# COURSE SHEET

*Mathematical Modeling and Graph Theory*
*Academic year 2023-2024*

## 1. About the program

| | | |
|---|---|---|
| 1.1 | University | University of Piteşti |
| 1.2 | Faculty | Sciences, Physical Education and Computer Science |
| 1.3 | Department | Mathematics-Computer Science |
| 1.4 | Field of study | Informatics |
| 1.5 | Cycle of studies | Master |
| 1.6 | Study Program / Qualification | Advanced techniques for information processing/ Advanced techniques for information processing |

## 2. Discipline data

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|---|---|---|---|---|---|---|---|---|---|---|---|
| 2.1 | Name of the discipline | | | | | *Mathematical Modeling and Graph Theory* | | | | | |
| 2.2 | The holder of the course activities | | | | | Assoc. prof. PhD Costel Bălcău | | | | | |
| 2.3 | Holder of laboratory activities | | | | | Assoc. prof. PhD Costel Bălcău | | | | | |
| 2.4 | Year of study | 1 | 2.5 | Semester | 1 | 2.6 | Type of assessment | E | 2.7 | Discipline regimen | O |

## 3. Estimated total time

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 3.1 | Number of hours per week | 4 | 3.2 | of which course | 2 | 3.3 | laboratory | 2 |
| 3.4 | Total hours of the curriculum | 56 | 3.5 | of which course | 28 | 3.6 | laboratory | 28 |

| Distribution of the time fund | hours |
|---|---|
| Study by textbook, course support, bibliography and notes | 56 |
| Additional documentation in the library, on specialized electronic platforms and in the field | 38 |
| Preparation of seminars/ laboratories, themes, papers, portfolios, essays | 40 |
| Tutoring | 6 |
| Examination | 4 |
| Other activities..... | - |

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| 3.7 | Total hours of self-study | 144 |
| **3.8** | **Total hours per semester** | **200** |
| **3.9** | **Number of credits** | **8** |

## 4. Preconditions (where applicable)

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| 4.1 | Curriculum | |
| 4.2 | Skills | Ability to analyze and synthesize, programming skills |

## 5. Conditions (where applicable)

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| 5.1 | Conduct of the course | Room with video projector |
| 5.2 | Conducting the seminar/laboratory | Laboratory room with video projector and computer equipment |

## 6. Acquired specific skills

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| Professional skills | Operation with scientific concepts and methods in the field of information processing in information systems;<br>Development of theoretical concepts and practical methods regarding the process of development and maintenance of computer applications;<br>Advanced information processing;<br>Realization of it projects in an interdisciplinary context;<br>Conceiving, designing and implementing information systems;<br>Management of information systems. |
| Transversal competences | Applying the rules of organized and efficient work, of responsible attitudes towards the scientific-professional field, for the creative capitalization of one's own potential, respecting the principles and norms of professional ethics;<br>Efficiently carrying out the activities organized in an interdisciplinary team by assuming execution and leadership functions, with the development of empathic capacities of inter-personal communication, networking and collaboration with various groups;<br>Elaboration of own professional development project; the use of effective methods and techniques for learning, information, research and capacity development, for valuing knowledge, for adapting to the requirements of a dynamic society and for communicating in Romanian and English. |

## 7. The objectives of the discipline

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| 7.1 The general objective of the discipline | ▶The acquisition by students of the basic knowledge, methods and techniques regarding the Mathematical Modeling, especially the Graph Theory, as well as the modalities of implementation and application to concrete situations. |
| 7.2 Specific objectives | *Cognitive objectives:*<br>▶ Knowledge of the studied models and their applicability.<br>▶ Learning advanced notions and algorithms from graph theory.<br>*Procedural objectives:*<br>▶ Use test problems for the studied mathematical models.<br>▶ Solve and implement problems from computer science modeled by graphs.<br>▶ Use and implement the main models and algorithms in graph theory.<br>▶ Highlights the applicability in other fields and in practical issues of the concepts and methods |

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| | studied.<br>▶ Investigate the problems from various perspectives, transfer knowledge and skills from one field to another.<br>*Attitudinal objectives:*<br>▶ Rigor in modeling, design and implementation of algorithms. |

**8. Contents**

| **8.1. Course** | | Nr. hours | Teaching methods | Observations Resources used |
|---|---|---|---|---|
| 1 | **Basic concepts of graph theory and linear programming**: examples, algorithms and tests. | 4 | Explication<br>Description and exemplification<br>Demonstration<br>Problematization<br>Heuristic conversation<br>Exercise | Blackboard<br>Pen tablet<br>Computer<br>Video projector<br>Documentary support<br>E-learning platform<br>Zoom |
| 2 | **Mathematical modeling through graphs**: examples. | 2 | | |
| 3 | **Steiner trees**: properties, NP-completeness, algorithms and applications. | 4 | | |
| 4 | **Minimum weight spanning arborescences**: algorithms and applications. | 2 | | |
| 5 | **Numerical invariants of graphs**: the independence number, the matching number, the transversal number, the edge covering number and the clique number: properties, NP-completeness, algorithms and applications. | 4 | | |
| 6 | **Maximum matchings**: mathematical models, the Berge-Norman-Rabin theorem, the Edmonds algorithm, perfect matchings and applications. | 4 | | |
| 7 | **Maximum network flows**: mathematical models, computing the invariants for bipartite graphs, algoritthms and applications. | 4 | | |
| 8 | **Other models of mathematical programming**: quadratic models, convex models, entropic models, examples, algorithms and tests. | 4 | | |

*Bibliography*


1. A.V. Aho, J.E. Hopcroft, J.D. Ullman, Data Structures and Algorithms, Addison-Wesley, Massachusetts, 2009.
2. Gh. Barbu, V. Păun, Programarea în limbajul C/C++, Ed. Matrix Rom, Bucureşti, 2011.
3. C. Bălcău, Combinatorică şi teoria grafurilor, Ed. Univ. din Piteşti, Piteşti, 2007.
4. C. Bălcău, Mathematical Modeling and Graph Theory – course notes (electronic support).
5. O. Bâscă, L. Livovschi, Algoritmi euristici, Ed. Univ. din Bucureşti, Bucureşti, 2003.
6. E. Ciurea, L. Ciupală, Algoritmi. Introducere în algoritmica fluxurilor în reţele, Ed. Matrix Rom, Bucureşti, 2006.
7. T.H. Cormen, Algorithms Unlocked, MIT Press, Cambridge, 2013.
8. T.H. Cormen, C.E. Leiserson, R.L. Rivest, C. Stein, Introduction to Algorithms, MIT Press, Cambridge, 2009.
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10. N. Dale, C. Weems, Programming and problem solving with JAVA, Jones & Bartlett Publishers, Sudbury, 2008.
11. D. Du, X. Hu, Steiner Tree Problems in Computer Communication Networks, World Scientific, 2008.
12. S. Even, Graph Algorithms, Cambridge University Press, 2012.
13. D. Fanache, Teoria algoritmică a grafurilor, Editura Paralela 45, Pitești, 2016.
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19. D. Jungnickel, Graphs, Networks and Algorithms, Springer, 2013.
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38. ***, Handbook of combinatorics, edited by R.L. Graham, M. Grotschel and L. Lovasz, Elsevier, Amsterdam, 1995.
39. ***, Handbook of discrete and combinatorial mathematics, edited by K.H. Rosen, J.G. Michaels, J.L. Gross, J.W. Grossman and D.R. Shier, CRC Press, Boca Raton, 2000.

| **8.2. Applications – Laboratory** | | Nr. hours | Teaching methods | Observations Resources used |
|---|---|---|---|---|
| 1 | **Basic concepts of graph theory and linear programming**: examples, algorithms and tests. | 4 | Explication<br>Description and exemplification<br>Case study<br>Exercise<br>Problematization<br>Individual themes<br>Group work<br>Debate | Blackboard<br>Pen tablet<br>Computer<br>Video projector<br>Documentary support<br>E-learning platform<br>Zoom |
| 2 | **Mathematical modeling through graphs**: examples. | 2 | | |
| 3 | **Steiner trees**: properties, NP-completeness, algorithms and applications. | 4 | | |
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| 5 | **Numerical invariants of graphs**: the independence number, the matching number, the transversal number, the edge covering number and the clique number: properties, NP-completeness, algorithms and applications. | 4 | | |
| 6 | **Maximum matchings**: mathematical models, the Berge-Norman-Rabin theorem, the Edmonds algorithm, perfect matchings and applications. | 4 | | |
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**9. Corroborating the contents of the discipline with the expectations of the representatives of the epistemic community, professional associations and employers in the field related to the program**

The competences acquired within the discipline allow the graduates to efficiently use the models and techniques specific to mathematical modeling and graph theory in solving the requirements related to the practice and research in the field of informatics. The contents are correlated with those of similar disciplines in prestigious universities in the country and abroad (such as MIT) and adjusted after discussions with representatives of local IT employers (such as RoWeb, Lisa, Prodinf, Kepler, Osf, Endava).

**10. Evaluation**

| Activity Type | 10.1 Assessment criteria | 10.2 Assessment methods | 10.3 Percent of final grade |
|---|---|---|---|
| 10.4 Course | Final evaluation | Written test (theory, algorithms and problems) | 50% |
| 10.5 Seminar/ Laboratory | Activity (solving proposed problems)<br>Homework | Verification of solutions, practical test<br>Homework check | 30%<br>20% |
| 10.6 Minimum performance standard | * Marks of at least 5 for the laboratory activity, for the homework and for the final evaluation (50% solving the requirements); final grade at least 5.<br>* Set of minimal knowledge for passing the final exam:<br>- Knowledge of the main models and algorithms studied;<br>- Knowledge of ways of adequate application and efficient implementation of these models and algorithms for solving the proposed problems. | | |

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| Date of completion<br>19.09.2023 | Course holder<br>Assoc. prof. PhD Costel Bălcău | Laboratory holder<br>Assoc. prof. PhD Costel Bălcău |
| Date of approval in the Department<br>19.09.2023 | Director Department (provider)<br>Assoc.prof. PhD Doru CONSTANTIN | Director Department (*beneficiary)*<br>Assoc.prof.PhD Doru CONSTANTIN |