Math 5750/6880 Game Theory - Fall 2020

Tu Th 12:25 PM - 01:45 PM
Instructor: Professor Elena Cherkaev
Email: elena@math.utah.edu
Location: Canvas
Zoom Handle: https://utah.zoom.us/j/94911452179
Office hour: Th 2-3 pm or by appointment
Homepage: http://www.math.utah.edu/~elena
When you are sending me an email please include ’5750’ in the subject line.

Mathematics is the Queen that rules the Universe

Text: E.N. Barron, Game theory: Introduction
The textbook can be read online or downloaded from the Marriott library.

Additional course materials: Thomas S. Ferguson, Game Theory, 2014
https://www.math.ucla.edu/~tom/Game_Theory/Contents.html
M.J. Osborne, An Introduction to Game Theory, 2002
H. Kuhn, Lectures on the Theory of Games, 2003
G. Owen, Game theory, 1982
Lecture Notes will be posted online.

Accessibility & Support: Please contact me via email and by Zoom
during office hour, after every class meeting, or by appointment.

Attendance I know that online learning could be unfamiliar, challenging,
and stressful. However, teleconferences are and will remain norms in today’s
professional world; we need to be ready.
- Online attendance is strongly encouraged. A part of the grade is based on
  in-class discussions.
- Please keep the cameras on during the class to communicate, see, and be
  seen by your classmates and instructor.

COVID-19 Considerations: Students must self-report if they test pos-
**Technical requirements**  Students are expected to be computer literate, and know how to use Canvas and Zoom. The Marriott library is loaning laptops to students who do not have a laptop: https://lib.utah.edu/coronavirus/checkout-equipment.php There is also information about wifi on that website. Because of live Zoom sessions, a reliable internet connection, and adequate bandwidth are needed. For technical assistance, review the Canvas Getting Started Guide for Students or contact TLT, Knowledge Commons, etc.

**Description**

**Content overview**  Conflicts are absolutely unavoidable in every aspect of our life and and their rational resolution and making an optimal decision is critical in every action when one needs to make a choice. Mathematical theory of games is a theory of modeling conflicts between different players (or parties, or agents) and methods of constructing optimal solutions (or making good decisions). Applications are numerous, we will discuss mathematical formulations and solutions of games or conflict problems arising in economics, politics, computer science, social and behavioral sciences.

The course gives an overview of ideas, models, and methods in the mathematical game theory that studies conflicts and interactions among independent agents or players. The class covers two-person and n-person games and methods of constructing their solutions. We will discuss the von Neumann minimax theorem and talk about various methods of finding saddle point solution in pure and mixed strategies. We will discuss Linear Programming (LP) method which solves a large class of optimization problems with linear equality and/or inequality constraints and is one of powerful methods of solution of matrix games and minmax optimization problems. We will also talk about Nash equilibrium and NonLinear Programming (NLP) method which can be used to find Nash equilibria. We will discuss n-person cooperative games and different ways to determine imputations or allocations. We will discuss a wide variety of examples illustrating the theory and modeling conflict problems arising in various applications.

**Course objectives and expected learning outcome**

The course gives an overview of ideas, models, and methods in the mathematical game theory. Upon successful completion of the course, a student should be able to:
- Understand, utilize, and manipulate basic concepts of game theory
- Understand theory of saddle point solution, and solution in pure and mixed strategies
- Learn algorithms for finding solutions of two-person games
- Learn Linear Programming (LP) method of solution of optimization problems with linear equality and/or inequality constraints
- Have a basic understanding of the concept of Nash equilibrium
- Learn efficient methods of constructing solution of matrix games
- Understand basic principles of modeling and solving cooperative games

Course design  The course consists of lectures, discussions, homework and project. Instructor’s online lectures will be delivered via Zoom and video conferencing on Canvas during class times. The lecture notes will be available on Canvas after the lecture.

Assignments, Assessment, and Grading  The homework will be assigned and expected to be done. There will be a midterm and final exams and a project. The grade is an average of the scores earned.

The syllabus may be changed  This syllabus is meant to serve as an outline and guide for our course. Please note that I may modify it with reasonable notice to you. I may also modify the Course Schedule depending of the needs of our class. Any changes will be announced in class and posted on Canvas.

Important dates
Last day to add without a permission code: Friday, August 28
Last day to add, drop, elect CR/NC, or audit classes: Friday, September 4
Last day to withdraw from classes: Friday, October 16
Classes end: Thursday, December 3

Holidays
Labor Day: Monday, September 7
Thanksgiving Break: Thurs.-Sun., November 26-29
Table 1: Tentative schedule  (Could be adjusted during the semester)

<table>
<thead>
<tr>
<th>No</th>
<th>Date</th>
<th>Subject</th>
<th>Text/pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Aug 24 - 28</td>
<td>Introduction. Two-person zero-sum matrix games. Dominated strategies, pure and mixed strategies.</td>
<td>Ch. 1</td>
</tr>
<tr>
<td>2</td>
<td>Aug 31-Sept 4</td>
<td>Graphical solution. The best mixed strategies. Lower and upper values of the game. Saddle point solution in pure strategies.</td>
<td>13-16</td>
</tr>
<tr>
<td>3</td>
<td>Sept 9 - 11</td>
<td>The von Neumann minimax theorem - Fundamental Theorem for all matrix games.</td>
<td>18-20</td>
</tr>
<tr>
<td>4</td>
<td>Sept 14 - 18</td>
<td>Methods of finding saddle point solution in mixed strategies for two-person zero-sum matrix games.</td>
<td>25-43</td>
</tr>
<tr>
<td>5</td>
<td>Sept 21 - 25</td>
<td>Graphical method of solution. The best response strategy (the strategy of the opponent is known).</td>
<td>45-48</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Solution methods for matrix games</td>
<td>Ch. 2</td>
</tr>
<tr>
<td>7</td>
<td>Oct 5 - 9</td>
<td>Matrix games and Linear Programming (LP) method</td>
<td>82-101</td>
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<td></td>
<td></td>
<td>Two-person nonzero sum games</td>
<td>Ch. 3</td>
</tr>
<tr>
<td>8</td>
<td>Oct 12 - 16</td>
<td>Nash equilibrium in nonzero sum games. Individual rationality, guaranteed payoffs, rational reaction sets.</td>
<td>118-129</td>
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<tr>
<td>9</td>
<td>Oct 19 - 23</td>
<td>Nash equilibrium in bimatrix games and methods of its computation. Rational reaction sets. Generalizations to n-dimensional case.</td>
<td>128-143</td>
</tr>
<tr>
<td>10</td>
<td>Oct 26 - 30</td>
<td>Nash equilibrium strategies in completely mixed nonzero-sum games. NonLinear Programming (NLP) method.</td>
<td>148-156</td>
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<td></td>
<td></td>
<td>N-person nonzero sum games and games with a continuum of strategies</td>
<td>Ch. 5</td>
</tr>
<tr>
<td>11</td>
<td>Nov 2 - 6</td>
<td>N-person nonzero sum games with a continuum of strategies.</td>
<td>Ch. 5</td>
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<td></td>
<td></td>
<td>N-person cooperative games</td>
<td>Ch. 6</td>
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<tr>
<td>13</td>
<td>Nov 16 - 20</td>
<td>A characteristic function, imputations, allocations. Domination. The core of undominated allocations.</td>
<td>288-310</td>
</tr>
<tr>
<td>14</td>
<td>Nov 23 - 25</td>
<td>The Shapley value. Voting systems.</td>
<td>335-347</td>
</tr>
<tr>
<td>15</td>
<td>Dec 1 - 3</td>
<td>Reserved</td>
<td></td>
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</tbody>
</table>
Course Policies

Late Assignments  I will be flexible where possible/appropriate. Please remember, however, that submitting a late assignment means that you are getting behind the class and it might be a signal that you need to put an effort to get on schedule.

Incomplete  According to university policy, to be considered for an incomplete, a student must have 20% or less of the course work remaining and be passing the course with a C or better. You must request an incomplete grade (and I will consider giving that grade) under exceptional circumstances.

Plagiarism  Plagiarism is unacceptable and results in F grade.

University of Utah policies

Discrimination and Harassment  If you or someone you know has been harassed or assaulted, you are encouraged to report it to the Title IX Coordinator in the Office of Equal Opportunity and Affirmative Action, 135 Park Building, 801-581-8365, or Office of the Dean of Students, 270 Union Building, 801-581-7066. To report to the police, contact the Department of Public Safety, 801-585-2677(COPS). Please see Student Bill of Rights, section E http://regulations.utah.edu/academics/6-400.php.

Names/Pronouns  Canvas allows students to change the name that is displayed AND allows them to add their pronouns to their Canvas name. Class rosters are provided to the instructor with the student’s legal name as well as "Preferred first name" (if previously entered by you in the Student Profile section of your CIS account, which managed can be managed at any time). While CIS refers to this as merely a preference, I will honor you by referring to you with the name and pronoun that feels best for you in class or on assignments. Please advise me of any name or pronoun changes so I can help create a learning environment in which you, your name, and your pronoun are respected. If you need any assistance or support, please reach out to the LGBT Resource Center. https://lgbt.utah.edu/campus/faculty_resources.php

English Language Learners  If you are an English language learner, please be aware of several resources on campus that will support you with
your language and writing development. These resources include: the Writing Center (http://writingcenter.utah.edu/); the Writing Program (http://writing-program.utah.edu/); the English Language Institute (http://continue.utah.edu/eli/). Please let me know if there is any additional support you would like to discuss for this class.

**Undocumented Student Support**  Immigration is a complex phenomenon with broad impact to those who are directly affected by it, as well as those who are indirectly affected by their relationships with family members, friends, and loved ones. If your immigration status presents obstacles to engaging in specific activities or fulfilling specific course criteria, confidential arrangements may be requested from the Dream Center. Arrangements with the Dream Center will not jeopardize your student status, your financial aid, or any other part of your residence. The Dream Center offers a wide range of resources to support undocumented students (with and without DACA) as well as students from mixed-status families. To learn more, please contact the Dream Center at 801.213.3697 or visit dream.utah.edu.

**Veterans Center**  If you are a student veteran, the U of Utah has a Veterans Support Center located in Room 161 in the Olpin Union Building. Hours: M-F 8-5 pm. Please visit their website for more information about what support they offer, a list of ongoing events and links to outside resources: http://veteranscenter.utah.edu/. Please also let me know if you need any additional support in this class for any reason.

**Wellness Statement**  Personal concerns such as stress, anxiety, relationship difficulties, depression, cross-cultural differences, etc., can interfere with a student’s ability to succeed and thrive at the University of Utah. For helpful resources, contact the Center for Student Wellness at www.wellness.utah.edu or 801-581-7776.

**Student Success Advocates**  The mission of Student Success Advocates is to support students in making the most of their University of Utah experience (ssa.utah.edu). They can assist with mentoring, resources, etc. Any student who faces challenges securing their food or housing and believes this may affect their performance in the course is urged to contact a Student Success Advocate for support (https://asuu.utah.edu/displaced-students).
The Americans with Disabilities Act  The University of Utah seeks to provide equal access to its programs, services and activities for people with disabilities. If you will need accommodations in the class, reasonable prior notice needs to be given to the Center for Disability & Access, 162 Olpin Union Building, 801-581-5020. CDA will work with you and the instructor to make arrangements for accommodations. All written information in this course can be made available in alternative format with prior notification to the Center for Disability & Access.

Addressing Sexual Misconduct  Title IX makes it clear that violence and harassment based on sex and gender (which includes sexual orientation and gender identity/expression) is a Civil Rights offense subject to the same kinds of accountability and the same kinds of support applied to offenses against other protected categories such as race, national origin, color, religion, age, status as a person with a disability, veteran status or genetic information. If you or someone you know has been harassed or assaulted on the basis of your sex, including sexual orientation or gender identity/expression, you are encouraged to report it to the University’s Title IX Coordinator; Director, Office of Equal Opportunity and Affirmative Action, 135 Park Building, 801-581-8365, or to the Office of the Dean of Students, 270 Union Building, 801-581-7066. For support and confidential consultation, contact the Center for Student Wellness, 426 SSB, 801-581-7776. To report to police, contact the Department of Public Safety, 801-585-2677(COPS).

Campus Safety  The University of Utah values the safety of all campus community members. To report suspicious activity or to request a courtesy escort, call campus police at 801-585-COPS (801-585-2677). You will receive important emergency alerts and safety messages regarding campus safety via text message. For more information regarding safety and to view available training resources, including helpful videos, visit safeu.utah.edu

University Counseling Center  The University Counseling Center (UCC) provides developmental, preventive, and therapeutic services and programs that promote the intellectual, emotional, cultural, and social development of the University of Utah students. They advocate a philosophy of acceptance, compassion, and support for those they serve and each other. They aspire to respect cultural, individual and role differences as they continually work toward creating a safe and affirming climate for individuals of all ages, cultures, ethnicities, genders, gender identities, languages, mental and phys-
ical abilities, national origins, races, religions, sexual orientations, sizes, and socioeconomic statuses.

Office of the Dean of Students  The Office of the Dean of Students is dedicated to being a resource to students through support, advocacy, involvement, and accountability. It serves as a support for students facing challenges to their success as students and assists with the interpretation of University policy and regulations. Please consider reaching out to the Office of Dean of Students for any questions, issues and concerns. 200 South Central Campus Dr., Suite 270. Monday-Friday 8 am-5 pm, https://deanofstudents.utah.edu.