SYLLABUS: ALGORITHMIC ECONOMICS
ECON C147 – CS C177

INSTRUCTOR: FEDERICO ECHENIQUE

The class provides an introduction to algorithmic questions in economic design. The class will cover problems of public goods and social choice, as well as allocative questions and private consumption. The focus is on normative questions: From the perspective of social goals, these are efficiency, fairness, and equity. In terms of private goals, the focus is on revenue maximization. The course will cover voting, fair division, pricing, auctions, and market mechanisms. There is an emphasis on the algorithmic questions that arise naturally in economic design.

Learning objectives.

- Understand the most important objectives that guide normative studies in microeconomics.
- Acquire a familiarity with the tools of microeconomics that guide modern economic design.
- Identify incentive issues, and develop a working knowledge of mechanism design.
- Recognize the computational constraints that arise in market design, and identify the common sources of computational complexity in economic environments.

Prerequisites.

The class has no prerequisites; the content of the class is, however, formal and mathematical. Students should be comfortable with formal mathematical proofs, and will be expected to write proofs on their own.

Grading.

There will be bi-weekly problem sets, which students can work on in groups of at most five students, a midterm, and a final exam. There will be at least one week between when a problem set is released and it is due. The homework counts for 30% of a student's grade. The midterm and exam count for 35% each. Homework turned in d days late will count for $(2/3)^d$ of its worth if turned in on time.

DSP accommodations.

Information about the university's Disabled Students' Program may be found on the DSP website:

`https://dsp.berkeley.edu/`

The program can provide support, and a letter for the instructor detailing the accommodations that are needed. Please reach out to the instructor if you have any questions.

Attendance.

The class meets weekly for in-person lectures. Attendance is not mandatory, but students are expected to attend all classes, and should make sure to obtain notes from any lectures that they have to miss. Attendance to discussion sections is equally important, but not mandatory.

Course content.

(1) Introduction to algorithmic economics: Efficiency in discrete allocation and serial dictarship. Fairness and cake-cutting.
(2) Voting and social choice problems. Arrow's theorem. Domain restrictions and how to avoid the conclusions of Arrow's theorem. An application to facility location problems and participatory budgeting.
(3) Social objectives: Efficiency. Quasilinear environments. Vickrey-Groves-Clark mechanisms. The computational complexity of welfare maximization.
(4) Social objectives: Equity and fairness in allocation problems. The competitive equilibrium from equal incomes. Algorithmic issues in market equilibrium.
(5) Fair division and cake cutting. Equitable division of indivisible objects.
(6) Fairness in classification. Fair machine learning.
(7) Revenue maximization: Optimal auctions. Case study: Ad-auctions for internet companies. The generalized second-price auction.
(8) Computational complexity of combinatorial auctions. Case study: airport slots.
(9) Market design and centralized labor markets. Case study: Justified envy and school choice.
(10) Random allocation problems. Ordinal efficiency and its conflicts with incentive compatibility.

(11) Communication complexity in economic mechanisms.

Readings.

The course will be based on the lectures prepared by the instructor, but with assigned readings from the following sources.

- Federico Echenique, Nicole Immorlica, and Vijay Vazirani *Online Matching-based Market Design* Cambridge University Press 2023.
- Jason Hartline *Mechanism design and approximation.* Book draft, 2023.
- Tim Roughgarden *Twenty lectures on on algorithmic game theory* Cambridge University Press, 2016.
- Nisan, Noam, Tim Roughgarden, Eva Tardos, and Vijay V. Vazirani, eds. *Algorithmic game theory.* Cambridge University Press, 2007.