SYLLABUS

1. Information regarding the programme

1.1 Higher education institution	**Babes-Bolyai University**
1.2 Faculty	**Faculty of Mathematics and Computer Science**
1.3 Department	**Department of Computer Science**
1.4 Field of study	**Computer Science**
1.5 Study cycle	**Undergraduate**
1.6 Study programme / Qualification	**Artificial Intelligence**

2. Information regarding the discipline

2.1 Name of the discipline (en) (ro)			**Metaheuristics** **Metaeuristici**				
2.2 Course coordinator			**Prof. dr. Camelia Chira**				
2.3 Seminar coordinator			**Prof. dr. Camelia Chira**				
2.4. Year of study	**2**	2.5 Semester	**4**	2.6. Type of evaluation	**E**	2.7 Type of discipline	**Compulsory**
2.8 Code of the discipline		MLE5205					

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

3.1 Hours per week	4	Of which: 3.2 course	2	3.3 seminar/laboratory	2 lab
3.4 Total hours in the curriculum	56	Of which: 3.5 course	28	3.6 seminar/laboratory	28
Time allotment:					hours
Learning using manual, course support, bibliography, course notes					20
Additional documentation (in libraries, on electronic platforms, field documentation)					30
Preparation for seminars/labs, homework, papers, portfolios and essays					28
Tutorship					6
Evaluations					10
Other activities:					

3.7 Total individual study hours	94
3.8 Total hours per semester	150
3.9 Number of ECTS credits	6

4. Prerequisites (if necessary)

4.1. curriculum	• Algorithms, data structures, statistics
4.2. competencies	• Average programming skills in a high-level object-oriented programming language

5. Conditions (if necessary)

5.1. for the course	- Projector
5.2. for the seminar /lab activities	- For lab activity, computers with a high processing speed are needed.

6. Specific competencies acquired

Professional competencies	CE 1.1 Description of concepts and research directions in artificial intelligence CE 1.2 Evaluation of solution quality and stability, and comparisons with solutions obtained using traditional methods CE 1.3 Use of methods, techniques and algorithms from artificial intelligence to model solutions to classes of problems
Transversal competencies	TC1 Application of efficient and rigorous working rules, manifest responsible attitudes towards the scientific and didactic fields, underlying the individual potential and respecting professional and ethical principles. TC3 Use of efficient methods and techniques for learning, information, research and development of abilities for knowledge exploitation, for adapting to the needs of a dynamic society and for communication in a widely used foreign language.

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

7.1 General objective of the discipline	• Metaheuristics aims to study specialized algorithms in solving complex problems
7.2 Specific objective of the discipline	• The course focuses on theoretical and practical aspects of metaheuristics and aims to provide an overview of the field and major types of metaheuristics. At the end of the course, students will be able to understand the basic principles that guide the development of metaheuristics and the associated algorithmic approaches, and will have knowledge of their applications.

8. Content

8.1 Course	Teaching methods	Remarks
1. Introduction to metaheuristics	• Interactive exposure • Conversation • Examples	
2. Complex problems and modelling real problems. Classical models vs metaheuristics in solving complex problems	• Interactive exposure • Conversation • Examples	
3. Representation, evaluation, neighborhood. Local search methods, hill-climbing algorithms	• Interactive exposure • Explanation • Conversation • Examples	

4. Single-point methods in solving complex problems – Tabu Search, Simulated Annealing	• Interactive exposure • Explanation • Conversation • Examples	
5. Population-based methods in solving complex problems	• Interactive exposure • Explanation • Conversation • Examples	
6. Evolutionary computing in solving optimization and search problems	• Interactive exposure • Explanation • Conversation • Examples	
7. Design of evolutionary algorithms: binary representation, real representation, vectors, permutations	• Interactive exposure • Explanation • Conversation • Examples	
8. Swarm intelligence models	• Interactive exposure • Explanation • Conversation • Examples	
9. State-of-the-art models	• Interactive exposure • Explanation • Conversation • Examples	
10. Computing models and hybrid systems	• Interactive exposure • Explanation • Conversation • Examples	
11. Hybrid models and examples of real-world applications	• Interactive exposure • Explanation • Conversation • Examples	
12. -14. Applications of metaheuristics	• Interactive exposure • Explanation • Conversation • Examples	

Bibliography

1. S. Russell, P. Norvig, Artificial Intelligence: A Modern Approach, Prentice Hall, 1995
2. C. Groşan, A. Abraham, Intelligent Systems: A Modern Approach, Springer, 2011
3. M. Mitchell, An Introduction to Genetic Algorithms, MIT Press, 1998
4. A. Hopgood, Intelligent Systems for Engineers and Scientists, CRC Press, 2001
5. Marco Dorigo, Christian Blum, Ant colony optimization theory: A survey, Theoretical Computer Science 344 (2005) 243 – 27
6. H.F. Pop, G. Şerban, Inteligenţă artificială, Cluj Napoca, 2004
7. A. E. Eiben, J.E. Smith, Introduction to Evolutionary Computing, Springer, 2003.
8. D. E. Goldberg, Genetic Algorithms in Search, Optimization and Machine Learning, Addison-Wesley, 1989.
9. K. A. De Jong, Evolutionary Computation: A Unified Approach. MIT Press, Cambridge, MA, 2006.
10. Z. Michalewicz, D. B. Fogel, How to solve it: Modern Heuristics, 2nd edition, Springer, 2004.

8.2 Seminar / laboratory	Teaching methods	Remarks
L1-L2. Solving search problems using standard methods and local search methods	• Explanation • Conversation • Individual study • Study case • Brainstorming • Simulation • Exercise	
L3-L4. Solving search and optimization problems using single-point methods		
L5-L6. Solving search and optimization problems using evolutionary algorithms		
L7-L8. Solving problems using swarm intelligence algorithms		
L9-L10. Extension and hybridization of heuristic algorithms		
L11-L13. Interpretation and analysis of results for heuristic algorithms in solving complex problems		

Bibliography

1. Z. Michalewicz, D. B. Fogel, How to solve it: Modern Heuristics, 2nd edition, Springer, 2004.
2. S. Russell, P. Norvig, Artificial Intelligence: A Modern Approach, Prentice Hall, 1995
3. C. Groşan, A. Abraham, Intelligent Systems: A Modern Approach, Springer, 2011
4. M. Mitchell, An Introduction to Genetic Algorithms, MIT Press, 1998
5. A. Hopgood, Intelligent Systems for Engineers and Scientists, CRC Press, 2001

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 respects the IEEE and ACM Curricula Recommendations for Computer Science studies.
- The course exists in the studying program of all major universities in Romania and abroad.
- The content of the course is considered by the software companies as important for developing the modelling and programming skills of students.

10. Evaluation

Type of activity	10.1 Evaluation criteria	10.2 Evaluation methods	10.3 Share in the grade (%)
10.4 Course	Know the basic concepts of the domain Apply the intelligent principles from the course to solve complex and difficult problems	Written exam	50%
10.5 Seminar/lab activities	Specification, design, implementation and testing of intelligent methods Solving effectively problems using the implemented methods	Sistematic evaluation of the student in solving tasks Evaluation of lab assignments	50%

10.6 Minimum performance standards
➢ Each student must demonstrate an acceptable level of knowledge and understanding of the domain, the ability to present knowledge in a coherent manner and the ability to establish connections and use this knowledge to solve problems. ➢ To pass the exam it is required to: o At least 2 lab assignments must be presented o The average grade (of the written exam and lab) must be minimum 5

Date	Signature of course coordinator	Signature of seminar coordinator
24.04.2024	Prof. univ. dr. Camelia Chira	Prof. univ. dr. Camelia Chira

Date of approval	Signature of the head of department
.....	Conf. dr. Adrian Sterca