**THE CHINESE UNIVERSITY OF HONG KONG**
**Department of Mathematics**
**UGEB2530C Games and Strategic Thinking**
**2024-2025 Term 2**

## Introduction

From the simple "rock, paper, scissors" game to complex buy-and-sell financial decisions, we encounter many games in our everyday lives. While you are trying to figure out what your opponents are doing, they are also trying to figure out what you are doing. To maximize your outcome, you may want to cooperate or compete with all or some of them. Game theory is a way to analyze what rational people like you and I should do under these circumstances, and what the expected outcome will be if optimal strategies are followed.

This course aims to provide students with a non-technical exploration of game theory. A mathematical background including addition, subtraction, and multiplication is required. We may need to do a few divisions somewhere in the course. All required mathematical materials will be covered at the beginning of the course.

We will start with very simple parlor games and then move on to more realistic problems in economics, social psychology, biology, and business, where optimal strategies that are against intuition will be epitomized. Many movies relate to game theory, for example, "Sophie's Choice" and "The Dark Knight". In particular, the celebrated "Nash equilibrium" glossed over by Russell Crowe in the movie "A Beautiful Mind" will be explained in full detail in simple mathematical terms.

We will also create a few interactive and interesting games. For the descriptions, regulations, and highlights of each game demo, please click the links below:

Different Games

Try them and have fun!

## Instructor


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## Assessment

- Homework Assignments = 15%
- In-class Activities, e.g., exercises/games = 10%

  There are thirteen in-class activities. We will take the best ten scores out of these thirteen activities.
- Mid-term exam = 30%

  Monday, 10 March 2025, 19:00 PM - 21:00 PM
- Final exam = 45%

  The date and venue of the final examination will be arranged centrally by the Registration and Examinations Section in the Registry.

### Homework Submission and Late submission policy

There will be three graded homework assignments. Please note that you MUST complete each homework assignment entirely by yourself. In case of difficulty, you may consult the lecturer and the teaching assistants during their office hours. Any answers that show evidence of collaboration with others will receive a score of zero; stronger action may also be taken. Do not copy the work of others! Be neat, concise, and well-organized. Late homework submissions will NOT be graded and will receive a score of zero.

### Midterm and Final Examination Policy

Please refer to the "Policy on Missed Midterm and Final Examinations" PDF file.

No reassessment or supplementary examination should be provided in any GE course if the student fails the final examination or is absent from any examination without permission.

## Teaching Schedule

All teaching materials will be found in CUHK Blackboard

Please be aware that the content discussed here should not be considered a replacement for the lectures. The lectures may present the material covered in the text differently or deviate from it completely. It's important for you to take your own notes during class.

- Week 1: Introduction Game Theory
  Examples of games in daily life, simultaneous non-cooperative two-player games, chicken game, normal form, Nash equilibria for pure strategies

- Week 2: Matrices and Probability
  Arithmetic of matrices, random variables, expected values

- Week 3-5: Zero-sum Games
  Zero sum game, minimax theorem, value of games, graphical method, applications of zero sum games.

- Week 6-8: Bimatrix Games
  Nash equilibrium, prudential strategies, security level, Pareto optimality.

- Week 9-10: Games in Extensive Form

- Week 11-12: Cooperative Games
  Threat strategies, threat differential, coalitions, characteristic function, superadditive, Shapley value

- Week 13: Voting Games
  Social choice, apportionment

## References

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   - Philip D. Straffin: Game Theory and Strategy, Mathematical Association of America, 1993
   - Peter Morris: Introduction to game theory, Springer-Verlag, 1994
   - Michael Maschler, Eilon Solan, Shmuel Zamir: Game theory; translated from Hebrew by Ziv Hellman ; English editor, Mike Borns Zamir, Shmuel Cambridge: Cambridge University Press 2013
   - Martin J. Osborne: An introduction to game theory, 2003.
     http://www.economics.utoronto.ca/osborne/igt/index.html
   - Avinash K. Dixit and Susan Skeath: Games of Strategy, 2004
   - Roy Gardner, Hoboken, NJ: Games for business and economics, c2003
   - Ken Binmore: Fun and Games - A Text on Game Theory, 1992.
2. Game Theory and Economy
   - Bierman, H. Scott, Fernandez, Luis: Game theory with economic applications, Addison-Wesley Pub. Co. c1993
   - Baye, Michael R.: Managerial economics and business strategy, New York: McGraw-Hill c2010
   - Aumann, Robert J., and Hart, Sergiu: Handbook of game theory with economic applications, Amsterdam: North-Holland
   - Meunier, Franc and Carre, James: Game theory: economics, theoretical concepts, and finance applications, New York: Novinka 2013

- Montet, Christian: Game theory and economics, Basingstoke, Hampshire; New York: Palgrave Macmillan 2003
- Webster, Thomas J: Introduction to game theory in business and economics, Armonk, N.Y.: M.E. Sharpe c2009

3. Other Applications

- Dufwenberg, Martin: Game Theory, Wiley Interdisciplinary Reviews: Cognitive Science, March 2011, Vol.2(2), pp. 167-173
- Bramer, M.A.: Computer game-playing: theory and practice, Chichester: Horwood New York: Wiley
- Leyton-Brown, Kevin and Shoham, Yoav: Essentials of Game Theory: A Concise, Multidisciplinary Introduction
- Griffin, Peter A: The theory of blackjack: the complete card counter's guide to the casino game of 21, Las Vegas, Nev.: Huntington Press 1999
- McMillan, John: Games, Strategies, and Managers, Oxford University Press
- Heiko Hotz: A Short Introduction to Game Theory https://www.theorie.physik.uni-muenchen.de/lsfrey/teaching/archiv/sose_06/softmatter/talks/Heiko_Hotz-Spieltheorie-Handout.pdf
- Gates, Scott, and Humes, Brian D.: Games, information, and politics: applying game theoretic models to political science, the University of Michigan Press c1997

4. Articles

- How to beat the Prisoner's Dilemma in the TV game show Golden Balls https://mindyourdecisions.com/blog/2012/04/24/how-to-beat-the-prisoners-dilemma-in-the-tv-game-show-golden-balls/
- Why do competitors open their stores next to one another? https://www.youtube.com/watch?v=jILgxeNBK_8
- Oxenham, Simon: Why Politicians All Seem The Same, Gas Stations Come In Pairs and Twitter is Turning Into Facebook https://bigthink.com/neurobonkers/why-politicians-are-all-the-same-gas-stations-come-in-pairs-and-twitter-is-becoming-facebook
- G. Kolata: What if They Closed 42d Street and Nobody Noticed? http://www.nytimes.com/1990/12/25/health/what-if-they-closed-42d-street-and-nobody-noticed.html
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- Friedman Daniel: On economic applications of evolutionary game theory, Journal of Evolutionary Economics, Springer-Verlag 1998
- The Iterated Prisoner's Dilemma and The Evolution of Cooperation https://www.youtube.com/watch?v=BOvAbjfJ0x0
- Bhuiyan, Bellal Ahmed: An overview of game theory and some application, Philosophy and Progress 2016
- Billingham, John: Bluffing and exploitation: An introduction to poker maths https://plus.maths.org/content/bluffing-and-exploitation-introduction-poker-maths

- Lucas Husted: Game theory challenge: Can you predict human behavior? https://www.ted.com/talks/lucas_husted_game_theory_challenge_can_you_predict_human_behavior
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- Willner-Giwerc, Max: Game Theory and Disarmament: Thinking Beyond the Table https://www.e-ir.info/2018/12/18/game-theory-and-disarmament-thinking-beyond-the-table/
- Fosner, Ajda: Economics and Mathematical Theory of Games http://www.fm-kp.si/zalozba/ISSN/1581-6311/10_245-256.pdf

## Learning outcomes

After the course, students will be able to:

- understand the basic notions, e.g. non-cooperative games, prisoner dilemma, Nash equilibrium, and principles of game theory.
- solve problems in game theory, e.g. zero sum games, minimax problems, cooperative game
- apply game theory to daily life problems.

| Grades | Descriptors |
|---|---|
| A | Demonstrates well integrated knowledge and a deep understanding of the basics of game theory and strategic thinking; able to completely solve unfamiliar and nonstandard problems, provide innovative approaches to challenging ones, and apply knowledge and skills to new and unfamiliar real life problems with strong and convincing explanations. |
| A- | Demonstrates good knowledge and a strong understanding of the basics of game theory and strategic thinking; able to provide highly accurate solutions to unfamiliar and nonstandard problems and apply knowledge and skills to new and unfamiliar real life problems with good explanations. |
| B | Demonstrates essential knowledge and a good understanding of the basics of game theory and strategic thinking; able to provide solutions to unfamiliar but standard problems, and apply knowledge and skills to standard real life problems with adequate explanations. |
| C | Demonstrates satisfactory knowledge and an understanding, perhaps with gaps, of the basics of game theory and strategic thinking; able to solve slight variations of routine problems and apply knowledge and skills to standard real life problems. |
| D | Demonstrates disconnected knowledge and only a limited understanding of the basics of game theory and strategic thinking, provides sketchy arguments with barely rigorous logic and can apply knowledge and skills to only simple and standard real life problems. |
| Fail | Unable to demonstrate sufficient knowledge and understanding of the basics of game theory and strategic thinking, unable to solve the simplest type of problems and shows little ability to apply knowledge to simple real life problems. |