Central European University
Department of Economics

1. Name of Course: Mathematical Methods for Economists

2. Lecturer: Katrin Rabitsch (Room: Nador 11, 409)

3. No. of Credits (no. of ECTS credits): 3 CEU credits (6 ECTS)

4. Semester or Time Period of the course: Fall term, weeks 1-6, *Tuesdays* and *Wednesdays* (11:00-12:50)

5. Pre-requisites: This is a compulsory, core class for first-year MA students.

6. Course Level: Master in Economics

7. Course Outline: The course covers the mathematical methods required for the study of modern dynamic economic models.

8. The goals of the course: The main aim of this course is to provide the students with the necessary tools for understanding, solving and analyzing modern dynamic economic models. Emphasis will be mostly on conceptual understanding and applications of standard tools used in the core graduate courses.

9. The learning outcomes of the course: Students are comfortable with solving basic difference equations and differential equations (or systems thereof). They have also familiarized with the theory on dynamic optimization in discrete or continuous time and applied these methods to simple examples of dynamic models.

10. More detailed display of contents:

Assumed Background

Basic knowledge of Linear Algebra, Calculus, Analysis as covered in the pre-session Mathematics course or as covered in undergraduate Mathematical Economics textbooks such as Simon, Carl P. and Lawrence Blume: *Mathematics for Economists*, W.W.

Norton, First Edition, 1994 or Chiang, Alpha C.: *Fundamental Methods of Mathematical Economics*, McGraw-Hill, Third Edition, 1984.

Preliminary Syllabus

- Introduction and review of important concepts: approximations and Taylor expansions, log-linearization, eigenvalues and eigenvectors
- Linear Difference equations and systems of linear difference equations
- Applications, discrete-time models
- Ordinary Differential equations and systems of differential equations
- Qualitative theory and stability, phase diagrams
- Applications, continuous time models
- Deterministic dynamic programming
- Markov Processes
- Stochastic dynamic programming
- Applications to dynamic programming
- Optimal control (continuous time), Hamiltonians

11. Assessment: There will be weekly individualized assignments during the term with a total of 50% weight in the assessment, and a final examination with also 50% weight. In order to get the minimum pass grade (C+) for the course, at least 50% of the marks must be obtained in both components of the assessment (assignments and final exam).

12. Contact details and Office Hours:

Office Hours:

Tuesday, 16.00-18.00. Office: 409.
My e-mail address is RabitschK@ceu.hu.

Seminars:

On *Thursdays*, 9:00-10:50
The T.A. for the course is Peter Harasztosi.

Preliminary weekly course breakdown
(as of Aug. 20, 2008, will be updated and/or modified!)

Lecture 1, Week 1, Tuesday, Sept. 23:
Introduction and review of important concepts, approximations and Taylor expansions, log-linearizations, eigenvalues and eigenvectors

REFERENCES (core):
Simon, Carl P. and Lawrence Blume: *Mathematics for Economists*, W.W. Norton, First Edition, 1994, Chapters 30.2, 30.3 and Chapters 23.1-23.5, 23.7-23.8
Sydsaeter, Knut and Peter J. Hammond.: *Mathematics for Economic Analysis*, 1995, Chapters 7.4, 14.4-14.5
Chiang, Alpha C.: *Fundamental Methods of Mathematical Economics*, McGraw-Hill, Third Edition, 1984, Chapters 9.5, 18.6, 11.3 pp. 326-329
Lecture notes

Lecture 2, Week 1, Wednesday, Sept. 24:
Linear difference equations and systems of linear difference equations

REFERENCES (core):
Sydsaeter, Knut and Peter J. Hammond.: *Mathematics for Economic Analysis*, 1995, Chapter 20
Chiang, Alpha C.: *Fundamental Methods of Mathematical Economics*, McGraw-Hill, Third Edition, 1984, Chapters 16-18
Lecture notes

Lecture 3, Week 2, Tuesday, Sept. 30:
Difference equations cont., applications, discrete-time models

REFERENCES (core):
Sydsaeter, Knut and Peter J. Hammond.: *Mathematics for Economic Analysis*, 1995, Chapter 20
Chiang, Alpha C.: *Fundamental Methods of Mathematical Economics*, McGraw-Hill, Third Edition, 1984, Chapters 16-18
Lecture notes

Lecture 4, Week 2, Wednesday, Oct. 1.:
Ordinary differential equations and systems of differential equations

REFERENCES (core):
Sydsaeter, Knut and Peter J. Hammond.: *Mathematics for Economic Analysis*, 1995, Chapter 21

Simon, Carl P. and Lawrence Blume: *Mathematics for Economists*, W.W. Norton, First Edition, 1994, Chapters 24
Chiang, Alpha C.: *Fundamental Methods of Mathematical Economics*, McGraw-Hill, Third Edition, 1984, Chapters 14-15, 18

Lecture 5, Week 3, Tuesday, Oct. 7:
Ordinary Differential equations and systems of differential equations cont., stability, phase diagrams, applications, continuous time models

REFERENCES (core):
Sydsaeter, Knut and Peter J. Hammond.: *Mathematics for Economic Analysis*, 1995, Chapter 21
Simon, Carl P. and Lawrence Blume: *Mathematics for Economists*, W.W. Norton, First Edition, 1994, Chapters 24, 25
Chiang, Alpha C.: *Fundamental Methods of Mathematical Economics*, McGraw-Hill, Third Edition, 1984, Chapters 14-15, 18

Lecture 6, Week 3, Wednesday, Oct. 8:
Deterministic dynamic programming: concepts of value function, Bellman equation, principle of optimality, contraction mapping theorem

REFERENCES (core):
Ljungqvist, Lars and Thomas J. Sargent: *Recursive Macroeconomic Theory*, Chapter 2, pp. 30-36
Jerome Adda and Russell Cooper: *Dynamic Economics*, MIT Press 2003, Chapter 2
Lecture notes
FURTHER REFERENCES (more advanced/ optional):
Nancy Stokey and Robert Lucas with Edward Prescott: *Recursive Methods in Economic Dynamics*, Harvard University Press, 1989, Chapters 2-5

Lecture 7, Week 4, Tuesday, Oct. 14:
Deterministic dynamic programming cont., applications:

REFERENCES (core):
Ljungqvist, Lars and Thomas J. Sargent: *Recursive Macroeconomic Theory*, Chapter 2, pp. 30-36
Jerome Adda and Russell Cooper: *Dynamic Economics*, MIT Press 2003, Chapter 2
Lecture notes
FURTHER REFERENCES (more advanced/ optional):
Nancy Stokey and Robert Lucas with Edward Prescott: *Recursive Methods in Economic Dynamics*, Harvard University Press, 1989, Chapters 2-5

Lecture 8, Week 4, Wednesday, Oct. 15:
Markov Processes, Stochastic dynamic programming

REFERENCES (core):
Simon, Carl P. and Lawrence Blume: *Mathematics for Economists*, W.W. Norton, First Edition, 1994, Chapters 23.6
Ljungqvist, Lars and Thomas J. Sargent: *Recursive Macroeconomic Theory*, Chapter 1, pp. 1-6 and Chapter 2, pp. 36-38
Lecture notes

<u>Lecture 9, Week 5, Tuesday, Oct. 21:</u>
Stochastic dynamic programming cont.

REFERENCES (core):
Ljungqvist, Lars and Thomas J. Sargent: *Recursive Macroeconomic Theory*, Chapter 2, pp. 36-38
Lecture notes
FURTHER REFERENCES (more advanced/ optional):
Nancy Stokey and Robert Lucas with Edward Prescott: *Recursive Methods in Economic Dynamics*, Harvard University Press, 1989, Chapter 9

<u>Lecture 10, Week 5, Wednesday, Oct. 22:</u>
Applications to dynamic programming

REFERENCES (core):
Ljungqvist, Lars and Thomas J. Sargent: *Recursive Macroeconomic Theory*, Chapter 2
Jerome Adda and Russell Cooper: Dynamic Economics, MIT Press 2003, Chapter 2
Lecture notes
FURTHER REFERENCES (more advanced/ optional):
Nancy Stokey and Robert Lucas with Edward Prescott: *Recursive Methods in Economic Dynamics*, Harvard University Press, 1989, Chapters 2-5

<u>Lecture 11, Week 6, Tuesday, Oct. 28:</u>
Optimal control (continuous time), Hamiltonians

REFERENCES (core):
Barro, R and X. Sala-i-Martin, *Economic Growth*, Mc-Graw Hill, 1995, Appendix on Mathematical Methods 1.3
Kamien, Morton. I. and Nancy L. Schwartz: *Dynamic Optimization: The Calculus of Variations and Optimal Control in Economics and Management*, Amsterdam, North-Holland. 1981, Second edition, 1991, Part 2

<u>Lecture 12, Week 6, Wednesday, Oct. 29:</u>
Optimal control cont., applications, review, Q & A

REFERENCES (core):
Barro, R and X. Sala-i-Martin, *Economic Growth*, Mc-Graw Hill, 1995, Appendix on Mathematical Methods 1.3
Kamien, Morton. I. and Nancy L. Schwartz: *Dynamic Optimization: The Calculus of Variations and Optimal Control in Economics and Management*, Amsterdam, North-Holland. 1981, Second edition, 1991, Part 2

EXAM, Tuesday, Nov. 4, 2008