Syllabus for Economics 122: Game Theory

SPRING 2024

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Classes: Tuesday and Thursday 9:00-10:20 am GIEDT 1003
Office hours: Wednesday, 10:30am-12:00pm and 1:00-2:30pm

First Midterm exam:	Thursday, April 25
Second Midterm exam:	Thursday, May 23
Final Exam [comprehensive]**:**	Monday, June 10, 6:00-8:00 pm

W A R N I N G : **(1)** You are expected to be familiar with the UC Davis Code of Academic Conduct (http://sja.ucdavis.edu/files/cac.pdf). Any suspected violation will be reported to the office of Student Support and Judicial Affairs. If you are found by SSJA to have cheated on an exam, you will receive an "F" in my entire course. If you are found to have cheated on assignments worth at least 2% of your course grade, you will receive one whole letter grade less than your final course score would have indicated.
(2) This is a conceptually demanding class. To earn a passing grade you need to work hard: **at least 9 hours of home study per week** (the Carnegie Rule does apply to this class). If you are not prepared to devote a lot of time and effort to this class you are strongly advised not to enroll in it.

***Prerequisites*:** Math 16A and 16B or 17A-17B or 21A-21B. If you have an aversion to, or difficulties with, abstract reasoning this course is **not** for you. To be successful in this course you need to be able to think logically and to have an inclination for mathematical reasoning.

Textbook (required): *Game Theory* by Giacomo Bonanno, 2018 (the pdf version is available for free, the printed version is available from Amazon.com in two volumes, Volume 1 for $18, Volume 2 for $22; see: http://faculty.econ.ucdavis.edu/faculty/bonanno/GT_Book.html). The textbook includes approximately 200 exercises with complete and detailed answers. It is essential that you go through the exercises associated with the sections of the book covered in class. Exam questions will be similar in format to the exercises in the book.

Web Page: http://www.econ.ucdavis.edu/faculty/bonanno/teaching/122/ On the web page you will find, homework problems, past exams with answers, additional lecture notes, additional practice problems etc.

Class participation and individual study: It is essential that you keep up with the lectures. Game theory cannot be learned in one week before an exam.

Homework. There are **6 Homework Problems**, *which can be downloaded from the web page*. For each problem set the due date is given on the web page. You should upload your answers in Canvas. Homework will be graded as follows: 50% of the questions will be picked randomly (the same for all students) and only those questions will be graded, as follows. Not submitted: 0 points. Fails to understand basic concepts: 1 point. Understands basic concepts but makes several mistakes: 2 points. Good (some mistakes, but no serious ones): 3 points. Very Good (essentially no mistakes): 4 points.

Exams and Grades: there will be **two** midterm exams and one (comprehensive) final exam. The dates of the exams are given above. Your overall class grade will be based on your performance in the homework and in the four exams with the following weights: 10% on the Homework (scaled to 100), 25% on each midterm and 40% on the Final. **I do NOT grade "on the curve"** (see below). For example, suppose that your scores are: (1) Homework 20 (out of 24), (2) First Midterm 72 (out of 100), (3) Second Midterm 68 (out of 100), (3) Final 82 (out of 100). Then your class score is $0.1 \cdot \frac{20}{24} \cdot 100 + 0.25 \cdot 72 + 0.25 \cdot 68 + 0.4 \cdot 82 = 76.1333$: which corresponds to a grade of B– (see below).

IMPORTANT RULES CONCERNING THIS COURSE. **No exceptions will be made**

(1) **You are expected to take all the exams (midterms and final).** If you miss one of the midterm exams for a documented medical reason, the weight of that exam will be transferred to the final (thus the final will have a weight of 65%). **If you miss two midterms or the final you will not pass this class.** At best you will get a grade of "Incomplete"; note that an Incomplete can only be given when there are documented medical reasons and when the work submitted up to that point is of "**passing quality"** (which will be taken to mean "**C– or better**"). In order to have a justified absence from an exam **you need to inform me before the scheduled time of the exam and you need to produce a medical certificate.**

(2) **Nobody will be allowed to take early examinations or later ones.** The dates of the midterms and final for this course are given on page 1.

(3) **I do NOT grade "on the curve".** I believe that your grade should reflect entirely what *you* have learned. Grades will be determined according to the scale below. Thus, in principle, everybody in the class could end up with an A. In the past the mean of each exam has been in the range 65-75.

score	100-98	97-93	92-88	87-83	82-78	77-73	72-68	67-63	62-58	57-53	52-48	47-43	42-0
grade	A+	A	A–	B+	B	B–	C+	C	C–	D+	D	D–	F

(4) **What method should I use to study?** Typically this is a question that I am asked a week or so before the final by students who are failing the class. Thus not a serious question! If, on the other hand, this is a serious question that you are asking **at the beginning of the Quarter**, then here is the answer. **(1)** You should come to class every time. **(2)** Each week (even better: after every class) you should review the notes you took that week, read the relevant chapter in the textbook and then try the relevant practice problems (exercises) in the textbook. It is **essential** that you go through the exercises in order to be well prepared for the exams. Exam questions will be somewhat similar to the exercises in the textbook and the homework. As you try the exercises, it is imperative that you do not look at the answers until you are confident that you have fully answered the question. If you look at the answers in order to get a clue, you are making a BIG mistake! If you get stuck, try to uncover the reason why you are stuck, do **not** look at the answers. Most likely, either you have forgotten an important definition or you have not studied the textbook and your notes carefully. **(3)** Spend at least 9 hours a week studying for this class.

PLEASE NOTE ALSO THE FOLLOWING:

(a) ACADEMIC DISHONESTY POLICY. In order to protect the integrity of a UC Davis degree and reward the sincere efforts of my students, academic dishonesty of any kind will not be tolerated. This includes using cell phones or notes on exams, copying or looking at another student's exam during the exam period, talking during exams or turning in work that was not originally generated by you and only you. I expect strict adherence to the Code of Academic Conduct at all times. Be sure you read it and understand it at http://sja.ucdavis.edu/cac.html. My policy is to refer all violations of the Academic Code to Student Support and Judicial Affairs for discipline and impose the strictest sanctions.

(b) The purpose of my and the TA's office hours is to *complement* classes and your individual study. When you come with a question you are expected to have spent some time thinking about it and to **have made some effort**. *At the very least* you must have read the relevant chapter in the book.

(c) *The only reason accepted by the Administration for a grade change is a mistake ("clerical error") in grading.* I am not allowed to make any other changes (e.g. to change a C into a D so that you can take the class again). So please don't ask me to do what I cannot do.

(d) "Dear Professor Bonanno, I am very concerned about my grade in 122 ….". Do you know how many messages like this I get a week or two before the Final? *Please take responsibility for your performance in the midterms.*

A special message to **graduating seniors**: do not come to me after the Final pleading for a C (or a B or whatever) on the grounds that this is your last class and if you don't pass it you will have to re-register for one more Quarter and you cannot afford that, and your lease is expiring, and you have a job but you will lose it if you don't start immediately, and your family will kill you and your spouse-to-be will call off the wedding and ... You know **now** that this is your last class, so start studying **now**!

General description of the course

There has been growing recognition that game theory is a crucial tool for understanding the modern business world. In **1994** the **Nobel prize** in economics was given to three game theorists: John Nash, John Harsanyi and Reinhardt Selten for their theoretical work in game theory which had a major impact on the development of several branches of economics (e.g. Industrial Organization, International Trade, Labor Economics, Macroeconomics, etc.). At the same time, the Federal Communications Commission was using game theory to help it design a $7-billion auction of the radio spectrum for personal communication services (naturally, the bidders used game theory too!). In **2005** the **Nobel prize** in economics was again given to two game theorists: Robert Aumann and Thomas Schelling. In **2007** the **Nobel Prize** was given to three game theorists: Leonid Hurwicz, Eric Maskin and Roger Myerson for their contributions to mechanism design. In **2012** the **Nobel Prize** was given to two game theorists: Lloyd Shapley and Alvin Roth for their work on matching. Once again, in **2020** the **Nobel Prize** was given to two game theorists: Paul Milgrom and Robert Wilson for their work on auctions.

Game Theory explains the behavior of rational individuals with interacting (often conflicting) interests. The subject was pioneered early this century by mathematicians Zermelo (1912) and von Neumann (1928). The breakthrough came with von Neumann and Morgenstern's book, *Theory of Games and Economic Behavior* (1944). This was followed by important work by Nash (1950-51) and Shapley (1953). It was originally thought that Game Theory would quickly solve all the problems in economics. However, the initial enthusiasm was followed by disappointment. One reason was the early focus on zero-sum games; these games are not very frequent in economics. Another reason was the assumption that players have complete information; also this is unusual in economic applications. A third reason was that, in classical game theory, the game was supposed to be played once; but in economics there is often repeated interaction. These flaws, however, were corrected in the 1960s and 1970s, a period during which Game Theory became extremely popular with economic theorists. Most importantly, Harsanyi developed a theory of games with incomplete information. Harsanyi's theory has become one of the most widely used tools in economics. In the last four decades Game Theory has also been important for the development of other fields, such as Political Science, International Relations, Sociology and Biology.

Game Theory is divided into two main branches. The first is *cooperative* Game Theory, which assumes that players can communicate, form coalitions, and sign binding agreements. It can be used to analyze voting behavior and other issues in Political Science and related fields. However, it turns out to be less important for economics. We will cover only a small portion of Cooperative Game Theory in this course (the core and the Shapley value). Most of the course is devoted to the other main branch, *non-cooperative* Game Theory. This is where we assume that the players *cannot* sign binding contracts. This theory is particularly useful for the study of imperfect competition (firms are forbidden to collude by antitrust laws).

While the emphasis will be on theoretical and conceptual aspects of Game Theory, we will also discuss a number of applications (mainly to economics, but also to political science).

List of topics and required reading.

1. Examples of games. Definition of strategic-form game. Definition of dominant strategy. Dominant strategy equilibrium Vickrey's second-price auction. The pivotal mechanism for truthful revelation of preferences. Iterative elimination of dominated strategies. Nash equilibrium.
Reading: Chapter 2 of textbook.

2. Definition of extensive-form game with perfect information. Examples. Backward induction. Selten's chain-store paradox. Strategies in perfect information games. Nash equilibrium versus backward induction.
Reading: Chapter 3 of textbook.

3. Extensive games with imperfect information. Strategies. Nash equilibrium versus subgame-perfect equilibrium.
Reading: Chapter 4 of textbook.

4-6. Expected utility theory. Reduced-form strategic games. Mixed strategies. Computation of mixed-strategy equilibria. Behavioral strategies in extensive games.
Reading: Chapters 5, 6 and 7 of textbook.

7-8. Knowledge and common knowledge. Probabilistic beliefs. Updating beliefs: Bayesian updating.
Reading: Chapter 8 and Sections 9.1 and 9.2 of Chapter 8 of textbook.

10. Weak sequential equilibrium.
Reading: Chapter 11 of textbook.

13. Static games of incomplete information. Bayesian-Nash equilibrium.
Reading: Chapter 14 of textbook.

14. Dynamic games of incomplete information.
Reading: Chapter 15 of textbook.

Additional Topic (may or may not be covered). Cooperative games: the core, the Shapley value.
Reading: the following files from the web page: Core.pdf, Shapley.pdf.