Algorithms For Democratic Decision-Making

MGMT 7405 / CPSC 7405 / ECON 5532 — Yale University, Spring 2026

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Classes: Mondays and Wednesdays 10:00–11:20 AM, Evans Hall, Gould Classroom 4220 (starts Jan 12)

Office Hours: Mondays and Thursdays 1:00-2:00 PM, Evans Hall, Office 3477

Course Webpage: https://jamie.tuckerfoltz.com/Teaching/AFDDM26/

Course Description

This course takes a mathematical look at how democratic institutions fairly allocate representation and aggregate preferences to make public decisions. We will begin with the foundational economics work in social choice theory on the design of voting systems. We will then progress through more modern developments from computer science on preference aggregation and fair allocation, including applications to AI and online platforms. The final part of the course will focus on institutions for distributing voting power. This includes traditional systems like apportionment and redistricting, as well as more radical proposals like liquid democracy and citizens assemblies. Throughout, particular focus will be given to designing efficient algorithms with theoretical guarantees.

Prerequisites and Enrollment

This course is geared toward PhD students in Operations, Computer Science, Economics, and related fields. Advanced undergraduates may enroll by instructor permission only, and will be held to the same standard as graduate students. The only firm prerequisite is that you must be comfortable reading and writing mathematical proofs, specifically in areas of discrete mathematics. It will be also helpful to have an understanding of basic concepts in game theory (mixed strategies, Nash equilibria) and CS/OR (linear programming, NP-completeness), though this content will be reviewed as needed.

Learning Objectives and Course Structure

There are three primary learning objectives:

- To build theoretical/mathematical research skills.
- To build presentation and communication skills.
- To gain exposure to the exciting and growing field on mathematical innovations for democracy.

This is a graduate-level, research-focused course. We will survey a wide range of topics at the frontiers of research, and each student will be expected to work in a group on a research project related to the course content. Most classes will consist of a 45-minute lecture, often involving group problem-solving exercises, followed by a 30-minute student presentation + discussion of a specific recent paper (assigned by preference from a list). Students are expected to attend class and actively participate. There will also be group project presentations at the end of the semester.

Grading

20% Attendance and participation.

20% Paper presentation 1

20% Paper presentation 2

30% Final project report (students will also submit a brief proposal and mid-term update)

10% Project presentation

Assignments will be submitted via Canvas. Slides for all student presentations are due at 11:59pm Anywhere on Earth on the day *before* the presentation. This is so that I have ample time to make sure the presentation will run on the technology in the classroom. All other due dates are listed on the Canvas Assignments tab and on the course calendar.

Final Projects

Each group will submit a final paper of at most 10 pages (not including references) in the style of `\documentclass[11pt]{article}`, due at the end of term. The paper should set out a novel research question and at least make partial progress towards answering it, including a plan and/or formal conjectures for how to move forward. The project must have some theoretical component. The best case scenario is that the project report becomes the seed of an eventual publication in an area related to your own research interests. There will be two formal check-ins in the latter half of the term where I will meet with groups individually to discuss ideas and offer advice. I will also have regular drop-in office hours.

Course Calendar and Materials

There is no textbook for this material. The main source of notes will be the lecture slides, which will be posted on the course webpage after each lecture (link at the top of this syllabus). The webpage will also have links to additional readings. All readings are optional. Skimming ahead on topics that you find interesting may be a good way to start thinking about potential projects.

Collaboration Policy

Both types of assignments – project reports and presentations – will be done in groups, which may or may not be the same. Students are all expected to contribute, and will each individually submit a detailed explanation of what they contributed to the final report, in terms of both ideas and writing.

Artificial Intelligence Policy

I use AI in my research sometimes, so you should feel free to as well. This can be useful for identifying prior work on a topic, explaining a concept, suggesting proof approaches, etc. However, if you use AI in this course, it is your responsibility to:

1. Take ownership of anything you write in your reports, slides, or say in your presentation, even if AI wrote the first version of it. **You** must fully understand what you are saying, and know that it is correct.

2. For the final project, you must keep track of **everything** you used AI for, in detail, and declare it when you submit your final project. Failing to disclose the use of AI will be considered a violation of Yale's academic integrity policy.

3. Do not let AI replace you as a writer. For instance, if you write a paragraph in your introduction motivating why your problem is interesting, it should be written in your own words, using your own ideas. I do not want to read about what AI thinks about a problem. I want to hear what **you** think.

Accessibility

If you have any needs or concerns about anything at all, please do not hesitate to reach out to me! I will work with you to ensure all components of the course are accessible and evaluation is equitable. And I will keep everything strictly confidential, to the greatest extent that is feasible.

Warnings About Evans Hall

I have had a student try to come visit me before who was denied entry into Evans Hall by security. For some reason, not all students have access by default. You may want to check with a guard in advance that your ID card has access so that you don't end up missing class on the first day! If you run into trouble, please email me and I'll get it sorted out as quickly as I can.

See the map below for finding the classroom and my office. Note that the third floor has multiple connected components and is not accessible via all staircases. To visit my office, you have to find a staircase/elevator on the South side of the building.