SYLLABUS

Metaheuristics

University year 2025-2026

1. Information regarding the programme

1.1. Higher education institution	**Babeș-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**
1.7. Form of education	**Full time**

2. Information regarding the discipline

2.1. Name of the discipline	**Metaheuristics**					Discipline code	**MLE5205**
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. Discipline regime	**Compulsory**

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/project	**2 lab**
3.4. Total hours in the curriculum	**56**	of which: 3.5 course	**28**	3.6 seminar/laboratory/project	**28**
Time allotment for individual study (ID) and self-study activities (SA)					**hours**
Learning using manual, course support, bibliography, course notes (SA)					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.

6.1. Specific competencies acquired [1]

Professional/essential competencies	• define the process • create software
Transversal competencies	• show initiative • think analytically

6.2. Learning outcomes

Knowledge	The student knows: • The graduate knows, understands and applies the basic concepts and the fundamental algorithms of Artificial Intelligence and is able to evaluate them based on metrics. • The graduate knows and understands the mathematical foundations needed to develop intelligent algorithms and is capable of using them for algorithm implementation.
Skills	The student is able to: • The graduate is able to formally describe issues addressed in various areas, and to model them as problems that can be addressed using Artificial Intelligence techniques. • The graduate has the necessary skills to apply various methods and tools for analysis and visualizing the results of the used Artificial Intelligence algorithms and techniques. • The graduate is able to apply fundamental algorithms of Artificial Intelligence in order to solve real-world problems.
Responsibility and autonomy:	The student has the ability to work independently to: • The graduate is able to write a scientific report.

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.

[1] One can choose either competences or learning outcomes, or both. If only one option is chosen, the row related to the other option will be deleted, and the kept one will be numbered 6.

8. Content

8.1 Course	Teaching methods	Remarks
1. Introduction to metaheuristics	Interactive exposure Conversation Explanation Examples	
2. Complex problems and modelling real problems. Classical models vs metaheuristics in solving complex problems		
3. Representation, evaluation, neighborhood. Local search methods, hill-climbing algorithms		
4. Single-point methods in solving complex problems – Tabu Search, Simulated Annealing		
5. Population-based methods in solving complex problems		
6. Evolutionary computing in solving optimization and search problems		
7. Design of evolutionary algorithms: binary representation, real representation, vectors, permutations		
8. Swarm intelligence models		
9. State-of-the-art models		
10. Computing models and hybrid systems		
11. Hybrid models and examples of real-world applications		
12. -14. Applications of metaheuristics		

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. Rezolvarea problemelor de căutare cu ajutorul unor metode standard şi de căutare locală	Conversaţia Algoritmizarea Brainstorming-ul Studiul de caz Simularea Studiul individual Exerciţiul Descoperirea	
L3-L4. Rezolvarea problemelor de căutare şi optimizare cu ajutorul metodelor de căutare de tip single-point		
L5-L6. Rezolvarea problemelor de căutare şi optimizare cu ajutorul algoritmilor evolutivi		
L7-L8. Rezolvarea problemelor cu ajutorul algoritmilor de tip swarm intelligence		
L9-L10. Extinderea şi hibridizarea algoritmilor euristici. Proiect în echipă.		
L11-L13. Interpretarea şi analiza rezultatelor algoritmilor euristici în rezolvarea unor probleme complexe. Proiect în echipă.		

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

Activity type	10.1 Evaluation criteria	10.2 Evaluation methods	10.3 Percentage of final grade
10.4 Course	• Know the basic concepts of the domain • Apply the intelligent principles from the course to solve complex problems	Written exam Presentation	50%
10.5 Seminar/laboratory	• Specification, design, implementation and testing of metaheuristics • Solving effectively problems using the implemented methods	Systematic evaluation of the student in solving tasks Evaluation of lab assignments	50%
10.6 Minimum standard of performance			
➢ 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, presentation and lab) must be minimum 5			

11. Labels ODD (Sustainable Development Goals)[2]

Not applicable.

Date: 14.04.2025

Signature of course coordinator: Prof. dr. Camelia Chira

Signature of seminar coordinator: Prof. dr. Camelia Chira

Date of approval: ...

Signature of the head of department: Assoc.prof.phd. Adrian STERCA

[2] Keep only the labels that, according to the *Procedure for applying ODD labels in the academic process*, suit the discipline and delete the others, including the general one for *Sustainable Development* – if not applicable. If no label describes the discipline, delete them all and write „*Not applicable*.".