* (in lieu of case study). They will also solve extra problems in both homework assignments and exams, with each assignment featuring a comprehensive question requiring detailed theoretical/programming elements, and midterm exam including an additional question.

6 Homework Assignments	*60%*
Mid-Term Exam	*20%*
Project report	*5%*
Project presentation	*15%*
Total	***100%***

Rubrics will be posted on D2L for all homework assignments.

Final Examination

There is no written final examination. Instead, we will have presentation for the case study (ECE 425) and project (ECE 525) in the classroom as per our schedule above before the finals week. The allocated final exam date (**TBD**) will be the due date for submission of deliverables for the case study and project. These deliverables could comprise written report, software code repository, slides, any graphics/recordings, etc.
More information on the final exam schedule is available at https://registrar.arizona.edu/faculty-staff-resources/room-class-scheduling/schedule-classes/final-exams

Grading Scale and Policies

The following scale will be used to award the final grades:

Percentage	Letter Grade
90% – 100%	**A**
80% – 89%	**B**
70% – 79%	**C**
60% – 69%	**D**
<60%	**E**

Homework assignment is “Due” at the time specified in the course schedule and/or D2L content pages beyond which the submission is considered as late.

Bonus: Each assignment also includes an "Incentive Date" to encourage students to complete and submit their homework early. Submitting by this date earns a *10% bonus* on that assignment. For example, if you submit an assignment before the Incentive Date and score 70/100, your final score will be 70 + (0.1 x 70) = 77/100.

Late homework (after final due date) and case study (ECE 425) / project (ECE 525) will not be accepted without prior approval from the instructor and will receive 0 points. Note that the most recent submission is considered as the final submission and accordingly late penalty, or bonus (for assignments) will be applied.

All dates and times mentioned in this course are in Mountain Standard Time (Arizona), which is UTC-7 hours. Arizona does not observe Daylight Saving Time.

Grading Policy for Graduate Students

There will be specific distinctions of graduate vs. undergraduate material on the mid-term exam and homework. In addition, the graduate students will have a project (report and presentation).

Course Communications

This course utilizes the University of Arizona's D2L course management system for assignments, exams, content distribution, and important announcements. Please log in regularly to check for new announcements, reminders, and course-related information. Throughout the semester, you are encouraged to communicate with your instructor via in-person lectures, email, phone calls, text messages, office hours, or by scheduling an in-person or Zoom meeting.

Course Policies

As a University of Arizona student, it is expected that you become familiar with and adhere to university-wide policies and procedures. Complete and up-to-date information can be found in the UA General Catalog.

Make-up exams

A make-up exam may only be granted under extraordinary circumstances. Students requesting a make-up exam should contact the instructor well in advance and provide written documentation for the reason they cannot attend the regularly scheduled exam. The acceptance of the justification provided by the student is at the discretion of the instructor. Requests for incompletes (I) and withdrawal (W) must adhere to the University policies.

Incomplete (I) or Withdrawal (W)

Requests for incomplete (I) or withdrawal (W) must be made in accordance with University policies, which are available at http://catalog.arizona.edu/policy/grades-and-grading-system#incomplete and http://catalog.arizona.edu/policy/grades-and-grading-system#Withdrawal, respectively.

Dispute of Grade Policy

You can dispute any grade that you receive within one week that the grade has been awarded.

Classroom Behavior Policy

To foster a positive learning environment, students and instructors have a shared responsibility. We want a safe, welcoming, and inclusive environment where all of us feel comfortable with each other and where we can challenge ourselves to succeed. To that end, our focus is on the tasks at hand and not on extraneous activities (e.g., texting, chatting, reading a newspaper, making phone calls, web surfing, etc.).

Threatening Behavior Policy

The UA Threatening Behavior by Students Policy prohibits threats of physical harm to any member of the University community, including to oneself. See http://policy.arizona.edu/education-and-student-affairs/threatening-behavior-students.

Accessibility and Accommodations

At the University of Arizona, we strive to make learning experiences as accessible as possible. If you anticipate or experience barriers based on disability or pregnancy, please contact the Disability Resource Center (520-621-3268, https://drc.arizona.edu/) to establish reasonable accommodations.

Code of Academic Integrity

Students are encouraged to share intellectual views and discuss freely the principles and applications of course materials. However, graded work/exercises must be the product of independent effort unless otherwise instructed. Students are expected to adhere to the UA Code of Academic Integrity as described in the UA General Catalog.
See: http://deanofstudents.arizona.edu/academic-integrity/students/academic-integrity.

The University Libraries have some excellent tips for avoiding plagiarism, available at http://new.library.arizona.edu/research/citing/plagiarism.
Selling class notes and/or other course materials to other students or to a third party for resale is not permitted without the instructor's express written consent. Violations of this and other course rules are subject to the Code of Academic Integrity and may result in course sanctions. Additionally, students who use D2L or UA e-mail to sell or buy these copyrighted materials are subject to Code of Conduct Violations for misuse of student e-mail addresses. This conduct may also constitute copyright infringement.

Nondiscrimination and Anti-harassment Policy

The University of Arizona is committed to creating and maintaining an environment free of discrimination. In support of this commitment, the University prohibits discrimination, including harassment and retaliation, based on a protected classification, including race, color, religion, sex, national origin, age, disability, veteran status, sexual orientation, gender identity, or genetic information. For more information, including how to report a concern, please see
http://policy.arizona.edu/human-resources/nondiscrimination-and-anti-harassment-policy

Our classroom is a place where everyone is encouraged to express well-formed opinions and their reasons for those opinions. We also want to create a tolerant and open environment where such opinions can be expressed without resorting to bullying or discrimination of others.

Additional Resources for Students

UA Academic policies and procedures are available at http://catalog.arizona.edu/policies

Campus Health

http://www.health.arizona.edu/

Campus Health provides quality medical and mental health care services through virtual and in-person care. Phone: 520-621-9202

Counseling and Psych Services (CAPS)

https://health.arizona.edu/counseling-psych-services

CAPS provides mental health care, including short-term counseling services, Phone: 520-621-3334

The Dean of Students Office's Student Assistance Program

http://deanofstudents.arizona.edu/student-assistance/students/student-assistance

Student Assistance helps students manage crises, life traumas, and other barriers that impede success. The staff addresses the needs of students who experience issues related to social adjustment, academic challenges, psychological health, physical health, victimization, and relationship issues, through a variety of interventions, referrals, and follow-up services.

Email: DOS-deanofstudents@email.arizona.edu

Phone: 520-621-7057

Survivor Advocacy Program

https://survivoradvocacy.arizona.edu/

The Survivor Advocacy Program provides confidential support and advocacy services to student survivors of sexual and gender-based violence. The Program can also advise students about relevant non-UA resources available within the local community for support.

Email: survivoradvocacy@email.arizona.edu

Phone: 520-621-5767

Campus Pantry

Any student who has difficulty affording groceries or accessing sufficient food to eat every day, or who lacks a safe and stable place to live and believes this may affect their performance in the course, is urged to contact the Dean of Students for support. In addition, the University of Arizona Campus Pantry is open for students to receive supplemental groceries at no cost. Please see their website at: *campuspantry.arizona.edu* for open times.

Furthermore, please notify the instructor if you are comfortable in doing so. This will enable the instructor to provide any resources they may possess.

Safety on Campus and in the Classroom

For a list of emergency procedures for all types of incidents, please visit the website of the Critical Incident Response Team (CIRT): https://cirt.arizona.edu/case-emergency/overview Also, watch the video available at https://arizona.sabacloud.com/Saba/Web_spf/NA7P1PRD161/common/learningeventdetail/crtfy000000000003560

Confidentiality of Student Records
http://www.registrar.arizona.edu/ferpa

Subject to Change Statement

Information contained in the course syllabus may be subject to change with advance notice, as deemed appropriate by the instructor.