Carnegie Mellon University

11-741/11-441 Machine Learning with Graphs

Time: Tue & Thu, 11:00am-12:20pm, Location: PH A21A

Semester: Fall**, Year:** 2025

Units: 12 (11-741) or 9 (11-441)**, Section(s):** A (Pittsburgh)

Instructor information

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TA Information

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Course Description

- Graphs offer a natural way to represent complex relationships among objects of all kinds. Neural network learning with graphs has become important in both academic research and industrial applications. This course (for graduate and undergraduate students who meet the prerequisites) offers a mixture of fundamental concepts, algorithms, basic and advanced models, and applications ranging from social impact analysis and knowledge graph reasoning to deep learning for solving NP-complete problems.

Prerequisites

- CS courses on data structures, algorithms, programming (e.g., 15-213), linear algebra (e.g., 21-241 or 21-341), and introductory probability (e.g., 21-325). Introductory Machine Learning (e.g., 10-701 or 10-601) and neural network courses will be helpful but not required.

Learning Resources

- No textbook is used in this course. Instead, relevant papers are listed as references. Course slides are available online for registered students via a user ID and password.

- We will use Piazza, Canvas and Gradescope to handle communications, homework submissions and gradings.

Exams

- Open-book midterm and final exams, with a set of questions (about 10) and a list of possible answers to choose from per question.
- Mid-term exam will cover the lecture contents in the 1st half of the semester, and the final exam will cover the lecture contents in the 2nd half.
- The exams will not focus on the contents of the HW assignments.
- No make-up exam will be arranged. That is, for those who cannot come to the exams as pre-specified in the syllabus, they just lose the exam scores.

Course Policies

- **Attendance in-person is highly encouraged.** Typically, students who often miss class-room discussions tend to perform less well in exams compared to those who actively participate.
- If lecturers or students cannot come to the in-person classes due to illness or exposure to COVID, videos of live recordings from this semester or a past semester will be offered through piazza. A notification will be sent out in advance by the instructors via piazza if they cannot deliver the lectures in person.
- All of us benefit from support during times of struggle. You are not alone. There are many helpful resources available on campus and an important part of the college experience is learning how to ask for help. Asking for support sooner rather than later is often helpful.

Homework (Programming Assignments)

- This course is cross listed as 11-741 (12 units for graduate students) and 11-441 (9 units for undergraduate students), respectively.
- 11-741 students are required to do all the 5 homework assignments and answer all the questions in the midterm and final exams.
- 11-441 students are required to do 4 out of the total of 5 homework assignments (by their own choices) and 70% of the exam questions (by their own choices). If an undergraduate chooses to do more homework assignments, we will use the best-4 scores in the final HW grading. Similarly, if an undergraduate chooses to do more exam questions, we will use the scores of the 70% best answered questions in the Exam grading.
- Detailed homework descriptions are listed below:
  - HW1. Implementing neural networks (CNN and RNN) for binary classification with word embedding on the Yelp review dataset and using software like TensorFlow or Keras.
  - HW2. Implementing soft-max logistic regression for multi-class classification of Yelp reviews, with the derivation of the gradients of the loss functions.
  - HW3. Implementing PageRank, Personalized PageRank and Query Sensitive PageRank methods for web-page popularity analysis and evaluating their retrieval performance on the CiteEval dataset.
  - HW4. Implementing Graph Neural Network (GNN) models for simi-supervised node classification, link prediction, and graph classification.
  - HW5. Reasoning with Knowledge Graphs; Node Embedding with TransE.

Grading Policies

	11-741	11-441
Mid-term Exam	15%	15%
Final Exam	15%	15%
Homework Assignments	14% x 5 =70%	17.5% x 4 = 70%

Students will be assigned the final letter grades based on the aggregated total scores (of exams and homework assignments), as specified below:

Letter Grade	Percentage Interval
A	90-100%
B	80-89%
C	70-79%
D	60-69%
R (F)	59% and below

❖ Cheating Policy & Late Policies

- Each student is required to sign the Cheating Policy Form (the form to sign), as the necessary condition for being graded,
- Homework is due by 11:59pm of the due date. It must be submitted by Gradescope. If Gradescope is down, it must be submitted by email to the TA.
- A 10% penalty is applied for each day that the homework is late.
- Make-up work policy or Re-grade policy: We do not offer these arrangements.

❖ Grace Days

- There are 5 grace days for the homework submissions.
- Grace days will be automatically and greedily applied when you submit a late homework.
- Each student will have 5 grace days in total, NOT PER INDIVIDUAL homework. So, if you use 5 days for HW1, then you will have no grace days for later homework.
- For each individual homework, the code and report are submitted separately for auto-grading purposes. The penalty will be computed based on the submission time of which ever was submitted last. So, if you only submit the report before the deadline without your code, or vice versa, it is still counted as a late submission.
- No penalty is applied if you use grace days.
- Grace days cannot be applied to the last homework (i.e., HW5), due to the tight window for grading.

Course Schedule (Slides)

Lecture ID	Date	Topics (with URLs of main readings)	HW Assignments
8/26	1	Introduction	
8/28	2	DL1 Word Embedding (CBOL, SkipGram, GloVe, etc.)	
9/2	3	DL2 Recurrent Neural Networks (RNN, LSTM)	
9/4	4	DL3. Convolutional Neural Networks (CNN Models)	HW1: RNN& CNN Classifiers Due 9/18 11:59pm
9/9	5	DL4. Neural Attention Models and Transformer	
9/11	6	DL5. LLM Architectures (Invited Lecture by Ruohong Zhang)	
9/16	7	DL6. LLM Scalable Oversight and Inference Scaling Laws (Invited Lecture by Shanda Li)	
9/18	8	Classification Fundamentals Part 1: Models & Decision Boundaries	HW2: Softmax with SGD Due10/2 11:59pm
9/23	9	Classification Fundamentals Part 2: Optimization & Convexity	
9/25	10	Classification Fundamentals Part 3: SGD & Evaluation	
9/30	11	Graph 1. Matrix Foundations for Graph-based Learning (Adjacency, Graph Laplacians, Eigendecompostion & SVD)	
10/2	12	Graph 2. HITS and PageRank)	HW3: PageRank Methods Due 10/23 11:59pm
10/7	13	Graph 3.PPR, TSPR, QPR and Rank-based Evaluation (Topic Sensitive PageRank)	
10/9		**Midterm Exam on Lectures 1-13 (Loc: HH B131; Time: Same as Lectures)**	
10/13-17		Fall Break (No Classes)	
10/21	14	Graph 4. Node Embedding (Laplacian Eigenmaps and DeepWalk)	
10/23	15	Graph 5. Graph Convolution Networks (GCNs)	HW4: Graph-based prediction tasks Due 11/13 11:59pm
10/28	16	Graph 6. Graph Neural Networks (GAT and GIN)	
10/30	17	Graph 7. Knowledge Graph Completion (TransE and RotatE)	

11/4		Democracy Day No Classes	
11/6	18	Graph8. Knowledge-Enhanced GCN (KE-GCN)	
11/11	19	Graph 9. Graphormer and GTN	
11/13	20	Graph 10. Neural Recommendation Systems (BPR, NGCF)	HW5: Node Embedding with TransE Due 11/30 11:59pm
11/18	21	Graph 11. Autoregressive (AR) CO Solvers (Neural TSP Solvers, Attention Model)	
11/20	22	Graph12. Non-autoregressive CO Solvers (DIMES)	
11/25	23	Graph13.Diffusion-based CO Solvers (DIFUSCO)	
11/26-28		Thanksgiving, no class	
12/2	24	Graph14.CO Evaluation and LLM-based Agentic CO Solvers (FrontierCO, CodePDE)	
12/4		**Final Exam on Lectures 14-24 (Loc: HH B131; Time: Same as Lectures)**	