

COURSE OUTLINE: MH4320

Course Title	Computational Economics		
Course Code	MH4320		
Offered	Study Year 4, Semester 1		
Course Coordinator	Bei Xiaohui (Asst Prof)	xhbei@ntu.edu.sg	6513 8655
Pre-requisites	{MH1200, MH2500} OR {MH2500, MH2802}		
AU	4		
Contact hours	Lectures: 39, Tutorials: 12		
For delivery from	AY 2023/24 semester 1		
Last revised	5 June 2023		

Course Aims

This course aims to introduce you to the fundamental concepts of game theory and mechanism design. Game theory, besides being of fundamental mathematical interest, is a main tool to model economic and strategic situations and then study the behavior of rational agents in such situations. Mechanism design is the study of how to design games (such as auctions) so that agents have incentive to act in a desirable way, e.g. by telling the truth. This course will improve your ability to model and analyze economics situations in a mathematical way. We will study the way rational agents will play games, based on their assumptions about the rationality of other agents. We will learn about the concept of Nash equilibria, which are solutions to games that no rational agent has an incentive to deviate from, and learn how to compute these.

In the second part of the course we turn to the problem of mechanism design, namely deciding systems for rational and strategic players. We will focus on the case where payments are allowed and players have money-valued preferences, which leads to auction theory and related topics. Students will learn how to design auctions and other economic mechanisms so that players have no incentive to lie, and to learn how to compute expected revenues. Students will also learn how to design economic mechanisms that have certain properties (if possible), and how to judge economic mechanisms, as well as to apply Bayesian reasoning to compute expected outcomes.

The course is aimed at 3rd and 4th year students interested in economics, mathematical modelling, and applied math in general.

Intended Learning Outcomes

Upon successfully completing this course, you should be able to:

1. Model strategic situations as extensive-form and strategic-form games
2. Compute equilibrium strategies for various forms of games
3. Find maxmin strategies for 0-sum games
4. Compute evolutionary stable strategies in evolution games
5. Compute allocation and payments in single-item and multi-item auctions
6. Design incentive-compatible mechanism for welfare-maximizing social choice
7. Evaluate different types of auction methods and their properties, and calculate revenues

Course Content

- Strategic-form games and Domination
- Nash Equilibria and Mixed Strategies
- Evolutionary Game Theory
- Maxmin Strategies, Zero-sum Games
- Extensive-Form Games, Zermelo's Theorem
- Subgame-Perfect Equilibrium, Games of Incomplete Information

- Single-Item Auctions, Single-Parameter Environment
- Myerson's Lemma
- VCG Mechanisms and Combinatorial Auctions
- Revenue Equivalence

Assessment

Component	Course ILOs tested	Weighting	Team / Individual	Assessment Rubrics
Continuous Assessment				
Tutorials				
Homework	1, 2, 3, 4, 5, 6, 7	10	team	See Appendix for rubric
Presentation	1, 2, 3, 4, 5, 6, 7	10	team	See Appendix for rubric
Mid-semester Quiz				
Short Answer Questions	1, 2, 3	20	individual	See Appendix for rubric
Examination (2 hours)				
Short Answer Questions	1, 2, 3, 4, 5, 6, 7	60	individual	See Appendix for rubric
Total		100%		

Formative Feedback

You will receive formative feedback through written responses to your homework submissions and verbal feedback through in-class and tutorial discussion. You will receive verbal feedback on your final project presentation. You will receive summative group feedback on the final exam following the conclusion of the module.

Learning and Teaching Approach

Lectures (39 hours)	<p>Derivation and demonstration: Helps you understand the motivation behind the mathematical notions and ideas presented in the course. Presents systematic ways to solve problems.</p> <p>Modeling: Develops your ability to model economic and strategic situations mathematically, and then reason about strategic issues.</p>
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Tutorials (12 hours)	<p>Modeling: Develops your ability to model economic and strategic situations mathematically, and then reason about strategic issues.</p> <p>Problem Solving: Develops your ability to solve a variety of problems in game theory and mechanism design</p>
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Reading and References

M. Maschler, E. Solan, S. Zamir. Game Theory. Cambridge University Press, 2013.
ISBN: 978-1107005488

This book covers many, but not all topics in the course. Optional.

Course Policies and Student Responsibilities

Absence due to medical or other reasons

If you are sick and not able to attend a midterm or missed the deadlines for your assignments, you must:

1. Send an email to the instructor regarding the absence.
2. Submit the original Medical Certificate* to an administrator.

*The Medical Certificate mentioned above should be issued in Singapore by a medical practitioner registered with the Singapore Medical Association.

In this case, the missed assessment component will not be counted towards the final grade. There will be no make-up midterm.

Homework Assignments

You are encouraged to collaborate on the assignments because peer-to-peer learning helps you understand the subject better and working in a team trains you to better communicate with others. There will be 3-4 homework assignments in this course which must be submitted for grading and feedback. These can be done by groups of any size between 1 and 4.

You have to submit group assignments, and hence, do take note of this collaboration policy:

- 1) Every group has to write up and submit one solution
- 2) If a group has used other collaborators, these must be explicitly identified
- 3) If you obtained a solution through research (e.g., on the web), you must acknowledge the source and write up the solution in your own words
- 4) It is a violation of the collaboration policy for you to permit anyone other than the lecturer and group members to see your written solutions. Ideas may be shared, but do not share your written solutions with other students outside your group
- 5) If you have any questions about the collaboration policy please talk to the lecturer.

Academic Integrity

Good academic work depends on honesty and ethical behaviour. The quality of your work as a student relies on adhering to the principles of academic integrity and to the NTU Honour Code, a set of values shared by the whole university community. Truth, Trust and Justice are at the core of NTU's shared values.

As a student, it is important that you recognize your responsibilities in understanding and applying the principles of academic integrity in all the work you do at NTU. Not knowing what is involved in

maintaining academic integrity does not excuse academic dishonesty. You need to actively equip yourself with strategies to avoid all forms of academic dishonesty, including plagiarism, academic fraud, collusion and cheating. If you are uncertain of the definitions of any of these terms, you should go to the [Academic Integrity website](#) for more information. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.

Course Instructors

Instructor	Office Location	Phone	Email
Bei Xiaohui (Asst Prof)	MAS-05-46	6513 8655	xhbei@ntu.edu.sg

Planned Weekly Schedule

Week	Topic	Course ILO	Readings/Activities
1	Strategic-form games and Domination	1	Chapter 1, 4
2	Nash Equilibria and Mixed Strategies	2	Chapter 4, 5
3	Evolutionary Game Theory	1, 2, 4	Chapter 6
4	Maxmin Strategies, Zero-sum Games	1, 2, 3	Chapter 4, 5
5	Extensive-Form Games, Zermelo's Theorem	1, 2	Chapter 3
6	Subgame-Perfect Equilibrium	1, 2	Chapter 3, 7
7	Games of Incomplete Information	1, 2	Chapter 9, 10
8	Single-Item Auctions	5	Chapter 12, Mid-semester Quiz
9	Single-Parameter Environment, Myerson's Lemma	5, 7	Lecture Notes
10	VCG Mechanisms	5, 6	Lecture Notes
11	Combinatorial Auction	5, 6, 7	Chapter 12
12	Revenue Equivalence	5, 7	Chapter 12
13	Review	1-7	Lecture Notes

Appendix 1: Assessment Rubrics

Rubric for Tutorials: Homework (10%)

There are no more than 5 questions for each homework and 20 in total. They assess your ability to:

- 1) Model strategic situations as extensive-form and strategic-form games
- 2) Compute equilibrium strategies for various forms of games
- 3) Find Maxmin strategies for 0-sum games
- 4) Analyze, which properties of social choice functions (such as elections) can be satisfied simultaneously
- 5) Design incentive-compatible mechanism for welfare-maximizing social choice
- 6) Evaluate different types of auction methods and their properties, and calculate revenues
- 7) Compute stable matchings and other allocation problem solution, and understand the player's abilities to manipulate the outcome of such mechanisms

Marks	Criteria
$\geq 90\%$	Solutions to the given questions satisfy the requirements and are within the set of possible correct answers in almost all instances.
75% to 89%	Solutions to the given questions satisfy the requirements and are within the set of possible correct answers in most instances. Some errors exist but they are not
65% to 74%	Solutions to the given questions satisfy the requirements and are within the set of possible correct answers in most instances. Some solutions are not quite correct or do not satisfy some of the requirements. Partial credits are awarded.
50% to 64%	Solutions to the given questions satisfy the requirements and are within the set of possible correct answers in many instances. Some solutions are not quite correct or do not satisfy some of the requirements. Partial credits are awarded. There appear to be major misconceptions for a few topics.
$< 50\%$	Did not attempt most of the questions; OR Solutions to the given problems and questions are incorrect and/or do not satisfy the requirements in most cases. There appear to be major misconceptions for many topics.

In principle, you would receive the same marks as your teammates. However, your score may vary should there be evidence that you did not contribute your part to the homework.

Rubric for Tutorials: Presentation (10%)

Each homework assignment problem will be presented by students in groups at each tutorial. They assess your ability to:

- 1) Explain core economic terms, concepts, and theories.
- 2) Apply oral communication skills within the discipline.

The student will be evaluated in groups based on your performance in the presentation and Q&A session. In principle, you would receive the same marks as your teammates. However, your score may vary should there be evidence that you did not contribute your part to the homework.

Mark	Criteria
>= 90%	Presentation: The presented solutions are correct. The presentation is creative as well as informative. All solution concepts are accurate and appropriately applied. Q&A: Answers to all questions are clear, accurate, and complete with sufficient details to
75% to 89%	Presentation: The presented solutions satisfy the requirements and are correct in most instances. The presentation is somewhat creative. Almost all solution concepts are accurate and appropriately applied. Q&A: Answers to questions are clear and relevant but insufficiently supported with details.
65% to 74%	Presentation: The presented solutions satisfy the requirements and are correct in most instances. The presentation is mostly bullet points with very few other elements. Many solution concepts are accurate and appropriately applied. Q&A: Answers are incomplete and key points are not clear. Short answers were given.
50% to 64%	Presentation: The presented solutions are correct in many cases. The presentation is not very creative, with only bullet points but no pictures, videos, etc. Some solution concepts are accurate according to the description provided, but there are some major inaccuracies or problems with the connections that are made. Q&A: Answers are irrelevant. Questions are not understood.
< 50%	Presentation: Did not give the presentation; OR The presented solutions are incorrect in most cases. The student lacks the competence to apply relevant scientific theories and methods. The presentation has significant deficiencies in terms of form, structure, and language. Q&A: No answer was given.

Rubric for Mid-semester Quiz: Short Answer Questions (20%)

The examination will use point-based marking (not rubrics based).

Rubric for Examination: Short Answer Questions (60%)

The examination will use point-based marking (not rubrics based).