ECO210: Mathematical Methods for Economic Theory

Department of Economics
University of Toronto
Winter 2019

Instructor:
John McNeill
Email: john.mcneill@utoronto.ca
Office Hours: Fridays, 10:15-11:15
Location: Max Gluskin House, GE344

Email communication:
When sending me an email, please include "ECO210" in the subject line. Also include your full name and student number in the body of the message. Due to spam filters, it is best to use a utoronto.ca address if possible. Questions about exercises can be addressed during regular lectures or office hours. I will not discuss mathematical problems via email; for those questions it is best to come to office hours.

Website:
The course website will be on Blackboard. Announcements will be posted on blackboard, or communicated to you via email, using your utoronto.ca email address.

Course Description:
This course covers mathematical methods commonly used in economic theory. In conjunction with MAT223 (Linear Algebra I), it is designed to be sufficient preparation for our third- and fourth-year economics courses.

The course covers basic multivariate calculus (focusing on the tools used in economics), the notions of concavity and convexity, the theory of constrained optimization, and the theory of differential equations. Illustrative examples are taken from economics, but the purpose of the course is to teach mathematical methods, not economic theory.

The main aim of the course is to teach you the techniques commonly used to solve the mathematical problems that arise in economics. A secondary aim is to teach you how to make rigorous mathematical arguments. The ability to make such arguments deepens your understanding of the techniques and also allows you to modify the techniques when they do not exactly fit a problem you have to solve. With the second aim in mind, we will be discussing some proofs.

The course content is sufficient mathematical preparation for a Master's degree in Economics. If you plan to continue to a PhD, you might consider taking more rigorous courses, like MAT235 or MAT237 and higher-level math courses. (These courses do not cover all the topics in this course, but are at a higher theoretical level.) Alternatively, you could take this course and then take higher-level math courses later.

Schedule:
Lectures will be held in GB248 on Wednesdays from 10:00 to 1:00.

Term Test 1 will be held on February 6th (Week 5) during our class time, at a location that will be announced.

Term Test 2 will be held on March 13th (Week 10) during our class time, at a location that will be announced.

Lectures are based on the online tutorial – see Text section below – found in the link below:
http://www.economics.utoronto.ca/osborne/MathTutorial/index.html

Below is the tentative schedule for the content we will be covering in ECO210.
This schedule is potentially subject to change – the syllabus will be updated to reflect any substantial scheduling changes.

Week Number	Date	Content
1	01/9/18	Sections 1.1, 1.2, 1.3, and 1.4 of tutorial
2	01/16/18	Sections 1.5, 2.1, 2.2, and 2.3 of tutorial
3	01/23/18	Sections 2.4, 2.5, and 3.1 of tutorial
4	01/30/18	Sections 3.2.1, 3.2.2, 3.2.3, of tutorial
5	02/06/18	Term Test 1
6	02/13/18	Sections 4.1, 4.2, 4.3, and 5.1 of tutorial
7	02/20/18	Reading Week, no class
8	02/27/18	Sections 5.2, 5.3, and 6.1.1 of tutorial
9	03/06/18	Sections 6.1.2, 6.1.3, 6.1.4, and 6.2 of tutorial
10	03/13/18	Term Test 2
11	03/20/18	Sections 7.1, 7.2, 7.3, and 7.4 of tutorial
12	03/27/18	Sections 7.5, 8.1, 8.2, and 8.3 of tutorial
13	04/03/18	Sections 8.4, 8.5 of tutorial

Text:
All the material required for the course is covered in an on-line tutorial prepared by Martin Osborne (found at http://www.economics.utoronto.ca/osborne/MathTutorial/index.html). I will follow it closely in the lectures.

While many previous students have found the on-line tutorial to be sufficient as a course text, some prefer additional discussion and examples. These can be found in the following:

Knut Sydsæter and Peter J. Hammond, *Mathematics for Economic Analysis* (Prentice Hall, 1995).

How useful will Sydsæter and Hammond's book be to you? In Fall 2003 Prof. Osborne conducted a survey of the students in the class. Of the 38 who responded, 24 used only the on-line tutorial and 14 used both the book and the tutorial, but found the tutorial more helpful. (None said they found the book more helpful.) Of the 38, 19 said they would recommend that a student taking the class not buy the book, 7 recommended buying the book if its price is less than $20, 5 recommended buying it if its price is between $20 and $30, 4 recommended buying it if its price is between $30 and $50, and the remaining 3 recommended buying it at any price.

Students who prefer a more formal approach that is slightly more advanced than the course may also consult the following:
Carl P. Simon and Lawrence Blume, *Mathematics for Economists* (Norton, 1994).

Prerequisites and Corequisites:
•Matrix multiplication
•Basic multivariate calculus (partial differentiation)
•Curve and set sketching
•Basic optimization for functions of a single variable (finding maxima and minima using calculus)

Most of these are covered briefly in the first section of the on-line tutorial; we will review them briefly at the beginning of the semester. To check your knowledge, you should do all the exercises in the first section of the tutorial: (logic, matrix algebra, solving simultaneous equations, intervals and functions, calculus, and graphing).

You are prepared for the course if and only if you have at most little difficulty with these exercises.

I will cover the last topic with which you should be familiar (basic optimization) later in the course. If you need to review the material, you can refer to the text used in the prerequisite courses, or read Sydsæter and Hammond, or consult the first section of the on-line tutorial.

The following sections of Sydsæter and Hammond are relevant to your review and preparation.
Material you should know, very little of which I will review:
Chs. 1, 2, 3, 12, 13
Material you should know, some of which I will review:
Ch. 4 (but only the idea, not the details, of limits)
Ch. 5 except 5.4 (covered in the course), 5.5, and 5.6
Ch. 6 through 6.5 (6.1--6.3: basic ideas only)
Section 7.1 (7.2 is covered in the course)
Ch. 8 through 8.4
Ch. 9 through 9.4
Ch. 10
Ch. 11 through 11.2
Ch. 15 through 15.6

Corresponding Material in Sydsaeter and Hammond:
Below is a summary of the chapters in Sydsaeter and Hammond that correspond (approximately) to the material covered in lecture:

Week 1-2: Review of basic logic, matrix algebra, and calculus

- Section 1.5; Ch. 4; sections 5.1-5.3; basic ideas in sections 6.1-6.3; sections 6.4 and 6.5; section 7.1; sections 8.1-8.4; Ch. 10; sections 11.1 and 11.2.

Week 2: Topics in multivariate calculus:

- Ch. 16 (omit discussion of directional derivatives on pp. 541-543, "A rough argument for the chain rule" on pp. 543-545, remarks about directional derivatives on p. 554, "Theoretical considerations" on pp. 556-557, section 16.4, "Geometric aspects of homogeneous functions" on pp. 567-569, and "Homothetic functions" on pp. 573-574, and section 16.10). (Order: 16.1-16.3, 16.7, 16.5-16.6, 5.4, 16.8, 16.9.)

Weeks 4 and 6: Concavity and convexity

- Sections 9.6 (omit Jensen's inequality on pp. 317-318), 9.5, 15.8 (omit Quadratic forms with linear constraints on p. 530), 15.9 (omit material on eigenvalues on pp. 533-534), 17.5-17.10 (omit "Jensen's inequality" on pp. 624--627).

Week 7: Optimization

- Sections 17.1-17.3 (with reference back to single variable optimization in section 7.2 and section 9.1).

Weeks 7-8: Optimization, interior optima

- Section 17.4 (with reference back to single variable optimization in sections 9.3, 9.4, and 9.2).

Weeks 8-9: Optimization, inequality constraints

- Sections 18.1-18.7.

Weeks 10-11: Optimization, inequality constraints

- Sections 18.8-18.10 (omit "An economic interpretation ..." on pp. 694--696 and "Properties of the value function" on pp. 696-697).

Week 12: Differential equations

- Ch. 21.

Evaluation:
To learn the material in this course, there is no substitute for solving problems. After each section of the tutorial is completed, you should do the exercises in it. Some of the problems on the term tests will be similar to the exercises, and so the problems in the tutorial are excellent practice.

There will be two term tests and a 2-hour final exam. Note that programmable or graphing calculators will not be permitted in either term test or in the final exam.

The final exam will count for 50% of the final mark. The term tests account for the remainder, with 30% allocated to your higher-scoring term test, and 20% allocated to the other term test.

If you miss a test due to sickness, you must notify me (via email or in person) within one week of the missed test and arrange to provide me with a doctor's note in physical copy (using the U of T official "Verification of Student Illness or Injury" form http://www.illnessverification.utoronto.ca). This form must be submitted to me in-person (I will not accept scanned or email copies of the note.) If you satisfy these criteria, your remaining term test will count for 35%, and your final exam will be worth 65% of your final grade. If you miss both tests and provide the necessary documentation, you will be required

to write a cumulative make-up test, which will count for 35% of your grade (with the final exam counting for the balance).

Marking Principles:
The following is a list of principles that I use in marking term tests and exams.

- You must give reasoning to get credit for an answer. If you give the right answer without any explanation you will get 0. For a problem whose solution requires a mathematical argument, an "explanation" must contain words that indicate how your mathematical arguments are linked, and how they answer the question.
- You get 0 if you give two answers to a problem, one right and one wrong.
- If you give the right answer and the right reasoning, but in addition add some incorrect reasoning, you will get less than full credit.
- I do not specifically take off points for poor English, but if the meaning of what you write is not clear you will lose points.

Accessibility Needs:
The University of Toronto is committed to accessibility. If you require accommodations for a disability, or have any accessibility concerns about the course, the classroom or course materials, please contact Accessibility Services as soon as possible: disability.services@utoronto.ca or http://studentlife.utoronto.ca/accessibility .

Academic Misconduct:
As a member of the University of Toronto, you will be held to the standards of academic integrity established by the University. The University is committed to upholding these standards, and accordingly takes these policies very seriously – be aware that violation of these standards will result in disciplinary action taken in accordance with university policy.
More information on the University of Toronto's policy on academic integrity can be found at:
http://www.artsci.utoronto.ca/osai/The-rules/what-is-academic-misconduct