

## Math 499, Game Theory, Spring 2025

**Exterior Course Website:** <http://www.stevenheilman.org/~heilman/499s25.html>

**Recommended Prerequisite:** 1 from (Math 307 or Math 407) and 1 from (MATH 225 or MATH 235)

**Course Content:** This course will present the mathematics of game theory, i.e. the quantitative modeling of strategic interaction. Topics include: impartial games, partisan games, zero sum games, von Neumann's Minimax Theorem, general sum games, Nash equilibrium, fixed point theorems, evolutionary game theory, signaling, coalitions, auctions, and social choice theory. Time permitting, we will cover quantum games, algorithmic game theory, and applications of game theory to neural networks, such as generative adversarial networks or Monte Carlo Tree Search. The target audience of this course is advanced undergraduate students in mathematics, economics, computer science, or related fields, with an interest in a mathematically focused course on game theory.

**Lecture Meeting Time/Location:** Mondays, Wednesdays, and Fridays, 12PM-1250PM GFS 105

**Instructor:** Steven Heilman, [stevenmheilman@gmail.com](mailto:stevenmheilman@gmail.com)

**Office Hours:** Mondays, 10AM-12PM, KAP 406G

**Textbook: There is no required textbook.** The recommended textbook is: Karlin and Peres, [Game Theory, Alive](#). (The book is freely available [online](#).)

**Other non-required textbooks:** [Game Theory](#), Maschler, Solan and Zamir. Compared to the book of Karlin-Peres, this book is larger and more comprehensive. However, it is also a more advanced textbook, so it might be difficult to read if you have not taken several advanced math classes.

See also the [A course in game theory](#) book of Thomas S. Ferguson

**Exam 1:** Wednesday, February 19, 12PM-1250PM, GFS 105

**Exam 2:** Friday, March 28, 12PM-1250PM, GFS 105

**Final Exam:** TBD [determined by USC schedule]

**Other Resources:** [An introduction to mathematical arguments](#), Michael Hutchings,  
[An Introduction to Proofs](#)  
[How to Write Mathematical Arguments](#)

**Extra Credit Project:** There will be an optional extra credit project, where students will create a computer program that plays a game (such as connect four or chess) in Python, and the top performers of a tournament will be awarded around 1% to 3% extra credit points for the course. The project would be due in the last week of class, and the "finals" of the tournament would occur in class during this time as well. Students can work in groups of up to three, and if a team wins some amount of extra credit, that credit will be split evenly among the participants. Also, copying any code from any online resource will result in automatic disqualification. Since I will be running the finals on a Microsoft Surface Tablet (without much memory or processing power), you should not use too many extra Python packages beyond some standard ones. More details are TBD.

**Email Policy:**

- My email address for this course is [stevenmheilman@gmail.com](mailto:stevenmheilman@gmail.com).

- It is your responsibility to make sure you are receiving emails from [stevenmheilman@gmail.com](mailto:stevenmheilman@gmail.com), and they are not being sent to your spam folder.
- Do NOT email me with questions that can be answered from this document.

**Exam Procedures:** Students must bring their USCID cards to the midterms and to the final exam. Phones must be turned off. Cheating on an exam results in a score of zero on that exam. Exams can be regraded at most 15 days after the date of the exam. This policy extends to homeworks as well. All students are expected to be familiar with the [USC Student Conduct Code](#). (See also [here](#).)

**Student Conduct:** Discrimination, sexual assault, and harassment are not tolerated by the university. You are encouraged to report any incidents to the Office of Equity and Diversity <http://equity.usc.edu/> or to the Department of Public Safety <http://capsnet.usc.edu/departement/departement-public-safety/online-forms/contact-us>. This is important for the safety whole USC community. Another member of the university community - such as a friend, classmate, advisor, or faculty member - can help initiate the report, or can initiate the report on behalf of another person. The Center for Women and Men <http://www.usc.edu/student-affairs/cwm/> provides 24/7 confidential support, and the sexual assault resource center webpage [sarc@usc.edu](mailto:sarc@usc.edu) describes reporting options and other resources.

**Accessibility Services:** If you are registered with accessibility services, I would be happy to discuss this at the beginning of the course. Any student requesting accommodations based on a disability is required to register with Accessibility Services and Programs (OSAS) each semester. A letter of verification for approved accommodations can be obtained from OSAS. Please be sure the letter is delivered to me as early in the semester as possible. OSAS is located in 301 STU and is open 8:30am-5:00pm, Monday through Friday.

<https://osas.usc.edu>

213-740-0776 (phone)

213-740-6948 (TDD only)

213-740-8216 (fax)

[OSASFrontDesk@usc.edu](mailto:OSASFrontDesk@usc.edu)

**Exam Resources:** Here are the exams and solutions I used when I last taught this class: [Exam 1](#), [Exam 1 Solution](#), [Exam 2](#), [Exam 2 Solution](#). [Final](#), [Final Solution](#), [Exam 1](#), [Exam 1 Solution](#), [Exam 2](#), [Exam 2 Solution](#). [Final](#), [Final Solution](#), [Here](#) is a page containing practice exams for another game theory class. [Here](#) is a page containing practice exams for another game theory class. [Here](#) is a page containing a practice midterm for another game theory class. [Here](#) is a page containing a practice final for another game theory class. Occasionally these exams will cover slightly different material than this class, or the material will be in a slightly different order.

### Homework Policy:

- Homeworks are due roughly every week, at **11:59PM Thursdays**.
- Homeworks are submitted in brightspace, under the "Assignments" tab. You are allowed unlimited submission "attempts" for an assignment, but only the last submission will be graded. To avoid internet issues, I recommend making your first submission of an assignment

well in advance of the deadline. (Note that phone tethering can also give you an internet connection to a computer.)

- Homeworks should be submitted as single PDF documents. One way to create a PDF document from paper homework assignments is the freely available [Adode Scan App](#).
- Late homework is not accepted.
- If you still want to turn in late homework, then the number of minutes late, divided by ten, will be deducted from the score. (The time estimate is not guaranteed to be accurate.)
- **Do not submit homework via email.**
- The **two lowest** homework scores will be dropped. This policy is meant to account for illnesses, emergencies, dropped internet connections, etc.
- You may not use the internet to try to find answers to homework problems.
- A random subset of the homework problems will be graded each week. However, it is strongly recommended that you try to complete the entire homework assignment.
- All homework assignments must be **written by you**, i.e. you cannot copy someone else's solution verbatim. However, collaboration on homeworks is allowed and encouraged.
- Homework solutions will be posted a few days after the homework is turned in.

### Grading Policy:

- The final course grade is weighted as the larger of the following two schemes:
- Scheme 1: class participation (3%), homework (17%), the first midterm (20%), the second midterm (25%), and the final (35%).
- Scheme 2: class participation (3%), homework (17%), the largest midterm grade (30%), and the final (50%).
- The grade for the semester will be curved. However, I do not "curve down" since anyone who exceeds my expectations in the class by showing A-level performance on the exams and homeworks will receive an A for the class.
- If you cannot attend one of the exams, you must notify me within the first two weeks of the start of the quarter. Later requests for rescheduling will most likely be denied.
- Class participation is not the same as attendance. I will never explicitly take attendance, but I will notice if someone is frequently absent. Things that increase your class participation grade include: asking good questions, paying attention in class, showing up on time or early to class, etc. Things that decrease your class participation grade include: excessive talking or disruptions during class, frequent absences, excessive texting/smartphone usage in class, frequent tardiness, etc.
- You must take the final exam to pass the course.

**Tentative Schedule:** (This schedule may change slightly during the course.)

Week	Monday	Tu	Wednesday	Thursday	Friday
1	Jan 13: 1.1, Impartial Games		Jan 15: 1.1.1, 1.1.2, Chomp, Nim	Jan 16: Homework 0 due (ungraded)	Jan 17: 1.1.3, Sprague-Grundy Theorem
2	Jan 20: No class		Jan 22: 1.2, Partisan Games	Jan 23: Homework 1 due	Jan 24: 1.2.1, Hex
3	Jan 27: 2.1, Two-Person Zero Sum Games		Jan 29: 2.2, Minimax Theorem, Background	Jan 30: Homework 2 due	Jan 31: 2.2, Minimax Theorem
4	Feb 3: 2.3, Domination		Feb 5: 3.1, General Sum Games	Feb 6: Homework 3 due	Feb 7: 3.2, Nash equilibria
5	Feb 10: 3.3, Correlated equilibria		Feb 12: 3.6, Fixed Point Theorems	Feb 13: Homework 4 due	Feb 14: 3.5, Nash's Theorem
6	Feb 17: No class		Feb 19: Midterm #1	Feb 20: No homework due	Feb 21: 3.7, Evolutionary Game Theory
7	Feb 24: 3.8, Signaling and Asymmetric Information		Feb 26: 4.1, Coalitions and Shapley Value	Feb 27: Homework 5 due	Feb 28: 5.1, Mechanism design
8	Mar 3: 5.2, Auctions		Mar 5: 5.2, Auctions	Mar 6: Homework 6 due	Mar 7: 6.1,6.2, Social Choice
9	Mar 10: 6.3, Arrow's impossibility theorem		Mar 12: Influences, Fourier analysis	Mar 13: Homework 7 due	Mar 14: Noise Sensitivity
10	Mar 17: No class		Mar 19: No class		Mar 21: No class
11	Mar 24: Quantum Games		Mar 26: CHSH inequality, Bell's inequality	Mar 27: No homework due	Mar 28: Midterm #2
12	Mar 31: Algorithmic Game Theory		Apr 2: Algorithmic Game Theory	Apr 3: Homework 8 due	Apr 4: Complexity of Nash Equilibria
13	Apr 7: Complexity of Nash Equilibria		Apr 9: Complexity of Nash Equilibria	Apr 10: Homework 9 due	Apr 11: Price of Anarchy
14	Apr 14: Bandits and Reinforcement Learning		Apr 16: Bandits and Reinforcement Learning	Apr 17: Homework 10 due	Apr 18: Monte Carlo Tree Search
15	Apr 21: Monte Carlo Tree Search		Apr 23: Monte Carlo Tree Search	Apr 24: Homework 11 due	Apr 25: Leeway
16	Apr 28: Leeway		Apr 30: Leeway	May 1: Homework 12 due	May 2: Review of Course

**Advice on succeeding in a math class:**

- Review the relevant course material **before** you come to lecture. Consider reviewing course material a week or two before the semester starts.
- When reading mathematics, use a pencil and paper to sketch the calculations that are performed by the author.

- Come to class with questions, so you can get more out of the lecture. Also, finish your homework at least **two days** before it is due, to alleviate deadline stress.
- Write a rough draft and a separate final draft for your homework. This procedure will help you catch mistakes. Also, I would very much recommend [typesetting](#) your homework. Learning LaTeX is a very important skill to have for doing mathematics. [Here](#) is a template .tex file if you want to get started typesetting.
- If you are having difficulty with the material or a particular homework problem, review Polya's [Problem Solving Strategies](#), and come to office hours.