Missouri University of Science and Technology — Department of Computer Science
Spring 2021 — **CS 6001: Algorithmic Game Theory**

SYLLABUS

Instructor: *Sid Nadendla* — **Email:** *nadendla@mst.edu*

1 Course Information

Course Website:	https://sites.google.com/a/mst.edu/nadendla/teaching/algorithmic-game-theory
Lecture hours:	Tuesdays & Thursdays; 11:00 AM - 12:15 PM
Lecture Venue:	Room 220, Computer Science Building
Instructor's Office:	313 Computer Science Building
Instructor's Office hours:	Wed. 3pm - 4pm. Otherwise, walk-in, or by appointment.
Contact Details:	nadendla@mst.edu, (573) 341-4090

2 Intended Audience & Prerequisites

This course is primarily designed for advanced graduate students (in computer science and beyond) who plan to use game theory actively in their research. Therefore, students taking this class are expected to have a strong foundation in algorithms ('C' or better grade in Comp Sci 5200), and artificial intelligence ('C' or better grade in Comp Sci 5400/5401), or game theory ('C' or better grade in Comp Sci 5001).

3 Textbook

In this course, we will not be following any one textbook. Therefore, students are not mandated to buy textbooks. However, students are encouraged to refer to one or more recommended books[1] from the following (non-exhaustive) list:

- **Noam Nisan *et al.* (Editors), "Algorithmic Game Theory, " Cambridge University Press, 2007.**
- Tamer Başar and Geert Jan Olsder, "Dynamic Noncooperative Game Theory," SIAM, 2nd Ed., 1999.
- John von Neumann and Oskar Morgenstern, "Theory of Games and Economic Behavior," 60th Anniversary Commemorative Edition, Princeton University Press, 2007.
- Yoav Shoham, Kevin Leyton-Brown, "Multiagent Systems: Algorithmic, Game-Theoretic, and Logical Foundations," Cambridge University Press, 2008.
- Y. Narahari, "Game Theory and Mechanism Design," IISc Press and the World Scientific Publishing Company, March 2014.
- T. Roughgarden, "Twenty Lectures on Algorithmic Game Theory," Cambridge University Press, 2016.

[1] Links to free electronic copies of the books will be provided in the website, if available.

4 Description

Algorithmic Game Theory is a course that develops rigorous mathematical framework to model, analyze and approximately solve complex adversarial problems in various real-world applications, particularly in computer science (e.g., cybersecurity, robotics and networking). Topics include principles of mechanism design (e.g. Revelation Principle, Preference Aggregation and Impossibility Results), strategic markets (e.g. auctions, matching), inefficiency of distributed solutions (e.g. price of anarchy, selfish routing), learning in games (e.g. ficticious play, online regret minimization, convergence to equilibria), and computing equilibria (e.g. PPAD Complexity Class, Lemke-Howson Algorithm).

5 Course Objectives

- Develop deeper insights about the design of strategic mechanisms and their limitations.
- Gain mastery with designing different types of markets.
- Become proficient in analyzing inefficiency of equilibria.
- Gain mastery in designing learning algorithms in repeated Bayesian game settings.
- Become proficient in analyzing the complexity of computing Nash equilibria.

6 Prospective List of Topics

In this course, we will tentatively cover six topics, each with mathematical rigor (theorem-proof style) in a lecture format, followed by a case study on some practical state-of-the-art paper(s) presented by students. Following are a list of potential topics we will cover in each topic, along with one example of a case study.

Topic	**Subtopics**
Mechanism Design	Revelation Principle, Impossibility Theorems, Quasi-Linear Environments
Case Study	Complexity of Manipulation in Voting
Markets	Auctions, Stable Matching
Case Study	Dynamic Pricing and Bandits
Inefficiency	Price of Anarchy, Selfish Routing, Braess Paradox
Case Study	PoA in Over-Provisioned Networks
Learning in Games	Ficticious play, Regret Minimization
Case Study	Monte-Carlo Tree Search using Deep Neural Networks
Games and Complexity	PPAD Class, Non-Linear Complementarity, Lemke-Howson Algorithm
Case Study	Stackelberg (Persuasive) Signaling.
Project Presentations	

7 Grading Information

Students' grades will be calculated based on 5 HW assignments, a case study, and a project, as shown below:

Assignments:	50% of total grade
Case Study:	20% of total grade
Project:	30% of total grade
Final Grade:	A: $[85-100]$, B: $[75-85)$, C: $[60-75)$, F: <60

All the grades will be posted and maintained on Canvas.

8 Course Policies & Campus Resources

8.1 Required Materials and COVID-19 Contingency Plans

In this in-person course, 6-feet distancing rule will be strictly enforced during lectures. To ensure a safe, trustworthy and flexible learning environment, a large enough classroom that can accommodate 18 students (at 40% class capacity) at a time has been chosen. Furthermore, the instructor will teach the class using an appropriate face-shield, and will allow students only if they have an appropriate face covering, unless an exception has been formally made to the student by campus administration. For more details, please visit **https://coronavirus.mst.edu** to learn about the campus policy. Although lectures will be streamed over Zoom, please note that the instructor uses white board extensively throughout the class in addition to the slides. Therefore, students are expected to attend the class in-person.

Homework assignments, peer reviews for case study presentations and project reports are to be submitted via Canvas, regarding which the instructor will discuss in the first class. As long as the campus remains open, in-class exams will be planned during lecture hours. However, in case of rampant spread of COVID-19 infection on campus in the midst of SP'21, the campus can mandate all the instructors to switch to online instruction, in which case, in-class activities will be replaced by online counterparts.

In order for this plan to work successfully, students are mandated to have laptops (even during in-class lectures for peer evaluations), web cams, scanners[2] (if submitting a hand-written assignment), headsets, microphones, or other resources to learn in an online synchronous setting. Most of these items are available for checkout from the Service Desk in the library. In order to maintain a safe environment within the classroom and beyond, students should always monitor their health regularly. Anyone exhibiting COVID-19 symptoms (e.g. body temperature of 100°F or higher) should notify covid@mst.edu immediately, and refrain from coming to the campus. Precautionary measures (e.g. wear face masks, maintain 6-feet distancing) should be followed and respected at all times.

8.2 S&Tconnect (https://canvas.mst.edu/ "Starfish" icon on toolbar)

S&T Connect enables students to request appointments with their instructors and advisors via the S&T Connect calendar, which syncs with the Outlook Exchange calendar. S&T Connect tracks each student's performance across all courses. S&T Connect Early Alert enables students to be provided with services as needs arise. S&T Connect training for faculty and staff is provided by Rachel Morris at rachelm@mst.edu or 573-341-7600.

[2]There are several mobile applications available in different platforms that can use the camera in smart devices to scan documents.

8.3 Statement about Copyright, FERPA, and Use of Video

It is vitally important that our classroom environment promote the respectful exchange of ideas. This entails being sensitive to the views and beliefs expressed during discussions whether in class or online. Please speak with me before recording any class activity. It is a violation of University of Missouri policy to distribute such recordings without my authorization and the permission of others who are recorded. More information is provided in the following link:
https://www.umsystem.edu/ums/elearning/policies

8.4 Accessibility and Accomodations

It is the university's goal that learning experiences be as accessible as possible. If you anticipate or experience physical or academic barriers based on a disability, please contact Student Disability Services at (573) 341-6655, sdsmst@mst.edu, visit http://dss.mst.edu/ for information.

8.5 Student Success Center

The Student Success Center is a centralized location designed for students to visit and feel comfortable about utilizing the campus resources available. The Student Success Center was developed as a campus wide initiative to foster a sense of responsibility and self-directedness to all S&T students by providing peer mentors, caring staff, and approachable faculty and administrators who are student centered and supportive of student success. Visit the SSC at 198 Toomey Hall; phone: 573-341-7596; E-mail: success@mst.edu; facebook: https://www.facebook.com/SandTssc; web: https://studentsuccess.mst.edu/

8.6 S&T Writing Center

The Writing Center's mission is to assist undergraduate and graduate students in their efforts to become better writers through structured one-on-one conversations with peer consultants. Writing Center consultants are fellow students whose strong writing skills and special training allow them to offer meaningful feedback and guidance. Appointments are currently virtual via WConline and Zoom. They will also offer select asynchronous services beginning in February, 2021. More information can be found at their website given below and through email: writing@mst.edu
https://writingcenter.mst.edu/

8.7 Student Honor Code & Academic Integrity

- The Honor Code all students are expected to follow can be found at this link:
  http://stuco.mst.edu/honor-code/.
- Page 30 of the Student Academic Regulations handbook describes the student standard of conduct relative to the University of Missouri System's Collected Rules and Regulations section 200.010, and offers descriptions of academic dishonesty including cheating, plagiarism and sabotage (found in the link below), all of which will be reported to the Vice Provost for Academic Support.
  http://registrar.mst.edu/academicregs/index.html
- Additional guidance including the University's Academic Dishonesty Procedures is available at
  http://academicsupport.mst.edu.

- Other resources for students regarding ethics and integrity can be found at http://academicsupport.mst.edu/academicintegrity/studentresources-ai.

8.8 Classroom Egress Map

Please familiarize yourself with the egress map for Room 220, Comp Sci Building posted at:

https://designconstruction.mst.edu/media/campussupport/designconstruction/secure/floorplan/R0055-8.5x11%20Fit.pdf

8.9 Well-Being and UCARE

Any of us may experience strained relationships, increased anxiety, feeling down, alcohol/drug misuse, decreased motivation, challenges with housing, food insecurity and so on. When your mental well-being is negatively impacted, you may struggle academically and personally. If you feel overwhelmed or need support, please make use of S&T's confidential mental health services at no charge. For a quick guide to campus resources that address specific issues please visit our Well-Being Referral Guide, available as a website at
https://minerwellness.mst.edu/well-being-referral-guide/. If you are concerned about a friend or would like to consult with a Care Manager, please make a UCARE referral for support and assistance.
https://stuaff.mst.edu/ucare/.
https://go.mst.edu/ucare-report

8.10 Nondiscrimination, Equity and Title IX

Missouri University of Science and Technology is committed to the safety and well-being of all members of its community, and to creating an environment free from discrimination and harassment.

The University does not discriminate on the basis of race, color, national origin, ancestry, religion, sex, pregnancy, sexual orientation, gender identity, gender expression, age, disability, protected veteran status, and any other status protected by applicable state or federal law. As used in this policy, the word "sex" is also inclusive of the term "gender."

Additionally, US Federal Law Title IX states that no member of the university community shall, on the basis of sex, be excluded from participation in, or be denied benefits of, or be subjected to discrimination under any education program or activity. Violations of this law include sexual harassment, sexual assault, dating/domestic violence, and stalking.

In accordance with The Collected Rules and Regulations University of Missouri, Missouri S&T requires that all faculty and staff members report, to the Missouri S&T Equity Officer, any notice of discrimination disclosed through communication including but not limited to direct conversation, email, social media, classroom papers and homework exercises.

Missouri S&T's Equity Officer and Title IX Coordinator is Chief Diversity Officer Neil Outar. Contact him (naoutar@mst.edu; (573) 341-6038; 203 Centennial Hall) to report violations of the university's nondiscrimination polices, including Title IX. To learn more about resources and reporting options (confidential and non-confidential) available to Missouri S&T students, staff, and faculty, please visit http://titleix.mst.edu.