Faculty of Economics and Business Administration

# COURSE UNIT DESCRIPTION

| Course unit title | Code |
|---|---|
| **Further Quantitative Methods** | |

| Lecturer(s) | Department, Faculty |
|---|---|
| **Coordinating: Assoc. Prof. dr. Gintautas Bareikis**<br>**Other: Prof. dr. Teodoras Medaiskis** | Faculty of Economics of Business Administration |

| Study cycle | Type of the course unit |
|---|---|
| First cycle | Optional |

| Mode of delivery | Period of implementation | Language of instruction |
|---|---|---|
| Face-to-face | 4 semester | English |

| Requisites | |
|---|---|
| **Prerequisites:** Mathematical methods | **Co-requisites (if relevant):** |

| Number of ECTS credits allocated | Student's workload (total) | Contact hours | Individual work |
|---|---|---|---|
| 5 | 130 | 36 | 94 |

**Purpose of the course unit and programme competences to be developed**

The aim of the course is to enhance students' skillset and develop students' abilities to carry out economic analysis, evaluation of economic and business decisions by means of mathematical optimization techniques, as well as to provide students with tools that are required to understand and develop rigorous theoretical models of economic processes and follow advanced courses in the third year of the program.

| Learning outcomes of the course unit | Teaching and learning methods | Assessment methods |
|---|---|---|
| 1.2 The ability to understand and develop economic processes based on rigorous mathematical arguments. | Problem-based teaching. | Open-ended questions and solution of problems in the exam, assessment of the rigour and quality of solutions to the problem sets |
| 2.1 The ability to apply the acquired knowledge of mathematical methods, appreciate their domain of application as well as limitations. | Problem-based teaching, problem set solution. | |
| 3.2 The ability to relate mathematically expressed arguments to the economic and social phenomena, and, vice versa, translate economic and social problems into the mathematical language. | Problem-based teaching, independent studies of literature | |
| 5.1 Being able to work independently, while solving problem sets, and expand own understanding, knowledge and skills. | Problem-based teaching, independent studies of literature, practising mathematical methods | |

| Course content: breakdown of the topics | Contact hours | Individual work: time and assignments |
|---|---|---|

| | Lectures | Tutorials | Seminars | Workshops | Laboratory work | Internship/work placement | **Contact hours, total** | **Individual work** | **Assignments** |
|---|---|---|---|---|---|---|---|---|---|
| 1. Arithmetic of the complex numbers. Vector spaces, linear independence, basis of a vectors. Space dimension, subspaces. Linear mapping between vector spaces. Kernel and image. Matrix diagonalization. Basis transformation. Eigen value-eigen-vector decomposition. | 3 | | 1 | | | | **4** | **12** | Studies of literature, example problems |
| 2. Function, open-closed sets in the metric spaces. Functions relations, correspondence. Convergence of a sequence in general metric spaces. Continuity in general spaces. | 2 | | 1 | | | | **3** | **5** | Studies of literature, example problems |
| 3. Introduction to discrete and continuous models: difference and differential equations. Stability conditions. | 4 | | 1 | | | | **5** | **11** | Studies of literature, example problems. Problem set 1. SHSS chapter 2 and Appendix A |
| 4. A differentiability in higher dimension. Series. Taylor approximation. Static Optimization: (a) Lagrange; (b) Kuhn-Tucker; (c) Interpretation of Multipliers; (d) Envelope Theorem. | 4 | | 1 | | | | **5** | **12** | Studies of literature, example problems. Problem set 2 SHSS chapter 3, CW chapters 12, 21.1-4, Sundaram chapters 5-6. |
| 5. Convexity. Convex sets and functions. Elements of convex analysis. | 2 | | 1 | | | | **3** | **6** | Studies of literature, example problems |
| 6. Problem of convex programming, geometrical interpretation. Non-constraint and constraint cases. Duality in convex programming. Applications | 4 | | 1 | | | | **5** | **12** | Studies of literature, example problems. Problem set 3 Sundaram chapters 7-8, CW chapters 21.5-7 |
| 7. Problem of optimal control theory in continuous and discrete time. Application within the modelling of economic processes. | 2 | | 1 | | | | **3** | **10** | Studies of literature, example problems |
| 8. Dynamic programming. Bellman‘s principle of optimality and recursive approach. | 3 | | 1 | | | | **4** | **11** | Studies of literature, example problems. Problem set 4 SHSS chapters 8-10, 12. Sundaram chapters 11-12. |
| 9. Examples of dynamic programming and recursive approach to economic analysis. | 2 | | | | | | **2** | **6** | Studies of literature, example problems. |
| 10. Correspondences and Fixed Points. Applications to General Equilibrium. | 2 | | 1 | | | | **5** | **9** | Studies of literature, example problems |
| **Total** | **28** | | **8** | | | | **36** | **94** | |

| **Assessment strategy** | **Weight %** | **Deadline** | **Assessment criteria** |
|---|---|---|---|
| Exam | 40 | The exam | Closed and open ended problems, with a focus on |

| | | | |
|---|---|---|---|
| | | session | mathematical rigour and ability to apply mathematical tools to economic problems. The exhaustiveness of the answer and the ability to creatively apply mathematical methods will be given a bonus. |
| Collioquim (Part of exam) | 40 | Middle of semester | Closed and open ended problems, with a focus on mathematical rigour and ability to apply mathematical tools to economic problems. The exhaustiveness of the answer and the ability to creatively apply mathematical methods will be given a bonus. |
| Four problem sets, each worth 5% | 20 | During the semester | Rigour and depth of solutions. |
| | | | |

| **Author** | **Publishing year** | **Title** | **Issue of a periodical or volume of a publication; pages** | **Publishing house or internet site** |
|---|---|---|---|---|
| **Required reading** | | | | |
| Alpha S. Chiang, Kevin Wainwright (Referred to as CW) | 2005 | Fundamental Methods of Mathematical Economics | | McGraw-Hill Higher Education |
| Knut Sydsaeter, Peter Hammond, Atle Seierstad, Arne Strom (Referred to as SHSS) | 2005 | Further Mathematics for Economic Analysis | | Prentice Hall |
| Rangarajan K. Sundaram | 1996 | A First Course in Optimization Theory | | Cambridge University Press |
| **Recommended reading** | | | | |
| Michael D. Intriligator | 2002 | Mathematical Optimization and Economic Theory. | | Prentice Hall |
| Lars Ljungqvist, Thomas J.Sargent | 2000 | Recursive Macroeconomic Theory | | The MIT press Cambridge, London |
| Knut Sydsaeter, Peter Hammond, Arne Strom | 2012 | Essential Mathematics for Economic Analysis. 4th edition. | | Pearson |
| Kelvin Lancaster | 1987 | Mathematical Economics. | | Collier Macmillan |
| Richard Bellman | 2010 | Dynamic Programming | | Princeton University Press |