**SYLLABUS**

## 1. Information regarding the programme

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| 1.1 Higher education institution | Babeş Bolyai University, Cluj-Napoca |
| 1.2 Faculty | Faculty of Mathematics and Computer Science |
| 1.3 Department | Department of Mathematics |
| 1.4 Field of study | Mathematics |
| 1.5 Study cycle | Bachelor |
| 1.6 Study programme / Qualification | Mathematics and Computer Science - English |

## 2. Information regarding the discipline

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|---|---|---|---|---|---|---|---|
| 2.1 Name of the discipline | Optimization Techniques | | | | | | |
| 2.2 Course coordinator | Prof. Nicolae Popovici, Ph.D. Habil. | | | | | | |
| 2.3 Seminar coordinator | Prof. Nicolae Popovici, Ph.D. Habil. | | | | | | |
| 2.4. Year of study | 3 | 2.5 Semester | 6 | 2.6. Type of evaluation | Exam | 2.7 Type of discipline | Compulsory |

## 3. Total estimated time (hours/semester of didactic activities)

| | | | | | |
|---|---|---|---|---|---|
| 3.1 Hours per week | 3 | Of which: 3.2 course | 2 | 3.3 seminar | 1 |
| 3.4 Total hours in the curriculum | 36 | Of which: 3.5 course | 24 | 3.6 seminar | 12 |
| Time allotment: | | | | | hours |
| Learning using manual, course support, bibliography, course notes | | | | | 24 |
| Additional documentation (in libraries, on electronic platforms, field documentation) | | | | | 6 |
| Preparation for seminars/labs, homework, papers, portfolios and essays | | | | | 12 |
| Tutorship | | | | | 12 |
| Evaluations | | | | | 10 |
| Other activities: .............. | | | | | |

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| 3.7 Total individual study hours | 64 |
| 3.8 Total hours per semester | 100 |
| 3.9 Number of ECTS credits | 4 |

## 4. Prerequisites (if necessary)

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| 4.1. curriculum | • Algebra 1 (Linear Algebra)<br>• Mathematical Analysis 2 (Differential Calculus on $R^n$) |
| 4.2. competencies | Ability to use basic theoretical notions and practical methods of linear algebra and mathematical analysis. |

## 5. Conditions (if necessary)

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| 5.1. for the course | • Beamer projector |
| 5.2. for the seminar /lab activities | • Standard infrastructure |

## 6. Specific competencies acquired

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| **Professional competencies** | **C1.4** Identify the appropriate mathematical models and methods for solving real-life problems.<br><br>**C3.1** Identify the fundamental notions and results needed to develop numerical algorithms. |
| **Transversal competencies** | **CT1** Work effectively and rigorously; adopt a responsible attitude towards science and learning; use the own creative potential; obey the rules and principles of professional ethic. |

## 7. Objectives of the discipline (outcome of the acquired competencies)

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| 7.1 General objective of the discipline | Study the mathematical foundations of several important optimization techniques, which are currently used in Operational Research. |
| 7.2 Specific objective of the discipline | Students should acquire knowledge about:<br>• Convex analysis;<br>• Linear optimization;<br>• Matrix game theory;<br>• Convex optimization. |

## 8. Content

| 8.1 Course | Teaching methods | Remarks |
|---|---|---|
| 1. Optimization problems in general setting; Classical models. | Direct instruction, mathematical proof, exemplification | |
| 2. Level sets; Existence and unicity of optimal solutions. | Direct instruction, mathematical proof, exemplification | |
| 3. Convex sets; Extreme points. | Direct instruction, mathematical proof, exemplification | |
| 4. Convex functions and some properties of their extrema. | Direct instruction, mathematical proof, exemplification | |
| 5. Linear optimization problems; Duality theorems. | Direct instruction, mathematical proof, exemplification | |
| 6. Primal feasible bases, dual feasible bases, and optimal bases. | Direct instruction, mathematical proof, exemplification | |
| 7. The Simplex Algorithm in primal form. | Direct instruction, mathematical proof, exemplification | |
| 8. The Simplex Algorithm in dual form. | Direct instruction, mathematical proof, exemplification | |

| | | |
|---|---|---|
| 9. Dual problems and extended problems - involving additional constraints. | Direct instruction, mathematical proof, exemplification | |
| 10. Matrix games. | Direct instruction, mathematical proof, exemplification | |
| 11. The relationship between the matrix games and the linear optimization problems. | Direct instruction, mathematical proof, exemplification | |
| 12. Convex optimization problems. | Direct instruction, mathematical proof, exemplification | |

Bibliography
1. BOYD, S., VANDENBERGHE, L.: Convex Optimization, Cambridge University Press, 2004.
2. BRECKNER, B.E., POPOVICI, N., Convexity and Optimization. An Introduction, EFES, Cluj-Napoca, 2006.
3. BRECKNER, W.W., Cercetare operaţională, Universitatea Babeş-Bolyai, Cluj-Napoca, 1981.
4. POPOVICI, N., Optimizare vectoriala, Casa Cartii de Stiinta, Cluj-Napoca, 2005.
5. MORDUKHOVICH, B.S., NAM, N.M., An easy path to convex analysis and applications, Morgan & Claypool Publishers, Milton Keynes, 2014.
6. VANDERBEI, R.: Linear Programming. Foundations and Extensions, Springer, Boston, 2008.

| 8.2 Seminar | Teaching methods | Remarks |
|---|---|---|
| 1-2. Special classes of convex sets. | Problem-based instruction, debate, mathematical proofs | |
| 3-4. Convex functions; Generalized convexity. | Problem-based instruction, debate, mathematical proofs | |
| 5-6. Optimization problems solved by the Simplex Algorithm in primal form. | Problem-based instruction, debate, mathematical proofs | |
| 7-8. Optimization problems solved by the Simplex Algorithm in dual form. | Problem-based instruction, debate, mathematical proofs | |
| 9-10. Matrix games. | Problem-based instruction, debate, mathematical proofs | |
| 11-12. Convex optimization problems. | Problem-based instruction, debate, mathematical proofs | |

Bibliography
1. BRECKNER, B.E., POPOVICI, N., Probleme de analiza convexa in $R^n$. Casa Cartii de Stiinta, Cluj-Napoca, 2003.
2. BRECKNER, B.E., POPOVICI, N., Probleme de cercetare operationala, EFES, Cluj-Napoca, 2006.
3. BRECKNER, W.W., DUCA, D., Culegere de probleme de cercetare operationala, Universitatea Babes-Bolyai, Facultatea de Matematica, Cluj-Napoca, 1983.
4. DUREA, M., O introducere in teoria optimizarii neliniare, Tehnopress, Iasi, 2012.

**9. Corroborating the content of the discipline with the expectations of the epistemic community, professional associations and representative employers within the field of the program**

- The course ensures a solid theoretical background, according to national and international standards, within bachelor programmes, on optimization theory, operations research, management, etc.
- The optimization techniques are currently applied in industry, medicine, insurance, etc.

**10. Evaluare**

| Type of activity | 10.1 Evaluation criteria | 10.2 Evaluation methods | 10.3 Share in the grade (%) |
|---|---|---|---|
| 10.4 Course | - Knowledge of theoretical concepts and capacity to rigorously prove the main theorems; - Ability to solve practical exercises and theoretical problems | Written Exam | 75% |
| 10.5 Seminar/lab activities | Attendance and active class participation | Continuous evaluation | 25% |
| 10.6 Minimum performance standards | | | |
| The final grade should be greater than or equal to 5. | | | |

Date          Signature of course coordinator          Signature of seminar coordinator

03.05.2019    Prof. Nicolae Popovici, Ph.D. Habil.      Prof. Nicolae Popovici, Ph.D. Habil.

Date of approval                                        Signature of the head of department

...........................................            Prof. Octavian Agratini, Ph.D.