COURSE OUTLINE

<table>
<thead>
<tr>
<th>Academic Year</th>
<th>AY1819</th>
<th>Semester</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Course Coordinator</td>
<td>Hartmut Klauck</td>
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<tr>
<td>Course Code</td>
<td>MH4320</td>
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<tr>
<td>Course Title</td>
<td>Computational Economics</td>
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<tr>
<td>Pre-requisites</td>
<td>MH1200 Linear Algebra I and MH2500 Probability &amp; Introduction to Statistic</td>
<td></td>
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<tr>
<td>No of AUs</td>
<td>4AU</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contact Hours</td>
<td>3 hours lectures, 1 hour tutorial</td>
<td></td>
<td></td>
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<tr>
<td>Proposal Date</td>
<td>18-May-2018</td>
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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 social choice, namely choosing from a set of alternatives, given the preferences of a set of players. We will see that many desirable properties of social choice functions cannot be satisfied, and then turn to ways to deal with this issue. The first way is to introduce payments and money-valued preferences, which leads to auction theory and related topics. Here 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. Secondly, we will consider mechanisms that do not allow payments, and study the ways manipulations by the players can be limited in this case. In the second part of the course students will 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 (ILO)

By the end of the 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

Teaching, Learning and Pedagogy Division
LT19A-B4-01, 50 Nanyang Avenue, Singapore 639798
65923739
TLPD-OBTL@ntu.edu.sg http://www.ntu.edu.sg/tlpd
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

Course Content
1) Extensive-form Games
2) Strategic-form Games
3) Solving Games by
   a) Dominating Strategies
   b) Equilibrium Strategies
   c) Maxmin Strategies
4) Zero-sum Games
5) Subgame-perfect Equilibria
6) Mixed Strategies
7) Computing Mixed Equilibria
8) Nash’s Theorem
9) Social Choice Theory
10) Arrow’s Theorem
11) Auctions
12) VCG-Mechanisms
13) Games of Incomplete Information and Bayesian Equilibria
14) Revenue Equivalence
15) Mechanisms without Money
    a) TTC mechanism
    b) Stable Matching

Assessment (includes both continuous and summative assessment)

<table>
<thead>
<tr>
<th>Component</th>
<th>Course ILO Tested</th>
<th>Related Programme LO or Graduate Attributes</th>
<th>Weighting</th>
<th>Team/Individual</th>
<th>Assessment rubrics</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Homework</td>
<td>1,2,3,4,5,6,7</td>
<td>A1, A2, A3, B1, B4, C2, E</td>
<td>20%</td>
<td>Team, size 1-4</td>
<td>Appendix 1</td>
</tr>
<tr>
<td>2. Midterm Test</td>
<td>1,2,3</td>
<td>A1, A2, C1</td>
<td>20%</td>
<td>Individual</td>
<td></td>
</tr>
<tr>
<td>3. Final Exam</td>
<td>1,2,3,4,5,6,7</td>
<td>A1, A2, B4, C1</td>
<td>60%</td>
<td>Individual</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>100%</td>
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</table>

Graduates of MAS programmes should be able to:

[Competence]
A1: {Understanding} independently process and interpret mathematical theories and methodologies, and apply them to solve problems

A2: {Rigour} formulate mathematical statements precisely using rigorous mathematical language

A3: {Intuition} discover patterns by abstraction from examples

A4: {Modern Tool Usage} use computer technology to solve problems, and to communicate mathematical ideas

Creativity
B1: {Critical Thinking} critically assess the applicability of mathematical tools in the workplace

B2: {Analysis} critically analyse data from a multitude of sources

B3: {Interdisciplinarity} build on the connection between subfields of mathematics to tackle new problems

B4: {Creativity} develop new applications of existing techniques

Communication
C1: {Communication} present mathematics ideas logically and coherently at the appropriate level for the intended audience

C2: {Teamwork} work in teams on complicated projects that require applications of mathematics, and communicate the results verbally and in written form

Civic-Mindedness
D: {Professionalism} develop and communicate mathematical ideas and concepts relevant in everyday life for the benefits of society

Character
E: {Ethics} act in socially responsible and ethical ways in line with the societal expectations of a mathematics professional, particularly in relation to analysis of data, computer security, numerical computations and algorithms

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

Learning and Teaching approach

<table>
<thead>
<tr>
<th>Approach</th>
<th>How does this approach support students in achieving the learning outcomes?</th>
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<tbody>
<tr>
<td>Derivation and demonstration</td>
<td>Helps you understand the motivation behind the mathematical notions and ideas presented in the course. Presents systematic ways to solve problems.</td>
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<tr>
<td>(Lectures)</td>
<td></td>
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<tr>
<td>Modeling</td>
<td>Develops your ability to model economic and strategic situations mathematically, and then reason about strategic issues.</td>
</tr>
<tr>
<td>(Lectures and Tutorials)</td>
<td></td>
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</table>
Problem Solving
(Tutorials) Develops your ability to solve a variety of problems in game theory and mechanism design

Reading and References

*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 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, but 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.

Collaboration is encouraged for your homework because peer-to-peer learning helps you understand the subject better and working in a team trains you to better communicate with others. As part of academic integrity, crediting others for their contribution to your work promotes ethical practice.

Course Instructors

<table>
<thead>
<tr>
<th>Instructor</th>
<th>Office Location</th>
<th>Phone</th>
<th>Email</th>
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<tbody>
<tr>
<td>Hartmut Klauck</td>
<td>MAS-05-44</td>
<td>6513-7190</td>
<td><a href="mailto:hklauck@ntu.edu.sg">hklauck@ntu.edu.sg</a></td>
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Planned Weekly Schedule

<table>
<thead>
<tr>
<th>Week</th>
<th>Topic</th>
<th>Course ILO</th>
<th>Readings/ Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Extensive-form games</td>
<td>1</td>
<td>Chapter 1,3</td>
</tr>
<tr>
<td>2</td>
<td>Strategic-form games and Domination</td>
<td>1</td>
<td>Chapter 4.1-4.6</td>
</tr>
<tr>
<td>3</td>
<td>Nash Equilibria and Maxmin Strategies</td>
<td>1,2,3</td>
<td>Chapter 4.8-4.10</td>
</tr>
<tr>
<td>4</td>
<td>Mixed Equilibria, Zero-sum Games</td>
<td>1,2,3</td>
<td>Chapter 4.12, 5.1</td>
</tr>
<tr>
<td>5</td>
<td>Computing Equilibria</td>
<td>2,3</td>
<td>Chapter 5.2</td>
</tr>
<tr>
<td>6</td>
<td>Computing Equilibria and Nash’s Theorem</td>
<td>2,3</td>
<td>Chapter 5.3</td>
</tr>
<tr>
<td>7</td>
<td>Social Choice Theory</td>
<td>4</td>
<td>Chapter 21</td>
</tr>
<tr>
<td>8</td>
<td>Auctions</td>
<td>5,6</td>
<td>Chapter 12.1-12.4</td>
</tr>
<tr>
<td>9</td>
<td>VCG-Mechanisms</td>
<td>5,6</td>
<td>Lecture Notes</td>
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</table>
### 10 Games of Incomplete Information
1.6 Chapter 9.4

### 11 Bayesian Equilibria
1.6 Chapter 12.4

### 12 Revenue Equivalence
6 Chapter 12.5

### 13 Stable Matchings
7 Chapter 22

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**Appendix 1: Grading Criteria for Homework**

There are 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

<table>
<thead>
<tr>
<th>Marks</th>
<th>Criteria</th>
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<tbody>
<tr>
<td>&gt;= 90%</td>
<td>Solutions to the given questions satisfy the requirements and are within the set of possible correct answers in almost all instances.</td>
</tr>
<tr>
<td>75% to 89%</td>
<td>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 significant in most cases.</td>
</tr>
<tr>
<td>65% to 74%</td>
<td>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.</td>
</tr>
<tr>
<td>50% to 64%</td>
<td>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.</td>
</tr>
<tr>
<td>&lt; 50%</td>
<td>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.</td>
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