Game Theory and Applications in Computer Science and Engineering

CSE 206G - 01

Announcements:

The instructor will be away the week of October 13-17 for the **GameSec conference** (https://www.gamesec-conf.org/index.php) in Athens.

On Tuesday October 14th, we will have a guest lecture from **Vaggos Chatziafratis** (https://cstheory.ucsc.edu/vaggos/) . He will lecture live in the normal classroom at the normal time.

On Thursday October 16th, the instructor will give the lecture remotely over Zoom (**link** (https://ucsc.zoom.us/j/95681316616?pwd=rzOAbcQazJVSg8lAaycd3QwjafARs4.1)), at the normal class time.

Instructor

John Musacchio
Office: E2-557
johnm@soe.ucsc.edu (mailto:johnm@soe.ucsc.edu)
Office Hours: (Tentative) 9-11 Fridays on Zoom [**Link** (https://ucsc.zoom.us/j/99837407187?pwd=oxXo2Vvi2QDqEACsRS3oK3CUTYtHjl.1)]

Lectures

Tuesdays & Thursdays 11:40 AM - 1:15 PM

J Baskin Engr 372

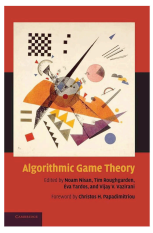
Description

This course covers the fundamentals of game-theory with a focus on game-theory's connections to computer science and engineering. These connections go in both directions. For example, computer science complexity theory sheds light on whether equilibria concepts from game-theory are plausible predictions of behavior by assessing whether computing an equilibrium is a tractable problem. Game-theory informs computer science and engineering about how the incentives of different users and/or stakeholders of computing system can lead to undesirable outcomes (e.g. poor utility across users, congestion, systems with serious security vulnerabilities...) It also provides a framework for analyzing the performance of various kinds of distributed systems, such as networks like the internet whose congestion is managed by end-to end rate control. We will also study mechanism design -- how games can be designed to achieve more desirable outcomes. Mechanism design has many applications in computing and engineered systems, such as the creation of markets of advertising on the internet (which has been a multibillion dollar market for over a decade), markets to allocate radio spectrum with complicated interference constraints, and markets for electricity.

The course uses game-theory textbooks, like the classic Game Theory textbook by MIT economist Drew Fudenberg and Nobel Laureate Jean Tirole, as well as key papers for more in-depth study of particular computer science to game-theory connections. We will also make extensive use of a compiled book titled Algorithmic Game Theory that has contributed chapters from many of the thought leaders on the connections between game theory and computer science.

Reading Material (Tentative)

Books:



[AGT '07] N. Nisan, T. Roughgarden, E´. Tardos, & V. Vazirani, ed., *Algorithmic Game Theory*, Cambridge University Press, 2007. 29-51.

Specific contributed chapters:

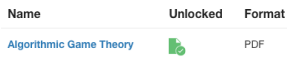
- [AGT Papadimitriou] C. Papadimitriou, "The Complexity of Finding Nash Equilibria," 29-51.
- [AGT Vazirani] V. Vazirani, "Combinatorial Algorithms for Market Equilibria," 103-134.
- [AGT T&W] E´. Tardos and T Wexler, "Network Formation Games and the Potential Function Method," 487-516.
- [AGT Roughgarden] T. Roughgarden, "Routing Games," 461-486.

Acquisition: **FREE ONLINE:** [**link** (https://www.cambridge.org/us/universitypress/subjects/computer-science/algorithmics-complexity-computer-algebra-and-computational-g/algorithmic-game-theory?format=HB)]

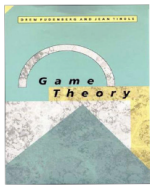
-Click in this under the book picture: 

-Then click on "Algorithmic Game Theory":

-Then click on "Algorithmic Game Theory":



Or buy a hard copy on Amazon: [link (https://a.co/d/iURGqnH)] (~$72 new, ~$50 used)



[F & T '91] D. Fudenberg & J. Tirole, *Game Theory*, MIT Press, 1991.

Acquisition: Buy on Amazon: [link (https://a.co/d/4oSMmb9)] (~$74 Hardcover or Kindle, ~$40 paper back)
UCSC Library Online access: [link (https://ucsc.primo.exlibrisgroup.com/permalink/01CDL_SCR_INST/ojisf2/cdi_proquest_miscellaneous_56545076)] (Only one student at a time)

[G '07] S. Goyal, *Connections: An Introduction to the Economics of Networks,* 2007.

Acquisition: UCSC Library Online access

- selected chapters

Other Readings:

[Akerlof '70] G. Akerlof, "The Market for 'Lemons': Quality Uncertainty and the Market Mechanism," *The Quarterly Journal of Economics*, 84(3), 1970, 488-500.

[Arrow '50] K. Arrow, "A Difficulty in the Concept of Social Welfare," *The Journal of Political Economy* 58(4), 1950, 328-346.

[A & M '10] L. Ausubel & P. Milgrom, "The Lovely but Lonely Vickrey Auction." in *Combi- natorial Auctions*, edited by P. Crampton, Y. Shoham, R. Steinberg, MIT Press, 2010, 17-40.

[DL & M '17] Dritsoula, P. Loiseau, and J. Musacchio, "A Game-Theoretic Analysis of Adver- sarial Classification," *IEEE Transactions on Information Forensics and Security*, 12(12), 2017, 3094-3109.

[EO & S `07] B. Edelman, M. Ostrovsky, M. Schwarz, "Internet Advertising and the Generalized Second-Price Auction: Selling Billions of Dollars Worth of Keywords," *American Economic Review*, 97(1), 2007, 242-259.

[MS & W '09] J. Musacchio, G. Schwartz, & J. Walrand, "A Two-Sided Market Analysis of Provider Investment Incentives with an Application to the Net Neutrality Issue," *Review of Network Economics*, 8(1), 2009, 22-39.

[Parkes '10] D. Parkes, "Iterative Combinatorial Auctions." in *Combinatorial Auctions*, edited by P. Crampton, Y. Shoham, R. Steinberg, MIT Press, 2010, 17-40.

[Varian '04] H. Varian, "System Reliability and Free Riding", in *Economics of Information Security*, Kluwer, 2004, 1-15.

[YLCPSS `25] J. Yan, Y. Luo, V. Chatziafratis, I. Panageas, P. Shahkar , and S. Stavroulakis, **"The Complexity of Finding Local Optima in Contrastive Learning," (https://arxiv.org/pdf/2509.16898)** to appear in Neurips2025.

Lecture Plan

Week	Lecture #	Date	Week-day	Topics	Readings
one	1	Sept. 25 [**slides (https://canvas.ucsc.edu/courses/86619/files/11398629?wrap=1)** ↓ **(https://canvas.ucsc.edu/courses/86619/files/11398629/download?download_frd=1)**]	Th	Nash Equilibrium, Nash Existence Theorem, Brouwer and Kakutani's Fixed Point Theorem, Iterated Strict Dominance	

two	2	Sept. 30 [slides (https://canvas.ucsc.edu/courses/86619/files/11433173?wrap=1) (https://canvas.ucsc.edu/courses/86619/files/11433173/download?download_frd=1)] [notes (https://canvas.ucsc.edu/courses/86619/files/11433174?wrap=1) (https://canvas.ucsc.edu/courses/86619/files/11433174/download?download_frd=1)]	Tu		F&T pg 3-14
	3	Oct. 2 [notes (https://canvas.ucsc.edu/courses/86619/files/11433175?wrap=1) (https://canvas.ucsc.edu/courses/86619/files/11433175/download?download_frd=1)]	Th		F&T pg 14-23, 45-48
three	4	Oct. 7 [notes (https://canvas.ucsc.edu/courses/86619/files/11451600?wrap=1) (https://canvas.ucsc.edu/courses/86619/files/11451600/download?download_frd=1)]	Tu		F&T pg 23-34
	5	Oct. 9	Th	Nash equilibrium Complexity, Lemke-Howson Alg	AGT `07 Ch by Papadim
four	6	Oct. 14	Tu	Extension of Nash equilibria complexity analysis to the Complexity of Finding Optima in Contrastive Learning. **Guest instructor Vaggos Chatziafratis, live in the classroom.** **(Primary instructor out of town for a conference.)**	YLCPSS `25 (https://a
	7	Oct. 16	Th	Zero- Sum Games, Duality, Detection Games, **Lecture live over Zoom from primary instructor. Zoom [Link] (https://ucsc.zoom.us/j/95681316616?pwd=rzOAbcQazJVSg8lAaycd3QwjafARs4.1)** **(Primary instructor out of town for a conference.)**	Zero-Sum_Games Note (https://canvas.ucsc.edu/ (https://canvas.ucsc.edu/download_frd=1) DL&M `17 (https://iee reload=true)
five	8	Oct. 21	Tu	Games with continuous strategy spaces, classic one-shot competition models	F&T pgs 14-15 & 34-36
	9	Oct. 23	Th	Selfish Routing, link pricing, extensive form games	AGT `07 Ch by Roughga
six	10	Oct. 28	Tu		F&T pg 67-83
	11	Oct. 30	Th	**MIDTERM**	

seven	12	Nov. 4	Tu	Backward Induction, Stackelberg competition, net neutrality modeling	MS&W '09
	13	Nov. 6	Th	Asymmetric Information, Signalling Games, Market for Lemons	Akerlof `70
eight		Nov. 11	Tu	**Veterans Day Holiday**	
	14	Nov. 13	Th	Asymmetric Information, Signalling Games, Market for Lemons (cont'd)	F &T Ch 6
nine	15	Nov. 18	Tu	Mechanism design, revelation principle, VCG, optimal mechanisms, nonlinear pricing	F & T Ch 7
	16	Nov. 20	Th		EO&S '07
ten	17	Nov. 25	Tu	Games on Graphs	G'07
			Th	**Thanksgiving Holiday**	
eleven	18	Dec. 2	Tu	Project Presentations	
	19	Dec. 4	Th		
		Dec. 9	Tu 12-3	**FINAL EXAM**	

Assessment

- Assignments 30%
- Project 25%
- Midterm 20%
- Final 25%

ACCESSIBILITY

UC Santa Cruz is committed to creating an academic environment that supports its diverse student body. If you are a student with a disability who requires accommodations to achieve equal access in this course, please affiliate with the DRC. I encourage all students to benefit from learning more about DRC services to contact DRC by phone at 831-459-2089 or by email at drc@ucsc.edu. For students already affiliated, make sure that you have requested Academic Access Letters, where you intend to use accommodations. You can also request to meet privately with me during my office hours or by appointment, as soon as possible. I would like us to discuss how we can implement your accommodations in this course to ensure your access and full engagement in this course.

TITLE IX/CARE ADVISORY

UC Santa Cruz is committed to providing a safe learning environment that is free of all forms of gender discrimination and sexual harassment, which are explicitly prohibited under Title IX. If you have experienced any form of sexual harassment, sexual assault,

domestic violence, dating violence, or stalking, know that you are not alone. The Title IX Office, the Campus Advocacy, Resources & Education (CARE) office, and Counseling & Psychological Services (CAPS) are all resources that you can rely on for support.

Please be aware that if you tell me about a situation involving Title IX misconduct, I am required to share this information with the Title IX Coordinator. This reporting responsibility also applies to course TAs and tutors (as well to all UCSC employees who are not designated as “confidential” employees, which is a special designation granted to counselors and CARE advocates). Although I have to make that notification, you will control how your case will be handled, including whether or not you wish to pursue a formal complaint. The goal is to make sure that you are aware of the range of options available to you and that you have access to the resources you need.

Confidential resources are available through CARE. Confidentiality means CARE advocates will not share any information with Title IX, the police, parents, or anyone else without explicit permission. CARE advocates are trained to support you in understanding your rights and options, accessing health and counseling services, providing academic and housing accommodations, helping with legal protective orders, and more. You can contact CARE at (831) 502-2273 or care@ucsc.edu.

In addition to CARE, these resources are available to you:

- If you need help figuring out what resources you or someone else might need, visit the Sexual Violence Prevention & Response (SAFE) website, which provides information and resources for different situations.
- Counseling & Psychological Services (CAPS) can provide confidential counseling support. Call them at (831) 459-2628.
- You can report gender discrimination and sexual harassment and violence directly to the University’s Title IX Office by calling (831) 459-2462 or by using their online reporting tool.
- Reports to law enforcement can be made to the UC Police Department, (831) 459-2231 ext. 1.
- For emergencies, call 911.

ACADEMIC INTEGRITY

All members of the UCSC community benefit from an environment of trust, honesty, fairness, respect, and responsibility. You are expected to present your own work and acknowledge the work of others in order to preserve the integrity of scholarship.

Academic integrity includes:

- Following exam rules
- Using only permitted materials during an exam
- Viewing exam materials only when permitted by your instructor
- Keeping what you know about an exam to yourself
- Incorporating proper citation of all sources of information
- Submitting your own original work

Academic misconduct includes, but is not limited to, the following:

- Disclosing exam content during or after you have taken an exam
- Accessing exam materials without permission
- Copying/purchasing any material from another student, or from another source, that is submitted for grading as your own
- Plagiarism, including use of Internet material without proper citation
- Submitting work that was produced by artificial intelligence (e.g., ChatGPT)
- Using cell phones or other electronics to obtain outside information during an exam without explicit permission from the instructor
- Submitting your own work in one class that was completed for another class (self-plagiarism) without prior permission from the instructor.
- Violations of the Academic Integrity policy can result in dismissal from the university and a permanent notation on a student’s transcript. For the full policy and disciplinary procedures on academic dishonesty, students and instructors should refer to the Academic Misconduct page at the Division of Undergraduate Education.

GENERATIVE ARTIFICIAL INTELLIGENCE

A Word About Integrity

Integrity—other people's perception of your word as true—is one of the most valuable assets you can cultivate in life. Being attentive to integrity in academic settings allows others to trust that you have completed work for which you are taking credit. This is

symbolic of the public trust from which you will benefit in your future occupation and activism after you graduate from UCSC.

The creativity of your words, expression, understanding, and knowledge matters a great deal in your work as a sociologist, and it matters to me. My AI policy reflects the emphasis our discipline places on original thought and scholarship.

AI Policy

In this class, I ask that you complete your work without using AI-generated sources to augment, think through, or write your assignments.

There is one exception: you are welcome to use AI tools for pre-submission editing (spell-check and grammar-check) as long as you do not use them for thinking or drafting. On rare occasions, I may create an assignment in which I ask you to critique content generated by AI; if this occurs, I will provide clear assignment-specific AI-use guidelines within the prompt.

If you submit work that appears to have been written using AI sources, I will ask you to meet with me to discuss your thinking and writing process. If, after our conversation, I conclude it's more likely than not that you did not personally complete an assignment you submitted under your name, I may refer you to your college provost for further conversation.

If you have questions about AI use and/or proper attribution of other people's work, please come ask me! Scholarly citing is not particularly intuitive, and part of my role is to help you learn those conventions.

INTELLECTUAL PROPERTY

The materials in this course are the intellectual property of their creators. As a student, you have access to many of the materials in the course for the purpose of learning, engaging with your peers in the course, completing assignments, and so on. You have a moral and legal obligation to respect the rights of others by only using course materials for purposes associated with the course. For instance, you are not permitted to share, upload, stream, sell, republish, share the login information for, or otherwise disseminate any of the course materials, such as: video and audio files, assignment prompts, slides, notes, syllabus, simulations, datasets, discussion threads. Conversely, any materials created solely by you (for example, your videos, essays, images, audio files, annotations, notes) are your intellectual property and you may use them as you wish.

RELIGIOUS ACCOMMODATION

UC Santa Cruz welcomes diversity of religious beliefs and practices, recognizing the contributions differing experiences and viewpoints can bring to the community. There may be times when an academic requirement conflicts with religious observances and practices. If that happens, students may request reasonable accommodation for religious practices. The instructor will review the situation in an effort to provide a reasonable accommodation without penalty. You should first discuss the conflict and your requested accommodation with your instructor early in the term. You or your instructor may also seek assistance from the Dean of Students office.

ALL-GENDER RESTROOMS

UC Santa Cruz is committed to the well-being of all students and cares about all students feeling safe and welcome, regardless of their gender identity, expression, and/or

embodiment. The Lionel Cantú Queer Center has worked with students and campus staff to create more safe and accessible restrooms for transgender and genderqueer students, staff, faculty, alumni, and UCSC visitors. A complete list of all-gender restrooms on campus was compiled and is maintained by the Cantú Queer Center.

REPORT AN INCIDENT OF HATE OR BIAS

The University of California, Santa Cruz is committed to maintaining an objective, civil, diverse and supportive community, free of coercion, bias, hate, intimidation, dehumanization or exploitation. The Hate/Bias Response Team is a group of administrators

who support and guide students seeking assistance in determining how to handle a bias incident involving another student, a staff member, or a faculty member. To report an incident of hate or bias, please use the following form: Hate/Bias Report Form.

STUDENT SERVICES

Counseling and Psychological Services

Many students at UC Santa Cruz face personal challenges or have psychological needs that may interfere with their academic progress, social development, or emotional wellbeing. The university offers a variety of confidential services to help you through difficult times, including individual and group counseling, crisis intervention, consultations, online chats, and mental health screenings.

Campus Mobile Crisis Team

If you are concerned about yourself or someone around you and feel they may be having a behavioral health crisis, do not hesitate to call our team. Behavioral Health concerns can

include mental health or substance use related situations where you or someone around you may be a danger to self or others. Dial 831-502-9988 to reach the team.

Reporting and Support Services

A resource to help students, faculty, staff and others report acts of bias as well as discrimination and harassment.

Student Success and Engagement Hub

The Division of Student Success provides campus-wide coordination and leadership for student success programs and activities across departments, divisions, the colleges, and administrative units.

Tutoring and Learning Support

At Learning Support Services (LSS), undergraduate students build a strong foundation for success and cultivate a sense of belonging in our Community of Learners. LSS partners with faculty and staff to advance educational equity by designing inclusive learning environments in Modified Supplemental Instruction, Small Group Tutoring, and Writing Support. When students fully engage in our programs, they gain transformative experiences that empower them at the university and beyond.

Slug Support Program

College can be a challenging time for students and during times of stress it is not always easy to find the help you need. Slug Support can give help with everything from basic needs (housing, food, or financial insecurity) to getting the technology you need during remote instruction.

To get started with SLUG Support, please contact the Dean of Students Office at 831-459-4446 or you may send us an email at deanofstudents@ucsc.edu.

Slug Help/Technology

The ITS Support Center is your single point of contact for all issues, problems or questions related to technology services and computing at UC Santa Cruz. To get technological help, simply email help@ucsc.edu.

On-Campus Emergency Contacts

For all other help and support, including the health center and emergency services, Click here to go to UCSC's Emergency Services page. **Always dial 9-1-1 in the case of an emergency.**

Course Summary:

Date	Details	Due
Fri Oct 3, 2025	Game Theory and Applications in Computer Science and Engineering (https://canvas.ucsc.edu/calendar?event_id=614037&include_contexts=course_86619)	9am to 11am
Fri Oct 10, 2025	Game Theory and Applications in Computer Science and Engineering (https://canvas.ucsc.edu/calendar?event_id=614038&include_contexts=course_86619)	9am to 11am
	Assignment 1 (https://canvas.ucsc.edu/courses/86619/assignments/760699)	due by 11:59pm
Thu Oct 16, 2025	Remote Lecture: CSE 206G on October 16th. (https://canvas.ucsc.edu/calendar?event_id=610248&include_contexts=course_86619)	11:40am to 1:15pm
Fri Oct 17, 2025	Game Theory and Applications in Computer Science and Engineering (https://canvas.ucsc.edu/calendar?event_id=614039&include_contexts=course_86619)	9am to 11am
Tue Oct 21, 2025	Assignment 2 (https://canvas.ucsc.edu/courses/86619/assignments/769934)	due by 11:10am

Date	Details	Due
Fri Oct 24, 2025	Game Theory and Applications in Computer Science and Engineering (https://canvas.ucsc.edu/calendar?event_id=614040&include_contexts=course_86619)	9am to 11am
Fri Oct 31, 2025	Game Theory and Applications in Computer Science and Engineering (https://canvas.ucsc.edu/calendar?event_id=614041&include_contexts=course_86619)	9am to 11am
Fri Nov 7, 2025	Game Theory and Applications in Computer Science and Engineering (https://canvas.ucsc.edu/calendar?event_id=614042&include_contexts=course_86619)	9am to 11am
Fri Nov 14, 2025	Game Theory and Applications in Computer Science and Engineering (https://canvas.ucsc.edu/calendar?event_id=614043&include_contexts=course_86619)	9am to 11am
Fri Nov 21, 2025	Game Theory and Applications in Computer Science and Engineering (https://canvas.ucsc.edu/calendar?event_id=614044&include_contexts=course_86619)	9am to 11am
Fri Nov 28, 2025	Game Theory and Applications in Computer Science and Engineering (https://canvas.ucsc.edu/calendar?event_id=614045&include_contexts=course_86619)	9am to 11am
Fri Dec 5, 2025	Game Theory and Applications in Computer Science and Engineering (https://canvas.ucsc.edu/calendar?event_id=614046&include_contexts=course_86619)	9am to 11am
	Syllabus Acknowledgement (New Quiz) (https://canvas.ucsc.edu/courses/86619/assignments/711931)	