IE 598GT: Topics in Game Theory and Fair Division

Spring 2021 (online) TR 3:30 - 4:50 PM CT

(Syllabus)

Instructor:	Jugal Garg (jugal@illinois.edu)
Course website:	`compass2g.illinois.edu`; `http://jugal.ise.illinois.edu/ie598.html`
Zoom link:	Available on COMPASS
Slack link:	`ie598gt.slack.com`
Office hours (Zoom):	Wednesdays 3:00 - 4:00 PM CT or by appointment

Course Communication

- All announcements, assignments, lecture slides, and other materials will be done through the course website on COMPASS.
- Synchronous lectures will be delivered via Zoom, which will also be recorded and posted on Compass with lecture slides after each lecture.

Course Description

The course will explore various topics at the intersection of economics and computation whose solutions have been deployed to solve a wide-range of real-life settings such as assigning medical residents to hospitals, allocating students to schools, assigning seats in courses, kidney exchange, refugee allocation, assigning public housing, airport traffic management, and so on. The course will cover the topics in foundations of game theory and fair division such as Nash equilibrium, bargaining, mechanism design, fair and efficient allocation of goods/chores, and their computation.

Prerequisites: IE 310 or equivalent; basic knowledge of optimization, probability, and linear algebra; mathematical maturity

References

1. *Game Theory: Analysis of conflict* by Roger Myerson, Harvard Press, 1997.
2. *Twenty Lectures on Algorithmic Game Theory* by Tim Roughgarden, Cambridge, 2016.
3. *A Course in Game Theory* by Osborne and Rubinstein, MIT Press, 1994.
4. *Fair Division: From cake-cutting to dispute resolution* by Steven J Brams and Alan D Taylor, Cambridge University Press, 1996.
5. *Fair division and collective welfare* by Hervé Moulin, MIT press, 2004.
6. *Cake-cutting algorithms: Be fair if you can* by Jack Robertson and William Webb, CRC Press, 1998.

Required Work and Grading Policy

1. 4 Homework assignments (60%)
2. Project (40%)

Tentative Course Outline

- **Week 1-2 (fair division of divisible items):** cut and choose protocol; fairness notions: envy-freeness (EF), proportionality (Prop); efficiency notions: Pareto optimality, (Nash) social welfare; competitive equilibrium
- **Week 3-5 (fair division of indivisible/mixed items):** fairness notions: envy-freeness up to one/any good (EF1/EFX), proportionality up to one good (Prop1), maximin share allocation (MMS); envy-cycle procedure; approximate MMS allocation
- **Week 6-8 (game theory):** Nash equilibrium; minimax theorem; support enumeration algorithm; Sperner's lemma; PPAD-hardness, Lemke-Howson algorithm; correlated equilibrium; bargaining and cooperation: Nash bargaining, core, Shapley value
- **Week 9-11 (Price of Anarchy):** Selfish routing; Potential games; Congestion games; Cost sharing games; best response dynamics; PLS
- **Week 12-13 (Mechanism design):** First price auction, second price (Vickery) auction; Myerson's lemma; VCG mechanism; Mechanism design without money: top trading cycle, kidney exchange
- **Week 14-15:** project presentations

Course Project

A course project can have at most 2 students. The project could be reading a couple of recent research papers, survey of some topic not covered in the class, or on a research problem. The evaluation of project is based on a written report (8-10 pages), class presentation and class feedback. We will have project presentations at the end of the course.

Academic Integrity

We will follow Student Code Part 4 1-401 through 1-406 (`https://studentcode.illinois.edu/article1/part4/1-401/`).

COVID-19

From the University:

> *Following University policy, all students are required to engage in appropriate behavior to protect the health and safety of the community, including wearing a facial covering properly, maintaining social distance (at least 6 feet from others at all times), disinfecting the immediate seating area, and using hand sanitizer. Students are also required to follow the campus COVID-19 testing protocol.*
>
> *Students who feel ill must not come to class. In addition, students who test positive for COVID-19 or have had an exposure that requires testing and/or quarantine must not attend*

class. The University will provide information to the instructor, in a manner that complies with privacy laws, about students in these latter categories. These students are judged to have excused absences for the class period and should contact the instructor via email about making up the work.

Students who fail to abide by these rules will first be asked to comply; if they refuse, they will be required to leave the classroom immediately. If a student is asked to leave the classroom, the non-compliant student will be judged to have an unexcused absence and reported to the Office for Student Conflict Resolution for disciplinary action. Accumulation of non-compliance complaints against a student may result in dismissal from the University.

Diminished mental health, including significant stress, mood changes, excessive worry, substance/alcohol abuse, or problems with eating and/or sleeping can interfere with optimal academic performance, social development, and emotional wellbeing. The University of Illinois offers a variety of confidential services including individual and group counseling, crisis intervention, psychiatric services, and specialized screenings at no additional cost. If you or someone you know experiences any of the above mental health concerns, it is strongly encouraged to contact or visit any of the UniversityâĂŹs resources provided below. Getting help is a smart and courageous thing to do – for yourself and for those who care about you.

Counseling Center: 217-333-3704, 610 East John Street Champaign, IL 61820

McKinley Health Center:217-333-2700, 1109 South Lincoln Avenue, Urbana, Illinois 61801