ECONOMICS 210: MATHEMATICAL METHODS FOR ECONOMIC THEORY

Department of Economics

University of Toronto

FALL 2012

Instructor

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Office Hours: Thursday 2-3:30pm (No office hours for the first week, appointment by Email.)

Location: Max Gluskin House, 150 St. George Street, and GE213 (Except: Oct. 25 in GE 40).

NOTE: 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 *mail.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.**

Website

Blackboard. Announcements will be posted on blackboard and communicated to you via email, so please make sure that you have a valid utoronto.ca e-mail address.

Schedule

Lectures will be held in SS1086 on Tuesdays from 2:10pm to 5:00pm.

(Tentatively) Term Test One will be held on Tuesday, October 9th (week 5) from 2:10 pm to 3:40pm, in SS1086 (regular classroom). There will be a lecture held in SS1086 following Term Test One, from 4:10pm to 5:00pm.

(Tentatively) Term Test Two will be held on Tuesday, November 6th (week 9) from 2:10pm to 3:40pm, in SS1086 (regular classroom). There will be a lecture held in SS1086 following Term Test Two, from 4:10pm to 5:00pm.

Lectures are based on the tutorial – see Text section below – found in the link below:

http://www.economics.utoronto.ca/osborne/MathTutorial/index.html

NO. of Week	Date	Content
Week 1	Sep. 11	Sections 1.1, 1.2, 1.3, 1.4, 1.5 and 1.6 of tutorial http://www.economics.utoronto.ca/osborne/MathTutorial/REVF.HTM
Week 2	Sep. 18	Sections 2.1, 2.2 and 2.3 of tutorial. http://www.economics.utoronto.ca/osborne/MathTutorial/CALF.HTM
Week 3	Sep. 25	Sections 2.4., 2.5 and 3.1 of tutorial. http://www.economics.utoronto.ca/osborne/MathTutorial/CALF.HTM
Week 4	Oct. 2	Sections 3.2.1, 3.2.2, 3.2.3 of tutorial and review session for Term Test 1. http://www.economics.utoronto.ca/osborne/MathTutorial/CCVF.HTM
Week 5	Oct. 9	TERM TEST 1 (Time: 2:10-3:40pm | Location: SS1086) and section 3.3 of tutorial (might also 3.4). http://www.economics.utoronto.ca/osborne/MathTutorial/CCVF.HTM
Week 6	Oct. 16	Sections 4.1, 4.2, 4.3 and 5.1 of tutorial. http://www.economics.utoronto.ca/osborne/MathTutorial/MOPF.HTM
Week 7	Oct. 23	Sections 5.2, 5.3 and 6.1.1 of tutorial. http://www.economics.utoronto.ca/osborne/MathTutorial/OPIF.HTM
Week 8	Oct. 30	Sections 6.1.2, 6.1.3, 6.1.4 and 6.2 of tutorial http://www.economics.utoronto.ca/osborne/MathTutorial/MOEF.HTM
Week 9	Nov. 6	TERM TEST 2 (Time: 2:10-3:40pm | Location: SS1086) and section 6.3 of tutorial. http://www.economics.utoronto.ca/osborne/MathTutorial/MOEF.HTM
Week 10	Nov. 13	No class (Fall break)
Week 11	Nov. 20	Sections 7.1, 7.2, 7.3, and 7.4 of tutorial. http://www.economics.utoronto.ca/osborne/MathTutorial/MOIF.HTM
Week 12	Nov. 27	Sections 7.5, 8.1 8.2, and 8.3 of tutorial. http://www.economics.utoronto.ca/osborne/MathTutorial/MOIF.HTM
Week 13	Dec. 4	Sections 8.4, 8.5 of tutorial. Review session for final (might also 8.6,8.7) http://www.economics.utoronto.ca/osborne/MathTutorial/DEEF.HTM

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, I will lead you through 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.

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).

Exclusions, Corequisites, Prerequisites

ECO210H1 Mathematical Methods for Economic Theory[24L/12T]
Prerequisite: ECO100Y1(67%)/ECO105Y1(80%); MAT133Y1(63%)/(MAT123H1(63%),MAT124H1(63%))/(MAT135H1(60%), MAT136H1(60%))/ MAT137Y1(55%)/MAT157Y1(55%)
Corequisite: ECO200Y1/ECO204Y1/ECO206Y1
Distribution Requirement Status: This is a Social Science course
Breadth Requirement: None

I expect you to be familiar with basic mathematical concepts and the following topics, which are covered in the prerequisite courses:

- •Basic logic
- •Matrices and solutions of simultaneous linear equations (including determinants and Cramer's rule) Note: If you have not studied matrices previously, you need to do so before taking this course (You can either learn the material independently, or take a basic math course that covers them.)
- •One variable calculus (differentiation and integration, including exponential and logarithmic functions)
- •Basic multivariate calculus (partial differentiation)
- •Curve and set sketching
- •Basic optimization for functions of a single variable (finding maxima and minima using calculus)

The first five topics are covered briefly in the first section of the on-line tutorial; I will review them in the first class. To check your knowledge, you should do all the exercises in the first section of the tutorial: Exercises on logic, Exercises on matrix algebra and solving simultaneous equations, Exercises on intervals and functions, Exercises on one-variable calculus, Exercises on multivariate calculus, and Exercises on graphical representation of functions. *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.

- • Material you should know, very little of which I will review:
  - o Chs. 1, 2, 3, 12, 13
- • Material you should know, some of which I will review:
  - o Ch. 4 (but only the idea, not the details, of limits)
  - o Ch. 5 except 5.4 (covered in the course), 5.5, and 5.6
  - o Ch. 6 through 6.5 (6.1--6.3: basic ideas only)
  - o Section 7.1 (7.2 is covered in the course)
  - o Ch. 8 through 8.4
  - o Ch. 9 through 9.4
  - o Ch. 10

- o Ch. 11 through 11.2
- o Ch. 15 through 15.6

Sections of Sydsæter and Hammond Related To On-line tutorial (optional)

Here is a summary of the material we will cover, with a link to the relevant section of the tutorial, and references to related material in Sydsæter and Hammond (below). I include this information for your convenience; for the exact sections of the tutorial that I will cover each week, please consult the Schedule section of the syllabus.

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: equality 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, you will have to get your hands dirty and to do the exercises! 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.

There will be two term tests and a three-hour final exam. Note that 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 remaining 50%, with 30% allocated to the term test for which you obtain your highest mark, 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. 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 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 take off points for poor English, but if the meaning of what you write is not clear you will lose points.
- I do not penalize small errors in algebra unless they lead to arguments that are simpler than the ones that arise in their absence.
- If you formulate a problem incorrectly, but use the correct methods correctly, you will not be penalized heavily unless your formulation leads to an analysis that is simpler than or very different from the one for the correct formulation.

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 (and non-academic) Misconduct

Please refrain from cheating. If you work hard, you will not fail in this course. Being honest is more important than scores.